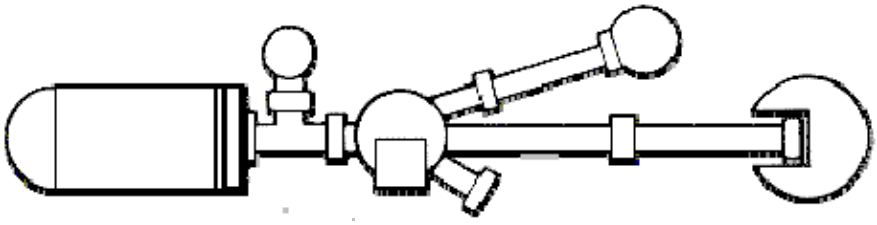
Welcome to the

20th International Conference on the Application of Accelerators in Research and Industry (CAARI 2008)



August 10 – 15, 2008

Renaissance Worthington Hotel

Fort Worth, Texas USA

Contact Details

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Conference Secretary
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Endorsed by the American Physical Society

CAARI 2008 COMMITTEES

Local Organizing Committee

Floyd Del McDaniel	Co-chair	University of North Texas
Barney L. Doyle	Co-chair	Sandia National Labs
Jerome L. Duggan	Chair Emeritus	University of North Texas
Margaret Hall	Conference Secretary	University of North Texas
Karen Sloan	Administrative Assistant	Sandia National Labs
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Topic Editors

Arlyn J. Antolak	USA
John E.E. Baglin	USA
Itzik Ben-Itzhak	USA
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Welcome!

The organizers would like to welcome everyone to the 20th International Conference on the Application of Accelerators in Research and Industry. This conference is being hosted by the University of North Texas (Denton) and Sandia National Laboratories (Albuquerque). CAARI 2008 is also being supported by several U.S. National Laboratories, industries and agencies most identified with accelerator technology. The Conference Co-chairs and the Topic Editors worked closely with the Session Chairs to develop the sessions and speakers.

This is the 20th International conference in the biennial series that began in 1968 as a *Conference on the Use of Small Accelerators for Teaching and Research* by Jerry Duggan, while he was a staff member at Oak Ridge Associated Universities. When Jerry joined the University of North Texas (UNT) in Denton, Texas, he continued the Conference series in 1974, holding the meeting on the UNT campus. When Lon Morgan joined Jerry as a co-organizer and brought in the industrial components of CAARI, it then became known the International Conference on the Application of Accelerators in Research and Industry (CAARI) or the "Denton" Conference. In 2004, Jerry Duggan, Del McDaniel, and Barney Doyle were co-organizers and moved the conference to Fort Worth, Texas, where it is held again this year.

CAARI brings together scientists from all over the world who use particle accelerators in their research and industrial applications. The CAARI conference can be considered a collection of symposia for the following topics:

- Accelerator Technology
- Atomic Physics
- Focus Ion Beams and PIXE
- Ion Beam Analysis
- Ion Beam Modifications
- Nano-Scale Fabrication
- National and Homeland Security
- Nuclear Physics
- Nuclear Based Analysis
- Medical Applications
- Medical Radioisotopes
- Radiation Effects
- Teaching with Accelerators

The Proceedings of CAARI-2008 will be published in the American Institute of Physics Conference Proceedings Series.

As with previous meetings in this series, the conference will comprise a mixture of plenary, invited review, invited technical, contributed talks and poster presentations. The oral sessions each day will run for two hours and are separated by the Industrial Exhibit show, breaks and lunch followed by Poster sessions in the early evening. The two-hour sessions allow a number of possible combinations of Review, Invited and Contributed talks. This year, the oral sessions will run through Friday afternoon. There will be a total of 85 oral sessions and 4 poster sessions. In addition to these, we have something new this year: the "greatest hits" from seven of the topic areas will have their talks videotaped throughout the week.

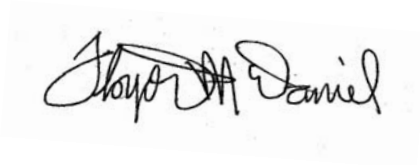
Each poster will be displayed from Monday through Thursday. Poster authors will stand by their posters during their assigned poster session. Special attention has been made regarding the format of the poster presentations to maximize availability and visibility. Posters are to be put "up" Monday by 1:00 pm. They will stay up during the entire conference, but please take them "down" by 8:30 am on Friday. The layout of the poster boards is such that there will be one (1) poster on each side of a 4 x 8 foot board. Participants are encouraged to visit the Rio Grande Room and view posters throughout the conference. During each poster session, one student will be selected to receive a cash award for the best poster in that session. Your Topic Editors will be the judges in each session. The award will be presented at the Banquet on Thursday.

The Industrial Exhibit Show will begin at 10:00 am on Monday and run through Thursday at 3:30 pm. We have a variety of vendors this year; please stop by, see their products, and say "thank you" to the representatives for continuing to support the CAARI conference. Without our exhibitors, CAARI would not be able to support students and attendees.

We hope that each of you enjoy the conference and find it intellectually stimulating. In the schedule, we have provided several opportunities to renew friendships and talk science at this meeting, including the Welcome Reception Sunday evening, the Conference Outing on Monday evening, the socials during each poster session, the Banquet on Thursday evening, and the Closing Ceremony on Friday.

The Conference Hotel, the Renaissance Worthington Hotel, is located in the heart of the downtown Fort Worth. There are 36 restaurants within walking distance of the Hotel, with varying price ranges. There are also three live comedy theatres, two movie theatres, museums, the Bass Concert Hall, nightclubs, bookstores, and beautiful walking areas for your enjoyment. Areas of interest include Historic Downtown, the Stockyards National Historic District, the Cultural District, the Fort Worth Zoo, and the Sundance Square for shopping. The Fort Worth Visitors and Convention Bureau will be happy to share the sights and sounds of the city with you. Please visit their table in the exhibit area for more information.

If there is anything we can do to make your conference experience and stay in Fort Worth, Texas, more enjoyable, just ask Del, Barney, Margaret or Karen. Enjoy!



CAARI 2008 Conference Co-Chairs

FINANCIAL SUPPORT

Financial support from sponsors, exhibitors and advertisers is an essential element of a successful conference. This support enables us to keep the registration fee to a minimum and to provide support for conference events, students and other attendees. We are very grateful to the sponsors, exhibitors and advertisers listed below for their support of CAARI 2008.

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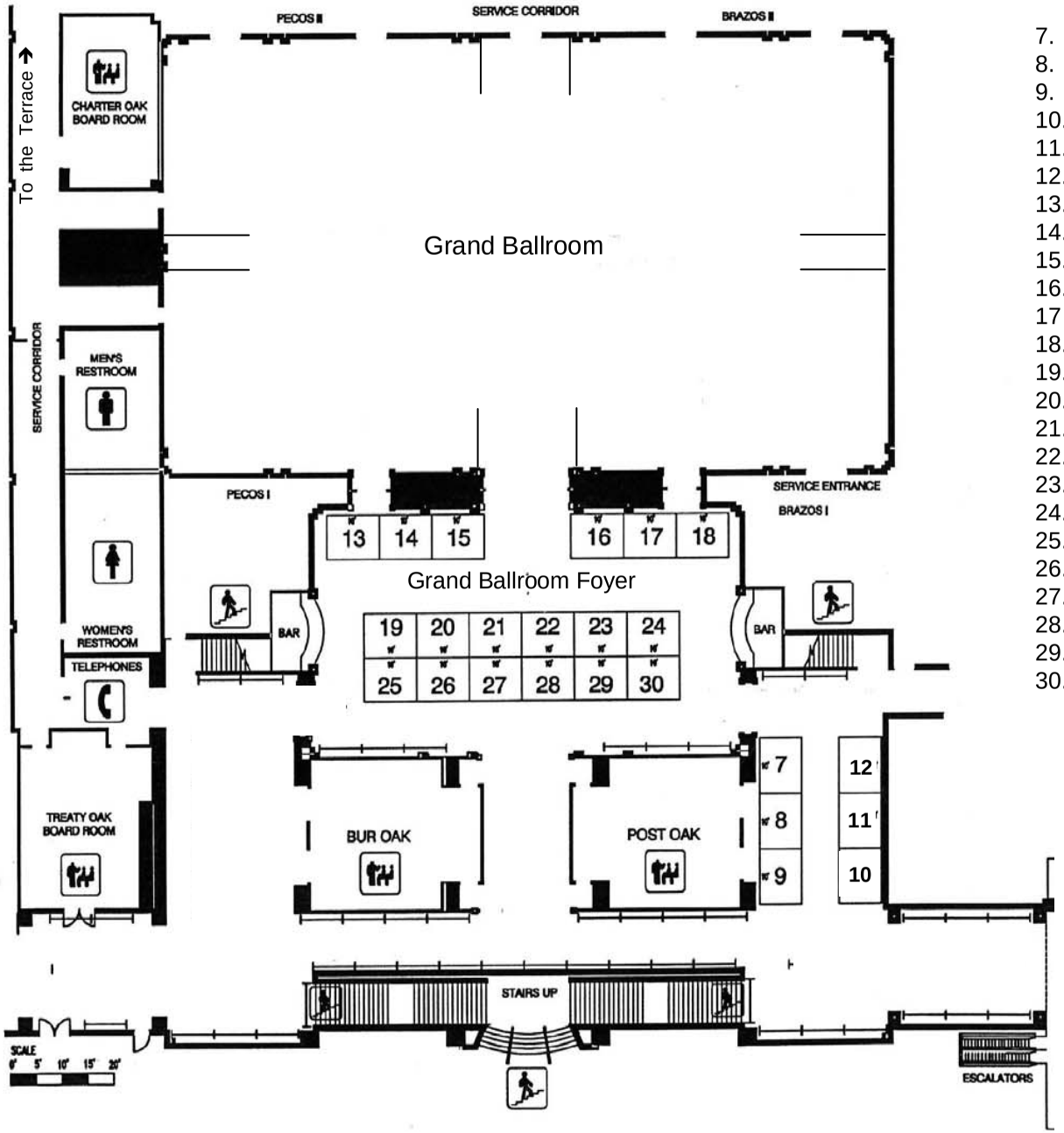
CAARI 2008

THE WORTHINGTON HOTEL

FORT WORTH, TEXAS

GRAND BALLROOM/ FOYER



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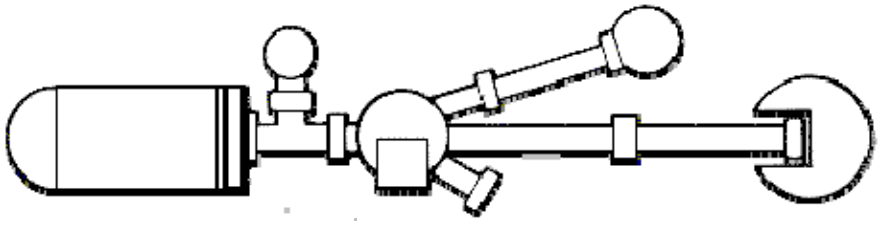


GENERAL INFORMATION

General Information

Oral Sessions

The oral program includes Review (30 minute), Invited (20 minute) and Contributed (15 minute) talks. The Plenary Session will be held on Monday at 8:30 am in Pecos I & II at the Renaissance Worthington Hotel. Oral talks will begin at 12:30 pm Monday and run through Friday. They will be held in Pecos II, Brazos I, Brazos II, Bur Oak, Post Oak on the mezzanine level and in West Fork, Trinity Central and Elm Fork on the lower level. Special video-taped sessions will be held in Pecos I throughout the week. You are invited to check the Program Schedule for the oral presentation of your choice.

Guidelines for Oral Presenters

- **Very important**: Each presentation **MUST** be in a PowerPoint or PDF file and read from a memory stick or CD. All presentations will be downloaded on the existing computer in the meeting room. LCD projector resolution is XGA 1024x780.
- **The presenting author must check in at the Manuscript Desk.**
- All memory sticks or CDs MUST be given to the Session Chair or the Conference Assistant prior to the session, for downloading at least 30 minutes prior to the start of the session.
- At least 20% of your talk time should be reserved for questions and answers. If your talk is 30 minutes, reserve 6 minutes for Q & A; if it's a 20 minute talk, reserve 4 minutes and for a 15 minute talk, reserve 3 minutes.

Industrial Exhibit Show

The Industrial Exhibit Show will be held in the Grand Ballroom Foyer. Hours are:

* Monday, 10:00 am to 4:00 pm
* Tuesday and Wednesday, 8:00 am to 5:00 pm
* Thursday, 8:00 am to 3:30 pm

Please visit the exhibit booths and give our vendors your support.

Poster Sessions and Socials

All Poster Sessions will be held in the Rio Grande room on the lower level of the Hotel. All posters are to be 'up' on display boards no later than 1:00 PM on Monday. Poster sessions will be held:

* Monday, 2:30 pm to 4:30 pm
* Tuesday and Wednesday, 5:30 pm to 7:30 pm
* Thursday, 3:30 pm to 5:30 pm

All posters in each session MUST be presented by an author during the period allocated for the session in order to be published in the proceedings. Posters will be presented on the same day as the oral session to which they are assigned, except that Friday session posters will be presented on Thursday. All posters will remain on boards through Thursday's poster session. Please retrieve your poster after 5:30 pm on Thursday. Any posters remaining after 8:30 am on Friday will be destroyed.

Cyber Café

The Cyber Café (email stations) will be located in the Treaty Oak Boardroom, just off the Grand Ballroom Foyer and Industrial Exhibit area. The Cyber Café hours are:

* Sunday, 1:00 pm to 6:00 pm
* Monday, 7:00 am to 4:00 pm
* Tuesday, 7:00 am to 5:30 pm
* Wednesday, 7:00 am to 10:00 pm
* Thursday, 7:00 am to 5:30 pm
* Friday, 7:00 am to 12:00 pm

Hotel Internet Connections

The Renaissance Worthington Hotel has complementary wireless high-speed internet connection on the Bridge and in the Hotel Lobby; it will connect you automatically. In the Bridge area, you must be on the marble floor near the windows in order to access it. There are tables and chairs available for seating. All the sleeping rooms have a data port with T1 internet connection at $9.95 plus tax per day. In the room, there is a device with an internet (Ethernet) cable, so all you have to do is "plug and play". Any questions, please contact the Front Desk at the Hotel.

Manuscript Submission

The manuscript deadline is Monday, August 11. All manuscripts are to be submitted on the web site.

Continental Breakfast and Breaks

Each morning of the conference, a Continental breakfast will be served in the Grand Ballroom Foyer. Morning and afternoon breaks will be served each day as appropriate for the day's events.

Lunch and Dinner

All lunches and dinners are on your own, except for the Conference Outing on Monday and Banquet on Thursday, which are included in your registration fee. Delegates are invited to sample local fare at nearby cafes and restaurants.

Meetings and Social Events

Welcome Reception

A Welcome Reception will be held Sunday, August 10, from 6:00 pm to 8:00 pm in Brazos I & II, Mezzanine level of the hotel.

Conference Outing

The Conference Outing will be held at the Stockyard Stations in the Stampede Room on Monday, August 11. Buses will depart from the hotel beginning at 4:45 pm and will return at 10:00 pm. The Outing will include a real Texas long-horn steer, special entertainment, and a speaker along with food and beverage. There will be plenty of time for sashaying in your hats and boots through the various shops and taking pictures before dinner at 7:00 pm. Be sure to bring your CAMERA!

Accompanying Persons Outing
The companions will meet on Tuesday, August 12, at 8:30 am in the RW Hotel lobby to board the bus. The first stop will be at the National Cowgirl Museum and Hall of Fame, and the Fort Worth Museum of Science & Industry. After visiting the museums, it's on to the University Park Village for shopping and lunch, returning to the Hotel around 3:00 pm.

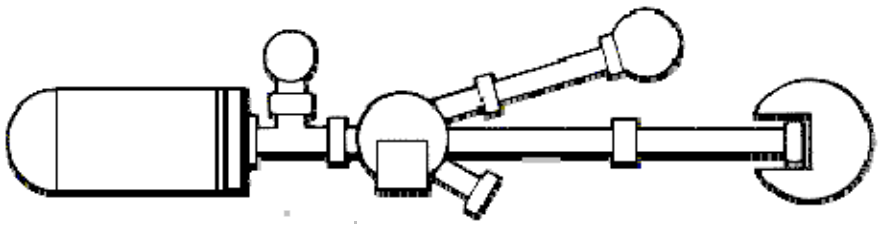
Topic Editors Dinner Meeting
The Topic Editors will meet with Del and Barney on Tuesday, August 12, beginning at 6:30 pm in Treaty Oak Boardroom, to set referee assignments for the CAARI 2008 manuscripts.

Student Appreciation Event
To celebrate our young scientists, a Student Appreciation Event will be held on Wednesday, August 13, at 7:30 pm in 8.0 Restaurant and Bar. 8.0 features the best live music in Fort Worth and is only a short walk from the hotel.

Topic Editors and Session Chairs Meeting
The Topic Editors and Session Chairs will meet with Del and Barney on Wednesday, August 13, at 9:30 pm. This meeting is to review the conference setup, sessions, paper submissions, and to discuss improvements for CAARI 2010. If you have any suggestions for the next CAARI conference, please write them clearly on paper and give to the Manuscript Desk volunteers prior to this meeting.

Conference Banquet
The conference banquet is scheduled for Thursday, August 14, from 6:00 pm to 10:30 pm in the Grand Ballroom. Entertainment will be provided by the Cosmic Cowboys along with special dance instruction.

Closing Ceremony
All participants and accompanying persons are cordially invited to attend the closing ceremony. It will be held on Friday, August 15, in the Rio Grande room at 4:15 pm.



CONFERENCE PROGRAM SCHEDULE

Opening Ceremony

Monday, August 11 – 8:00-8:30 AM

Welcome to CAARI 2008

8:00 AM

F. Del McDaniel
Regents Professor, Physics Department
University of North Texas

Barney L. Doyle
Manager, Radiation Solid Interactions Department
Sandia National Laboratories

Guest Speakers

8:10 AM

Dr. Viswanath Prasad
Vice President for Research and Economic Development
University of North Texas

8:20 AM

Dr. Richard H. Stulen
Chief Technology Officer and Vice President
Science and Technology, and Research Foundations
Sandia National Laboratories

UNT
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NORTH TEXAS

Office of the Vice President for Research and Economic Development

Vish Prasad is the Vice President for Research and Economic Development at the University of North Texas (UNT), the largest university in the Dallas-Fort Worth Metroplex and fourth largest university in the State of Texas, with 34,000 students. At UNT, Dr. Prasad is responsible for promoting the University's mission in research, original scholarship and artistic creativity, building a research park (UNT Discovery Park), and fostering partnerships with government agencies and various industries. He also oversees the university's intellectual property and technology transfer policies and programs.

Prior to joining UNT in October 2007, Dr. Prasad served as the Executive Dean of Engineering and Computing (2005-2007) and Dean of Engineering (2001-2005) at Florida International University (FIU), one of the twenty-five largest universities in the US. Before moving to FIU, Dr. Prasad served as the Associate Dean for Research and Graduate Studies, Leading Professor of Mechanical Engineering, and Professor of Materials Science and Engineering at Stony Brook University – State University of New York (1993-2001).

Dr. Prasad earned his Ph.D. from the University of Delaware in Mechanical Engineering, and throughout his career has done extensive research in thermo-fluid sciences, energy systems, electronic materials and micro-electronics. He has published over two hundred invited and/or refereed articles, edited/co-edited several books and symposium volumes, and organized numerous conferences, symposia and workshops. He serves as the lead editor of "Annual Review of Heat Transfer," and as a member of the editorial advisory boards of two other journals. Dr. Prasad is an elected Fellow of the American Society of Mechanical Engineers (ASME). In the past, he has served as a member of the USRA Microgravity Research Council for a major NASA Program, as the Chair of several ASME Heat Transfer Division Committees, and as an associate editor of the ASME Journal of Heat Transfer. Dr. Prasad has served as a PI or Co-PI on grants of over $15 millions funded by NSF, Air Force, Army, Navy, DOE and industry; built a DOD Consortium of academia, industry and federal labs to conduct research on semiconductor crystal growth; developed a state-of-the-art crystal growth research facility; and served as a Co-PI of an NSF Materials Center (MRSEC).

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BIOGRAPHY

Dr. Richard H. Stulen

Vice President & Chief Technology Officer
Sandia National Laboratories

Dr. Richard Stulen is the Chief Technical Officer and Vice President of Science and Technology & Research Foundations at Sandia National Laboratories. In his line role, he is responsible for R&D activities of over 1300 scientists and engineers working in nanoscience and technology, materials science, advanced fusion and pulsed power technology, high-performance computing, radiation sciences, microelectronics and microsystems, and engineering sciences. Dr. Stulen is also responsible for Sandia's technology transfer program, the Science, Technology, and Engineering Strategic Management Unit, and the Nuclear Weapons Program's Science and Technology programs.

Dr. Stulen earned his Ph.D. degree in solid state physics from Purdue University and joined Sandia National Laboratories as a Member of the Technical Staff in 1976. During his career, he has organized and chaired international workshops and published extensively in areas related to surface science and Extreme Ultraviolet (EUV) lithography. In 1999, he received Lockheed Martin's prestigious NOVA award for technical excellence. His previous positions include Director of the Exploratory Systems and Development Center focusing on homeland security and the CEO and COO of the Extreme Ultraviolet Lithography Virtual National Laboratory. He served on the 2003 DoD Defense Science Board Summer Study on Homeland Security and is currently on the Board for the New Mexico Center for Advanced Computing.

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Revised, November 2007

Sandia National Laboratories

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company for the United States Department of Energy under contract DE-AC04-94AL85000.

CAARI 2008 Program Schedule - August 10-15

Sunday

1 - 6 PM Registration Open
1 - 6 PM Cyber Café Open - Treaty Oak Boardroom
6 - 8 PM Welcome Reception - Brazos I & II

							Lower Level			
	Pecos I *(Videotaped)*	**Pecos II**	**Brazos I**	**Brazos II**	**Bur Oak**	**Post Oak**	**West Fork**	**Trinity Central**	**Elm Fork**	**Legend**
Monday, 8/11										
8:00 AM	Opening Ceremony									
8:30 AM	**Plenary**									
10:00 AM	Industrial Exhibit Show - Grand Ballroom Foyer									
11:30 AM	***LUNCH***									
12:30 PM	***MA***	**IBM01**	**NP01**	**IBA01**	**AT01**			**RE01**	**AP01**	AP - Atomic Physics
2:30 PM	Poster Session - P1 - Rio Grande Room, Lower Level									
4:30 PM	**Conference Outing**									AT - Accelerator Technology
Tuesday, 8/12										
8:00 AM	Industrial Exhibit Show - Grand Ballroom Foyer									ED - Teaching with Accelerators
8:30 AM	***FIBP***	**IBM02**	**NP02**	**NBA01**	**AT02**		**MA02**	**RE02**	**AP02**	
10:30 AM	***BREAK, Networking, Industrial Exhibit Show, LUNCH***									FIBP - Focused Ion Beams & PIXE
1:00 PM		**IBM06**	**NP03**	**IBA02**	**AT03**	**FIBP01**	**MA03**	**RE03**	**AP03**	
3:00 PM	***BREAK***									IBA - Ion Beam Analysis
3:30 PM	***NHS***	**IBM04**	**NP04**	**NBA02**	**AT04**	**FIBP02**	**MA04**	**RE04**	**AP04**	
5:30 PM	Poster Session - P2 - Rio Grande Room, Lower Level									IBM - Ion Beam Modification
Wednesday, 8/13										
8:00 AM	Industrial Exhibit Show - Grand Ballroom Foyer									MA- Medical Applications
8:30 AM		**IBM08**	**NP05**	**NHS01**		**FIBP03**	**MA05**	**RE05**	**AP05**	
10:30 AM	***BREAK***									MR - Medical Radioisotopes
11:00 AM	***ED***									
12:00 PM	***LUNCH***									NSF - Nano-Scale Fabrication
1:00 PM	***NSF***	**IBM05**	**NP06**	**NHS02**	**AT06**	**FIBP04**	**MA06**	**RE06**	**AP06**	
3:00 PM	***BREAK***									NHS - Nat'l & Homeland Security
3:30 PM	***AP***	**IBM07**	**NBA03**	**IBA03**	**AT07**	**FIBP05**	**MA07**	**NSF01**	**RE07**	
5:30 PM	Poster Session - P3 - Rio Grande Room, Lower Level									NP - Nuclear Physics
Thursday, 8/14										
8:00 AM	Industrial Exhibit Show - Grand Ballroom Foyer									NBA - Nuclear-Based Analysis
8:30 AM		**IBM03**	**NBA04**	**NHS07**	**ED01**	**FIBP06**	**MA08**	**NSF02**	**RE08**	
9:30 AM	***MR***									RE - Radiation Effects
10:30 AM	***BREAK, Networking, Industrial Exhibit Show, LUNCH***									
1:00 PM		**IBA04**	**NP07**	**NHS06**	**ED02**		**MR01**	**NSF03**	**AP07**	
3:00 PM	***BREAK***									
3:30 PM	Poster Session - P4 - Rio Grande Room, Lower Level									
6:00 PM	**Conference Banquet & Entertainment**									
Friday, 8/15										
8:30 AM		**IBA05**	**NBA05**	**NHS04**			**MR02**	**NSF04**	**AP08**	
10:30 AM	***BREAK***									
11:00 AM		**IBA06**	**NP08**	**NHS05**	**NBA06**		**MR03**	**NSF05**		
1:00 PM	***LUNCH***									
2:00 PM		**IBA07**	**NP09**	**NHS03**			**SIBL**	**NSF06**		
4:15 PM	**Closing Ceremony - Rio Grande Room, Lower Level**									

6:30 PM Tuesday Topic Editors Dinner Meeting

7:30 PM Wednesday Sudent Appreciation Event

CAARI-2008 SCHEDULE OF EVENTS - SUNDAY, August 10, 2008

1:00 - 6:00 PM	**Registration Open**	**The Bridge**
1:00 - 6:00 PM	**Manuscript Desk Open**	**The Bridge**
1:00 - 6:00 PM	**Cyber Café Open**	**Treaty Oak Boardroom**
6:00 - 8:00 PM	**Welcome Reception**	**Brazos I & II**
7:30 - 8:30 PM	**Conference Assistants Training**	**Bur Oak**

CAARI-2008 SCHEDULE OF EVENTS - MONDAY, August 11, 2008

7:00 AM - 4:00 PM	Registration and Manuscript Desk Open	The Bridge
7:00 AM - 4:15 PM	Cyber Café Open	Treaty Oak Boardroom
7:00 AM	Continental Breakfast	Grand Ballroom Foyer
8:00 AM	Welcome and Conference Opening – Floyd Del McDaniel and Barney L. Doyle	Pecos I & II

Vishwanath Prasad, Ph.D.
Vice President for Research and Economic Development
University of North Texas, Denton

Richard H. Stulen, Ph.D.
Chief Technology Officer and Vice President of Science and Technology, & Research Foundations
Sandia National Laboratories

Plenary Session — Pecos I & II

	P01	ABS #	**Chairs: Floyd Del McDaniel and Barney L. Doyle**
8:30 AM	Richard P. Levy	427	*The Future of Particle Therapy in Medicine: The Next Likely Steps*
9:10 AM	Mikio Takai	572	*Beam Processing and Analysis for Nano Science and Technology*
9:50 AM	George Vourvopoulos	201	*Active Interrogation Systems for Homeland Security*

10:00 AM — Industrial Exhibit Show Opens — Grand Ballroom Foyer

11:30 AM — LUNCH *(your own arrangements)*

General Sessions

Pecos I

	Videotaped Review Session		
	MA		**Title: Medical Applications**
		ABS #	**Chair: Richard P. Levy and Eugen B. Hug**
12:30 PM	Richard P. Levy	429	*Medical Applications of Accelerator Technology: Overview*

Pecos II

	IBM01		**Title: Ion Implantation - New Directions**
		ABS #	**Chair: Bibhudutta Rout**
12:30 PM	Daryush Ila	344	*Fabrication of Nanoscale Nano-systems by MeV Ion Beam*
12:55 PM	Thomas N. Horsky	140	*Current Trends in Ion Implantation*
1:20 PM	Peter Hosemann	364	*Overview of small scale materials studies using ion beam irradiations*
1:45 PM	Richard R. Greco	217	*The effects of Ga+ irradiation on the defect density and mechanical properties of single crystal copper*
2:00 PM	Ke-Ming Wang	204	*Optical Waveguides in Oxide Crystals Formed by MeV Heavier Ion with Lower Dose*
2:15 PM	Jesse J. Carter	225	*Modification of Metallic Glass Alloy Cu50Zr45Ti5 by Using High Fluence Ne Ion Irradiation*

CAARI-2008 SCHEDULE OF EVENTS - MONDAY, August 11, 2008

General Sessions

Brazos I

	NP01		Title: New Radioactive Ion Beam Facilities - Overviews
		ABS #	**Chair: Alfredo Galindo-Uribarri**
12:30 PM	Sydney Gales	590	*SPIRAL2 at Ganil: A World Leading ISOL Facility for the Next Decade*
1:00 PM	Tohru Motobayashi	TBD	
1:30 PM	Zbigniew Majka	599	*FAIR project – status and research program*
2:00 PM	Alberto Andrighetto	446	*The SPES Project at LNL*
2:20 PM	James R. Beene	638	*Electron Beam Driven Radioactive Beam Production*

Brazos II

	IBA01		Title: Ion Beam Analysis Theory and Simulations
		ABS #	**Chair: Nuno P. Barradas**
12:30 PM	Dries Smeets	48	*A breakthrough in real-time RBS: artificial neural networks*
1:00 PM	Rafael P. Pezzi	62	*Advanced modeling of ion energy loss for high resolution elemental depth profiling using ions at intermediate energies*
1:30 PM	Alexander Gurbich	256	*An algorithm to simulate the effect of surface roughness on backscattering spectra*
2:00 PM	Melanie J. Webb	251	*Thin film depth profiling using simultaneous particle backscattering and nuclear resonance profiling*
2:15 PM	Peter H. Stoltz	530	*Simulation of a cold cathode ion source for a compact neutron generator*

Bur Oak

	AT01		Title: Particle-Induced and Thermal Gas Desorption
		ABS #	**Chair: Michel Kireeff Covo**
12:30 PM	Edgar Mahner	286	*A review of heavy-ion induced desorption studies for particle accelerators*
1:00 PM	Janez Setina	517	*Outgassing of vacuum materials: thermal desorption, diffusion and permeation*
1:30 PM	S.Y. Zhang	173	*Experimental background due to particle Induced gas desorption in RHIC*
1:45 PM	Emma Hedlund	412	*Heavy Ion Induced Desorption in the Energy Range 5-17.7 MeV/u*
2:00 PM	Gao-Yu Hsiung	124	*Desorption of the NEG-coated aluminum chamber*
2:15 PM	Y. Tito Sasaki	484	*Stainless Steel Outgassing Rate Reduction to E-15 torr liter/cm2 s*

Trinity Central

	RE01		Title: Radiation Environments & Materials Challenges Facing Nuclear Energy Research
		ABS #	**Chair: Yongqiang Wang**
12:30 PM		TBD	
1:10 PM	Roger E. Stoller	539	*Challenges for Materials in a DT Fusion Environment*
1:50 PM	Stuart Maloy	534	*Radiation Environments and Materials Challenges in Advanced Fast Reactors*

Elm Fork

	AP01		Title: Atomic Physics and Related Phenomena I
		ABS #	**Chair: Kevin D. Carnes**
12:30 PM	Daniel Fischer	267	*Reaction microscopes in heavy-ion storage rings - results and prospects*
1:00 PM	Markus S. Schoeffler	61	*Capture and ionization of the Helium-Dimer by ion impact*
1:30 PM	Buddhika S. Dassanayake	141	*Electron and Ion Guiding Through Insulating Polymer Nanocapillaries*
2:00 PM	Vladimir Horvat	139	*K and L X-Ray Transitions in Multiply Ionized Atoms Produced in Heavy Ion Collisions*

CAARI-2008 SCHEDULE OF EVENTS - MONDAY, August 11, 2008

2:30 - 4:30 PM	**Poster Session 1**	Posters in AP01, AT01, IBA01, IBM01, NP01, RE01	**Rio Grande Room**

4:00 PM **Industrial Exhibit Show Closes**

4:15 PM **Cyber Café Closes**

4:30 PM	Conference Outing - Board the Buses	**FW Stockyards**

4:30 PM *Daily Session Concludes*

CAARI-2008 SCHEDULE OF EVENTS - TUESDAY, August 12, 2008

8:00 AM - 4:00 PM	Registration and Manuscript Desk Open	The Bridge
7:00 AM - 5:30 PM	Cyber Café Open	Treaty Oak Boardroom
7:30 AM	Continental Breakfast	Grand Ballroom Foyer
8:00 AM	Industrial Exhibit Show Opens	Grand Ballroom Foyer

General Sessions

Pecos I

	Videotaped Review Sessions		
	FIBP		**Title: Focused Ion Beams and PIXE**
		ABS #	**Chair: Javier Miranda**
8:30 AM	Arun Persaud	87	*Single ion doping with high spacial resolution*
9:00 AM	Javier Garcia Lopez	50	*Applications of High Energy PIXE using 18 MeV protons to the study of Cultural Heritage samples*
9:30 AM	Satoshi Harada	497	*Innovation of microcapsules that enables drug targeting through radiotherapy*

Pecos II

	IBM02		**Title: Ion Electron Beam Modification of Carbon Nanotubes**
		ABS #	**Chair: Igor O. Usov**
8:30 AM	Arkady V. Krasheninnikov	45	*Irradiation-induced phenomena in carbon nanomaterials*
9:00 AM	Csilla Miko	42	*Electron and UV irradiation effects in CNTs*
9:30 AM	Zoltan Osvath	57	*Ion irradiation effects in carbon nanotubes*
10:00 AM	Ananta R. Adhikari	14	*Irradiation assisted modification of carbon nanotubes and their use in polymer composites*

Brazos I

	NP02		**Title: Nuclear Structure and Astrophysics**
		ABS #	**Chair: Gary E. Mitchell**
8:30 AM	Aaran J. Couture	314	*DANCEing with the Stars: Measuring Neutron Capture on Unstable Isotopes with DANCE*
8:50 AM	Xiaodong Tang	274	*Conquer the challenges*
9:10 AM	Ravin S. Kodikara	341	*Measurement of the (p,γ) cross sections of 46Ti, 64Zn, 114Sn, and 116Sn at astrophysically relevant energies*
9:30 AM	Dan Bardayan	287	*New Measurements of spectroscopic factors for low-lying 16N levels*
9:50 AM	Gencho Y. Rusev	212	*Dipole-strength distributions below the giant dipole resonance in the stable even-mass molybdenum isotopes*
10:10 AM	Robert Hatarik	312	*Using 171,173Yb(d,pγ) to benchmark a surrogate reaction for neutron capture*

CAARI-2008 SCHEDULE OF EVENTS - TUESDAY, August 12, 2008

General Sessions

Brazos II

	NBA01		Title: Positron Studies: Annihilation, Basic Physics & Applications I
		ABS #	**Chair: Carroll A. Quarles**
8:30 AM	Y.C. Jerry Jean	388	*Review of Positron Spectroscopy Applied to Polymeric Materials*
9:00 AM	Ayman I. Hawari	216	*The Intense Slow Positron Beam and Associated Spectrometers at the NC State University PULSTAR Reactor*
9:20 AM	Marcus A. Gagliardi	148	*Defect Density Mapping of Shot Peened Materials using Positron Annihilation Spectroscopy*
9:40 AM	Jingyi Wang	236	*Positron Annihilation Lifetime Spectroscopy Study of the Cross-Link Density and Temperature Dependence of Free Volume in Rubber-Carbon Black Composites*
10:00 AM	Vakhtang Makarashvili	145	*Doppler Broadening Analysis of Steel Specimens using Accelerator Based in-situ Pair Production*
10:15 AM	Aurelie Gentils	44	*Determination of defects in 6H-SiC single crystals implanted with 20-MeV Au ions*

Bur Oak

	AT02		Title: Electrostatic Accelerator Facilities
		ABS #	**Chair: Serban Dobrescu**
8:30 AM	Matthias G. Klein	158	*Accelerator system development at HVE*
9:00 AM	Rajanikant Choudhury	190	*Applications of 14MV BARC-TIFR Pelletron Accelerator for Interdisciplinary Research*
9:30 AM	Joao A.M. Pereira	281	*Time-of-Flight Accelerator Mass Spectrometry (TOF-AMS) of Large Molecular Ions at MeV Energies*
9:45 AM	Serban Dobrescu	127	*The Bucharest FN Tandem Accelerator: modernization and development*

West Fork

	MA02		Title: Radiobiology of Particles
		ABS #	**Chair: Eleanor A. Blakely**
8:30 AM	Eleanor A. Blakely	621	*Radiobiology of Particles: Introduction and Overview*
9:00 AM	Michael F. Moyers	485	*Out-of-field Dose for Scanned and Scattered Proton Beams*
9:20 AM	Wayne D. Newhauser	616	*Do Contemporary Proton Therapy Systems adequately protect Pediatric Patients from Stray Radiation?*
9:40 AM	Phillip J. Taddei	614	*Effective Dose from Stray Radiation for a Patient Receiving Proton Therapy for Cancer of the Liver*
10:00 AM	Thilo Elsaesser	299	*Biological Treatment Planning for Tumor Therapy with Carbon Ions*

Trinity Central

	RE02		Title: Radiation Effects in Metals and Alloys
		ABS #	**Chair: Peter Hosemann**
8:30 AM	Michael J. Demkowicz	576	*Combining Experiments with Atomistic Modeling to Design Radiation Damage Resistant Composite Materials*
8:55 AM	Xinghang Zhang	28	*Enhancement of radiation tolerance by interfaces in nanostructured metallic materials*
9:15 AM	Nan Li	241	*Hardening in Al/Nb multilayers induced by helium ion irradiations*
9:30 AM	Fabian Naab	478	*Effects induced by low-flux ion irradiation in the Ni4Mo alloy*
9:45 AM	Gary A. Glass	387	*Sputter etching of metals with high energy heavy ions*
10:00 AM	Lali Tchelidze	101	*Positron Annihilation Energy and Lifetime Spectroscopy Studies for Radiation Defects in Stainless Steel*
10:15 AM	Tahir Cagin	396	*Molecular Dynamics Simulation of Radiation Cascades in Transition Metals with pre-existing defects: Point Defects, Dislocations, and Grain Boundaries*

CAARI-2008 SCHEDULE OF EVENTS - TUESDAY, August 12, 2008

General Sessions

Elm Fork

	AP02		Title: Atomic Physics and Related Phenomena II
		ABS #	**Chair: Joseph H. Macek**
8:30 AM	Sergey Ovchinnikov	444	*Evolution of quantum systems from microscopic to macroscopic scales*
9:00 AM	David Seely	362	*Production of long-lived H2-, HD-, and D2- during grazing scattering collisions of H3+, D3+ and D2H+ ions with KBr, KCl, and LiF surfaces*
9:25 AM	Ronald E. Olson	114	*Charge Exchange and X-ray Emission Cross Sections for Multiply-Charged Ions Colliding with Water*
9:50 AM	Charles C. Havener	320	*Isotope Effects in Ion-Atom Collisions*
10:15 AM	Jurij Simcic	319	*Experiments at the JPL Highly Charged Ion Facility and their Relevance for Atomic Physics and Astrophysics*

10:30 AM BREAK, Networking, Industrial Exhibit Show, LUNCH (*your own arrangements)*

Pecos II

	IBM06		Title: Novel Applications of Ion Solid Interactions
		ABS #	**Chair: Yanwen Zhang**
1:00 PM	William J. Weber	555	*Effects of Ionization on Ion-Beam-Induced Amorphization*
1:20 PM	Lucille A. Giannuzzi	460	*Application of ion-solid interactions for reducing damage in FIB prepared specimens*
1:50 PM	Carl J. McHargue	428	*The Structure of Sapphire Implanted with Carbon at Room Temperature and 1000 C*
2:10 PM	John Baglin	361	*Ion Beam Nano-Engineering Opportunities in Industrial Applications*
2:40 PM	Moni Behar	9	*Coulomb heating of channeled C2 molecules in Si*

Brazos I

	NP03		Title: Recent Advances in Experimental Nuclear Science I
		ABS #	**Chair: Stephen A. Wender**
1:00 PM	Jolie A. Cizewski	372	*Neutron transfer reactions: surrogates for neutron capture for basic and applied nuclear science*
1:25 PM	Tony S. Hill	461	*The Global Nuclear Energy Partnership (GNEP) and the Need for Precision Nuclear Data*
1:50 PM	Mike Heffner	481	*The Fission TPC Project*
2:15 PM	Anton P. Tonchev	533	*Photodisintegration Cross Section on 241Am*
2:30 PM	Sara K. Wuenschel	316	*Particle Identification in the Upgraded NIMROD-ISiS Detector*
2:45 PM	Indra M. Govil	189	*Tri-axial Shape co-existence and a New Aligned Band in 178 Os*

Brazos II

	IBA02		Title: Ion Beam Materials Analysis
		ABS #	**Chair: Yongqiang Wang**
1:00 PM	Yongqiang Wang	492	*Handbook of Modern Ion Beam Materials Analysis: The Second Edition*
1:30 PM	Alexander Gurbich	263	*Physics of the interaction of charged particles with nuclei*
1:50 PM	Lin Shao	232	*Dechanneling in Rutherford Backscattering Spectrometry Analysis*
2:10 PM	Melanie J. Webb	510	*Pitfalls in Ion Beam Analysis*
2:30 PM	Weiming Zhang	559	*Investigation of Si and C disorder distributions and Pt-implanted profile in 6H-SiC*
2:45 PM	Gregoire Chene	268	*Recent developments at the IPNAS Cyclotron of Liege - Use of high-energy alpha and proton beams for RBS measurements*

CAARI-2008 SCHEDULE OF EVENTS - TUESDAY, August 12, 2008

General Sessions

Bur Oak

	AT03		Title: Industrial Accelerators / Facilities
		ABS #	**Chair: Robert W. Hamm**
1:00 PM	Robert W. Hamm	424	*Industrial applications of accelerators*
1:25 PM	Marshall R. Cleland	310	*A New High-Current DC Proton Accelerator*
1:50 PM	Roberto M. Uribe	342	*Monte Carlo Simulations of the Irradiation of Alanine Coated Film Dosimeters with Accelerated Electrons*
2:05 PM	Mitsuru Ueasaka	509	*Quality Upgrade of 950 keV Portable X-band Linac*
2:20 PM	Liang Lu	150	*Design Study of IH Type Aceelerator for Semiconductor*
2:35 PM	Akira Sakumi	250	*Operation of Cartridge-type Photocathode RF gun with Bi-alkali high QE cathode*
2:50 PM	Vesselin I. Dimitrov	200	*Radiation Effects Testing Facility ISIS-IAC*

Post Oak

	FIBP01		Title: Focused Ion Beams in Materials Science
		ABS #	**Chair: Paolo Rossi**
1:00 PM	Paolo Olivero	51	*Three-dimensional lithography and functionalization of single crystal diamond with focused keV and MeV ion beams*
1:30 PM	David G. Cahill	52	*Ion Beam Analysis of Materials for Water Purification*
1:50 PM	Alexander D. Dymnikov	377	*Optimal parameters of high energy ion microprobe systems comprised of Louisiana lenses*
2:05 PM	Paul P. Tesch	403	*High Brightness Plasma FIB for Nanoscale and Microscale Milling Applications*
2:20 PM	Bibhudutta Rout	410	*Growth of self-assembled epitaxial gold silicide structures on silicon surfaces: RBS Studies with an ion microprobe*
2:35 PM	Jiro Matsuo	415	*Molecular imaging with swift heavy ions (MeV-SIMS)*
2:50 PM	Somjai Sangyuenyongpipat	512	*Lithography with MeV energy ions for biomedical applications:accelerator considerations*

West Fork

	MA03		Title: Medical Accelerator Technology for Cancer Therapy
		ABS #	**Chair: George B. Coutrakon**
1:00 PM	Eugene Fourkal	18	*Acceleration of protons by high-power lasers for clinical applications. Current challenges and future directions*
1:20 PM	Jan H. Timmer	276	*Design features of an integrated proton therapy solution*
1:35 PM	George J. Caporaso	182	*A Compact Linac for Intensity Modulated Proton Therapy Based on a Dielectric Wall Accelerator*
1:55 PM	Carol J. Johnstone	615	*Operating and Innovations in FFAGs for Proton and Ion Therapy*
2:10 PM	Kenneth Gall	620	*The Still River Compact Proton Therapy System*
2:30 PM	Kazuo Hiramoto	220	*Development of Synchrotron-based Technology for Advanced Proton Therapy*
2:45 PM	Todd J. Satogata	304	*Rapid Cycling Synchrotrons for Cancer Therapy*

CAARI-2008 SCHEDULE OF EVENTS - TUESDAY, August 12, 2008

General Sessions

Trinity Central

	RE03		Title: Radiation Effects in Semiconductors and Devices
		ABS #	**Chair: Vivian Zhu**
1:00 PM	Michael A. Xapsos	568	*The Near-Earth Radiation Environment*
1:30 PM	Lloyd Massengill	586	*Moore's Law vs. Soft Errors – Can Modeling Show the Way?*
1:50 PM	Rachel S. Goldman	582	*Formation of Nanostructures on Semiconductor Surfaces using Focused-Ion Beams*
2:10 PM	James Salzman	569	*Hardening Commercial Technologies for Multiple Markets*
2:30 PM	Michael S. Martin	226	*Amorphization Mechanism of Strained SiGe Alloys*
2:45 PM	Ki Bui Ma	203	*Diffusion of Antimony in Silicon in the Presence of Point Defects*

Elm Fork

	AP03		Title: Atomic Physics and Related Phenomena III
		ABS #	**Chair: John A. Tanis**
1:00 PM	Eduardo C. Montenegro	142	*Water Fragmentation and Energy Loss near the Bragg-Peak by Heavy Ions*
1:30 PM	Adriana Gagyi Palffy	4	*Resonant Nuclear Excitation via Coupling to the Atomic Shell*
2:00 PM	Regina C. Reuschl	138	*Quantum Electrodynamic Effects in He-like Uranium*
2:30 PM	Shahin Abdel Naby	82	*M-Shell Dielectronic Recombination: Theoretical Studies*

3:00 PM — BREAK — Grand Ballroom Foyer

Pecos I

	Videotaped Review Sessions		
	NHS		**Title: National and Homeland Security**
		ABS #	**Chair: Arlyn J. Antolak**
3:30 PM	Richard C. Lanza	550	*Today, Tomorrow and the Day after Tomorrow: Present and Future Trends in Imaging for NHS*
3:55 PM	Tsahi Gozani	391	*Neutron and Photon Active Inspection for Threat Materials - Principles and Applications*
4:20 PM	Vlado Valkovic	259	*New/Future Approaches to Explosives/Chemical Detection*
4:45 PM	Ahmed Badruzzaman	489	*Radioactive Sources in Hydrocarbon Exploration and Production: Needs, risks and alternatives*
5:10 PM	Brandon Blackburn	214	*Detection in Harsh Active Interrogation Environments*

Pecos II

	IBM04		Title: IBM of Nanosized Semiconductors
		ABS #	**Chair: Anand P. Pathak**
3:30 PM	Leonard C. Feldman	452	*Nanoscale Science with Ion Beams*
4:00 PM	Durga P. Mahapatra	191	*MeV Au ion induced nanocrystal formation in amorphized Si layers*
4:20 PM	Binaya K. Panigrahi	291	*Ion Beam Synthesis and Optical Properties of Ge, SiC, InN, and ZnO Nanoclusters*
4:40 PM	Anand P. Pathak	29	*Investigation of strain in AlGaN/GaN Multi Quantum Wells by complementary techniques*
5:00 PM	Natarajan Sathish	20	*RBS/Channeling and HRXRD studies on swift heavy ion irradiated AlGaN/GaN heterostructures*
5:15 PM	Isaac Y.S. Ow	7	*Fabrication of micron-size distributed Bragg reflectors in porous silicon*

CAARI-2008 SCHEDULE OF EVENTS - TUESDAY, August 12, 2008

General Sessions

Brazos I

	NP04		Title: Physics of Radioactive Ion Beams
		ABS #	**Chair: Alfredo Galindo-Uribarri**
3:30 PM	Mark L. Huyse	622	*Physics with Radioactive Ion Beams: the European ISOL-based effort*
3:55 PM	Enrico Farnea	458	*Gamma spectroscopy of neutron-rich nuclei with CLARA-PRISMA*
4:15 PM	Zsolt Podolyak	440	*Nuclear spectroscopy at RISING/GSI*
4:35 PM	Noemie B. Koller	584	*Measurements of Magnetic Moments of Short-lived Nuclear States*
4:55 PM	Joseph Cerny	454	*Reinvestigation of direct two-proton radioactivity of 94Agm (JII = 21+, 6.7 MeV)*
5:15 PM	Jolie A. Cizewski	375	*Single-neutron excitations in neutron-rich nuclei near 132Sn*
5:35 PM	Alfredo Galindo-Uribarri	618	*Nuclear Structure Studies with Radioactive Ion Beams in the Mass A=80 Region*

Brazos II

	NBA02		Title: Positron Studies: Annihilation, Basic Physics & Applications II
		ABS #	**Chair: Carroll A. Quarles**
3:30 PM	James R. Danielson	448	*New Plasma Tools for Antimatter Science*
4:00 PM	Robert D. DuBois	116	*Projectile Charge Effects in Differential Ionization by Positrons and Electrons*
4:20 PM	Alex Weiss	502	*Positron Annihilation Induced Auger and Gamma Spectroscopy*
4:40 PM	David B. Cassidy	218	*The development and applications of an accelerator based positron source*
5:00 PM	N.G. Fazleev	390	*The effects of surface reconstructions and electron-positron correlations on surface states and annihilation characteristics of positrons trapped at reconstructed semiconductor surfaces*

Bur Oak

	AT04		Title: Radiation Detectors for Accelerator Applications
		ABS #	**Chair: Lin Shao**
3:30 PM	Mohammed A. Mestari	41	*Real-Time Dosimetry for Radiobiology Experiments Using 25 MeV LINAC*
3:50 PM	Geoge Kharashvili	177	*Development and Testing of Gallium Arsenide Photoconductive Detectors for Ultra Fast, High Dose Rate Pulsed Electron and Bremsstrahlung Radiation Measurements*
4:10 PM	Arthur K. Pallone	356	*Performance of a small high-pressure xenon detector at sub-MeV photon energies with an example application to ion beam analysis*
4:30 PM	Mohammed A. Mestari	89	*OSL vs. Radiochromic Film Response in a Pulsed Irradiation Environment*
4:45 PM	Efrain R. Chavez	570	*Two dimensional neutron detection and some applications in Nuclear Physics Experiments*
5:00 PM	Csaba M. Rozsa	515	*BrilLanCe(™)380 (LaBr3:Ce) scintillator with APD light sensor*

Post Oak

	FIBP02		Title: Single Ion Implantation
		ABS #	**Chair: Edward S. Bielejec**
3:30 PM	Takahiro Shinada	589	*Single-Ion Implantation for Single-Dopant Controlled Devices*
4:00 PM	Arun Persaud	87	*Single ion doping with high spacial resolution*
4:30 PM	Andrew D.C. Alves	453	*Advances in the nanoscale positioning of single ions*
5:00 PM	John A. Seamons	466	*Single ion detection with Geiger mode avalanche diodes for low ion energy detection*

CAARI-2008 SCHEDULE OF EVENTS - TUESDAY, August 12, 2008

General Sessions

West Fork

	MA04		**Title: Ion Beam Initiatives**
		ABS #	**Chair: William T. Chu**
3:30 PM	Michael G. Herman	386	*Planning for a Particle Therapy Facility at Mayo Clinic*
3:50 PM	Xiaodong Wu	318	*Objective Considerations of a Particle Therapy Center*
4:10 PM	Gerhard H. Kraft	493	*Ion Beam Therapy in Europe*
4:30 PM	Carl M. Kleffner	472	*The Heidelberg Ion Therapy (HIT) Accelerator Coming into Operation*
4:50 PM	Dennis F. Falkenstein	181	*Integration of Innovations for Particle Therapy Solutions*
5:10 PM	Damien Prieels	474	*Development of the IBA Carbon/Proton Therapy System*

Trinity Central

	RE04		**Title: Radiation Response of Complex Structures and Systems**
		ABS #	**Chair: Srinivasan G. Srivilliputhur**
3:30 PM	Alfredo Caro	571	*Challenges in studying radiation response in complex materials*
4:00 PM	Taku Watanabe	439	*Radiation Damage in UO2 by Molecular Dynamics Simulation*
4:20 PM	Ming Tang	421	*A Comparison Between Radiation Damage Effects in Uranium Surrogates and Uranium Bearing Oxides with Delta-phase Structures*
4:40 PM	Jincheng Du	588	*Molecular Dynamics Simulations of Radiation Induced Structure Changes during Ion Implantation in Oxide Ceramics*
5:00 PM	Marilyn E. Hawley	547	*AFM Characterization of Oxide Multilayer Surfaces Modified by Heavy Ion Beam Irradiation*
5:15 PM	Patrick E. Gygli	334	*Resistance of an Extreme Halophile to a Variety of Types of Radiation*

Elm Fork

	AP04		**Title: Interrogating Ion Beams with Photons**
		ABS #	**Chair: Oded Heber**
3:30 PM	Ian Williams	TBD	*Excited Ions in Intense Femtosecond Laser Pulses*
4:00 PM	Itzik Ben-Itzhak	313	*Interrogating molecular-ion beams by ultra-short intense laser pulses*
4:30 PM	Henrik B. Pedersen	210	*FLASH photofragmenation of molecular ions*
5:00 PM	Yoni Toker	58	*Radiative Cooling of Small Aluminum Clusters*

5:00 PM **Industrial Exhibit Show Closes**

5:30 PM **Cyber Café Closes**

5:30 - 7:30 PM	**Poster Session 2**	Posters in AP02, AP03, AP04, AT02, AT03, AT04, FIBP01, FIBP02, IBA02, IBM02, IBM04, IBM06, MA02, MA03, MA04, NBA01, NBA02, NP02, NP03, NP04, RE02, RE03, RE04	**Rio Grande Room**

6:30 PM Topic Editors Dinner Meeting **Treaty Oak Boardroom**

7:30 PM *Daily Session Concludes*

CAARI-2008 SCHEDULE OF EVENTS - WEDNESDAY, August 13, 2008

8:00 AM - 4:00 PM	Registration & Manuscript Desk Open	The Bridge
7:00 AM - 10:00 PM	Cyber Café Open	Treaty Oak Boardroom
7:30 AM	Continental Breakfast	Grand Ballroom Foyer
8:00 AM	Industrial Exhibit Show Opens	Grand Ballroom Foyer

General Sessions

Pecos II

	IBM08		**Title: Ion Beam Modification of Polymers**
		ABS #	**Chair: Jacek K. Jagielski**
8:30 AM	Dariusz M. Bielinski	33	*Modification of Polymer Materials by Ion Bombardment*
9:00 AM	Yoichi Sugita	471	*Ion-Beam Surface Modification for Implantable Biomaterials*
9:30 AM	A. Leslie Evelyn	578	*Ion Beam Processing of Polymers: Basics and Applications*
10:00 AM	Azher M. Siddiqui	255	*Structural and optical characterization of 60 MeV Si5+ ion irradiated PoT-PVC blends*
10:15 AM	Bopha Chhay	337	*Enhanced stiffness of GPC composites by MeV Ion bombardment*

Brazos I

	NP05		**Title: Recent Advances in Experimental Nuclear Science II**
		ABS #	**Chair: Gary E. Mitchell**
8:30 AM	Abigail Bickley	84	*An active target time projection chamber for nuclear structure and reactions experiments*
8:50 AM	Micah S. Johnson	31	*Nuclear resonance fluorescence and isotopic mapping of containers*
9:10 AM	Frank Gunsing	55	*Neutron time-of-flight measurements at n_TOF, CERN*
9:30 AM	Dugersuren Dashdorj	53	*Study of the photon strength functions for Gadolinium isotopes with the DANCE array*
9:50 AM	Kyungyuk Chae	235	*Searching for resonances in the unbound 6Be nucleus*
10:10 AM	Stratos Galanopoulos	152	*Systematic investigation of caloric curves of reconstructed quasiprojectiles from collisions in the Fermi energy regime*

Brazos II

	NHS01		**Title: Imaging / Radiography for National and Homeland Security**
		ABS #	**Chair: Richard C. Lanza**
8:30 AM	William Bertozzi	10	*Imaging and Radiography with Nuclear Resonance Fluorescence and Effective-Z (EZ-3DTM) Determination*
9:00 AM	Richard Sheffield	501	*Low Dose Gamma Ray Transmission Radiography for Detection of SNM using Monoenergetic Gamma Rays*
9:20 AM	Gongyin Chen	102	*X-Ray Cargo Inspection: Status and Trends*
9:40 AM	Helen Boston	59	*Distinguishing illicit materials using a Compton Imager*
10:00 AM	David Perticone	54	*Automated detection with high energy radiation*
10:20 AM	Sergey Korenev	205	*The Pulsed Electron Beam Compression for Radiography*

CAARI-2008 SCHEDULE OF EVENTS - WEDNESDAY, August 13, 2008

General Sessions

Post Oak

	FIBP03		Title: Basic Theoretical and Experimental Aspects of PIXE
		ABS #	**Chair: Ziga Smit**
8:30 AM	Gregory Lapicki	482	*Evaluation of Lá x-ray production cross sections for PIXE applications*
9:00 AM	Helmut Paul	106	*Some new results on stopping power for fast ions*
9:20 AM	Novella Grassi	137	*Developments in the external beam setups at LABEC, Florence*
9:40 AM	Javier Miranda	324	*Measurement of K–L radiative vacancy transfer probabilities in rare earth elements bombarded with 12C and 16O ions*
9:55 AM	David Jezersek	308	*Analysis of textile fibers by in-air PIXE*
10:10 AM	Thomas Dupuis	246	*Middle energy PIXE preliminary experiments*

West Fork

	MA05		Title: Clinical Ion Beam Applications I: Target Delineation, Particle Treatment Delivery & Dose-delivery Verification
		ABS #	**Chair: Gerhard H. Kraft**
8:30 AM	Gerhard H. Kraft	500	*Clinical ion beam application: planning, application, quality control*
9:10 AM	Alexander Schmidt	494	*Scanned carbon pencil beams for tumor therapy*
9:40 AM	Georgy Shakirin	469	*Application of Positron Emission Tomography for Radiotherapy Monitoring*
10:10 AM	Damien Prieels	477	*Development of Pencil Beam Scanning for Proton Therapy*
10:30 AM	Vladimir A. Bashkirov	595	*Development of Proton Computed Tomography for Applications in Proton Therapy*

Trinity Central

	RE05		Title: Ion Irradiation/Implantation Effects in Ceramic Materials
		ABS #	**Chair: Weilin Jiang**
8:30 AM	Patrick Kluth	432	*Ion tracks in silica*
9:00 AM	Marie-France Barthe	457	*Properties of Vacancy defects induced by irradiation in SiC*
9:20 AM	Weilin Jiang	455	*Orientation dependence of disorder accumulation and recovery in silicon carbide*
9:40 AM	Chonghong Zhang	393	*Damage accumulation in gallium nitride and silicon carbide irradiated with energetic heavy ions*
10:00 AM	Vladimir Skuratov	75	*Stress depth profiles in Al2O3:Cr irradiated by swift heavy ions*
10:15 AM	Haiyan Wang	49	*Ion Irradiation Effects in Nanolayered Nitride Coatings*

Elm Fork

	AP05		Title: Ion Atom Collisions at FAIR/GSI
		ABS #	**Chair: Eric Wells**
8:30 AM	Harald Braeuning	97	*Measurement of polarization for radiative electron capture transitions in highly charged ions*
9:00 AM	Siegbert Hagmann	111	*Electron transfer to continuum in near relativistic ion-atom collisions*
9:30 AM	Yasunori Yamazaki	513	*Atomic physics involving antiprotonic complex: antihydrogen atoms and antiprotonic atoms*
10:00 AM	Yuan Liu	306	*A Resonant Ionization Laser Ion Source for Radioactive Ion Beams*

10:30 AM BREAK Grand Ballroom Foyer

CAARI-2008 SCHEDULE OF EVENTS - WEDNESDAY, August 13, 2008

General Sessions

Pecos I

	Videotaped Review Sessions		
	ED		**Title: Education**
		ABS #	**Chair: Justin M. Sanders**
11:00 AM	Jeffrey R. Vanhoy	265	*Accelerator-Based Laboratory Activities at USNA*
11:20 AM	Antonio C. Santos	134	*Using accelerators for teaching electromagnetism to high-school students*
11:40 AM	Jason J. Engbrecht	168	*Undergraduate Research Experiences in Positron Beams at St. Olaf*

12:00 PM LUNCH *(your own arrangements)*

Pecos I

	Videotaped Review Sessions		
	NSF		**Title: Nano-Scale Fabrication**
		ABS #	**Chair: John E.E. Baglin**
1:00 PM	Session Chairs		*Highlights Preview: Ion Beam Nano-Scale Fabrication*
			Title: Ion Beam Nanotechnology Tools
			Chair: John E.E. Baglin
1:10 PM	John Baglin	365	*Few-Nanometer Patterning of Surfaces, Thin Films and Resists -- Issues and New Approaches*
1:30 PM	Ximan Jiang	243	*Research on High-Resolution High-Throughput Ion Beam Lithography and Imaging Based on Plasma Ion Sources*
2:00 PM	Peter Kovac	303	*Ion Projection Technology System*
2:20 PM	William B. Thompson	496	*The Helium Ion Microscope for Sub-nanometer Imaging and Analysis*
2:40 PM	Jason E. Sanabia	520	*ionLiNE - a New Tool Concept for Nanofabrication*

Pecos II

	IBM05		**Title: Ion Beam Modification - New Perspectives**
		ABS #	**Chair: Moni Behar**
1:00 PM	Werner Wesch	408	*Ion Beam Synthesis of Transition Metal Nanoclusters in Silicon*
1:30 PM	Yanwen Zhang	373	*Response of Materials to Single Ion Events*
2:00 PM	Remigio Cabrera-Trujillo	295	*Ion Beam Modification at the molecular level: Comparison of molecular target and molecular projectile fragmentation*
2:30 PM	Fredrico Garrido	290	*Radiation Effects in Fluorite-type Nuclear Oxides*

Brazos I

	NP06		**Title: Instrumentation for Radioactive Ion Beams**
		ABS #	**Chair: Alfredo Galindo-Uribarri**
1:00 PM	Carl E. Svensson	541	*First Results with TIGRESS and Accelerated Radioactive Ion Beams from ISAC*
1:15 PM	Mario Cromaz	587	*The GRETINA Spectrometer*
1:30 PM	Helen Boston	574	*The Advanced GAmma Tracking Array, AGATA*
1:45 PM	William A. Peters	300	*Measurement of the Efficiency of the Modular Neutron Array (MONA) at the NSCL*
2:00 PM	Catalin Matei	169	*The Development of a Versatile Array of Neutron Detectors at Low Energy*
2:15 PM	Juan J. Vega	35	*Effect of signal noise on the learning capability of an artificial neural network*
2:30 PM	Anthony N. Villano	298	*Improved Energy Resolution of Radioactive Beams at the UM-UND \emph{TwinSol} Facility*

CAARI-2008 SCHEDULE OF EVENTS - WEDNESDAY, August 13, 2008

General Sessions

Brazos II

	NHS02		Title: Technologies for Detecting Nuclear/Radiological Contraband
		ABS #	**Chair: R. Leon Feinstein**
1:00 PM	R. Leon Feinstein	518	*Active Interrogation Technologies for Nuclear Detection - Overview*
1:15 PM	Tsahi Gozani	434	*Conventional and Non-conventional Nuclear Material Signatures*
1:40 PM	Steve Korbly	194	*A Novel Electron Accelerator for Non-Intrusive Interrogation Applications*
2:05 PM	Christopher P.J. Barty	507	*Tunable, Monochromatic X-rays in Interrogation - Production and Use*
2:25 PM	Donald P. Umstadter	463	*Development of a source of quasi-monochromatic MeV energy photons for detection of special nuclear materials*
2:45 PM	Timothy Shaw	389	*Fissile Material Detection by Differential Die Away Analysis*

Bur Oak

	AT06		Title: Cluster Ion Beam Facilities and Industrial Applications
		ABS #	**Chair: Noriaki Toyoda**
1:00 PM	Isao Yamada	122	*Review of cluster ion beam facility and technology*
1:20 PM	Kozo Mochiji	77	*Extremely low damage SIMS by using size-selected gas cluster ion beam*
1:40 PM	Jiro Matsuo	414	*Secondary ion emission under large cluster ion irradiation*
2:00 PM	Zinetulla Insepov	542	*Advanced surface polishing for accelerator technology using ion beams*
2:20 PM	Hiromichi Isogai	163	*Precise silicon wafer fabrication process using gas cluster ion beams*
2:40 PM	Noriaki Toyoda	156	*Energy loss and beam transport properties of gas cluster ion beams*

Post Oak

	FIBP04		Title: PIXE in Cultural Heritage
		ABS #	**Chair: Javier Garcia Lopez**
1:00 PM	Novella Grassi	112	*PIXE applied to Cultural Heritage: recent studies at LABEC, Florence*
1:30 PM	Maria A.Ontalba Salamanca	479	*PIXE Technique Contribution in Archaeometallurgical Studies*
1:50 PM	Ziga Smit	43	*PIXE-PIGE analysis of Carolingian glass from Slovenia*
2:05 PM	F. David Correll	167	*PIXE Analysis of Metal Hull Bolts from HMB DeBraak*
2:20 PM	Mohamad A. Roumie	108	*PIXE protocols for cluster analysis of archeological samples: the funny filter case*

West Fork

	MA06		Title: Clinical Ion Beam Applications II: Proton Therapy (Clinical results, indications, innovative treatment concepts)
		ABS #	**Chair: Eugen B. Hug**
1:00 PM	Eugen B. Hug	573	*The Clinical Practice of Proton Radiotherapy: Overview and Recent Developments*
1:30 PM	Yevgeniy I. Luchin	532	*Proton Conformal Radiation Therapy and Radiosurgery of Intracranial Lesions: Dubna Experience*
1:50 PM	Erik L. Blomquist	628	*Proton Beam Radiotherapy in Uppsala: Past, Present and Future*
2:05 PM	Sameer R. Keole	631	*The Role of Protons In Pediatric Malignancies*
2:25 PM	Andrew L. Chang	633	*Patch Field Technique in Proton Beam Radiation Therapy for Selective Tissue Avoidance*
2:45 PM	Andrew K. Lee	629	*Proton Beam Therapy for Prostate Cancer*

CAARI-2008 SCHEDULE OF EVENTS - WEDNESDAY, August 13, 2008

General Sessions

Trinity Central

	RE06		**Title: Radiation-Matter Interactions for Radiation Detections**
		ABS #	**Chair: Ross E. Muenchausen**
1:00 PM	Ernst I. Esch	357	*Nano-composite based radiation detectors for beam experiments*
1:30 PM	Bret D. Cannon	422	*Accelerating Discovery of Improved Radiation Detection Materials*
2:00 PM	Luiz G. Jacobsohn	487	*Radioluminescence investigation of ion-irradiated phosphors*
2:20 PM	Eduardo G. Yukihara	580	*Heavy Charged Particle Effect on Al2O3:C Radiation Detectors*
2:40 PM	Sy Stange	443	*Development of Nanocomposite Scintillators for Gamma-Ray Measurement*

Elm Fork

	AP06		**Title: Molecular Fragmentation**
		ABS #	**Chair: Itzik Ben-Itzhak**
1:00 PM	Eric Wells	172	*Bond rearrangement following collisions between fast ions and ammonia or methane*
1:30 PM	Sankar De	222	*Ion induced dissociation dynamics of acetylene*
2:00 PM	Kevin D. Carnes	544	*Collision Induced Dissociation for 1.5 keV/amu HeH^+ Impact on Argon*
2:30 PM	Antonio C. Santos	135	*Dissociative and non-dissociative ionization of the O2 molecule by the impact of 0.75-3.5 MeV He+*

3:00 PM BREAK Grand Ballroom Foyer

Pecos I

	Videotaped Review Sessions		
	AP		**Title: Atomic Physics**
		ABS #	**Chair: Itzik Ben-Itzhak**
3:30 PM	Sergey Ovchinnikov	444	*Evolution of quantum systems from microscopic to macroscopic scales*
4:00 PM		TBD	
4:30 PM		TBD	

Pecos II

	IBM07		**Title: Ion Track Lithography**
		ABS #	**Chair: Punit Kohli**
3:30 PM	Lane A. Baker	445	*Scanning Ion Conductance Microscopy of Ion Tracked Membranes*
4:00 PM	Thomas W. Cornelius	459	*Nanowires synthesised in ion track-etched membranes*
4:30 PM	Bibhudutta Rout	409	*Fabrication of multi-level micro-tunnels in SU-8 using High Energy Ion Beam Lithography*
5:00 PM	Punit Kohli	499	*Writing with Nanotubes*

CAARI-2008 SCHEDULE OF EVENTS - WEDNESDAY, August 13, 2008

General Sessions

Brazos I

	NBA03		**Title: Neutron Generators and Applications**
		ABS #	**Chair: A.J. Caffrey**
3:30 PM	Vincent Tang	355	*Crystal Driven Neutron Source: A New Paradigm for Miniature Neutron Sources*
3:50 PM	David L. Chichester	117	*Commercial Electronic Neutron Generator Technology and Applications*
4:10 PM	Charles K. Gary	525	*High Intensity, Pulsed, D-D Neutron Generator*
4:25 PM	Tsahi Gozani	437	*Temporal Enhancement of Material Signatures in Pulsed Neutron Sources Applications*
4:40 PM	Alexander P. Barzilov	149	*Characterization of a Pulse Neutron Source Yield under Field Conditions*
4:55 PM	Tetsuro Matsumoto	311	*Novel generation method of 24-keV monoenergetic neutrons using accelerators*
5:10 PM	Leon Forman	634	*On the Development of a Miniature Neutron Generator for the Brachytherapy Treament of Cancer*
5:30 PM	Istvan Dioszegi	174	*14 MeV Neutron Generator as Thermal Neutron Source*

Brazos II

	IBA03		**Title: IBA of Technologically Important Oxide Films** (Dedicated to Prof. Richard J. Smith's 60th Birthday)
		ABS #	**Chair: Vaithiyalingam Shutthanandan**
3:30 PM	Theva Thevuthasan	456	*Ion beam Analysis of Technologically Important Oxides*
4:00 PM	C.V. Ramana	323	*Oxide Films and Surfaces for Optical and Electrical Device Applications - Ion Beam Analysis and Surface Modification*
4:20 PM	Asghar N. Kayani	36	*High temperature thermal stability and oxidation resistance for magnetron-sputtered CrAlON coatings on 430 steel*
4:40 PM	Weerasinghe Priyantha	317	*Interface Mixing of Fe-Al Interface and role of Ti, V and Zr as a Stabilizing Interlayer at the Interface*
5:00 PM	Hui Chen	293	*Ion beam analysis on Cr retention and oxidation resistance of coatings on SS430 interconnect for solid oxide fuel cells application*
5:20 PM	Bert Brijs	160	*The analysis of very thin SiON layers, a TOF-ERD approach*

Bur Oak

	AT07		**Title: Ion Source Technology**
		ABS #	**Chair: Peter A. Zavodszky**
3:30 PM	Hannu A. Koivisto	157	*Electron Cyclotron Resonance ion sources for highly charged ion beams*
4:00 PM	Martin P. Stockli	565	*Ramping Up the SNS Beam Power with the LBNL Baseline H- Source*
4:20 PM	Yong-Seok Hwang	285	*Study on various plasma Ion sources for focused ion beam*
4:40 PM	Oliver K. Kester	76	*Charge breeding applications of EBIS/T devices*
5:00 PM	Paul P. Tesch	406	*High Brightness Inductively Coupled Plasma Source for Accelerator Applications*
5:10 PM	Peter A. Zavodszky	371	*Brightness Studies of the Ion Beams Produced by SUSI - the Superconducting Source for Ions*
5:20 PM	Arthur K. Pallone	369	*Opto-Electric Characterisation of an AC Field Controlled Electrospray*
5:30 PM	Matthew W. Francis	234	*The Solubility and Diffusivity of Helium in Mercury with Applications to the Spallation Neutron Source*

CAARI-2008 SCHEDULE OF EVENTS - WEDNESDAY, August 13, 2008

General Sessions

Post Oak

	FIBP05		Title: PIXE in Life and Environmental Sciences
		ABS #	**Chair: Corina Solis**
3:30 PM	Thomas E. Gill	202	*PIXE's role in understanding emission characteristics and composition of dust aerosols in western Texas (USA)*
4:00 PM	Satoshi Harada	497	*Innovation of microcapsules that enables drug targeting through radiotherapy*
4:30 PM	Indra M. Govil	188	*Regional PIXE facility at Chandigarh (India) and trace element analysis of Aerosol and Medical samples*
4:50 PM	Corina Solis	488	*Heavy Metals Inputs from Atmospheric Deposition and Wastewater Irrigation to Agricultural Soils in the Mezquital Valley in Central Mexico*
5:10 PM	Rahul Mehta	322	*Studies of Hard and Soft Tissue Elemental Compositions in Mice and Rats Subjected to Simulated Microgravity*

West Fork

	MA07		Title: Clinical Ion Beam Applications III: Carbon & Other Heavier-Ion Therapy (clinical results, indications, innovative treatment concepts)
		ABS #	**Chair: Hirohiko Tsujii**
3:30 PM	Hirohiko Tsujii	413	*Overview of carbon and other heavier-ion therapy*
3:50 PM	Jun-etsu Mizoe	282	*Carbon ion therapy at NIRS*
4:10 PM	Yoshio Hishikawa	94	*Proton and Carbon-Ion Beam therapy in Hyogo Ion Beam Medical Center (HIBMC)*
4:30 PM	Stephanie E. Combs	604	*Carbon Ion Radiotherapy Using Intensity-Controlled Active Rasterscanning – The Heidelberg Results*
4:50 PM	Roberto Orecchia	253	*Indications of carbon ion therapy at CNAO*
5:10 PM	Tatsuya Ohno	522	*Estimating the need for particle beam radiotherapy in Japanese cancer patients*

Trinity Central

	NSF01		Title: Ion Beam Lithography
		ABS #	**Chair: Naoki Kishimoto**
3:30 PM	Jőrg K.N. Lindner	495	*NSL Masks: New ways of Forming Surface Nanopatterns with Ion Beams*
4:00 PM	Ananya Roy	585	*Energetic Neutral Particle Lithography for Sub-50 nm Array Fabrication*
4:15 PM	Masafumi Taniwaki	468	*Nano-cell Fabrication using the Behavior of Point Defects Induced by Ion Irradiation*
4:35 PM	Vincent M. Donnelly	464	*Nanopantography: A method for parallel writing of etched and deposited nano-patterns*
4:55 PM	Patrick Weber	266	*Ion beam etching : replication of nanostructured 3D stencils*
5:10 PM	Ruy Sanz	161	*Magnetic patterns induced by restricted ion irradiation through different masks*

Elm Fork

	RE07		Title: Damage Kinetics and Defect Evolution
		ABS #	**Chair: J. Kyle McDonald**
3:30 PM	Robert M. Fleming	519	*Gain-Defect Correlations in Ion and Neutron Irradiated Silicon Bipolar Transistors*
4:00 PM	Edward S. Bielejec	451	*Damage Relationships between the QASPR Relevant Facilities*
4:20 PM	Jeffrey H. Warner	450	*Displacement Damage-Induced Electrical and Structural Changes in Gallium Arsenide Photovoltaic Devices Following Ion Irradiation*
4:40 PM	Zengfeng Di	288	*Evolution of implantation induced damage under further ion irradiation: influence of damage type*
5:00 PM	Yuri Petrusenko	170	*Radiation Effects in Binary and Multicomponent Solids*
5:15 PM	Adrianne R. Spilker	368	*Optical Restoration of Damaged Lead Fluoride Crystals*

CAARI-2008 SCHEDULE OF EVENTS - WEDNESDAY, August 13, 2008

5:00 PM **Industrial Exhibit Show Closes**

5:30 - 7:30 PM	**Poster Session 3**	Posters in AP05, AP06, AT06, AT07, FIBP03, FIBP04, FIBP05, IBA03, IBM05, IBM07, IBM08, MA05, MA06, MA07, NBA03, NHS01, NHS02, NP05, NP06, NSF01, RE05, RE06, RE07	**Rio Grande Room**

7:30 PM *Daily Session Concludes*

7:30 PM	Student Appreciation Event	Club 8.0

9::30 PM Topic Editors and Session Chairs Meeting with Del and Barney TBD

10:00 PM **Cyber Café Closes**

CAARI-2008 SCHEDULE OF EVENTS - THURSDAY, August 14, 2008

8:00 AM - 4:00 PM	Information Desk Open	**The Bridge**
7:00 AM - 5:30 PM	Cyber Café Open	**Treaty Oak Boardroom**
7:30 AM	Continental Breakfast	**Grand Ballroom Foyer**
8:00 AM	Industrial Exhibit Show Opens	**Grand Ballroom Foyer**

General Sessions

Pecos II

	IBM03		**Title: IBM - Nanostructures, Cluster Beams, Swift Ions**
		ABS #	**Chair: Theva Thevuthasan**
8:30 AM	Liviu Popa-Simil	583	*The use of accelerator and advanced-materials to improve the nuclear energy*
8:55 AM	Parmendra K. Bajpai	592	*Swift Heavy Ion Beam Modified Behaviour of Pure and Doped TGS Crystals*
9:20 AM	Vaithiyalingam Shutthanandan	598	*Formation of Periodic Nano-Strucutres using High-energy Ions*
9:40 AM	Zihua Zhu	524	*Molecular Depth Profile of Sugar Films: A Comparison Study of C60 Ions and Traditional Cs+ and O2+ Ions*
10:00 AM	Parasmani Rajput	394	*X-ray Standing Wave Study of Swift Heavy Ion Induced Modification in Fe/Si Films*
10:15 AM	Durga P. Mahapatra	195	*Low energy Si_5^-cluster ion induced amorphization and a possible phase transition in Si*

Brazos I

	NBA04		**Title: Neutron and Charged Particle Activation Analysis**
		ABS #	**Chair: Doug P. Wells**
8:30 AM	Herbert D.G. Maschner	623	*Photon Activation Analysis in Archeology*
8:50 AM	Christian R. Segebade	591	*Photon Activation Analysis - An Analytical Application of High Energy Electron Accelerators*
9:10 AM	Edward H. Seabury	340	*A Comparison of Neutron-Based Non-Destructive Assessment Methods for Chemical Warfare Materiel and High Explosives*
9:25 AM	Jaromy R. Green	307	*A Prior Method of Using Photon Activation Analysis to Determine Unknown Trace Element Concentrations in a NIST Standard*
9:40 AM	Yasushi Sato	155	*Measurement of activated Au foils by 2πβ+2πβ-γ coincidence counting and EGS5 Monte Carlo calculation*
9:55 AM	Hideki Harano	292	*Accelerator-based neutron fluence standard at the National Metrology Institute of Japan*

Brazos II

	NHS07		**Title: Frontier Accelerator-based Technologies for NHS**
		ABS #	**Chair: Cameron G.R. Geddes and William A. Barletta**
8:30 AM	Carl Schroeder	40	*Laser-plasma accelerator based radiation sources*
9:00 AM	Jeroen van Tilborg	370	*Intense broad-bandwidth THz radiation from laser-wakefield-accelerated electron bunches*
9:20 AM	Christopher P.J. Barty	506	*Optimized laser and accelerator systems for ultrabright gamma-ray generation*
9:40 AM	Ronald D. Ruth	636	*The Compact Light Source*
10:00 AM	Timothy Antaya	640	*Compact High Field Cyclotrons and Synchrocyclotrons- Prospects and Applications*
10:20 AM	Willem G.J. Langeveld	350	*Intensity Modulated Advanced X-Ray Source (IMAXS) for Homeland Security Applications*

CAARI-2008 SCHEDULE OF EVENTS - THURSDAY, August 14, 2008

General Sessions

Bur Oak

	ED01		Title: Teaching and Undergraduate Research with Accelerators I
		ABS #	**Chair: Justin M. Sanders**
8:30 AM	William A. Barletta	441	*USPAS and its role in educating the next generation of accelerator scientists and engineers*
9:00 AM	Antonio C. Santos	134	*Using accelerators for teaching electromagnetism to high-school students*
9:20 AM	Jason J. Engbrecht	168	*Undergraduate Research Experiences in Positron Beams at St. Olaf*
9:40 AM	Scott M. LaBrake	529	*Undergraduate Teaching and Research at Union College using a Pelletron Particle Accelerator*
9:55 AM	Richard J. Smith	483	*Teaching Ion Beam Analysis in the context of Solid Oxide Fuel Cell materials research*
10:10 AM	Stephen H. Irons	221	*Undergraduate and graduate accelerator experiments at Yale*

Post Oak

	FIBP06		Title: PIXE in Materials Science
		ABS #	**Chair: Javier Miranda**
8:30 AM	V. Shutthanandan	433	*Application of PIXE in Spintronics Material Research*
9:00 AM	Javier Garcia Lopez	50	*Applications of High Energy PIXE using 18 MeV protons to the study of Cultural Heritage samples*
9:20 AM	Fern E. Gauntlett	436	*Proton scanning microbeam analysis of gold flecks suspended in foam*
9:40 AM	Hollis L. Bowman	325	*Particle Induced X-ray Emission Spectroscopy (PIXE) and Cyclic Voltammetry (CV) Analysis of Selected Children's Toys for Lead*
10:00 AM	Bobby Sistani	597	*Comparative PIXE Analysis of Modern and Ancient Coins*

West Fork

	MA08		Title: The Future of Particle Therapy in Medicine: The Next Likely Steps
		ABS #	**Chair: Richard P. Levy**
8:30 AM	Richard P. Levy	430	*The Future of Particle Therapy in Medicine: The Next Likely Steps*

Trinity Central

	NSF02		Title: Surface Patterning and Topography (Ripples)
		ABS #	**Chair: Daryush Ila**
8:30 AM	Rachel S. Goldman	581	*Self-Assembled Nanostructures: Buffer Layer Patterning and Confined States*
9:00 AM	Bashkim Ziberi	70	*Self-organized nanostructuring on Si and Ge surfaces due to low-energy ion beam erosion*
9:30 AM	Bashkim Ziberi	405	*Ion Induced Pattern Formation on III/V Semiconductors by Low-Energy Ion Beam Erosion*
9:40 AM	Joshua M. Pomeroy	328	*Highly charged ion (HCI) modified surfaces – scanning probe and transport studies*
10:10 AM	Giancarlo Rizza	104	*A model system to give insights into the behavior of a second phase under irradiation*

Elm Fork

	RE08		Title: Radiation Effects in Biological and Chemical Systems
		ABS #	**Chair: Jefferson L. Shinpaugh**
8:30 AM	Simon M. Pimblott	514	*Experiment-with-Modeling Study of the Radiation Chemistry of Nuclear Waste Systems*
9:00 AM	Mamta D. Naidu	526	*Radiobiology at the NASA Space Radiation Laboratory*
9:25 AM	Thomas Schlathölter	575	*Ionization and fragmentation of biomolecules and biomolecular clusters upon keV ion impact*
9:50 AM	Larry H. Toburen	435	*Doubly-differential electron yields produced by fast protons and fluorine ions passing through molecular gases frozen on thin metal foils*
10:10 AM	Michael Dingfelder	431	*Monte Carlo simulations of electron emission yields from biological materials and thin metal foils after proton impact*

CAARI-2008 SCHEDULE OF EVENTS - THURSDAY, August 14, 2008

General Sessions

Pecos I

	Videotaped Review Sessions		
	MR		**Title: Medical Radioisotopes**
		ABS #	**Chair: A. Gaylord King**
9:30 AM	A. Gaylord King	527 & 528	*Commercialization of Medical Products using Accelerator Produced Isotopes: "From the laboratory to the marketplace"*

10:30 PM BREAK, Industrial Exhibit Show, LUNCH *(your own arrangements)*

Pecos II

	IBA04		**Title: Hydrogen Profiling**
		ABS #	**Chair: Ivancica Bogdanovic Radovic**
1:00 PM	James A. Knapp	98	*Ion beam analyses of H, D, T and 3He in thin films*
1:20 PM	Marcus Wilde	64	*High-resolution depth profiling of absorbed hydrogen in palladium nanocrystals*
1:40 PM	Francois Schiettekatte	347	*Simulating multiple scattering effects on coincidence spectra*
2:00 PM	Pascal Berger	566	*Looking for the Graal of a high temperature protonic conducting fuel cell: what can we learn from hydrogen ion beam analysis?*
2:20 PM	Zdravko Siketic	47	*Quantitative analysis of hydrogen using TOF ERDA spectroscopy*
2:40 PM	Brian Lovelace	199	*Transmission ERD Depth Profiling of Hydrogen in Alpha-Gamma Phase Titanium Hydride*
2:50 PM	Manjula I. Nandasiri	34	*Ion beam analysis of the thermal stability of hydrogenated diamond-like carbon thin films on Si substrate*

Brazos I

	NP07		**Title: Production & Acceleration of Ion Beams for Industrial, Medical and Research Applications I**
		ABS #	**Chair: Daniel W. Stracener**
1:00 PM	Thierry Stora	605	*Target designs to accommodate high primary beam intensities for future Radioactive Ion Beam facilities (HIE-ISOLDE, EURISOL)*
1:25 PM	Marek Lewitowicz	610	*Production of High-Intensity Rare Isotope Beams at SPIRAL 2*
1:50 PM	Evelyne L. Cottereau	609	*The ALTO facility for the production of rare nuclei*
2:15 PM	Georg Bollen	603	*Rare Isotope Beam Manipulation - Stopping, Cooling, Breeding*
2:40 PM	Jiban J. Das	490	*Possible upgrade of an existing tandem accelerator facility to an ISOL facility for neutron rich rare isotope beams*

Brazos II

	NHS06		**Title: Advanced Detectors for National and Homeland Security**
		ABS #	**Chair: Robert M. Mayo and Brandon Blackburn**
1:00 PM	Peter E. Vanier	175	*Thermal neutron imaging in an active interrogation environment*
1:30 PM	Paul A. Hausladen	85	*Portable fast-neutron imaging using fast-timing, position-sensitive detectors*
2:00 PM	Nolan E. Hertel	554	*Dose Studies for a Bremmstrhalung-based Photonuclear Interrogation System*
2:20 PM	Michael King	562	*Energy Deposition Measurements in an Organic Semiconductor Fast Neutron Detector*
2:40 PM	Francis Y. Tsang	606	*Liquid Semiconductor Radiation Detector*

CAARI-2008 SCHEDULE OF EVENTS - THURSDAY, August 14, 2008

General Sessions

Bur Oak

	ED02		Title: Teaching and Undergraduate Research with Accelerators II
		ABS #	**Chair: Justin M. Sanders**
1:00 PM	Justin M. Sanders	277	*Accelerator-based experiments for introductory-level undergraduates*
1:30 PM	Jeffrey R. Vanhoy	265	*Accelerator-Based Laboratory Activities at USNA*
1:50 PM	Daniel K. Marble	359	*Teaching and Research with Accelerators at Tarleton State University*
2:10 PM	Helio Takai	279	*MARIACHI, forefront science by scientists, teachers and students*
2:30 PM	Rahul Mehta	333	*Enhancing the Undergraduate experience: Atomic and Nuclear Physics experiments at an Accelerator facilty*
2:45 PM	Arthur K. Pallone	338	*Construction and demonstration of a prototype low-cost, small-sized scanning transmission ion microscope of moderate resolution with educational and other potential applications*

West Fork

	MR01		Title: Application of Accelerators for the Development of Medical Isotopes
		ABS #	**Chair: A. Gaylord King**
1:00 PM	Jaime Simon	83	*Intratumoral Administration of Particle Emitting Radionuclides*
1:30 PM	Wolfgang H. Runde	442	*The U.S. Department of Energy Isotope Program: Isotope Production Using an Integrated Network of Accelerators*
2:00 PM	Janet M. Sisterson	38	*Activation & production of neutrons in beam line components by proton beams*
2:30 PM	Min Goo Hur	245	*The improvement of FDG synthesizer using MFC controller*

Trinity Central

	NSF03		Title: Nanopores and Bio-Sensors
		ABS #	**Chair: Robert L. Zimmerman**
1:00 PM	Renato A. Minamisawa	272	*Ion Beam Fabrication of Nanopores in Polymer Membranes*
1:30 PM	Jiali Li	392	*Solid-state Nanopore Fabrication by Noble Gas Ion Beams and Electron Beams*
2:00 PM	Bradley Ledden	348	*Ion Beam Energy and Species Dependence on Solid-state Nanopore Fabrication*
2:20 PM	Ryan Rollings	349	*Electrical Noise Characterization of Low Energy Ion Beam Fabricated Nanopores*
2:40 PM	Emel S. Urkac	26	*Electrochemical Behaviour of Disposable Electrodes Prepared by Ion Beam Based Surface Modification for Biomolecular Recognition*

Elm Fork

	AP07		Title: Secondary Emission (ions, electrons, photons)
		ABS #	**Chair: Thomas Kvale**
1:00 PM	J.R. Dennison	425	*Electron Yields of Highly Insulating Materials Under Varying Electron Fluence*
1:30 PM	Joshua D. Thomas	339	*Determination of the Secondary Emission Coefficient γ in Electron Capture Cross Section Measurements for Low-Energy, Multiply-Charged Ion Atom Collisons*
2:00 PM	Alexander Zinovev	103	*On the Role of Non-Equlibrium Electrons in Charge State Formation of Sputtered Atoms*
2:30 PM	Jefferson L. Shinpaugh	417	*Doubly differential electron yields from thin metal foils induced by fast ion impact*

CAARI-2008 SCHEDULE OF EVENTS - THURSDAY, August 14, 2008

3:30 - 5:30 pm	**Poster Session 4**	Posters in AP07, AP08, ED01, ED02, FIBP06, IBA04, IBA05, IBA06, IBA07, IBM03, MA08, MR01, MR02, MR03, NBA04, NBA05, NBA06, NHS03, NHS04, NHS05, NHS06, NHS07, NP07, NP08, NP09, NSF02, NSF03, NSF04, NSF05, NSF06, RE08	**Rio Grande Room**

3:30 PM **Industrial Exhibit Show Closes**

5:30 PM **Cyber Café Closes**

5:30PM *Daily Session Concludes*

6:00 PM	Conference Banquet	**Grand Ballroom**

CAARI-2008 SCHEDULE OF EVENTS - FRIDAY, August 15, 2008

8:00 AM - 12:00 PM	Information Desk Open	**The Bridge**
7:00 AM - 12:00 PM	Cyber Café Open	**Treaty Oak Boardroom**
7:30 AM	Continental Breakfast	**Grand Ballroom Foyer**

General Sessions

Pecos II

	IBA05		**Title: Low and Medium Energy Ion Scattering**
		ABS #	**Chair: Robert D. Kolasinski**
8:30 AM	Bruce E. Koel	538	*Characterization and control of reactivity at Pt alloy surfaces*
8:50 AM	Torgny Gustafsson	596	*Composition and Structure of high-k Materials on Silicon and New Channel Materials*
9:10 AM	Fred W. Meyer	343	*Low-Energy Grazing Ion-Scattering from Alkali-Halide Surfaces: a Novel Approach to C-14 Detection*
9:30 AM	Igor V. Veryovkin	354	*Sputter Depth Profiling of Solar Wind Implants by RIMS: Extending the Limits of Dynamic Range and Sensitivity*
9:50 AM	Robert D. Kolasinski	600	*Modeling Low Energy Ion Scattering with MARLOWE: Comparison of Theory with Experiment*
10:10 AM	Jacinto A. Liendo	2	*New measurements of carbon and oxygen concentrations in formvar and amniotic fluid by use of lithium forward elastic scattering*

Brazos I

	NBA05		**Title: Nonproliferation Analysis Techniques**
		ABS #	**Chair: Philip L. Cole**
8:30 AM	Alan W. Hunt	30	*Active Inspection Techniques for the Quantification and Identification of Fissionable Materials*
9:00 AM	Mathew T. Kinlaw	593	*Preliminary Assessment of Fissionable Material Detection From Standoff Distances*
9:30 AM	David L. Chichester	118	*Active Interrogation Using Electronic Neutron Generators for Nuclear Safeguards Applications*
10:00 AM	Syed F. Naeem	60	*X-ray Fluorescence (XRF) Assay using Laser Compton Scattered (LCS) X-rays*

Brazos II

	NHS04		**Title: Physics and Modeling for National and Homeland Security**
		ABS #	**Chair: Sara A. Pozzi**
8:30 AM	R. Leon Feinstein	521	*Challenges in Modeling and Decision Algorithms for NHS Applications*
8:50 AM	James R. Lemley	TBD	*Development of technologies for standoff detection of nuclear materials by the Defense Threat Reduction Agency*
9:10 AM	Nolan E. Hertel	374	*Physics Data and Modeling: How much can you really tell?*
9:30 AM	Laurie S. Waters	296	*MCNPX Improvements for Threat Reduction Applications*
9:50 AM	Nathaniel J. Cunningham	543	*High-energy laser-accelerated electron beams for long-range interrogation*
10:05 AM	Phillip C. Womble	213	*Evaluation of the Doppler-Broadening of Gamma-Ray Spectra from Neutron Inelastic Scattering on Light Nuclei*
10:20 AM	Alexander P. Barzilov	184	*Monte Carlo Analysis of Pulse Neutron Based Active Interrogation of Cargo*

CAARI-2008 SCHEDULE OF EVENTS - FRIDAY, August 15, 2008

General Sessions

West Fork

	MR02		Title: Use of Accelerators for the Production of Medical Products
		ABS #	**Chair: A. Gaylord King**
8:30 AM	A. Gaylord King	579	*Low Energy Cyclotron Irradiation as a Source for Radiochemical Actinium-225*
9:00 AM	John Armbruster	238	*Cyclotron Requirements for Multi-disciplinary Programs*
9:30 AM	Hirofumi Seki	423	*Application of Proton LINAC for Medical Use for PBT, PET and BNCT*
9:50 AM	Liviu S. Craciun	558	*Design of an automated system for synthesis of [18F] FDG for PET investigation at IFIN-HH Bucharest*

Trinity Central

	NSF04		Title: Implantation, Nanoparticles and Self-Assembly
		ABS #	**Chair: Sjoerd Roorda**
8:30 AM	Koichi Awazu	146	*Synthesis of Elongated and Oriented Gold Nanorods in SiO2 by Ion Irradiation*
9:00 AM	Naoki Kishimoto	498	*Spatial Control of Nanoparticles by Patterned Ion Implantation*
9:30 AM	Jianping Zhao	399	*Organized Nanostructures Induced by Very Low Energy Ion Beam*
9:50 AM	Jinghao He	326	*Self-Organized Layering in the Growth of Phase-Separated Films under Ion Bombardment*
10:10 AM	Emel S. Urkac	27	*Effect of Metal and Metal Gas Hybrid Ion Implantation on Properties of Various Materials and their Possible Applications in Industry*

Elm Fork

	AP08		Title: Stored Particle Atomic Research Collaboration (SPARC)
		ABS #	**Chair: Colm T. Whelan**
8:30 AM	Reinhold H. Schuch	602	*Relativistic Collisions and Extremely Strong Fields*
9:00 AM	John A. Tanis	147	*Electron Capture and Loss Processes in Forward Electron Emission in Fast Ion-atom Collisions*
9:25 AM	Thomas T.S. Stoehlker	516	*Challenges for Atomic Physics at the Future International Heavy Ions Facility FAIR*
9:50 AM	Zoltan Harman	270	*Direct laser acceleration of ions for application in cancer radiotherapy*
10:10 AM	Regina C. Reuschl	537	*Experimental developments for the Lamb shift investigation in heavy ions*

10:30 AM BREAK Grand Ballroom Foyer

Pecos II

	IBA06		Title: General Ion Beam Analysis
		ABS #	**Chair: Lin Shao**
11:00 AM	Michael J. Demkowicz	329	*The He solubility limit in buried Cu-Nb interfaces*
11:20 AM	Shude Yao	153	*Strain Depth Profiling of III-V Semiconductors by Using Channeling Rutherford Backscattering Spectrometry Analysis*
11:40 AM	Khalid Hossain	380	*Compositional and strain characterizations of Ion Beam synthesized GexSi1-x thin film*
12:00 PM	Max Doebeli	128	*IBA with high resolution gas ionization detectors*
12:15 PM	Cydale C. Smith	315	*Compositional Analysis on SiO2/SixGex Multilayers byIon Beam Depth Profiling*
12:30 PM	Bilal A. Nsouli	192	*Atorvastatin™ Quantification in Anti-Hyperlipidemic Commercial Solid Drugs using the PIGE Technique*
12:45 PM	Melanie J. Webb	165	*Characterisation of Gunshot Residue Particles using Simulatenous Treatment of PIXE and RBS Spectra*

CAARI-2008 SCHEDULE OF EVENTS - FRIDAY, August 15, 2008

General Sessions

Brazos I

	NP08		Title: Recent Advances in Experimental Nuclear Science III
		ABS #	**Chair: Brant M. Johnson**
11:00 AM	John C. Hill	545	*Use of Resistive Plate Chambers in the Upgrade of the PHENIX Forward Spectrometers*
11:25 AM	Michal A. Szelezniak	641	*STAR Vertex Detector Upgrade - HFT Pixel Development*
11:50 AM	Brian C. Stein	46	*Updates to the Forward Array Using silicon Technology (FAUST)*
12:15 PM	W.J. Llope	639	*The Large Area Time-of-Flight (TOF) Upgrade for the STAR Detector*
12:40 PM	J. Matthew Durham	503	*The PHENIX Hadron Blind Detector*

Brazos II

	NHS05		Title: Advanced Neutron / Photon Generators for NHS
		ABS #	**Chair: Ka-Ngo Leung**
11:00 AM	Yong-Seok Hwang	382	*Studies of discharge characteristics in a cylindrical inertial electrostatic confinement fusion device as a neutron generator*
11:20 AM	Kai Masuda	239	*Research and development of compact neutron sources based on inertial electrostatic confinement fusion*
11:40 AM	Kristin L. Hertz	366	*Development of an Electrostatic Field Desorption Ion Source for Active Neutron Interrogation*
12:00 PM	Richard L. Fink	39	*Carbon nanotube based deuterium ion source for improved neutron generators*
12:15 PM	Stephen E. Sampayan	120	*Development and Testing of an Ultra Compact Piezotransformer Driven,Pulsed Neutron Source*
12:30 PM	Ying Wu	68	*Neutron generator for API*
12:45 PM	Michael King	99	*Performance of a compact gamma tube*
1:00 PM	Arun Persaud	88	*A Tandem-Based Compact Dual-Energy Gamma Generator*

Bur Oak

	NBA06		Title: Synchrotron Applications
		ABS #	**Chair: V. Rao Donepudi**
11:00 AM	Tetsuya Yuasa	505	*Fluorescent X-Ray Computed Tomography towards Molecular Imaging: Proof-of-Concept Experiment*
11:30 AM	Alexander Rack	577	*Synchrotron radiation based imaging methods for industrial applications at the German light source ANKA*
12:00 PM	V. Rao Donepudi	72	*Utilization of advanced micro-CT to image rat lumber vertebra using 20, 25 and 30 keV synchrotron X-rays*

West Fork

	MR03		Title: Medical Use of Accelerator Produced Isotopes
		ABS #	**Chair: A. Gaylord King**
11:00 AM	Paolo Rossi	252	*Performance of a Lanthanum Bromide detector and a new conception collimator for Radiopharmaceuticals Molecular Imaging in Oncology*
11:30 AM	Padmakar V. Kulkarni	535	*Radiolabled polymeric nanopartilcles for imaging Alzheimer's plaques in a mouse model of Alzheimer's' Disease (AD)*
12:00 PM	Jonas D. Fontenot	619	*Comparison of X-ray and Proton Radiographs for Localization of Patients Treated for Prostate Cancer*
12:30 PM	Thomas J. Maloney	637	*Labeling of peptides with In-111 for a steril non-pyrogenic inject able drug for terminal cancer patients.*

CAARI-2008 SCHEDULE OF EVENTS - FRIDAY, August 15, 2008

General Sessions

Trinity Central

	NSF05		Title: Nanowires, Nanorods, 3-D Structures
		ABS #	**Chair: John E.E. Baglin**
11:00 AM	Shinji Matsui	467	*Three-Dimensional Nanostructure Fabication by Focused-Ion-Beam Chemical-Vapor-Deposition*
11:30 AM	Sjoerd Roorda	309	*Metal Nanorod Fabrication*
12:00 PM	Moon J. Kim	278	*Nano-fabrication and characterization of individual one dimensional nanostructure devices*
12:20 PM	Wei-Kan Chu	447	*Ion-Beam Assisted Fabrication of GaN nanorod and Applications*
12:40 PM	Hyung Joo Woo	233	*Patterned exfoliation of GaAs based on masked helium implantation and subsequent rapid thermal annealing*

12:00 PM **Cyber Café Closed**

1:00 PM LUNCH (your own arrangements)

Pecos II

	IBA07		Title: Advances and Applications of IBIL and RBS
		ABS #	**Chair: Noemi R. Rebollo**
2:00 PM	Chun-Yen Cheng	504	*The ion beam induced luminescence of Mn-doped GaAs thin-film using helium-beam annealing*
2:20 PM	Janelle Villone	419	*Optimization of Ion-Luminescent Properties of GaN and InGaN/GaN Quantum Well Structures for Application in Ion-Photon Emission Microscopy*
2:40 PM	Noemi R. Rebollo	511	*De-stabilization study by Ionoluminescence of t'-phase zirconia co-doped with Gd and Eu*
3:00 PM	George M. Klody	130	*New High Resolution RBS System*
3:20 PM	Marc Mallepell	129	*Annular gas ionization detector for backscattering spectrometry*
3:40 PM	Wei Hua	224	*Studies on Ion Beam Induced Damage in Si during Channeling Rutherford Backscattering Spectrometry Analysis*

Brazos I

	NP09		Title: Production & Acceleration of Ion Beams for Industrial, Medical and Research Applications II
		ABS #	**Chair: Daniel W. Stracener**
2:00 PM	Iain D. Moore	601	*Laser Ionization at the IGISOL Facility*
2:30 PM	Jens Lassen	608	*Solid-State Laser, Resonant Ionization Laser Ion Source (RILIS) at Radioactive Ion Beam Facilities*
3:00 PM	Yuan Liu	475	*Efficient Isobar Suppression by Photodetachment in a RF Quadrupole Ion Cooler*
3:20 PM	John Eliades	540	*Isobar Selection at eV Energies*
3:40 PM	Cara Jost	536	*Radioactive Ion Beam Purification by Selective Adsorption*

CAARI-2008 SCHEDULE OF EVENTS - FRIDAY, August 15, 2008

General Sessions

Brazos II

	NHS03		Title: Technologies for Detecting Chemical / Biological Contraband
		ABS #	**Chair: Vlado Valkovic**
2:00 PM	Bertrand Perot	11	*Detection of illicit drug samples with the EURITRACK system*
2:30 PM	Oleg V. Bochkarev	12	*Tagged neutrons system based on portable neutron generator for explosives detection in cargo containers*
2:50 PM	Giuseppe Viesti	8	*Material recognition using neutron/gamma interrogation with time tagged fission sources*
3:10 PM	Davorin Sudac	159	*Detection of explosives in the objects on the sea bottom*
3:30 PM	Amar Sinha	473	*Simulation Studies for the Optimization of Tagged Neutron Based Explosive Detection System*
3:40 PM	Francoise Mulhauser	563	*Nuclear Solutions for Development: Combined Devices for Explosives Detection & Humanitarian Demining*
3:50 PM	Jasmina Obhodas	164	*Matrix characterization in threat material detection processes*

West Fork

	SIBL		Title: The New Ion Beam Laboratory (IBL) at Sandia National Laboratories
		ABS #	**Chair: Barney L. Doyle**
2:00 PM	Barney L. Doyle	n/a	*A New Multi-purpose Accelerator Laboratory*
2:30 PM	F. Del McDaniel	n/a	*Ion Beam Laboratory Design Considerations*
3:00 PM	Paolo Rossi	n/a	*Radiation Shielding for the Ion Beam Laboratory*
3:30 PM	Group Discussion	n/a	*Radiation Protection Interlocks and ALARA Safeguards in the Ion Beam Laboratory*

Trinity Central

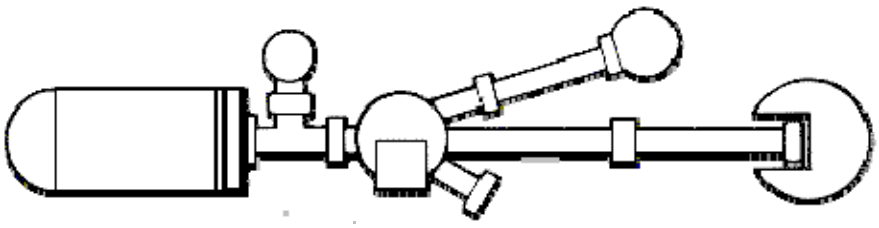
	NSF06		Title: Controlled Adhesion of Cells on Surfaces
		ABS #	**Chair: Robert L. Zimmerman**
2:00 PM	Geoffroy Guibert	131	*Surface Treatment of Polymers by Ion Beam Irradiation to Control the Human Osteoblast Adhesion*
2:30 PM	S. Ismet D. Deliloglu Gurhan	219	*Bio Applications of Ion Accelerators to Control Cell Attachment*
3:00 PM	Emel S. Urkac	25	*Cell Attachment Studies and Antibacterial Properties of Ag and Ag+N Ion Implanted UHMWPE Samples*

4:15 PM	Closing Ceremony	**Rio Grande Room**

5:00 PM ***CAARI 2008 Conference Concludes***

Have a safe trip home!

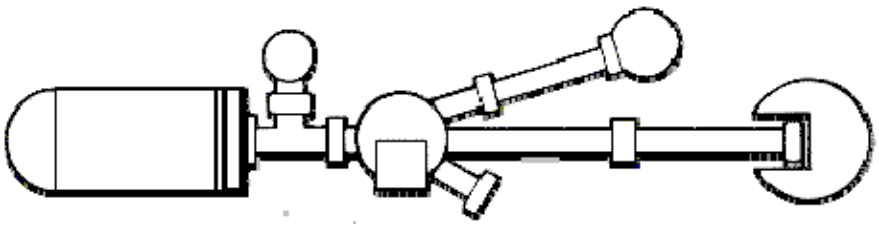
Del, Barney, Margaret, Karen and the CAARI Staff
thank you for your participation and support - see you in 2010!



ABSTRACTS

PLENARY, INVITED, CONTRIBUTED TALKS AND POSTERS

In Order by Day of the Week



MONDAY

MON-PL01-1 #427 - Invited Talk - Monday 8:30 AM - Pecos I

The Future of Particle Therapy in Medicine: The Next Likely Steps

Richard Philip Levy
Radiation Medicine, Loma Linda University Medical Center, 11234 Anderson Street, Loma Linda CA 92354, United States

Since its discovery in 1895, ionizing radiation has been used to treat cancer. Clinical-outcome observations quickly motivated an ongoing effort to achieve an improved therapeutic ratio of tumor-cell kill to normal-tissue injury. One of the most important time-tested strategies toward this goal has been to conform more tightly the delivered dose to the delineated target volume. As more precise 3D-conformal treatment has been sought, charged-particle therapy has ascended to the pinnacle of radiation oncology, due to the intrinsic Bragg-peak depth-dose-distribution quality of hadron beams. The clinical benefit of treatment with protons and helium nuclei (compared with X-irradiation) has been well established for more than 25 years for many types of tumors. However, some 15 to 20% of neoplastic disorders have proven relatively radio-resistant to even aggressive treatment of this kind. For these tumors, treatment with heavier hadrons (eg, carbon and neon nuclei) offers great potential benefit, since these particle beams have increased relative biological effectiveness (RBE). However, optimal biological-effect treatment planning requires development of reliable RBE modeling algorithms. And improved 3D-dose-delivery necessitates more efficient beam-scanning techniques, and access to a wide range of beam-entry angles via isocentric patient-positioning tables, and non-horizontal beam lines or gantries. The future of particle therapy will be best advanced by facilities that have ready access to selecting hadrons ranging from protons to neon, thereby permitting randomized-trial comparison of the effectiveness of the various hadrons for different diseases.

MON-PL01-2 #572 - Invited Talk - Monday 8:30 AM - Pecos I

Beam Processing and Analysis for Nano Science and Technology

Mikio Takai
Center for Quantum Science and Technology under Extreme Conditions, Osaka University, Machikaneyama 1-3, Toyonaka Osaka 560-8531, Japan

Localized physical and chemical reactions, induced by focused ion beams (FIBs) at an energy of 30 keV or less, such as etching and deposition have successfully been applied to local modification of mask defects (mask repair), prototyping of integrated circuits, and preparation of TEM (Transmission Electron Microscopy) samples. Localized deposition using chemical reactions induced by electron beams (EBs) can provide much smaller structures than those using FIBs. These techniques have recently become a standard tool for structuring two or three dimensional nano structures with a sophisticated pattern generator for applications to science and technology. Stoichiometry of the processed layers and mechanical and electrical properties of micro- and nano-structures, fabricated by the beam induced processing, have been discussed. Recent developments of nano fabrications using FIBs and EBs and the issues arising from the process such as residual defects and contamination during processing were discussed.

A nondestructive nano analysis technique using Rutherford backscattering with a medium energy FIB at an energy of 150 keV has been developed to realize a three dimensional visualization of nano structures and applied to the processed areas using FIBs and EBs.

Nano devices such as single electron transistors with side gates and field electron emitters, fabricated by FIB and EB induced processes without defects and contamination, were demonstrated as examples of nano beam processing and analysis. Electron transports in nano structured wires such as variable range hopping in EB deposited Pt wires, electron coherency in FIB deposited Pt wires, and Coulomb oscillation in source-drain current versus gate voltage, i.e., single electron transport, and electron emission patterns from field emitters, showing electron interference, are discussed.

MON-PL01-3 #201 - Invited Talk - Monday 8:30 AM - Pecos I

Active Interrogation Systems for Homeland Security

George Vourvopoulos
Science Applications International Corporation (SAIC), 5816 Lake Melrose Drive, Orlando FL 32829, United States

Passive systems using primarily photons (x-rays and gamma rays) have been extensively deployed worldwide for cargo inspection. These systems produce radiographic images, and some of them, through the use of distinct ranges of photon energies, can separate low Z from high Z materials. The ability, however, to identify in cargo, quickly and from a distance, weapons of mass destruction (high explosives, chemical warfare agents, special nuclear materials) hidden or shielded in small or large containers has been an elusive task. This has been the challenge for the active interrogation systems, several of which have been under intense research and development in the last decade. Unfortunately, no such system has yet been deployed (other than as a prototype) for routine inspection in a civilian environment. Using neutrons, photons, and muons, these systems couple nuclear

physics to advanced accelerator engineering, and challenging detector, data acquisition and data reduction /analysis techniques. A review of the different methodologies will be presented and results from them will be shown.

MON-MA - VTS-1 #429 - Invited Talk - Monday 12:30 PM - Pecos I

Medical Applications of Accelerator Technology: Overview

Richard P Levy[1], Eleanor A Blakely[2], William T Chu[2], George B Coutrakon[1], Eugen B Hug[3], Gerhard H Kraft[4], Hirohiko Tsujii[5]
[(1)]Radiation Medicine, Loma Linda University Medical Center, 11234 Anderson Street, Loma Linda CA 92354, United States
[(2)]Life Sciences, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley CA 94720, United States
[(3)]Center for Proton Radiation Therapy, Paul Scherrer Institute, Villigen, Switzerland
[(4)]Biophysics Research Group, Gesellschaft für Schwerionenforschung (GSI, German Heavy Ion Research Center), Darmstadt, Germany
[(5)]Research Center Hospital for Charged Particle Therapy, National Institute of Radiological Sciences, Chiba, Japan

Therapeutic irradiation with various hadrons has been developed to achieve the clinical benefit of improved 3D-dose distribution. Protons and helium nuclei have radiobiological properties similar to x-rays. Heavier hadron irradiation (eg, carbon and neon nuclei) has been developed to take advantage of increased relative biological effectiveness (RBE) per physical dose unit. Integrated diagnostic PET, CT and MRI imaging has led to marked improvement in 3D-target delineation, thus permitting more aggressive target-volume treatment. Accelerator technology with both synchrotrons and cyclotrons has been rapidly developing to improve the efficiency of clinically delivering these hadrons. Concurrently, improvement continues with more-compact rotating gantries and non-horizontal fixed-beam lines, as well as with robotically controlled patient-positioning tables --- all intended to permit isocentric beam-direction access via six degrees of freedom (three translational, and three rotational). However, important technical issues remain regarding whether optimally conformal 3D-dose-distribution is best achieved by using a voxel-based or volumetric-layering technique of beam scanning. Treatment planning to produce uniform biological effectiveness within the target volume requires that reliable RBE data be integrated with the physical dose distribution. However, considerable debate remains about whether to use uniform RBE within the irradiated target and adjacent normal-tissue volumes, or to use voxel-based (local-effects) RBE modeling based on the parameters of the specific hadron employed, the beam energy and dose per fraction within each irradiated voxel, and the particular histologic endpoints of interest in the treatment field. Furthermore, important clinical issues remain regarding hadron selection and the optimization of dose-fractionation parameters in the treatment of various tumor types located in different anatomic sites. Extensive laboratory and clinical studies have already been performed to enable better understanding of many of these variables, leading to the development of new and ongoing clinical trials.

MON-AP01-1 #267 - Invited Talk - Monday 12:30 PM - Elm Fork

Reaction Microscopes in heavy-ion storage rings - results and prospects

Daniel Fischer[1], R. Moshammer[1], S. Hagmann[2], T. Ferger[1], M. Gudmundsson[3], M. Schäfer[1], N. Nofal[2], A. Gumberidze[2], R. Reuschl[2], M. Trassinelli[2], H. Bräuning[2], C. Dimopoulou[2], M. Steck[2], C. Brandau[2], C. Kozhuharov[2], Th. Stöhlker[2], M. Schöffler[4], T. Zouros[6], H.Rothard[5], J.Ullrich[1]
[(1)]Max-Planck Institute for Nuclear Physics, Saupfercheckweg 1, Heidelberg 69 117, Germany
[(2)]GSI, Darmstadt, Germany
[(3)]Stockholm University, Stockholm, Sweden
[(4)]University of Frankfurt, Frankfurt, Germany
[(5)]GANIL, Caen, France
[(6)]University of Crete, Heraklion, Greece

Recently, for the first time a Reaction Microscope has been installed in an ion storage ring, the ESR at GSI in Darmstadt, in order to study the dynamics of break-up reactions in collisions of highly charged ions (HCI) with atoms and molecules. The Reaction Microscope enables measurements of kinematically complete data sets by momentum resolved and coincident detection of all target fragments (electrons and the recoil ion) produced in a single collision. Combined with the ESR, which provides beams of a wide range of projectile charge states and energies with excellent intensity and emittance, it represents the ideal tool to obtain highly differential information on fundamental processes in HCI-atom collisions. The results of the first experiments on target ionization and charge transfer in collisions between He, Ne, and Ar targets and highly charged projectiles ranging from 13 AMeV U^{92+} to 400 AMeV Ni^{28+} will be presented.

MON-AP01-2 #61 - Invited Talk - Monday 12:30 PM - Elm Fork

Capture and ionization of the Helium-Dimer by ion impact

Markus S. Schoeffler, Jasmin Titze, Hong-Keun Kim, Robert E. Grisenti, Nadine Neumann, Lothar Ph. H. Schmidt, Ottmar Jagutzki, Horst Schmidt-Boecking, Reinhard Doerner
Institut fuer Kernphysik, Johann Wolfgang Goethe-University, Frankfurt, Max-von-Laue-Str. 1, Frankfurt 60438, Germany

In contrast to a covalent bound molecule, Van-der-Waals bound systems show a much larger internuclear separation. With a binding energy of 1.1 mK, corresponding to an average bond length of 100 a. u. (larger than a C60 fullerene), the Helium dimer (He2) is the most exotic example. The only prove of their existence and average bond length estimation was done by Schöllkopf, Grisenti and coworkers 10 years ago. Single and double charged projectiles with energies of 25 - 150 keV/u were used to fully fragment the Helium dimer into two He+-ions. Using the COLTRIMS (COLd Target Recoil Ion Momentum Spectroscopy) imaging technique we measured the three dimensional momentum vector of all fragments. We found two different fragmentation/decay mechanisms.

MON-AP01-3 #141 - Invited Talk - Monday 12:30 PM - Elm Fork

ELECTRON AND ION GUIDING THROUGH INSULATING POLYMER NANOCAPILLARIES*

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The observation of slow ion guiding through insulating nanocapillary foils inclined to the incident beam direction in which ions are transmitted with negligible energy loss or change in charge state, suggests that the inner walls of the capillaries collect charges such that electrostatic repulsion inhibits close collisions with the surfaces [1]. Motivated by these studies, the guiding of electrons through insulating nanocapillaries has been investigated [2]. In our work, electron guiding was observed through a foil of insulating polyethylene terephthalate (PET or Mylar) at 500 and 1000 eV incident energies. The results showed that a significant intensity of electrons was transmitted up to a foil tilt angle of 11° for 500 eV and 7° for 1000 eV. A linear dependence between the observation angle and tilt angle was also observed, as in the case of highly charged ions. Notably, it was found that electrons experience a significant energy loss during the guiding process, unlike positive ions, indicating that electrons undergo both elastic and inelastic scattering in their interactions with the capillary wall [2].

In new studies, we have investigated the transmission of 250, 350, 500, 800 and 1000 eV electrons using the same PET foil. Direct transmission at a foil tilt angle of zero degrees was observed and analysed for these energies, and the guiding effect was confirmed and studied for 350, 500, 800 and 1000 eV at a foil tilt angle of 3°. Again, the spectra showed significant energy losses for the transmitted electrons, in agreement with the previous results. [2].

Presently, investigations are being carried out on the transmission and guiding of fast ions through PET and the guiding of electrons through glass capillaries.

*This research was supported by an award from Research Corporation.

MON-AP01-4 #139 - Contributed Talk - Monday 12:30 PM - Elm Fork

K and L X-Ray Transitions in Multiply Ionized Atoms Produced in Heavy Ion Collisions

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The spectra of x rays emitted from atoms under bombardment by heavy ions reflect the distribution of vacancies remaining following post-collision rearrangement. High-resolution x-ray spectroscopy has been applied to study these vacancy distributions as a function of projectile and target atomic number, and projectile energy. The targets included both solids and gases. It was found that scaling laws predicted by the geometrical model [B. Sulik et al., Nucl. Instr. & Meth., Phys. Res. B 28, 509 (1987)] can be used to describe the systematic behavior of the x-ray peak intensity distributions. Consequently, our experimental results were used to establish a set of "universal" curves that provide the means to make reliable predictions for other collision systems as well as information about the influence of multiple core vacancies, interatomic transitions, and characteristic principal quantum number on the x-ray intensities.

MON-AT01-1 #286 - Invited Talk - Monday 12:30 PM - Bur Oak

A review of heavy-ion induced desorption studies for particle accelerators

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Abstract: During high-intensity heavy-ion operation of several particle accelerators worldwide, large dynamic pressure rises of orders of magnitude were caused by lost beam ions that impacted under grazing angle onto the vacuum chamber walls. This ion-induced desorption, observed for example at CERN, GSI, and BNL, can seriously limit the ion intensity and beam lifetime of the accelerator. For the heavy-ion program at CERN's Large Hadron Collider collisions between beams of fully stripped lead (208Pb82+) ions with a beam energy of 2.76 TeV/nucleon and a nominal luminosity of 10^27 cm-2s-1 are foreseen, the GSI future project FAIR (Facility for Antiproton and Ion Research) aims at a beam intensity of 10^12 uranium (238U28+) ions per second to be extracted from the synchrotron SIS18. Over the last years an experimental effort has been made to study the observed dynamic vacuum degradations, which is important to understand and overcome for present and future particle accelerators. The paper reviews the results obtained in several laboratories using dedicated test setups, the mitigation techniques found and their implementation in accelerators.

MON-AT01-2 #517 - Invited Talk - Monday 12:30 PM - Bur Oak

Outgassing of vacuum materials: thermal desorption, diffusion and permeation

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Production of sufficiently low pressures in the energy and time efficient way is a major challenge in any vacuum processes. Working pressure in a vacuum system is a counterbalance of available pumping speed and total gas flow rate resulting of continuous gas desorption from the chamber walls and inflow from the technological process. Vacuum processes are very diverse and span more than 15 decades of pressure: from coarse vacuum to extremely high vacuum (XHV). For a proper design of the vacuum chamber, the vacuum engineer needs reliable data on outgassing of constructional materials for the actual working conditions. Lots of data for common vacuum materials can be found in the literature, but there is considerable scatter in these data due to differences in sample quality, preparation techniques, cleaning procedures and measurement methods. Different methods for measuring outgassing and possible sources of errors in such measurements will be discussed.

Three typical practical examples of outgassing will be presented: water adsorption on the chamber walls during exposure to atmosphere and subsequent outgassing during pump down, permeation of atmospheric gases through elastomeric O-ring seals and hydrogen outgassing from stainless steel in recombination limited model. In ultrahigh vacuum (UHV) and XHV systems the dominant gas is hydrogen that is dissolved in the material used in its construction. Hydrogen atoms continuously diffuse towards the inner surface of chamber walls where they recombine into hydrogen molecules, which can desorb into the vacuum. To achieve UHV and XHV, any sources of outgassing have to be reduced to the lowest practical values. Established methods such as pre-treatment of materials (vacuum firing, air bake) and in-situ baking of the vacuum chamber will be discussed.

MON-AT01-3 #173 - Invited Talk - Monday 12:30 PM - Bur Oak

Experimental background due to particle Induced gas desorption in RHIC

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Beam-gas collision created experimental background, i.e., singles, has affected the heavy ion and polarized proton operations in Relativistic Heavy Ion Collider (RHIC) at the Brookhaven National Laboratory (BNL). The gas molecules in interaction region (IR) are mainly caused by the electron induced gas desorption, and the electrons are produced from the beam induced electron multipacting, or electron cloud. The background has a dependence on the usual electron cloud related parameters, such as the bunch intensity, bunch spacing, and the solenoid field at the IR. It also has a dependence on the beam-chamber interaction. Mitigations to experimental background are discussed. These include the beam chamber improvement and the manipulation of the solenoid fields at IR. A possible improvement of the beam-chamber interaction is discussed as well.

MON-AT01-4 #412 - Invited Talk - Monday 12:30 PM - Bur Oak

Heavy Ion Induced Desorption in the Energy Range 5-17.7 MeV/u

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Ion-induced desorption is a serious luminosity limitation for high current heavy ion accelerators. Therefore, ion-induced desorption is intensively studied in different laboratories worldwide. In 2006 an experimental program was started at The Svedberg Laboratory in Uppsala, Sweden. Here, argon induced desorption yields (released molecules per incident ion) have been measured for materials commonly used in accelerators: 316LN stainless steel, Cu, etched Cu, Au coated Cu, Ta and TiZrV NEG coated stainless steel. The samples were formed as flat and tubular geometries in order to investigate the impact from secondary particles on the desorption yield. Argon beams were used in the energy range 5-17.7 MeV/u, hitting the samples at perpendicular and grazing incidence angles. It was found that the highest desorption yield was from 316LN and the etched Cu. Desorption from a Cu sample at grazing incidence angle of 125 mrad was an order of magnitude larger than at normal incident angle. The impact from secondary particles were between 5-10% on the desorption yield. The partial pressures inside the saturated NEG coated tube bombarded with heavy ions were up to 20 times larger than those inside the activated one. However, the partial pressure of methane remained the same. The desorption yields after NEG saturation for CH4, H2 and CO2 were found to be very close to the yields measured after the activation, while CO increased by up to a factor of 5. The total desorption yield for the saturated NEG tube at a grazing incident angle of 17 mrad was up to 25 times higher compared to 316LN stainless steel at perpendicular incidence angle.

MON-AT01-5 #124 - Invited Talk - Monday 12:30 PM - Bur Oak

Desorption of the NEG-coated aluminum chamber

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The NEG-coating, composed of ZrTiV with a lower temperature of activation, has been developed as a large surface getter pump for the aluminum (Al-) chamber of small aperture and long length with a very poor conductance. However, the outgas of discharged gases, Ar or Kr, as well as the hydrocarbon molecules inside the NEG-coated Al-chamber has been measured. The desorption of the so-called inert gases with heavier atomic mass resided inside the chamber results in the potential problem of higher cross section of scattering with the traveling beam hence reduces the life time seriously. To verify the outgas source of CH4, the NEG-coated Al-chamber exposed with heavy water (D2O) has been investigated. It shows the D2O and methane are the only outgases from the non-coated Al chamber exposed with D2O. However, more outgas of CDxHy, CD4, and the C2DxHy complexes have been measured in the case of NEG-coated Al chamber. Desorption of C2DxHy molecules can be reduced by exposing the NEG-coated surface with synchrotron radiation photons. The fact of beam cleaning effect verifies the source of C2DxHy molecules are produced and desorbed from the NEG film. The NEG-coated stainless steel (SS-) chambers exposed with either D2O or H2O illustrate the similar results in the case of Al-chambers. The dissociation of D2O exposed on the NEG surface for both Al- and SS-chambers are confirmed. The chemical compounds of CmDx and CmDxHy are found produced and desorbed from the NEG-coated chambers after baking and activation.

MON-AT01-6 #484 - Invited Talk - Monday 12:30 PM - Bur Oak

Stainless Steel Outgassing Rate Reduction to E-15 torr liter/cm2 s

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The commonly used methods of reducing particle-induced and thermal gas desorption from stainless steel are chemical cleaning, surface polishing, and baking. The first two reduce the adsorbed impurities and inhibit further adsorption. Baking reduces both adsorbed and absorbed molecules and atoms. Hydrogen is the predominant absorbed (interstitial) atoms in stainless steel. Surface polishing is done mechanically or electrochemically, and can reduce desorption rate to E-13 torr liter/cm2 s at room temperature.

Baking may be air bake or vacuum firing, pre-baked or in situ-baked. It can reduce the rate to an E-14 range. A combination of electrochemical polishing and vacuum firing, often referred to as Quantum Passivation, attains the best result: an outgassing rate under 2E-15 torr liter/cm2 s. The paper discusses the details of these techniques and their effects on desorption.

MON-IBA01-1 #48 - Invited Talk - Monday 12:30 PM - Brazos II

A breakthrough in real-time RBS: artificial neural networks

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Rutherford backscattering spectrometry (RBS) has proven most valuable in studies where the compositional depth profile of thin films is investigated as a function of thermal treatment. Conventionally, several specimens are subjected to different heat treatments and subsequently analyzed one by one for a complete overview of the response of a thin film to thermal annealing. It is much more convenient to determine the specimen properties in real time, i.e. during annealing. Not only does this drastically decrease the workload; it also virtually eliminates the influence of small differences in the experiments.

Real-time RBS, however, suffers from the drawback that the analysis of the hundreds of spectra obtained in a typical experiment is very time consuming. Artificial Neural Networks (ANNs) offer a solution to this as RBS spectra are analysed instantaneously by neural networks and without human interference. Although ANNs are capable of analysing RBS spectra in a very short time, the drawback is that a new network has to be built for each system studied.

The combination of artificial neural networks and real-time RBS however, results in a perfect synergy and may herald the breakthrough of real-time RBS as well as ANNs for the analysis of RBS data. The huge number of spectra involved in real-time RBS experiments can be analyzed instantaneously with ANNs, and the construction and training of neural networks pays off because of the large number of similar spectra that have to be analyzed.

We will present the progress in real-time RBS credited to the routine use of ANNs. In our contribution we comment on the construction and training of neural networks for specific studies, e.g. studies of silicide growth kinetics, marker experiments and elemental redistributions during thin film reactions, and on the advantages of real-time RBS over conventional annealing experiment.

MON-IBA01-2 #62 - Invited Talk - Monday 12:30 PM - Brazos II

Advanced modeling of ion energy loss for high resolution elemental depth profiling using ions at intermediate energies

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In principle, the depth distribution of the different chemical elements near the surface of solids can be determined quantitatively and absolutely with subnanometric depth resolution using medium energy ion scattering (MEIS), a refined version of Rutherford backscattering spectrometry (RBS). The asymmetry in the ion energy loss distributions revealed by high resolution energy analyzers is a direct consequence of the asymmetric character of inelastic energy transfers during individual atomic collisions. This work reviews the stochastic modeling of ion energy loss, evaluates the additional energy loss following the excitation and/or ionization of the target scatterer atom during the near central collision, and presents an analytical approach to ion energy-loss distributions capable of simplifying MEIS data analysis. The analytical approach preserves the accuracy of ab-initio calculations, evaluating energy loss effects overlooked by standard calculations based on Gaussian and modified Gaussian distributions. Results are compared with first principles calculations and experimental MEIS spectra from 0.2 to 1.5 nm-thick HfO2 films on Si, supporting the application of this analytical model for proton scattering in the kinetic energy range from 100 to 200 keV. Although the work reported here has been undertaken aiming at elemental profiling using MEIS, all considerations for the extraction of concentration versus depth information from experimental MEIS spectra apply directly to the interpretation of high resolution Rutherford backscattering spectra (HRBS).

MON-IBA01-3 #256 - Invited Talk - Monday 12:30 PM - Brazos II

An algorithm to simulate the effect of surface roughness on backscattering spectra

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An algorithm is developed allowing the simulation of the influence of random surface roughness on an experimental RBS spectrum. It is demonstrated how roughness can be parameterised in order to reproduce reduced yield at the leading edge of the spectrum caused by the roughness. Calculations of spectra for different roughness parameters are made. The applicability of the approach developed was proved by simulation of the RBS spectrum collected from a shot blasted steel plate sample.

MON-IBA01-4 #251 - Contributed Talk - Monday 12:30 PM - Brazos II

Thin film depth profiling using simultaneous particle backscattering and nuclear resonance profiling

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We report an important extension to the DataFurnace code for Ion Beam Analysis which allows users to simultaneously and self-consistently analyse Rutherford (RBS) or non-Rutherford (EBS) elastic backscattering together with particle-induced gamma-ray (PIGE) spectra. We show that the code works correctly with a well-known sample. Previously it has not been feasible to self-consistently treat PIGE and RBS/EBS data to extract the depth profiles. The PIGE data can be supplied to the code in the usual way as counts versus beam energy, but the differential cross-sections for the PIGE reaction are required. The existing feature of DataFurnace that allows the inverse operation of extracting cross-sections from the data can therefore also be used to extract the PIGE cross-sections.

MON-IBA01-5 #530 - Contributed Talk - Monday 12:30 PM - Brazos II

Simulation of a cold cathode ion source for a compact neutron generator

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We present simulation results for the performance of a neutron tube with a cold cathode ion source. We use the VORPAL code, which features (i) full three-dimensional geometry for the fields, including self-consistent fields from the ions, (ii) Monte Carlo collisions, including ionization and charge exchange, (iii) surface effects including secondary electron emission due to electron or ion impact. The simulations we present here model only diatomic deuterium ions. Future simulations will include tritium and helium and will allow for atomic species creation and transport using a Monte Carlo modeling of dissociation. One comparison we present is including charge exchange versus not including charge exchange. We show that including charge exchange results in a decrease of a factor of two in full-width-at-half-maximum of the diameter of the ion beam on target from roughly 4mm without charge exchange to roughly 2mm with charge exchange. We also present results for ion plamsa temperature in the source and for the neutron yield.

MON-IBM01-1 #344 - Invited Talk - Monday 12:30 PM - Pecos II

Fabrication of Nanoscale Nano-systems by MeV Ion Beam

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We have used MeV ion beam to form Nanolayers of Nanocrystals of various materials within selected host materials. The layered structures were produced by sequentially co-depositing host along with selected species and depositing the host alone. We have observed that the Nanocrystals are formed along the direction of MeV Ion beam passage due to the electronic ionization of the substrate. One system consists of Nanolayers (Quantum Well) of Nano-Crystals (Quantum Dots) to generate optical filters (OF) with variable window as well as highly efficient thermoelectric generators (TEG)**. To generate highly efficient TEG we had to enhance the electrical conductivity as well as the thermal insulation and increase the Seebeck Coefficient. For some of the material systems we had to dope the nanolayers by keV implantation of selected species followed by MeV bombardment. In some selected material systems we formed nanolayered structures by co-deposition followed by MeV bombardment to form

Nanocrystals. We measured thermal conductivity (using 3w technique), electrical conductivity, and the Seebeck coefficient as a function of ion bombardment fluence for several selected material systems produced in house. The induced nanoscale effects enhanced the thermoelectric properties of selected materials, which are increased figure of merits. We will discuses the mechanism behind such ion beam bombardment effects and the reason why thermoelectric properties may be changed.

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MON-IBM01-2 #140 - Invited Talk - Monday 12:30 PM - Pecos II

Current Trends in Ion Implantation

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Ion implantation has been widely used in mainstream semiconductor device manufacturing for more than thirty years. The design of early commercial implanters incorporated features borrowed from the accelerator technology of the day. In recent years, multiple new commercial platform designs have been released into mainstream manufacturing. These designs have been driven by the industry's rapidly changing device manufacturing requirements for leading edge transistor fabrication. For example, new applications in Complementary Metal Oxide Semiconductor (CMOS) logic and memory devices include the strain engineering of transistor channels to increase carrier mobility, the incorporation of very highly doped multi-gate structures, and the formation of ultra-shallow, abrupt p-n junctions.

Continuous scaling to smaller and smaller transistor critical dimensions has drastically reduced average ion beam energies so that the transmission of beam current to the wafer is limited by space charge. At the same time, dose requirements have sharply increased, and substrate diameter has increased from 200mm to 300mm. These combined factors have resulted in reduced wafer throughput for conventional platform designs. Some of the techniques which have been successfully implemented to improve wafer throughput, and thus reduced the cost per wafer implant, include deceleration techniques, molecular implant, cluster implant, and plasma doping.

This talk will focus on these new platform designs and their capabilities, as well as the specific implant requirements which drive them.

MON-IBM01-3 #364 - Invited Talk - Monday 12:30 PM - Pecos II

Overview of small scale materials studies using ion beam irradiations

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A range of materials (Tantalum, oxide dispersion strengthened steels, Ferritic martensitic steels) where tested in an ion beam environment to study the radiation induced mechanical property changes. While it cannot substitute for true reactor experiments, irradiation by charged particles from accelerators can reduce the number of reactor experiments and support fundamental research for a better understanding of radiation effects in materials. Based on the nature of low energy accelerator experiments, only a small volume of material can be uniformly irradiated. Micro and nanoscale post irradiation tests thus have to be performed. In addition the ion irradiation can be performed under different environments such as high temperature or in liquid metal. We show here that nanoindentation, micro-compression testing, 3D atomic probe analysis on conventional and nanostructured materials before and after ion irradiation at different temperatures are useful methods to evaluate the radiation induced hardening and can be carefully compared to large scale materials irradiation testing. This presentation intends to show how advanced small scale material testing and analysis techniques can be used to evaluate the materials property changes due to ion irradiation.

MON-IBM01-4 #217 - Contributed Talk - Monday 12:30 PM - Pecos II

The effects of Ga+ irradiation on the defect density and mechanical properties of single crystal copper

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Focus Ion Beam (FIB) instruments are routinely used to produce complex microstructures in various materials, including preparing thin sectional specimens for Transmission Electron Microscopy (TEM) and fabricating micropillars for micro-compression testing. The assumption is that the 10s keV energy Ga+ ions employed by FIB produce no or little influence on the defect structure in the specimen prior to TEM characterization or produce insignificant influence on its mechanical properties

prior to micro-compression or nano-indentation hardness measurements. To confirm this hypothesis, here we used Ga+ ion beams from a high current implanter to study the defect accumulation and mechanical properties of a single crystalline copper. The amount of gallium implanted in Cu during a typical FIB process was previously measured in the literature [1] and is here repeated using the high current ion implanter. The perceived radiation damage in the copper is evaluated using channeling Rutherford Backscattering Spectroscopy (c-RBS) and the mechanical hardness is measured using nanoindentation. The results will be reported and the possible implications will be discussed.

[1] D. Kiener, C. Motz, M. Rester, M. Jenko, G. Dehm, Materials Science and Engineering A 459 (2007) 262-272

MON-IBM01-5 #204 - Contributed Talk - Monday 12:30 PM - Pecos II

Optical Waveguides in Oxide Crystals Formed by MeV Heavier Ion with Lower Dose

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Optical waveguides are key structures for integrated optics and optical communication. There are different methods to fabricate it. Ion implantation is one of an attractive method. It has several advantages over conventional method such as metal diffusion, ion exchange. In 1978, $LiNbO_3$ waveguides were fabricated with MeV He ions with the dose of 10^{16} ions/cm^2, since then a series of waveguides in oxide crystals have been fabricated including laser crystal, nonlinear crystal and photorefractive crystal. Recently MeV heavier ions with lower dose of 10^{13}-10^{14} ions/cm^2 have been successfully used to fabricate the waveguides in some oxide crystals. Using this model more than 10 waveguides in oxide crystals have been fabricated with enhanced refractive index in waveguide region.

In this paper, planar waveguides in x-cut $RbTiOPO_4$ crystals were fabricated by 6.0 MeV C^{3+} ion implantation at doses of 5×10^{13} ions/cm^2 and 1×10^{14} ions/cm^2. The dark mode spectroscopy of the planar waveguides was measured using a prism coupling arrangement before and after annealing. An increase of the both n_x and n_y refractive indices obtained after proper annealing. The bright near field intensity distribution of the transverse-electric and transverse-magnetic modes in the annealed waveguide was collected and studied by end-coupling method. Also channel waveguides in it have been studied. Rutherford backscattering/channeling technique has been performed to investigate quality of $RbTiOPO_4$ crystals.

MON-IBM01-6 #225 - Contributed Talk - Monday 12:30 PM - Pecos II

Modification of Metallic Glass Alloy Cu50Zr45Ti5 by Using High Fluence Ne Ion Irradiation

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The structural changes induced by high-energy Neon gas atoms in a metallic glass alloy Cu50Zr45Ti5 (CZT) were studied. After ion irradiation of 140 keV Ne+ to a fluency of 3E17 cm-2, nanoindentation tests and high resolution transmission electron microscope were used to characterize the irradiated samples. Significant hardness changes are observed in a region with presence of both nanocrystals and gas bubbles. The study suggests the feasibility of fabricating a high strength, low density metallic glass by using gas ion implantation.

MON-NP01-1 #590 - Invited Talk - Monday 12:30 PM - Brazos I

SPIRAL2 AT GANIL: A WORLD LEADING ISOL FACILITY FOR THE NEXT DECADE

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To pursue the investigation of a new territory of nuclei with extreme N/Z called "terra incognita" several projects, all aiming at the increase by several orders of magnitude of the RIB intensities are now under discussions worldwide.

The main goal of SPIRAL2 is clearly to extend our knowledge of the limit of existence and the structure of nuclei deeply in the medium and heavy mass region (A=60 to 140) which is to day an almost unexplored continent.

SPIRAL 2 is based on a high power, CW, superconducting driver LINAC, delivering 5 mA of deuteron beams at 40MeV (200KW) directed on a C converter+ Uranium target and producing therefore more 5x1013fissions/s. The expected radioactive beams intensities for exotic species in the mass range from A=60 to A=140, of the order of 106 to 1010pps will surpass by two order of magnitude any existing facilities in the world. These unstable atoms will be available at energies between few KeV/n to 15 MeV/n. The same driver will accelerate high intensity (100µA to 1 mA), heavier ions up to Ar and later on up to Xe at 14 MeV/n producing also proton rich exotic nuclei. The heavy ions capabilities as well as the very large intensities of this driver may open unique opportunities in the field of Super Heavy Elements.

The investment costs of 136 M€ and personnel costs reach 60 M?, for the period 2006-2013. Funding from EU 7th framework and from others partnership countries are expected to contribute for about 20% to this budget. The status of the construction will be outlined.

Based on Letter of intents process, large international collaborations are proposing innovative new instrumentation and methods for the for SPIRAL2 facility. Scientific and technical R&D programs in collaboration with EU and International partners will be presented.

MON-NP01-2 #TBD - Invited Talk - Monday 12:30 PM - Brazos I

Tohru Motobayashi

MON-NP01-3 #599 - Invited Talk - Monday 12:30 PM - Brazos I

FAIR project - status and research program

Zbigniew Majka
FAIR, Planckstr. 1, Darmstadt D-64291, Germany

FAIR project (Facility for Antiproton and Ion Research) which is a particle accelerator complex and will be set up in Darmstadt, Germany, as a joint effort of more than a dozen countries. FAIR will provide up to 3,000 physicists and other scientists from Europe and from across the world the possibility to conduct cutting edge research in five fields: physics of the structure of atomic nuclei, physics of antimatter, physics of nuclear matter under extreme conditions, plasma physics, physics of the atomic shell, as well as in related applications. During the seminar the status of the FAIR project and the preparation for further research will be presented.

MON-NP01-4 #446 - Invited Talk - Monday 12:30 PM - Brazos I

The SPES Project at LNL

alberto andrighetto
Laboratori di Legnaro, INFN, Via dell'Università 2 , Legnaro (PD) 35020, Italy

The SPES project at Laboratori di Legnaro of INFN (Italy) is concentrating on the production of neutron-rich radioactive nuclei by the Uranium fission at a rate of 1013 fission/s . The emphasis to neutron-rich isotopes is justified by the fact that this vast territory has been little explored, at exceptions of some decay and in-beam spectroscopy following fission.. The Rare Ion Beam (RIB) will be produced by ISOL technique using the proton induced fission on a Direct Target of UCx.

The most critical element of the SPES project is the Multi-Foil Direct Target. Up to day the proposed target represents an innovation in term of capability to sustain the primary beam power. The design is carefully oriented to optimize the radiative cooling taking advantage of the high operating temperature of 2000oC.

The main goal of the proposed facility is to provide an accelerator system to perform forefront research in nuclear physics by studying nuclei far from stability. The SPES project is concentrating on the production of neutron-rich radioactive nuclei with mass in the range 80-160. The final energy of the radioactive beams on target will range from few MeV/u up to 10 MeV/u for A=130 using the exiting ALPI linac as RIB post-accelerators.

MON-NP01-5 #638 - Invited Talk - Monday 12:30 PM - Brazos I

Electron Beam Driven Radioactive Beam Production

James R. Beene
Physics Division, Oak Ridge National Laboratory, Bethel Valley Rd, Oak Ridge TN 37831, United States

Photofission of actinide targets induced by bremsstrahlung from high-power electron beams is a very cost effective method for producing very high yields of very neutron-rich radioactive species. Advantages of this production method result from effects ranging from the relatively "cold" nature of photofission, resulting in low neutron emission multiplicity and consequently more neutron-rich final fragments, to the comparatively low cost of high power (>100keV) electron accelerators in the relevant beam energy range. This paper will explore in some detail characteristics of photofission and the beam-target interaction that are important to a rare isotope facility employing this process. Based on these characteristics, advantages as well as potential limitations of such a facility will be discussed.

MON-RE01-1 #TBD - Invited Talk - Monday 12:30 PM – Trinity Central

MON-RE01-2 #539 - Invited Talk - Monday 12:30 PM – Trinity Central

Challenges for Materials in a DT Fusion Environment

Roger Earl Stoller
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Structural materials proposed for use in conceptual designs for DT fusion reactors are similar to those considered for advanced fission reactors; they include variants of complex ferritic-martensitic steels, and silicon carbide composites. Potential coolants include helium, water, lithium and lithium compounds, and lead alloys. The unique aspects of the DT fusion reactor environment, and the differences from fission reactors, predominantly arise from the differences between the DT and fission neutron energy spectra. Fission neutrons are born with a broad spectrum of energies peaking near 0.65 MeV (the flux at 10 MeV is reduced by a factor of 350), whereas the DT fusion neutron spectrum is essentially mono-energetic at 14.1 MeV. Although the energy of the fusion neutrons is quickly reduced by collisions with the materials that comprise the reactor structure, materials nearest the plasma are exposed to a neutron energy spectrum that is significantly different from that obtained in fission reactors. In addition, the first structural wall in a fusion reactor is exposed to a very high surface heat load due to charged particles and photons leaving the plasma. The impact of the uniquely fusion aspects of the radiation damage environment will be discussed. For example, a primary effect of higher energy neutrons in the fusion spectrum is enhanced nuclear transmutation reactions, due to the existence of nuclear reactions with threshold energies between 2 and 15 MeV in many structural materials. The transmutation products of greatest concern are hydrogen and helium because these gases can significantly impact microstructural evolution and be synergistic with displacement damage phenomena. Although a variety of theoretical and experimental techniques have been applied to examine the role of helium on microstructural stability and mechanical property changes, key aspects of the behavior and effects of helium remain unresolved.

MON-RE01-3 #534 - Invited Talk - Monday 12:30 PM – Trinity Central

Radiation Environments and Materials Challenges in Advanced Fast Reactors

Stuart A. Maloy
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One of the main objectives of the Global Nuclear Energy Partnership is to develop advanced fast reactors to burn minor actinides in a transmutation fuel to transform the actinides in a way that makes them easier to store as waste, not a proliferation concern, and produce electricity. Achieving these goals in an efficient manner requires irradiating fuels in fast reactors to high burnups (greater than 20%). Thus, the core materials must be able to withstand significant radiation damage incurred during irradiation (greater than 200 dpa). Presently, fuels are limited to a maximum burnup of 20% because of clad material limitations (e.g. void swelling, creep, fuel clad chemical interaction). If materials were developed and qualified to doses greater than 200 dpa, higher burnups could be achieved without having to replace the cladding and duct. Development and testing of ferritic/martensitic steels and advanced alloys is being performed through international collaborations to perform fast reactor irradiations and testing of FFTF irradiated materials and components after high dose irradiation (200 dpa and greater). In the near term, plans are underway to screen advanced alloys and perform in-situ testing using domestic irradiation facilities such as thermal test reactors (ATR at Idaho National Laboratory and HFIR at Oak Ridge National Laboratory) and an accelerator driven test facility (Materials Test Station proposed to be built at Los Alamos National Laboratory using the 800 MeV proton beam). Also, a fundamental understanding of irradiation effects is being gained through ion irradiations and multi-scale modeling. Progress on these activities will be presented.

MON-AP01-P1 #17 - Poster - Monday 2:30 PM – Rio Grande Room

Electron transfer in p-Ar collisions at keV energies

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(3)Instituto de Ciencias Nucleares, Universidad Nacional Autonoma de Mexico, Apartado Postal 48-3, Mexico Mexico, D.F. 01000, Mexico

Absolute differential and total cross sections for single electron capture of H^+ ions impinging on Ar atoms in the energy range of 1.0-5.0 keV and scattering angles from -5.0 to 5.0 degrees are reported. The absolute differential cross (DCS) sections for all acceleration energies shows a decreasing behavior with increasing angle, showing an overall decrease of six orders of magnitude. The total cross section is found to be between the range of 4 and 15 Å^2. The total cross sections display an increasing behavior as a function of the incident energy. The absolute differential and total cross section are compared with other available measurements and theoretical approach.

MON-AP01-P2 #96 - Poster - Monday 2:30 PM – Rio Grande Room

L x-ray intensity ratios in Pb with protons

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(2)Department of Chemistry, M.L.N. College, Santpura Road, Yamuna Nagar, Haryana 135001, India

Accelerators play a significant role in investigation of inner-shell excitation through the impact of protons, which has shown renewed interest recently [1]. These studies indicate that in case of L-shell ionization, most of the experiments have been conducted with protons having energies greater than 500 keV [2]. Thus, there is not only a lack of experimental data but there also exists a large discrepancy between the experimental measurements and the theoretical calculations based on different models, prevailing in this energy regime [3]. In view of this, we present the measured values of L x-ray intensity ratios in Pb, namely, L_ℓ / L_α, L_β / L_α and L_γ / L_α with protons over the energy range 225 keV - 400 keV using Van de Graaff accelerator. Their energy dependence and comparison with theoretical calculations will also be discussed. These observations have yielded a data in the low energy region, which helps in the emergence of better understanding of proton induced x-ray emission phenomenon.

1. B.N. Jones and J.L. Campbell, Nucl. Instr. and Meth. **B 258** (2007) 299.
2. A. Kahoul, M. Nekab, Nucl. Instr. and Meth. **B 234** (2005) 412.
3. Harsh Mohan and Arvind Kumar Jain, Nucl. Instr. and Meth. **B** (Elsevier Publication), *in press* (2008).

MON-AP01-P3 #115 - Poster - Monday 2:30 PM – Rio Grande Room

Angular Distributions for Li^0 formation in single collision of Li^+ on different gases

Albin Gonzalez Davis[2], Alfonso Guerrero Tapia[1], J. Carlos Poveda Jaramillo[1], Ignacio Alvarez Torres[1], Carmen Cisneros Gudiño[1]
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(2)Escuela de Física, Universidad de Panamá, Panamá, Panama

Absolute differential cross sections have been measured for Li^0 formation in single collisions of Li^+ on Ar, H_2 and Ne from 1 to 5 keV. Total cross sections obtained by direct integration of these differential cross sections are in good agreement with earlier cross section measurements in the energy range common to the experiments and with simple theoretical models. The differential cross sections monotonically decreases with H_2 as a target, in the other hand with Ar and Ne, there is some indication of some transitions taking place at non zero value of $\tau=E\psi$ because do exhibit τ-dependent structures attributed to the presence of excited states been the 2s-2p the most intense.

A comparison to the differential cross sections plotted as a function of the reduced variables $\psi \sin\psi d\sigma/d\omega$ versus $E\psi$ is also presented with a comparison of the maxima of the present data with the data of other authors.

Acknowledgments: The research was partially supported by joint grants of CONAYCT and DGAPA-UNAM

MON-AP01-P4 #125 - Poster - Monday 2:30 PM – Rio Grande Room

Role of measured vacancy de-excitation parameters in the proton induced x-ray emission

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The proton induced inner-shell vacancy decay processes comprised of radiative and nonradiative transitions are characterized by the fluorescence, Auger and Coster-Kronig yields [1]. These studies have been progressing over the last four decades [2], resulting in close and stringent comparisons of the measured values with the predictions of theoretical models. Sarkadi and Mukoyama [3] had suggested that perturbation of the atomic field can induce the promotion of ion-induced vacancies from one sub-shell to another, prior to their decay. This effect is not related to the conventional Coster-Kronig process, which is a competing channel with radiative and Auger decay for the de-excitation of any vacancy after the ionization event. This effect increases rapidly as proton energy is reduced. To include another effect involved in the x-ray emission process, Lapicki [4] proposed a model to correct the fluorescence yields by multiple ionization. This assumption considers the creation of holes in the outer shells by the incoming projectiles, with an equal probability for each shell. In view of the present circumstances, we report in this paper, the measured values of these atomic parameters for W using AN - 400 accelerator and their energy dependence. Recent progress in theoretical calculation indicates that the treatment of the ion-atom collision process within the prevailing models requires further modification. Their role in understanding this phenomenon and recent progress in this regard will be highlighted. Needs and opportunities for further work will also be discussed.

1. Rohit Thakkar, Babita Sharma and K.L. Allawadhi, Radiation Physics and Chemistry **75** (2006) 1482.
2. J.L. Campbell, Atomic Data and Nuclear Data Tables **85** (2003) 291.
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4. G. Lapicki, Radiation Physics and Chemistry **76** (2007) 475.

MON-AP01-P5 #261 - Poster - Monday 2:30 PM – Rio Grande Room

Energy loss and straggling of 1.5 to 6.5 MeV H, He and Li ions in the PHB biopolymer

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Energy loss and straggling for 1.5-3.5 MeV ^{1}H ions, 2.0-5.0 MeV ^{4}He ions and 2.5-6.5 MeV ^{7}Li ions in the polyhydroxybutyrate (PHB) foil were measured by means of a transmission technique. The obtained stopping forces were compared with the SRIM calculation and the database of the ICRU Report 73. Most of the experimental results compared quite favorably with the ICRU Report 73. The measured data of energy loss straggling were in satisfactory agreement with those yielded by an empirical formula, except at lower energies. The validity of Bragg's rule applied to stopping forces and energy loss straggling for H, He and Li ions in the biopolymer foil were also discussed.

MON-AP01-P6 #305 - Poster - Monday 2:30 PM – Rio Grande Room

Electrostatic Systems for Antihydrogen Studies

Carlos A Ordonez
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An existing quest to trap antihydrogen requires the development of a knowledge base concerning a variety of processes that take place within the same environment, such as antiproton and positron trapping, cooling and mixing, antiproton-positron recombination, and trapping of antihydrogen. Much of the research is presently taking place at the CERN Antiproton Decelerator facility. There exist various issues associated with mixing antiprotons and positrons, while also capturing antihydrogen atoms, by using both a nested Penning trap and a magnetic well [see, for example: C. A. Ordonez, Phys. Rev. E 76 (2007) 017402]. Theoretical studies are reported here of two electrostatic systems, which may be useful for achieving the goal of trapping antihydrogen in sufficient quantities for spectroscopy and gravity studies. One system provides for charged particle transport through an electrode configuration that produces a spatially periodic electrostatic potential. A novel characteristic of the system is that the spatial period of the electrostatic potential is much smaller than the electrode radius. It is found that for a given applied voltage difference, axial transport is possible for a large range of both the angle of divergence and the particle kinetic energy. The results are not dependent on the particle mass or sign of charge. The configuration may serve to radially compress a charged particle beam such as a mixed beam of antiprotons and positrons, or to extract a cooled antiproton beam that is produced as described in [J. R. Danielson et al., Appl. Phys. Lett. 90 (2007) 081503] and then expanded along a divergent magnetic field. The second system provides for particle confinement using a centrifugal-electrostatic (Kingdon-type) trap. Particle confinement is described in terms of the formation of an effective potential energy well. The conditions required for forming the deepest effective potential energy well are assessed.

MON-IBA01-P1 #257 - Poster - Monday 2:30 PM – Rio Grande Room

Evaluation of proton elastic scattering for IBA

A. Gurbich
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Results achieved during the first year of the implementation of the partner project with Sandia National Laboratories are presented. The aim of the project is to develop a comprehensive database of evaluated differential cross sections for IBA. The evaluation consists in the elaboration of the most accurate possible cross-sections through incorporation of the all relevant experimental data in the framework of nuclear physics theory. The evaluated differential cross sections for proton elastic scattering are presented, comparison with the available experimental information is made, and discrepancies and other problems are discussed.

MON-IBA01-P2 #260 - Poster - Monday 2:30 PM – Rio Grande Room

Stopping power of different ions in Si measured with a bulk sample method and Bayesian inference data analysis

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[(2)]*Rudjer Boskovic Institute, P.O. Box 180, Zagreb 10002, Croatia*

The accuracy of ion beam analysis experiments depends critically on the stopping power values available. While for H and He ions accuracies normally better than 5% are achieved by usual interpolative schemes such as SRIM, for heavier ions the accuracy is worse. One of the main reasons is that the experimental data bases are very sparse, even for important materials such as Si. New measurements are therefore needed. Measurement of stopping power is often made with transmission in thin films, with the usual problems of film thickness homogeneity. We have previously developed an alternative method based on measuring bulk spectra, and fitting the yield by treating the stoppoing power as a fit parameter in a Bayesian inference Markov chain Monte Carlo procedure included in the standard IBA code NDF. We report on improvements of the method and on its application to the determination of the stopping power of several ions in Si. To validate the method, we also apply it to the stopping of 4He in Si, which is known with a 2% accuracy.

MON-IBA01-P3 #327 - Poster - Monday 2:30 PM – Rio Grande Room

Measurements and evaluation of proton elastic scattering from nitrogen up to 5 MeV

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Nitrogen is often present as a main constituent in the bulk targets or is important constituent in thin films. Typical analysis of samples containing nitrogen with protons is mainly done at energies above Coulomb barrier where no Rutherford cross sections can be applied. Therefore, for a quantitative analysis and depth profiling of nitrogen it is important to know exact cross sections. Motivation for present work was to supply new experimental data for the evaluation of $^{14}N(p,p)^{14}N$ cross sections, especially at energies above 3 MeV where experimental data are scarce.

The cross sections for the elastic scattering of protons from natural nitrogen at non-Rutherford scattering energies were measured at three scattering angles: 118°, 150° and 165° (lab) in the laboratory energy range from 2.4 up to 5 MeV. From measured yield data cross sections for $^{14}N(p,p)^{14}N$ were extracted. The measured data were parameterized using nuclear physics theory. The obtained results provide the evaluated differential cross sections for nitrogen (p,p) elastic scattering in the energy region up to 5 MeV for all backscattering angles. The benchmark experiment was performed in order to examine if N excitation function measured in the present work could simulate properly the experimentally obtained N thick target yield.

MON-IBM01-P1 #71 - Poster - Monday 2:30 PM – Rio Grande Room

Surface blistering characteristics due to ion-implanted hydrogen in Si<111>

Jenq-Horng Liang[1,2], Ching-Hsiang Hu[1], Chih-Ming Lin[3], Yen-Ting Liu[3]
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[(3)]Department of Applied Science, National Hsinchu University of Education, 521, Nanda Road, Hsinchu 30014, Taiwan

In recent years, the innovative "smart cut" technique has been widely-accepted as the most efficient method to fabricate silicon-on-insulator (SOI) materials and most researches have been focused on Si<100> wafers. However, the use of silicon wafers with different orientation (e.g. <111>) is of prime significance in various fields such as micro sensors and actuators in micro-electro-mechanical systems (MEMS) applications. Furthermore, surface blistering acts as an excellent indicator to predict whether the SOI materials can be successfully fabricated or not. An exhaustive understanding of how does surface blistering depend on silicon orientation is thus essential and constitutes the key objective of this study to room-temperature implant 5×10^16 cm^-2 40 keV hydrogen ions into Si<111> wafers. Following implantation, furnace annealing (FA) treatments were performed at temperatures ranging from 200 to 600 oC for 1 h. Characteristic measurements, including Raman scattering spectroscopy (RSS), optical microscopy (OM), and secondary ion mass spectrometry (SIMS), were employed to probe the local vibration modes of Si-H bonds and vacancy-H complexes, the appearance of optically-detectable blisters and craters, and the trapping of hydrogen atoms and gettering of oxygen atoms, respectively. The results of this study were investigated by comparing with those using Si<100> wafers. It was found that surface blistering characteristics are silicon-orientation dependent. In particular, Si<111> specimens possess higher threshold post-annealing temperatures to initialize optically-detectable blisters and craters compared to Si<100> ones. In addition, greater amount, smaller size, but similar covered-area fraction of optically-detectable blisters are existed in the former compared to the latter. However, the craters in the former are less in the amount, similar in the size, and less in the covered-area fraction compared to the latter. Furthermore, the hydrogen-trapping and oxygen-gettering phenomena in the former become remarkable at higher post-annealing temperatures and contain less peak concentrations compared to the latter.

MON-IBM01-P2 #180 - Poster - Monday 2:30 PM – Rio Grande Room

Photoluminescence from ion beam synthesized carbon nanoclusters embedded in thermally grown SiO2

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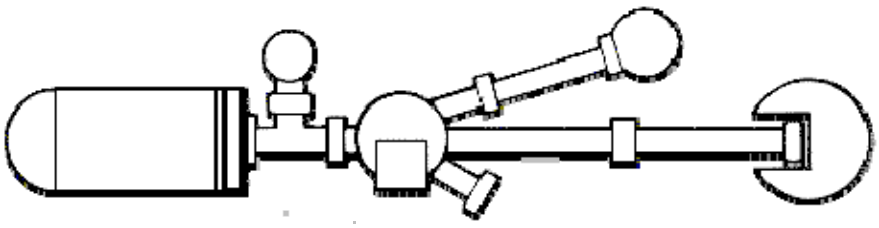
A low energy (KeV) carbon negative ion (C -) beam implantation into thermally grown SiO2 with different fluencies followed by subsequent annealing was used to synthesize light emitting nanoclusters. The precipitate formation of carbon nanoclusters into silica was monitored by using Rutherford backscattering spectrometry and Raman spectrometry. The photoluminescence measurements were carried out to study the possible light emission from the sample. The light emission properties of the carbon nanoclusters, corresponding to the implantation fluences and annealing environment, will be presented.



TUESDAY

TUE-FIBP – VTS-1 #87 - Invited Talk - Tuesday 8:30 AM – Pecos I

Single ion doping with high spacial resolution

Arun Persaud[1], Arunabh Batra[1], Jeff Bokor[2], Tzv. Ivanov[3], Cheuk Chi Lo[2], Ivo W Rangelow[3], Andreas Schuh[1,3], Christoph D Weis[1,3], Thomas Schenkel[1]

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The ability to place single donor atoms at a precise location inside a target material opens the door to the fabrication of new devices. Our interest is in using this technique to build quantum computer test devices in silicon that will utilize the spin of single donor atoms. In this talk we will address the key issues of the single ion implantation process and also show results from recent experiments.

The main concerns in single ion implantation are alignment, spot size and single ion detection. We control the alignment of the sample to the implantation spot by integrating a scanning probe into our ion implanter. The spot size is controlled by using a small nano-sized aperture integrated into the cantilever of the scanning probe. This enables us to image the sample and align the aperture to the target with nanometer resolution. We will discuss the current state of the scanning probe setup and resolution limits.

Single ion detection is achieved by implanting into a pre-fabricated device (here a transistor) and monitoring the source-drain current. The implanted ion creates damage causing a change in the source-drain current that can be measured at room temperature. We will present data showing single ion hits and discuss integration of this technology with the scanning probe setup.

Furthermore, we will present a possible road to single spin readout using the above mentioned technology components and results from preliminary experiments.

This work was supported by LPS/NSA and by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231. The work on the AFM-probes was supported by the EU-Commission under the "PRONANO"- Project.

TUE-FIBP – VTS-2 #50 - Invited Talk - Tuesday 8:30 AM – Pecos I

Applications of High Energy PIXE using 18 MeV protons to the study of Cultural Heritage samples

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Early in the development of PIXE technique it was stated that High Energy PIXE (HEPIXE) using protons at high energy would present some advantages compared to the commonly used 1-3 MeV protons. One of the benefits of HEPIXE is the significant increase of the K- and L-lines X-ray production cross sections with respect to those of lower energy protons. This makes possible the identification of medium and heavy elements not only by their L-lines but also by their K-lines, which simplifies, in principle, the analysis.

In this work, several thick metallic certified reference materials (pure lead, bronze and 18 K gold) of potential interest for archeometrical applications were bombarded with 18 MeV protons using the cyclotron accelerator at Centro Nacional de Aceleradores, Seville, Spain. We will show that the nuclear reactions that take place in the target can modify considerably the PIXE spectra, not only by increasing the background by Compton scattering, or by introducing interference of low energy gamma-rays in the X-ray region, but also by the emission of the characteristic X-rays of element Z+1 during the internal conversion decays of the excited nuclei formed in (p, xn) processes. This effect is particularly pronounced for high-Z elements, for which the cross sections of (p, xn) nuclear reactions and PIXE K-line are comparable, and for which the phenomenon of internal conversion is relatively important.

The higher depth explored when using HEPIXE represents an asset for the analysis of thick targets, especially if the surface composition is different from that of the bulk material. As an example, we will present the analysis of two fibulae of the Later Bronze Age and of the First Iron Age presenting a well characterized corrosion layer at the surface; a comparison between the results obtained by 3 and 18 MeV protons PIXE will be made.

TUE-FIBP – VTS-3 #497 - Invited Talk - Tuesday 8:30 AM – Pecos I

Innovation of microcapsules that enables drug targeting through radiotherapy

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[(3)]Takasaki Institute of the Radiation Chemistry Research Establishment, Japan Atomic Energy Research Institute, 1233 Watanuki, Takasaki Gunma 370-1207, Japan

[(4)]Cyclotron Center, Iwate Medical University, 348-58 Tomegamori, Takizawa Iwate 020-0173, Japan

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We developed fluoroscopically detectable liquid-core microcapsules with a high affinity for radiation-induced P-selectin that release anticancer drugs on radiation. By treating Meth A fibrosarcoma in BALB/c mice with 2 radiotherapy sessions, we tested the microcapsules' ability to target the anticancer drug and increase the antitumor effect via synergistic effect in combination of targeted anticancer drugs with radiation.

The microcapsules were prepared by spraying a mixture of 3% hyaluronic acid and 2% alginate, supplemented with 0.2 mmol carboplatin on 0.5 mol/l FeCl₂ containing 0.1 µmol/l P-selectin glycoprotein ligand-1 and FcSv antibody to P-selectin. To induce P-selectin, the tumor was radiated with 5 or 10 Gy ⁶⁰Co γ rays. Next, 1 x 10¹⁰microcapsules were injected i.v. 1 h before the P-selectin level peaked and were allowed to interact with P-selectin for 1-6 h postradiation. Then the 2nd sessions were conducted, identical to the 1st session. P-selectin was detected by in situ hybridization and western blotting. The distribution of carboplatin was imaged and quantified using particle-induced X-ray emission.

The microcapsules were 20.3 ± 3.8 µmφ, with a 19.7 &plusmn 1.2 µmφliquid core. The 1st session proximally induced P-selectin, which peaked 6 h postradiation; P-selectin was expressed in 78.1±6.7% and 93.4 ± 7.8% endothelial cells after 5 Gy and 10 Gy radiations, respectively. The microcapsules were injected 5 h after the 1st session and could be traced fluoroscopically. Maximum accumulations were observed 6.2 ± 1.7 h postinjection, as in the microscopic study. After the 2nd session, the accumulated microcapsules released the carboplatin and gelatinized their outer shell. The released carboplatin increased the antitum or effect via synergistic effect with radiation.

Our microcapsules will provide new potential to radiation through drug localization limited to the irradiated area. These factors will bring about better tumor control and a decrease in the adverse effects.

TUE-AP02-1 #444 - Invited Talk - Tuesday 8:30 AM - Elm Fork

Evolution of quantum systems from microscopic to macroscopic scales

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Even though the static properties of quantum systems have been known since the early days of quantum mechanics, accurate simulation of dynamical break-up or ionization remains a theoretical challenge despite our complete knowledge of the relevant interactions. The simulations are challenging because of highly oscillatory exponential phase factors in the electronic wave function and the infinitesimally small values of the continuum components of electronic probability density at large times after the collision. The approach we recently developed, so-called, the regularized time-dependent Schrödinger equation method, has addressed these difficulties by removing the diverging phase factors and transforming the time-dependent Schrödinger equation to an expanding space. The evolution of the electronic wave function was followed to internuclear distances of R = 100,000 a.u. or 5 microns, which is of the order of the diameter of a human hair. Our calculations also revealed unexpected presence of free vortices in the electronic wave function. The discovered vortices also bring new light on the mechanism of transferring of the angular momentum from an external to internal motion. The connection between the observable momentum distribution and the time-dependent wave function implies that vortices in the wave function at large times are imaged in the momentum distribution.

TUE-AP02-2 #362 - Invited Talk - Tuesday 8:30 AM - Elm Fork

Production of long-lived H_2^-, HD^-, and D_2^- during grazing scattering collisions of H_3^+, D_3^+ and D_2H^+ ions with KBr, KCl, and LiF surfaces

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H_2^- is the simplest and arguably most fundamental negative molecular ion and is an important intermediate state in various collision processes. While debate about the existence of molecular hydrogen anions has been on-going for many years, only recently has direct evidence been reported for long-lived metastable anion production in a sputter ion source (e.g., R. Golser et al., PRL 2005). At ORNL we are exploring a new production method using a novel apparatus originally developed for C-14 detection (see talk by F.W. Meyer in Friday session IBA05) : 4-22.5 keV H_3^+, D_3^+ and D_2H^+ ions from the ORNL CAPRICE ECR ion source are directed at grazing incidence onto large-area KBr, KCl and LiF single-crystal surfaces, where they undergo dissociative and electron capture interactions without significant loss of energy. The resulting H_2^-, HD^-, and D_2^- ion fragments are dispersed in a large-acceptance two-stage electrostatic analysis system and are detected by a two-dimensional position sensitive detector. The fragments are strongly peaked at the expected fractional energy carried by the respective fragments, i.e. at 2/3 of the incident kinetic energy in the case of the incident H_3^+, and D_3^+ ions, and 3/5 and 4/5 in the case of HD^- and D_2^- production, respectively, from incident D_2H^+. The fractional kinetic energy of the negatively charged molecular ions produced by dissociation during grazing surface scattering permits their unambiguous identification and eliminates the possibility of isotopic contamination in the case of the incident D_3^+ and D_2H^+ beams.

TUE-AP02-3 #114 - Contributed Talk - Tuesday 8:30 AM - Elm Fork

Charge Exchange and X-ray Emission Cross Sections for Multiply-Charged Ions Colliding with Water

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Total and state selective nl-electron capture cross sections will be presented for highly charged ions Z = 4-10, 14, 18 and 26 colliding with water molecules. The energy range investigated was from 10 eV/amu (v = 0.02 a.u.) to 100 keV/amu (v = 2 a.u.). An initialization for the 1B1 and 3A1 orbitals of the water molecule is introduced based on the one center expansion of Moccia. The Z-dependence of the calculated total cross sections is in reasonable agreement with the recent data of Mawhorter et al [Phys. Rev. A 75, 032704 (2007)]. The energy dependence of the n- and l-level populations is investigated. The K-shell x-ray emission cross sections are determined by using the calculated state-selective electron capture results as input and then applying hydrogenic branching and cascading values for the photon emission. Our results compare favorably with experimental data from the KVI -Groningen, Jet Propulsion Laboratory and Lawrence Livermore National Laboratory groups. Double electron capture calculations are presented for the O6+ system. The resulting cross sections indicate the importance of multiple electron capture, followed by Auger decay, in the single capture spectra.

*Work at UNS supported by PGI 24/F038 and PICTR 03/0437 of the ANPCyT (Argentina). Work at UMR supported by the Office of Fusion Energy Sciences, DOE

TUE-AP02-4 #320 - Invited Talk - Tuesday 8:30 AM - Elm Fork

Isotope Effects in Ion-Atom Collisions

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Isotope effects for charge transfer processes have recently received increased attention (Stolterfoht *et al.*, PRL **99**, 103201 (2007)). The ion-atom merged-beams apparatus at Oak Ridge National Laboratory is used to measure charge transfer for low energy collisions of multi-charged ions with H and D. The apparatus has been relocated and upgraded to accept high velocity beams from the 250 kV High Voltage Platform at the Multi-Charged Ion Research Facility. The higher velocity beams allow, for the first time, measurements with both H and D from keV/u down to meV/u collision energies. When charge transfer occurs at relatively large distances (via radial couplings) the ion-induced dipole attraction leads to trajectory effects (Havener *et al.*, ICPEAC XVII Proceedings, Brisbane, 381 (1991)) causing differences in the charge transfer cross section for H and D. A strong isotope effect (nearly a factor of two) has been observed in the cross section for Si^{4+} + H(D) below 0.1 eV/u. However, no differences were observed for N^{2+} + H(D). Strong effects have been predicted for the fundamental system He^{2+}+ H(D, T) by Stolterfoht *et al.,* at collision energies below 200 eV/u where charge transfer occurs primarily through united-atom rotational coupling. Currently we are exploring systems where rotational coupling is important and isotopic differences in the cross section can be observed.

TUE-AP02-5 #319 - Contributed Talk - Tuesday 8:30 AM - Elm Fork

Experiments at the JPL Highly Charged Ion Facility and their Relevance for Atomic Physics and Astrophysics

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The Atomic and Molecular Physics Group conducts a number of different experiments involving collisions of highly-charged ions. The wide range of available ions and charge states produced in the *Caprice*-type ion source allows one to study fundamental atomic-physics processes. One extracts basic collision data that are also relevant to high electron-temperature plasmas such as found in fusion devices, solar and stellar atmospheres, and cometary atmospheres. An experimental setup which merges electron and ion beams to interact along tens of centimeters to obtain absolute electron-ion excitation cross sections will be explained. Other experiments include the measurements of absolute ion-neutral single and multiple charge exchange cross sections, X-ray emission phenomena, and metastable lifetimes of highly-charged ions. Recent results of the group will be presented. This work was carried out at JPL/Caltech under agreement with NASA.

TUE-AT02-1 #158 - Invited Talk - Tuesday 8:30 AM - Bur Oak

Accelerator system development at HVE

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Throughout the years, HVE has continuously extended the capabilities of its accelerator systems to meet the rising demands from a diverse field of applications, among which are deep level ion implantation, micro-machining, neutron production for biomedical research, isotope production or accelerator mass spectrometry.

Characteristic for HVE accelerators is the coaxial construction of the all solid state power supply around the acceleration tubes. With the use of solid state technology, the accelerators feature high stability and very low ripple. Terminal voltages range from 1 to 6 MV for HVE Singletrons and Tandetrons. The high-current versions of these accelerators can provide ion beams with powers of several kW.

In the last years, several systems have been built with terminal voltages of 1.25 MV, 2 MV and 5 MV. Recently, the first system based on a 6 MV Tandetron has passed the factory tests. It supports accelerator mass spectrometry as well as IBA / IBM applications in separate high-energy side beam lines and is equipped with four ion sources. The first high-current 3 MV system, featuring a dual injector that comprises two multi-cusp ion sources for high current H and He beams and an additional sputter source, is presently in the testing stage.

TUE-AT02-2 #190 - Invited Talk - Tuesday 8:30 AM - Bur Oak

Applications of 14MV BARC-TIFR Pelletron Accelerator for Interdisciplinary Research

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The 14MV tandem pelletron accelerator set up jointly by BARC and TIFR at Mumbai has been catering to research in a number of interdisciplinary areas. The accelerator provides light and heavy ion beams with currents up to microamperes and is used for both fundamental and applied areas in nuclear, atomic, condensed matter physics, material science, radio-isotope, polymer irradiation and radio-biology research. There is also a facility for secondary neutron beam production for irradiation applications. Some of the applications are micro-filter formation by ion beam track etching, radiation induced segregation by proton irradiation of stainless steel, actinide radio-tracer production, accelerator mass spectrometry for 36Cl, nuclear data measurements by surrogate reactions, nuclear reaction and spectroscopy studies.

Recently, this facility has been upgraded with a superconducting LINAC booster having quarter wave resonators for increasing the beam energies up to a further 14MV per charge state for various ions. Several detector facilities are being set up that include a charged particle array, HPGe clover detector array, recoil spectrometer for production of radioactive beams etc. for carrying out experiments in nuclear physics and allied areas. There is plan to augment the LINAC facility by another injector based on ECR source, RFQ and low-beta superconducting modules.

The present talk will cover the discussion of these accelerator facilities and the results of investigations carried out with these facilities in various areas of research.

TUE-AT02-3 #281 - Contributed Talk - Tuesday 8:30 AM - Bur Oak

TIME OF FLIGHT ACCELERATOR MASS SPECTROMETRY (TOF-AMS) OF LARGE MOLECULAR IONS AT MeV ENERGIES

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The feasibility of using TANDEM electrostatic particle accelerators as linear TOF analyzers for molecular ions (TOF-AMS) is reported in this work. A home made ion source, based on Matrix Assisted Laser Desorption Ionization (MALDI), was coupled to the TANDEM electrostatic particle accelerator of LAMFI-USP. In this system, ions produced in the ion source travel the whole accelerator line (~ 8 m) having their time of flight measured between the two ends of the TANDEM. The MALDI ion source is positioned at the 0o entry line of a 1.7 MV TANDEM accelerator and can produce negatively charged molecular ions, with masses above 10.000 u. These ions are pre-accelerated to 10 keV and the electrostatic focusing elements at the accelerator injection system are used to direct the beam into the gas-stripper. The collisions between the accelerated molecular ions and the gas particles in the stripper produce charge exchange and dissociations (Collision Induced Dissociation - CID). Positive ions gain further energy in the second acceleration stage while neutralized particles remain with the velocities gained in the first acceleration stage. A MCP assembly, located at the end of the 0o line, is used to detect the ionic and neutral reaction products. Experimental TOF-AMS spectra were obtained for CsI, C60 and Insulin samples using a time to digital converter (TDC). Peaks due to non dissociated clustered ions [Mn-]+, charged fragments m[Mn-]+q and neutralized particles [Mn-]0 were found in all studied samples showing that the TOF-AMS spectrometer is able to distinguish not only the laser desorbed ions but also their characteristic fragmentation and charge exchange pathways. The highest mass detected so far is for clusters containing 3 insulin molecules (mass ~ 17.000 u). In conclusion, TANDEM accelerators can actually be useful for time of flight analysis of large molecular ions produced by MALDI.

TUE-AT02-4 #127 - Contributed Talk - Tuesday 8:30 AM - Bur Oak

The Bucharest FN Tandem Accelerator: modernization and development

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The Bucharest electrostatic FN tandem accelerator, installed in 1973 and upgraded in 1983 to 9 MV, has been used so far for atomic and nuclear physics studies as well as for different applications using accelerated ion beams. In the last three years an ambitious program of modernization of the tandem accelerator including the replacement of the old accelerator equipment by new ones, installation of a pelletron system for the Van de Graaff generator and installation of new negative ion injectors was undertaken. In parallel a development of the tandem accelerator was started by installing the equipment necessary for AMS applications and in 2009 is scheduled to be installed a beam pulsing system in the nanosecond range. All these works, aimed to transform the tandem accelerator in a reliable and efficient tool for research and applications, are presented in detail. The main present and planned uses of the ion beams delivered by the Bucharest tandem accelerator are shortly presented too.

TUE-IBM02-1 #45 - Invited Talk - Tuesday 8:30 AM - Pecos II

Irradiation-induced phenomena in carbon nanomaterials

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Recent experiments [1] on ion and electron irradiation of carbon nanostructures demonstrate that beams of energetic particles may serve as tools to change the morphology and tailor mechanical, electronic and even magnetic properties of nanostructured carbon systems, and first of all, carbon nanotubes. We systematically study irradiation effects in carbon nanotubes and other forms of nano-structured carbon experimentally and theoretically by employing atomistic computer simulations and using various models ranging from empirical potentials to time-dependent density functional theory. In this presentation, I will briefly review the recent progress in our understanding of electron- and ion-irradiation-induced phenomena in nano-structured carbon and present our recent theoretical [2,3] and experimental [4] results. In particular, I will report our recent calculations of the electronic

stopping power in nanostructures carried out within the framework of time-dependent density-functional theory [2]. Throughout the presentation I will emphasize the ``beneficial'' role of irradiation and irradiation-induced defects and impurities in carbon and boron-nitride nanotubes and related systems.

[1] For an overview, see A.V. Krasheninnikov and F. Banhart, Nature Materials, 6 (2007) 723.
[2] A.V. Krasheninnikov, et al, Phys. Rev. Lett., 99 (2007) 016104.
[3] A. Tolvanen et al, Appl. Phys. Lett. 91 (2007) 173109.
[4] O. Lehtinen et al, to be published.

TUE-IBM02-2 #42 - Invited Talk - Tuesday 8:30 AM - Pecos II

Electron and UV irradiation effects in CNTs

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Very soon following the discovery of carbon nanotubes (CNTs), it was shown that prolonged exposure of CNTs to the electron beam can lead to irreversible shape changes. For instance nanotubes develop ripples and eventually break under intense irradiation.

In situ resistivity and mechanical measurements on oriented singlewall nanotubes (SWNT) bundles have illustrated that electron irradiation is not always a destructive process, but that it can also be exploited as a cure for one of the most serious flaws of carbon nanotubes, the weak intertube interaction in SWCNTs.

We have found a minimum in the resistivity as a function of irradiation dose. For low irradiation doses the effect of the generated point defects is largely offset by the established covalent bonds between tubes, increasing both the conductivity and the bending modulus. However, increasing dose leads to deterioration of the CNT wall structure and a significant loss of both mechanical strength and electric conductivity. Therefore an alternative non-destructive way is desirable to strengthen CNT fibers.

In contrast to high energy electrons during electron irradiation, the photon energy of the ultraviolet irradiation is not sufficient to displace the carbon atoms in the nanotube. However, our in situ resistivity and mechanical measurements revealed that illumination by UV light leads also to cross-linked nanotubes in the fiber, which can be explained by the photo-chemistry between the functional groups on the surface of SWNTs and dimethyl-formamide molecules trapped between the nanotubes. Both the conductivity and the mechanical strength significantly increase upon illumination leaving the graphitic structures intact, which makes UV irradiation more promising for reinforcement of CNT fibers and opens the door to produce CNT based composites with high strength and conductivity on a large scale.

TUE-IBM02-3 #57 - Invited Talk - Tuesday 8:30 AM - Pecos II

Ion irradiation effects in carbon nanotubes

Zoltán Osváth[1], Gábor Vértesy[1], Viera Skákalová[2], Yun Sung Woo[2], Siegmar Roth[2], József Gyulai[1], László Péter Biró[1]
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[(2)]Max Planck Institute for Solid State Research, Heisenbergstrasse 1, Stuttgart 70569, Germany

In the first part of the talk, several interesting phenomena observed on irradiated carbon nanotubes will be reviewed. For example, the shrinkage of nanotube diameter and the welding of two nanotubes was observed during TEM investigations [P. M. Ajayan et al., Phys. Rev. Lett. 81 (1998) 1437] and also under focused Ga+ ions [M. S. Raghuveer et al., Appl. Phys. Lett. 84 (2004) 4484]. These structural changes in the nanotube walls can be explained by the large number of simple or multiple vacancies induced by irradiation which can transform into other defect types (e.g. non-hexagonal rings) by dangling bond saturation. Molecular dynamics simulations show that ion irradiation can induce covalent bonds between adjacent nanotubes in a bundle of single-wall nanotubes [E. Salonen et al., Nucl. Instr. & Meth. B 193 (2002) 603]. The bonds created between nanotubes improve the mechanical [A. Kis et al., Nature Mater. 3 (2004) 153] and transport properties [H. Stahl et al., Phys. Rev. Lett. 85 (2000) 5186] of the bundle.

In the second part of the talk I will present our experimental results obtained from the STM investigation of ion irradiated carbon nanotubes, as well as results obtained from transport measurements. Individual carbon nanotube point defects were produced by low dose (5 x 10^11 ions/cm2) Ar+ ion irradiation of 30 keV. These point defects were detected by STM/STS experiments [Z. Osváth et al., Phys. Rev. B 72 (2005) 045429]. The obtained images were compared to the simulated STM images of carbon nanotube defects existing in the literature [A. V. Krasheninnikov et al., Phys. Rev. B 63 (2001) 245405]. The effect of Ar+-irradiation on the electrical transport in an individual single wall carbon nanotube (SWCNT) and in SWCNT films was also investigated [V. Skákalová et al., Phys. Status Solidi B 243 (2006) 3346].

TUE-IBM02-4 #14 - Invited Talk - Tuesday 8:30 AM - Pecos II

Irradiation assisted modification of carbon nanotubes and their use in polymer composites

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Carbon nanotubes (CNTs) have unique structures and a range of fascinating properties. If the structures can be controllably tailored by post-synthesis techniques such as irradiation, for example by introducing controlled number of defects; it may lead to better control in electronic applications. Ion irradiation offers a unique way to investigate defect structures of CNTs and their influences on CNTs' various properties. The understanding of energetic ion beam effects on CNTs is of great technological importance, since CNTs are promising for applications such as in space exploration.

In the first part, I will talk on the effects of energetic ions (Hydrogen, Helium or Neon) on the thermal stability of single wall nanotubes (SWNTs) mat. SWNTs were irradiated with ions of energy in MeV to various doses in the range of 1013 - 1016 cm-2. Compared to pristine SWNTs, thermal stability of SWNTs is found to increase by about 30° C for the SWNTs implanted with Hydrogen and by about 17° C after He implantation. This is believed due to the cross-linking between nanotubes. The activation energies for thermal oxidation under various conditions were also extracted, with values ranging from 1.13 eV (for pristine SWNTs) to 1.37 eV, depending on ion doses and species.

In the second half, I will talk the use of ion irradiation technique in polymer nanocomposites. Here defects were introduced in nanotubes using irradiation before composite formation. The defect dynamics and hence the interaction behavior of randomly dispersed nanotubes polymer composites were investigated with several analysis techniques. The results from these techniques indicate that at low number of defects, not only increase the interaction between filler and matrix, but also enhance the thermal stability of the composites. Based on the experimental evidences, a model is proposed to explain the increase in thermal stability.

TUE-MA02-1 #621 - Invited Talk - Tuesday 8:30 AM - West Fork

Radiobiology of Particles: Introduction and Overview

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Radiotherapists today have an increasing number of tools to treat benign and malignant disease. Hadron therapies with their enhanced options for dose-sparing of normal tissues surrounding the tumor, as well as in the case of carbon ions, enhanced effectiveness against radioresistant lesions, represent the most significant alternatives to conventional radiotherapy. Radiobiology with cells and animal models to assess acute and late effects has been important to preclinical comparisons of charged particle treatment modalities, and to optimization of early beam delivery parameters such as selection of ion and energy, dose fraction and overall treatment time. Some specific examples of radiobiology with samples derived from patients treated with particle beams have also provided unique insights to improved treatments.

Although there are points of consensus on how biological effectiveness of particle doses should be determined, there is not uniform agreement on the recommended technical approaches. Some of the disparity is due to differences in beam delivery, and the resulting complexity in the radiation quality of particle treatment fields for which it is difficult to capture a single measurement of clinical effectiveness. The CAARI 2008 Medical Applications program comprehensively covers each of the important aspects necessary to fully review current issues in Hadron therapy. The Radiobiology Session MA02 will focus on the continued need for radiotherapists, physicists, theoretical modelers, and radiobiologists to work together to assure an adequate understanding of biological and clinical effectiveness for improving implementation and reducing uncertainties in future treatment planning with Hadron therapies.

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TUE-MA02-2 #485 - Contributed Talk - Tuesday 8:30 AM - West Fork

Out-of-field Dose for Scanned and Scattered Proton Beams

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The dose delivered outside of the primary field to non-target tissues is of concern in all types of radiotherapy. For a given radiation type, this dose is dependent upon the delivery technique. Proton beams may be spread laterally to cover the target volume using scattering foils or magnetic scanning. Although scattered beams always use apertures or multi-leaf collimators to limit the radiation to normal tissues, scanning beams may or may not use them. A direct comparison of out-of-field dose for different proton delivery techniques has been thwarted because no institution has, thus far, used multiple delivery techniques and comparisons have had to make extrapolations from measurements or calculations made using different field sizes, ranges,

modulations, and collimator-to-skin distances. In this study, the Monte Carlo program MCNPX was used to simulate the dose deposited outside of the primary field for scattered/collimated (STC), scanned/collimated (SNC), and scanned/uncollimated (SNU) beams that have the same field size and penetration depth within the patient. The out-of-field doses ranged from 10^{-3} to 10^{-7} of the prescribed dose. The ratio of STC to SNU dose varied from 2 to 420 depending upon the depth and distance off axis. As the out-of-field doses are very small for all beam delivery techniques, decisions regarding which technique is appropriate for a given patient or facility should be based upon the magnitude of the out-of-field dose per unit prescribed dose rather than the ratio of doses for the different techniques.

TUE-MA02-3 #616 - Invited Talk - Tuesday 8:30 AM - West Fork

Do Contemporary Proton Therapy Systems adequately protect Pediatric Patients from Stray Radiation?

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Proton beam therapy has provided safe and effective treatments for a variety of adult cancers. In recent years, there has been increasing interest in utilizing proton therapy to treat children with cancer. The rationale for this is that proton therapy allows better sparing of healthy tissues. Minimizing exposures of normal tissues is especially important in children because they are more susceptible to consequential late effects, including the development of radiogenic second cancer years, that may occur decades after treatment of the first cancer. It is well understood that the doses to normal tissues are typically lower with proton therapy compared with photon therapy. However, relatively little attention has been paid to whole-body exposures to the stray neutron radiation that is inherent to proton therapy. In this presentation, we will review the physical processes that lead to neutron exposures, discuss the role of mitigating these exposures using advanced proton beam delivery systems, and present a comparative analysis of the risk of second cancer incidence following various external beam therapies. In addition, we will discuss uncertainties in the relative biological effectiveness of neutrons for carcinogenesis and the impact of this uncertainty on risk predictions for survivors of childhood cancer who received proton therapy.

TUE-MA02-4 #614 - Invited Talk - Tuesday 8:30 AM - West Fork

Effective Dose from Stray Radiation for a Patient Receiving Proton Therapy for Cancer of the Liver

Phillip J. Taddei[1], Dragan Mirkovic[1], Jonas D. Fontenot[1], Annelise Giebeler[1], Rui Zhang[1], Sunil Krishnan[1], Pablo Yepes[2], Yuanshui Zheng[1], Wayne D. Newhauser[1]
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Because of its advantageous depth-dose relationship, proton radiotherapy is an emerging treatment modality for patients with liver cancer. Although the proton dose distribution conforms to the target, healthy tissues throughout the body receive low doses from stray radiation, particularly secondary neutrons that originate both in the treatment unit and in the patient. The aim of this study was to calculate the effective dose from stray radiation and estimate the corresponding second cancer risk for a patient receiving proton beam therapy for cancer of the liver. Effective dose from stray radiation was calculated using detailed Monte Carlo simulations of a passive-scattering proton treatment unit and a voxelized human phantom. The treatment plan and phantom were based on CT images of an adult patient treated for liver cancer at our institution. Preliminary results suggest that effective dose from stray radiation was approximately 0.5 Sv, 70% of which was from neutrons originating outside of the patient while the remaining 30% was from neutrons originating within the patient. The corresponding excess lifetime risk of fatal second cancer was 2%. These results establish a baseline estimate of the stray radiation dose and corresponding risk for an adult patient undergoing proton radiotherapy for cancer of the liver and supports the suitability of passively-scattered proton beams for the treatment of liver tumors.

TUE-MA02-5 #299 - Invited Talk - Tuesday 8:30 AM - West Fork

Biological Treatment Planning for Tumor Therapy with Carbon Ions

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In recent years, heavy particles gained in importance for tumor therapy due to two desirable properties. The beneficial energy deposition with the largest dose in the tumor region and the advantageous biological effectiveness of heavy ions offer enormous potential for treatment with an as yet unmatched high tumor conformity for many indications. Based on this prospect, several dedicated clinical facilities are being constructed, approved or planned all over the world

Treatment planning for carbon ion therapy requires a biophysical model to include the biological effects related to the irradiation with heavy ions. The relative biological effectiveness (RBE) quantifies these specific effects and must be determined at each position in the irradiation field. It depends on the energy of the primary beam and all its fragments, the irradiated tissue and the dose level.

The Local Effect Model (LEM) developed at GSI is currently the only model that is used for treatment planning which takes these dependences into account. It calculates the RBE of different ions for cell lines or tissues starting from the corresponding experimental/clinical photon data and an amorphous track structure model.

We use the LEM to investigate the RBE dependence of carbon ion on the linear-quadratic parameters of the corresponding photon survival curve, the ions' energy and the ion species, and compare it to experimental cell inactivation data. Moreover, the applicability of the LEM is demonstrated by in vivo experiments measuring the radiation tolerance of the rat spinal cord in order to estimate the normal tissue complication probability. Finally, we use the LEM to calculate the biologically effective dose for a typical clinical scenario for treatments of patients with chordoma. Here, we find a significantly larger therapeutic ratio for carbon ions than for protons.

TUE-NBA01-1 #388 - Invited Talk - Tuesday 8:30 AM - Brazos II

Review of Positron Spectroscopy Applied to Polymeric Materials

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Positron and Positronium annihilation spectroscopy has been pursued and advanced by many scientists and engineers in its applications to chemical and polymeric systems during the last decade [1]. This presentation will focus on our recently collaborative investigations of positron annihilation in nano-scale polymers and composites, polymeric membranes [2-4]. Promising advancements in using intense tunable slow positron beams will be presented. Other aspects of applying positron annihilation to the disciplines of chemistry, nanotechnology, chemical engineering, materials science, energy research, molecules with positrons, biological and medical sciences will be discussed.

[1] Principles and Applications of Positron and Positronium Chemistry; Jean, Y.C; Mallon, P.E.; Schrader, D.M., Eds.; World Sci.: Singapore, 2003.

[2] Jean, Y.C. et al, Spectrochimica Acta A, 61, 1683 (2005).
[3] Chen, H.M., et al, Macromolecules, 40, 7542 (2007).
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TUE-NBA01-2 #216 - Invited Talk - Tuesday 8:30 AM - Brazos II

The Intense Slow Positron Beam and Associated Spectrometers at the NC State University PULSTAR Reactor

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An intense slow positron beam is in its early stages of operation at the PULSTAR research reactor at North Carolina State University. The PULSTAR is an open pool 1-MW research reactor that is fueled with uranium dioxide enriched to 4% in uranium 235. The reactor core is viewed by five beam ports. The positron beam line is installed in a beam port that has a 12 x 12 inch cross sectional view of the core. The positrons are created in a tungsten converter/moderator by pair-production using gamma rays produced in the reactor core and by neutron capture reactions in a cadmium cladding surrounding the tungsten. Upon moderation, slow (~ 3 eV) positrons that are emitted from the moderator are electrostatically extracted, focused and magnetically guided until they exit the reactor biological shield with 1-keV energy and approximately 3-cm beam diameter. A magnetic beam switching and transport system has been installed and tested that directs the beam into one of two spectrometers. The spectrometers are designed to implement state-of-the-art PALS and DBS techniques to perform positron and positronium annihilation studies of nanophase in matter. A unique aspect of the PULSTAR is its reduced fuel-to-water ratio. This characteristic, combined with the close coupling between the core and the beam ports, allows maximizing the thermal neutron flux and enhancing the gamma-ray flux at the entrance of a given beam port. For a relatively low power research reactor, these attributes enabled the generation of a beam with an intensity exceeding 6E8 positrons per second. The implementation of this project at a university research reactor (URR) is ideal for expanding the use of positron techniques in nanoscience. The URR setting offers many advantages including: open access, a well established engineering and operation infrastructure, modest cost for academic users, and relatively low cost for general users.

TUE-NBA01-3 #148 - Invited Talk - Tuesday 8:30 AM - Brazos II

Defect density mapping of shot peened materials using positron annihilation spectroscopy

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Using a 22Na source S-parameter measurements were made using positron annihilation spectroscopy (PAS) on both damaged and undamaged copper pieces. Although PAS measurements have often been used to compare the relative differences in the S-parameter of several materials this experiment will focus on these relative differences made by the measurable, repeatable technique of shot peening. By measuring several pieces of copper a relationship between S-parameter and shot peening intensities can be seen, and further analysis will show that the S-parameter reaches a saturation point where no further damage can be observed through measurement. Finally a relative defect density map will be shown demonstrating the various shot intensities on a single copper plate.

TUE-NBA01-4 #236 - Invited Talk - Tuesday 8:30 AM - Brazos II

Positron Annihilation Lifetime Spectroscopy Study of the Cross-Link Density and Temperature Dependence of Free Volume in Rubber-Carbon Black Composites

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Positron annihilation lifetime spectra have been measured for rubber with carbon black (CB) filler as a function of temperature and sulfur concentration. The purpose is to understand how the free volume of the vulcanized composite material is affected by the cross-link density, which is proportional to the sulfur concentration, both above and below the rubber glass transition temperature (Tg). The samples are tin-coupled solution styrene-butadiene (Sn-SSBR) rubber with 50 parts per hundred rubber (phr) N774 CB mixed with a range of sulfur concentrations. The results show the o-Ps pickoff lifetime, and thus the free volume, decrease with cross-link density both above and below Tg. The o-Ps lifetime intensity, which in part measures the amount of free volume in the rubber, also decreases with cross-link density. An interesting observation is that for composites with the 50 phr of CB the o-Ps lifetime intensity is constant over the entire temperature range, regardless of cross-link density. Possible explanations for the positronium lifetime spectra will be discussed in terms of a model for the composite material.

TUE-NBA01-5 #145 - Contributed Talk - Tuesday 8:30 AM - Brazos II

Doppler Broadening Analysis of Steel Specimens using Accelerator Based in-situ Pair Production

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Positron Annihilation Spectroscopy (PAS) techniques can be utilized as a sensitive probe of defects in materials. Studying these microscopic defects is very important for a number of industries in order to predict material failure or structural integrity. We have been developing gamma-induced pair-production techniques to produce positrons in thick samples (~ 4-40 g/cm^2, or ~ 0.5-5 cm in steel) [1]. These techniques are called 'Accelerator-based Gamma-induced Positron Annihilation Spectroscopy' (AG-PAS). We have begun testing the capabilities of this technique for imaging of defect densities in thick structural materials.

As a first step, a linear accelerator (LINAC) was employed to produce photon beams by stopping 15 MeV electrons in a 2-3 mm thick tungsten converter. The accelerator is capable of operating with 30-60 ns pulse width, up to 200 mA peak current at 1 kHz repetition rate. The highly collimated bremsstrahlung beam was striking our mechanically damaged P91 grade (modified 9Cr-1Mo) steel tensile specimens, after traveling through a 1.2 m thick concrete wall. Annihilation radiation was detected by a well shielded and collimated high-purity germanium detector (HPGe) and conventional Positron Annihilation Energy Spectroscopy (PAES) was performed to determine *S* and *W* parameters for our samples.

This work was funded by a grant from DOE # DE-FC07-Q6ID14780.

[1] D.P. Wells et al, NIMA **562**, 688 (2006).

TUE-NBA01-6 #44 - Contributed Talk - Tuesday 8:30 AM - Brazos II

Determination of defects in 6H-SiC single crystals implanted with 20-MeV Au ions

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Knowledge of the vacancy defects is crucial as these defects play a significant role in determining the macroscopic behaviour of the silicon carbide (SiC) and so its suitability for use in several applications. Indeed silicon carbide is a promising semiconductor material for high-power and high frequency devices. SiC has also potential uses in nuclear applications: it has been proposed for structural components in fusion reactors, and fuel cladding materials for gas-cooled fission reactors. It is thus important to better understand the behaviour of silicon carbide under irradiation.
Model materials have been used in this work. Hexagonal silicon carbide 6H-SiC (0001)-oriented single crystals doped with nitrogen have been purchased from CREE, Inc. 20-MeV Au ions implantations have been performed in these crystals at room temperature at several fluences in the range 10^{12}-10^{16} cm^{-2}, using the facilities of UFRGS, Brazil.

The evolution of the induced defects as a function of the ion implantation fluence has been studied as a function of depth below the surface using a slow monoenergetic positron beam (SPBDB). Doppler broadening profiles of the annihilation radiation were measured as a function of incident positron energy in the range 0.5 to 25 keV. Two different behaviours of the (S,W) characteristics have been observed depending on the ion fluence: at low fluence, the comparison of (S,W) values with previous results shows that divacancies V_{Si}-V_C are detected [1]. At high fluence new (S,W) values are obtained indicating the detection of a new kind of defects. Among the defects which can be related to these new (S,W) values, we will discuss the formation of nano-domains of silicon in the light of complementary experiments.

[1] M.-F. Barthe *et al*, Phys. Rev. B **62** (2000) 16638.

TUE-NP02-1 #314 - Invited Talk - Tuesday 8:30 AM - Brazos I

DANCEing with the Stars: Measuring Neutron Capture on Unstable Isotopes with DANCE

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Isotopes heavier than iron are known to be produced in stars through neutron capture processes. Two major processes, the slow (s) and rapid (r) processes are each responsible for 50% of the abundances of the heavy isotopes. While the r process takes place far from stability and has been difficult to investigate both experimentally and theoretically, more progress has been made on the s process, which follows the line of nuclear beta stability. The neutron capture cross sections of the isotopes on the s process path reveal information about the expected abundances of the elements as well as stellar conditions and dynamics. Until recently, however, measurements on unstable isotopes, which are most important for determining stellar temperatures and reaction flow, have not been experimentally feasible.

The Detector for Advance Neutron Capture Experiments (DANCE) located at the Los Alamos Neutron Science Center (LANSCE) was designed specifically to perform time-of-flight neutron capture measurements on unstable isotopes for nuclear astrophysics, stockpile stewardship, and advanced reactor development. DANCE is a 4-pi barium fluoride scintillator array which can perform measurements on sub-milligram samples of isotopes with half-lives of as little as a few hundred days.

I will discuss the nuclear astrophysics campaign for measuring cross sections at DANCE including past measurements and future directions which we plan to pursue.

TUE-NP02-2 #274 - Invited Talk - Tuesday 8:30 AM - Brazos I

Conquer the challenges

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The charged particles induced reactions, such as the (p,γ), (α,γ), (α,p) and heavy ion fusion reactions, play important roles in the stellar evolution. Because of the strong energy dependence of the Coulomb penetration factor, the cross sections decrease exponentially as the incident energy approach the interested astrophysical energy regions, which make these experiments very challenging. In this talk, I will discuss two challenging problems in experimental nuclear astrophysics, the $^{12}C(\alpha,\gamma)^{16}O$ reaction and the sub-barrier heavy ion fusion reactions.

TUE-NP02-3 #341 - Invited Talk - Tuesday 8:30 AM - Brazos I

Measurement of the (p,γ) cross sections of 46Ti, 64Zn, 114Sn, and 116Sn at astrophysically relevant energies.

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Nearly all nuclei with masses greater than that of iron have abundances which are not attributed to normal stellar burning processes. Most of these nuclei can be synthesized via astrophysical *r* - and *s*- processes. However the production mechanism of the *p*-nuclei is not well known.

Measuring (p,γ) cross sections of *p*-nuclei at astrophysically relevant energies is always important in determining astrophysical *S*-factors. This paper describes an attempt taken to measure the (p,γ) cross sections of 46Ti, 64Zn, 114Sn, and 116Sn using the Western Michigan University (WMU) accelerator facility.

Targets were irradiated using a monoenergetic proton beam with energy ranging from 1 MeV to 4 MeV in steps of 300 KeV. Targets were then transferred to a counting station were the gamma ray emission was detected using two HPGe coaxial gamma detectors.

Radiative proton captures on 116Sn and 64Zn are compared to previous measurements while extending the measured energy range of the cross sections. From these measurements, astrophysical *S*-factors have been deduced by integrating NON-SMOKER results which have been scaled to the deduced *S*-factors in the measured energy range. Comparisons are made to thermonuclear reaction rates from the MOST and NON-SMOKER statistical model calculations.

When exploring 114Sn(p,γ)115Sb cross sections it is found out that the calculated and experimental *S*-factors are in better agreement at higher beam energies, indicating that any possible disagreement at low energies may be due to shell closure effects in the Sn nuclei for the proton induced reactions.

The measured cross sections of the 116Sn(p,γ)117Sb reaction were higher than those predicted by theory and in agreement at higher energies with previously measured cross sections.

The deduced reactions rates for proton radiative captures on 46Ti and 64Zn, on the other hand, seem to be in fair agreement with those predicted by theory.

TUE-NP02-4 #287 - Invited Talk - Tuesday 8:30 AM - Brazos I

New Measurements of spectroscopic factors for low-lying 16N levels

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Fluorine-19 is easily destroyed in many astrophysical environments and, therefore, it is one of the few naturally occurring isotopes whose nucleosynthesis is still quite uncertain. One suggestion for its production is via the 15N(alpha,gamma)19F reaction in asymptotic giant branch (AGB) stars. It is impossible to accurately estimate the amount of 19F that may be produced,

however, because many of the reaction rates are not well known. In particular, the 15N(n,gamma)16N reaction bypasses 19F production leading instead to 16O. The 15N(n,gamma)16N reaction proceeds mostly through direct capture, and thus the rate depends on neutron-spectroscopic factors of low-lying 16N levels. These spectroscopic factors have been measured once, but the value obtained (~0.5) differed significantly from the expected values (~1). Understanding these spectroscopic factors is also important for fine-tuning shell model calculations. Nitrogen-15 has a closed neutron shell, and thus neutron spectroscopic factors of low-lying 16N states should be near unity if one is populating single-particle levels in the 15N(d,p)16N reaction. A deviation from unity would provide a significant challenge for the shell-model in this mass region.

To address these issues, we have performed a new study of the 15N(d,p)16N reaction. We have conducted our measurement in inverse kinematics by bombarding a 100 μg/cm2 CD2 target with a 100-MeV 15N beam from the Holifield Radioactive Ion Beam Facility. Reaction protons were detected at laboratory angles between 70-170 degrees using a combination of the SIDAR and ORRUBA silicon detector arrays. The states of astrophysical interest were observed and angular distributions extracted. The data and analysis will be presented.

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TUE-NP02-5 #212 - Contributed Talk - Tuesday 8:30 AM - Brazos I

Dipole-strength distributions below the giant dipole resonance in the stable even-mass molybdenum isotopes

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Dipole-strength distributions in the stable even-mass molybdenum isotopes up to the neutron-separation energies have been studied in photon-scattering experiments with bremsstrahlung at the superconducting electron accelerator ELBE at the Research Center Dresden-Rossendorf, Germany, and with monoenergetic photon beams at the HIgS facility at TUNL. In order to determine the dipole-strength distribution up to the neutron emission threshold, statistical methods were developed for the analysis of the measured spectra. The measured spectra of scattered photons were corrected for detector response and atomic background by simulations using the code GEANT3. Simulations of gamma-ray cascades were performed in order to correct the intensities of ground-state transitions for feeding from high-lying levels and to determine their branching ratios. The photoabsorption cross sections obtained for the stable even-mass molybdenum isotopes from the present (g,g) experiments are combined with (g,n) data from literature

resulting in a photoabsorption cross section covering the full range from about 4 to about 15 MeV, which is of interest for nuclear astrophysics network calculations. Novel information about the low-energy tail of the Giant Dipole Resonance and the energy spreading of its strength is derived. The dipole-strength distributions deduced from the present photon-scattering experiments show that the dipole strength increases with the neutron number of the Mo isotopes. The experimental results are discussed in the frame of QRPA calculations in a deformed basis which describe the increasing strength as a result of the increasing deformation.

TUE-NP02-6 #312 - Contributed Talk - Tuesday 8:30 AM - Brazos I

Using ^{171,173}Yb(d,pγ) to benchmark a surrogate reaction for neutron capture

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Neutron capture cross sections on unstable nuclei are important for many applications in nuclear structure and astrophysics. Measuring these cross sections directly is a major challenge and often impossible. An indirect approach for measuring these cross sections is the surrogate reaction method, which makes it possible to relate the desired cross section to a cross section of an alternate reaction that proceeds through the same compound nucleus. A neutron transfer reaction such as (d,p) has the advantage over a direct (n,γ) measurement in that it can be performed in inverse kinematics with radioactive ion beams, which would allow experiments to be performed on nuclei with much shorter half lives.

To benchmark the validity of using the (d,pγ) reaction as a surrogate for (n,γ), the ^{171,173}Yb(d,pγ) reactions were measured with the goal to reproduce the known [1] neutron capture cross section ratios of these nuclei. The (d,pγ) reactions were measured using an 18.5 MeV deuteron beam from the 88-Inch Cyclotron at LBNL. The reaction protons were measured using the Si

detector array STARS and coincident γ-rays were detected using 6 Ge Clover detectors (LiBerACE). Results comparing the surrogate ratios with the neutron capture cross sections from [1] will be presented.

Work supported in part by the U.S. Department of Energy and National Science Foundation.

[1] K. Wisshak et al., Phys. Rev. C **71**, 051602 (2005).

TUE-RE02-1 #576 - Invited Talk - Tuesday 8:30 AM - Trinity Central

Combining Experiments with Atomistic Modeling to Design Radiation Damage Resistant Composite Materials

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Metallic multilayered nanocomposites with layer thicknesses on the order of nanometers have been shown to possess remarkable tolerance to irradiation. This behavior is due to the high volume fraction of interfaces contained in these materials. We couple experiments and atomistic modeling to understand the structure of the interfaces and the role they play as sinks for radiation-induced point defects. The insights gained from our synergistic approach allow us to construct a general model of the effect of interfaces on radiation damage reduction and to propose strategies for the informed design of radiation tolerant nanocomposite materials. We acknowledge the support of the LANL Directed Research and Development program, a LANL Director's fellowship, and the DOE Office of Basic Energy Sciences.

TUE-RE02-2 #28 - Invited Talk - Tuesday 8:30 AM - Trinity Central

Enhancement of radiation tolerance by interfaces in nanostructured metallic materials

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Enhancement of radiation tolerance is necessary to improve the performance of metallic materials in harsh radiation environment. He ion irradiation, though not ideal for simulating real nuclear radiation environment, does provide an effective approach to study fundamental radiation damage mechanisms in metallic materials. Our recent studies show that nanostructured metallic materials may possess enhanced radiation tolerance. We have used a top-down approach, equal channel angular pressing (ECAP), to synthesize bulk nanostructured metals (T91); and a bottom-up approach, magnetron sputtering, to fabricate nanostructured metallic multilayers. Two multilayer systems with individual layer thickness ranging from 1 to 200 nm were studied: immiscible Cu/V multilayers with fcc/bcc interface, and miscible Fe/W multilayers with bcc/bcc interface. Bulk nanostructured metals and multilayers were subjected to He ion irradiation up to a peak damage of 5 dpa. Radiation induced evolutions of microstructure and mechanical properties in these materials will be discussed. Evidence of enhanced radiation tolerance indicates that stable interfaces (grain boundaries and layer interfaces) in nanostructured materials are effective sinks for radiation induced point defects. Nanoscale microstructure refinement and design have the potential to significantly enhance radiation tolerance of metallic materials.

TUE-RE02-3 #241 - Contributed Talk - Tuesday 8:30 AM - Trinity Central

Hardening in Al/Nb multilayers induced by helium ion irradiations

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We report on the evolution of microstructure and mechanical properties of sputter-deposited Al/Nb multilayers, with body centered cubic (bcc)/face centered cubic (fcc) type interface, subjected to helium ion irradiations. Radiations were performed by using 100 keV He+ ions with a dose of 6×10^16/cm^2. Helium bubbles, 1-2 nm in diameter, were observed in both Al and Nb

and along layer interfaces. Radiation hardening depends on the individual layer thickness, h. When h > 25 nm, the hardness barely changes, whereas the hardening is significant at smaller h. Potential mechanisms of radiation hardening due to introduction of defects and the formation of new phases along interfaces are discussed.

TUE-RE02-4 #478 - Contributed Talk - Tuesday 8:30 AM - Trinity Central

Effects induced by low-flux ion irradiation in the Ni4Mo alloy

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Irradiation induced random displacements of atoms and replacement collision sequences are possible mechanisms for grain size changes and phase transformations. In this study Ni4Mo alloy samples were subject to low-flux bombardment by ion beams. Sample regions were irradiated while the energy density of the bombarding beams was carefully controlled and the non-irradiated regions were kept close to room temperature. This way the irradiation induced temperature increase was highly localized creating "quench-like" conditions. After the irradiation samples were annealed at low temperature, where the growth rate is slow but due to proper irradiation conditions there was high density of nucleation sites. These conditions favor the formation of fine grain structures. Disordering under irradiation is not very obvious at high temperatures irradiations because vacancies can move very fast and the defects can dissolve in some regions near point defect sinks, or can change size in other regions. Irradiation can increase the ordering kinetics via the increased vacancy concentration, but can also induce disordering. Such order-disorder effects could be observed in these two-phase alloys through the formation of precipitates. The purpose of the study was to follow irradiation induced order-disorder transition and gran size change in irradiated Ni-Mo alloys.

TUE-RE02-5 #387 - Contributed Talk - Tuesday 8:30 AM - Trinity Central

Sputter etching of metals with high energy heavy ions

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For decades implantation of high energy heavy ions into many substrates, both conducting and insulating, has been used to affect a wide variety of physical properties such as wetting, friction, electrical resistance, corrosion resistance, and reflectivity. These property changes can be the result of chemical interactions between the specific ion species implanted and the substrate atoms as well as damage effects due to the passage of heavy ions. This presentation will demonstrate that irradiation of substrates with high energy heavy ions in sufficient fluences will result in a sputter etching process that has been applied to successfully fabricate microstructures in many metals, most notably copper, silver, aluminum, and stainless steel. This high energy, heavy ion technique can have some significant advantages compared to the low energy focused ion beam (FIB) technique for creating microstructures.

TUE-RE02-6 #101 - Contributed Talk - Tuesday 8:30 AM - Trinity Central

Positron Annihilation Energy and Lifetime Spectroscopy Studies for Radiation Defects in Stainless Steel

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High Energy proton (up to 800 MeV) and spallation neutron irradiated samples of stainless steel 316L and Mod 9Cr1Mo were studied using positron annihilation energy and lifetime spectroscopy. Doses delivered to 316L were up to 10 displacements per atom (dpa) and doses to 9Cr1Mo were up to about 2.5dpa.

Studies of T-parameter, which is calculated as the ratio of the number of counts in the wings of the Doppler-broadened 511 keV peak to the number of counts in the center of the peak, showed that it dropped sharply from 0 to 3.5 dpa, and then remained constant up to 10 dpa in 316L. In 9Cr1Mo, quite the opposite, T-parameter dropped sharply from 0 dpa to 1dpa, but from 1 dpa to 2.5 dpa it grew larger. We consider that this is due to Molybdenum ?decoration' of defects in 9Cr1Mo.

We saw no change in the positron lifetime for doses above 3.5dpa in 316L. However, for steel 9Cr1Mo the positron lifetime in defects decreased with dose for doses from 1.02 dpa to 2.46 dpa. This implies that the electron density at the annihilation sites, defects in this case, increased. This may be due to the helium or other gases inside the defects, the concentration of which increased when applying more dose.

These results led us in both cases to investigate lower doses. We measured energy and lifetime spectra in 316L and 9Cr1Mo samples that were irradiated under the similar conditions as the above samples, but with doses less than 0.1dpa. These results fill in the gap between 0 and 1 dpa and suggest that most of the change in T-parameter occurs below 0.054 dpa.

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TUE-RE02-7 #396 - Contributed Talk - Tuesday 8:30 AM - Trinity Central

Molecular Dynamics Simulation of Radiation Cascades in Transition Metals with pre-existing defects: Point Defects, Dislocations, and Grain Boundaries

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Using state of the art Molecular Dynamics Simulation approaches implemented for parallel architectures we study the radiation cascades in transition metals with grain boundaries to investigate the influence of pre-existing defects. We use Nickel as the model system with pre-existing defects: vacancies, edge dislocations and bi-crystals interfaced through STL grain boundaries. Each type of defect -point defects, line defects, planar defects- are treated separately in simulations to isolate the effects for each type. The interaction potentials used in these simulations are many body potentials of Sutton-Chen type, optimized to represent the anisotropic mechanical and thermal properties of the transition metals accurately.

TUE-AP03-1 #142 - Invited Talk - Tuesday 1:00 PM - Elm Fork

Water Fragmentation and Energy Loss near the Bragg-Peak by Heavy Ions

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This work review new measurements of fragmentation of water by C- ions, protons and He+ ions [1-4] at the distal region of the Bragg peak. Protons and Carbon ions are currently used in the clinical stages of tumor treatment therapies and the planning of this type of therapy is based on the premise that tumor death follows closely the stopping power profiles of the ions along whole of their trajectories including the Bragg peak, where the major damage occurs. The comparison of the fragmentation pattern by these various projectiles challenges the assumption of placing entire reliance on stopping powers. The results presented in Refs 1-4 show that the water related damage and projectile energy loss is greatly dependent on the dynamics of water fragmentation processes through ionization, electron capture and projectile electron loss, and provides a quantitative assessment of the damage and the energy loss quantities particularly at the distal part of the Bragg peak. Since water radicals are known to give rise to almost 70% of tumor death, these results highlights the importance of these water fragmentation processes and questions the present reliance placed on the high energy based stopping power energy loss models. It also shows that heavy ions based therapies are conceptually different from those with protons, electrons and photons as far as the distribution of primary radical production is concerned. These findings are expected to have a direct implication in future treatment planning and radiation dose calculations.

[1] H. Luna and E.C. Montenegro, Phys. Rev. Lett. 94 (2005) 43201.
[2] E. C. Montenegro et al. Phys. Rev. Lett. 99 (2007) 213201.
[3] H. Luna et al. Phys. Rev. A 75 (2007) 042711.
[4] P. M. Y. Garcia et al. Phys. Rev. A xx (2008) xxxxx.

TUE-AP03-2 #4 - Invited Talk - Tuesday 1:00 PM - Elm Fork

Resonant nuclear excitation via coupling to the atomic shell

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Processes at the borderline between atomic and nuclear physics open the possibility to explore nuclear properties via experiments involving highly-charged ions. The coupling of nuclei to atomic shells in the process of nuclear excitation by electron capture (NEEC) can lead to a number of nuclear effects. In the resonant process of NEEC, the recombination of a continuum electron into a bound atomic shell leads to the excitation of the nucleus [1]. When occuring into an excited electronic bound state, NEEC is followed by fast x-ray emission, changing the electronic configuration of the ion. For some heavy highly-charged ions, the electronic x-ray de-excitation suppresses the internal conversion nuclear decay channel and leads therefore to lifetime prolongation of the excited nuclear state and an increase of the NEEC resonance strengths of up to two orders of magnitude [2]. Applications of this process to the measurement of the not yet experimentally observed NEEC and to dense astrophysical plasmas are discussed.

NEEC can also act as an efficient nuclear excitation mechanism, in particular as triggering mechanism releasing on demand the energy stored in nuclear isomers - long-lived nuclear excited states. A comparison with other isomer triggering mechanisms shows that, among these, NEEC is the most efficient one [3]. An experimental verification of our findings at the borderline of atomic and nuclear physics may be provided by upcoming ion storage ring facilities that will commence operation in the near future.

[1] A. Palffy, W. Scheid and Z. Harman, Phys. Rev. A 73, 012715 (2006)
[2] A. Palffy, Z. Harman, C. Kozhuharov, C. Brandau, C.H. Keitel, W. Scheid, T. Stöhlker, Phys. Lett. B (2008) accepted
[3] A. Palffy, J. Evers and C.H. Keitel, Phys. Rev. Lett. 99, 172502 (2007)

TUE-AP03-3 #138 - Invited Talk - Tuesday 1:00 PM - Elm Fork

Quantum Electrodynamic Effects in He-like Uranium

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Heliumlike ions are the simplest multi-body atomic systems which can be investigated in the regime of very strong fields. They serve as a unique probe to verify our understanding of correlation, relativistic and Quantum Electrodynamic (QED) effects. In the past years, theoretical investigations of theses fundamental systems achieved a considerable improvement in accuracy for the non-QED and QED part, completely calculated to the level of $(Z\alpha)4$, in the electron-electron interaction [1].

We present the first direct measurement of the excited levels in He-like uranium, by observing the intra-shell transition $1s2p\ ^3P_2$ to $1s2s\ ^3S_1$ in He-like uranium via x-ray spectroscopy. For the set-up a combination of a Bragg crystal-spectrometer - providing high spectral resolution - and a solid-state Ge-detector - covering a broad energy region - was used. The experiment was performed at the gasjet-target of the ESR storage ring at GSI, Darmstadt, Germany. The He-like charge state was produced via electron capture into H-like ions in collisions with a N_2-gasjet at a beam-energy of 43 Mev/u. As a reference line the $^2P_{3/2}$ to $^2S_{1/2}$ transition in Li-like uranium was used which has been determined with an accuracy of 4359.37 ± 0.21 eV in a former experiment at the EBIT in Livermore [2,3].

[1] A. N. Artemyev et al, Phys. Rev. A **71**, 062104 (2005)
[2] P. Beiersdorfer et al, Phys. Rev. Lett. **71**, 3939 (1993)
[3] P. Beiersdorfer et al., Nucl. Instr. and Meth. B **99**, 114 (1995)

TUE-AP03-4 #82 - Invited Talk - Tuesday 1:00 PM - Elm Fork

M-Shell Dielectronic Recombination: Theoretical Studies

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Dielectronic recombination (DR) is an important atomic physics process that is relevant to astrophysical plasma modelers. DR is responsible for the charge state balance as well as the cooling of plasmas, and it is the dominant electron-ion recombination process in both photoionized and collisionally-ionized plasmas. Accurate and reliable calculations for DR rate coefficients are needed to analyze the spectra obtained from astrophysical observations. Over the past few years, our group has computed reliable DR and radiative recombination (RR) data for all isoelectronic sequences up through Mg-like ions using a state-of-the-art multiconfiguration Breit-Pauli (MCBP) approach. Recently, we have focused our work on the complex third-row M-shell isoelectronic sequences, especially Al-like. Although there exist some DR calculations for S^{3+}, they were performed only within a non-relativistic LS-coupling approximation and for electron-ionized, higher temperatures. Fe^{13+} DR calculations have been completed and tested against the Heidelberg heavy-ion Test Storage Ring facility measurements. Semi-relativistic DR cross sections and rate coefficient calculations for a wide range of Al-like ions using the level-resolved distorted-wave AUTOSTRUCTURE program will be presented. The effect of ground-state fine structure on the DR rates will be discussed. These calculations include final-state-resolved partial DR and RR rate coefficients from the initial ground and metastable levels spanning a temperature range of 10 Z^2 K - 10^7 Z^2 K, where Z is the initial ionic charge. Our computed Maxwellian DR rate coefficients are fitted into a simple formula for efficient dissemination of data and ease of use in plasma modeling codes, and comparisons to existing data will be shown.

TUE-AT03-1 #424 - Invited Talk - Tuesday 1:00 PM - Bur Oak

Industrial applications of accelerators

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About half of the particle accelerators that have been manufactured by for-profit entities worldwide are used for industrial applications. These commercial systems utilize a wide range of accelerator technologies, including direct voltage systems, rf and microwave linacs, and cyclic accelerators. They accelerate either electrons or ions with energies and currents spanning more than six orders of magnitude. The numerous applications cover a broad range of business segments from low energy electron beam systems for welding, machining, and product irradiation to high energy cyclotrons and synchrotrons for medical isotope production and synchrotron radiation production. While industrial accelerator manufacturing is not a high profile business, these systems have a significant impact on people's lives and the world's economy because so many commonly-used materials and products, both durable and consumable, are processed by charged particle beams. Wide scale industrial use of many of these processing tools has resulted in the rapid growth of the business of producing and selling them. This paper is a review of the current status of industrial accelerators worldwide, including the technologies, the applications, the vendors and the market sizes.

TUE-AT03-2 #310 - Invited Talk - Tuesday 1:00 PM - Bur Oak

A New High-Current DC Proton Accelerator

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A high-current (>20 mA) dc proton accelerator is being developed for applications such as boron neutron capture therapy (BNCT) and the detection of explosive materials by mono-energetic gamma resonance imaging. The high voltage accelerator (1.4 to 2.8 MeV) will be a single-ended industrial Dynamitron® system equipped with a compact microwave ion source. A magnetic mass analyzer will be inserted between the ion source and the acceleration tube to reject heavier ions. Also, a high vacuum pump near the ion source will be used to minimize the flow of neutral gas into the acceleration tube. For BNCT, a lithium target for generating epithermal neutrons is also being developed that will be capable of dissipating the high power of the proton beam. For the detection of explosives, special targets will be used to generate gamma rays with suitable energies for exiting nuclides in explosive materials. Proton accelerators with these high-current, high-energy capabilities are not presently available.

TUE-AT03-3 #342 - Contributed Talk - Tuesday 1:00 PM - Bur Oak

Monte Carlo Simulations of the Irradiation of Alanine Coated Film Dosimeters with Accelerated Electrons

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The Monte Carlo code PENELOPE was used to simulate the irradiation of alanine coated film dosimeters with electrons beams with energies from 1 to 5 MeV being produced by a high-current industrial electron accelerator. This code includes a geometry package that defines complex quadratic geometries, such as those of the irradiation of products in an irradiation processing facility. In the present case the energy deposited on a water film at the surface of a wood parallelepiped was calculated using the program PENMAIN, which is a generic main program included in the PENELOPE distribution package. The results from the simulation were then compared with measurements performed by irradiating alanine film dosimeters with electrons using a 150 kW Dynamitron™ electron accelerator. The alanine films were placed on top of a set of wooden planks using the same geometrical arrangement as the one used for the simulation. The way the results from the simulation can be correlated with the actual measurements, taking into account the irradiation parameters, is described. An estimation of the percentage difference between measurements and calculations is also presented.

TUE-AT03-4 #509 - Contributed Talk - Tuesday 1:00 PM - Bur Oak

Quality Upgrade of 950 keV Portable X-band linac

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We are developing a portable 950 keV X-band (9.4GHz) linac X-ray source for on-site nondestructive evaluation of erosion of metal pipes at a petrochemical complex. Condition based maintenance of an impeller of a pump is also available by synchronized transmitted snapshot. To realize it, we adopted a compact X-band 9.4 GHz magnetron of 250 kW for RF generation device. The whole device such as power supply and cooling device are also downsized. 20 keV therminoic electron gun is used for an electron injector. Designed dose rate of X-ray converted at a W target is 0.2 Gy/min at 1-m distance.

We designed an accelerating tube that has the  mode for the lower energy part and the /2 mode cavity for the higher. We manufactured the accelerating tube and carried out the beam acceleration test. We already conformed that the electron beam was accelerated up to to 950 keV. However, large beam loading may attribute to the beam current oscillation and lack of the amplitude. After the beam test, we set up the X-ray metal target to generate the X-rays. We evaluated the X-ray parameters and succeeded in obtaining radiography images.

We are analyzing the detailed sources of the problem and redesigning a new tube. We can design the new tube that has more stable and robust cavities. Further, we are going to use an automatic frequency controller for more stable RF operation. Updated design and experimental results are presented..

TUE-AT03-5 #150 - Contributed Talk - Tuesday 1:00 PM - Bur Oak

DESIGN STUDY OF IH TYPE ACCELERATOR FOR SEMICONDUCTOR

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A new accelerator which will be used as an implanter of semiconductor industrial is being designed now. Our research purposes are design a new implanter which is lower cost, higher efficiency and applicable to semiconductor manufacturing. The particles which will be used or accelerated are P2+ ions.

Despite using average RF power, our DT (drift tube) linac which is taken an IH structure has an amazing merit which is its superior power efficiency that is 5-20 times higher than that of other RF linear accelerators like Alvarez type and RFQ type accelerator in the low and middle energy range. Therefore, it is possible to generate higher voltages (2-5 times) than in other system with the same RF feeding power that makes compacted injection with high efficiency success. And we choose alternative-

phase-focusing (APF) system to focus beam by combination of focus-defocus sections alternately. APF structure is suitable to shorten cell length.

By using PARMILA and PMLOC which are being used as simulation soft ware we have been calculating orbit computation, and, by using MICROWAVE STADIO we can simulate electromagnetic field distribution. The results of orbit computation which had been gained shows that this IH-APF type DT linac can accelerate particles which were inputted with 20Kev/u up to 1.5MeV/u for charge to mass ratio 2/31 with operation frequency of 60MHz, and the total length is only 600mm, DT bore is 18mm. Compare to others used as implanter of semiconductor manufacturing, this linac we are designing is definitely compacted and miniaturized one.

Another special unique feature we chose is double beam bunch structure in the initial two cells. The phases of gap 1 and gap 2 are -90o and 30o mean that the particles are bunched and synchronized twice. The simulation results show that the total transmission achieved about 40%.

TUE-AT03-6 #250 - Contributed Talk - Tuesday 1:00 PM - Bur Oak

Operation of Cartridge-type Photocathode RF gun with Bi-alkali high QE cathode

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We have been developing a compact exchangeable cartridge-type cathode system for the BNL-type IV photocathode RF gun. We can replace a cathode without breaking vacuum of the RF gun so that a high quantum efficiency photocathode is not exposed by oxygen or moisture. We've already tested a Cs2Te cathode and obtain high intensity current beam of 7nC after the gun, 4nC after the 18 MeV accelerating structure, respectively. The quantum efficiency of the cathode is 3.7%. We propose a Na2KSb cathode, which has the possibility to be driven by visible light over 400 nm (violet range). The work function of Na2KSb is 2.4 eV, which is lower than the photon energy of 400 nm. We tested the cathode and obtained the quantum efficiency of 1% at the wavelength of 266nm. The lifetime of T1/2 is more than 100 hours surrounded at the vacuum pressure of 4*E-8 Torr.

Using this system, we investigate the applications for observation of the radiation- chemical reaction by the pulse-radiolysis system in a time-range of picoseconds and sub-picoseconds.

TUE-AT03-7 #200 - Contributed Talk - Tuesday 1:00 PM - Bur Oak

Radiation Effects Testing Facility ISIS-IAC

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The high dose rate electron and X-ray gamma radiation effect test facility ISIS at the Idaho Accelerator Center is described, with emphasis on the design and implementation of a high power, multi-shot, bremsstrahlung converter. In electron beam mode ISIS produces a 35ns long, 10kA pulse of ~6MeV electrons. When this beam is directed to the new bremsstrahlung converter, which does not need repair / replacement for hundreds of shots, the system is capable of delivering a X-ray dose of ~50 krad(Si) over 4-5 cm2 area at a dose rate in excess of 1.5E12 rad/s and at a reprate of ~5 shots/h.

TUE-FIBP01-1 #51 - Invited Talk - Tuesday 1:00 PM - Post Oak

Three-dimensional lithography and functionalization of single crystal diamond with focused keV and MeV ion beams

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Diamond is a material with extreme physical properties: high mechanical and radiation hardness, chemical inertness, spectrally wide transparency, high carrier mobility, high dielectric strength, bio-compatibility.

Such unique features make this material extremely appealing for many applications, ranging from micro-optical devices to particle detectors, and from micro-fluidics to nano-electromechanical and bio-electromechanical systems. More recently, optical centers in diamond demonstrated to have a great potential in quantum information processing (quantum cryptography, quantum computing).

In order to express the vast potentialities of this material, it is necessary to control the nano-fabrication and optical functionalization of artificial diamond single crystals, which represent the ideal substrates in terms of material quality and

reproducibility. Interestingly, the same properties that make diamond so attractive (particularly, its chemical inertness) also determine a major challenge in their fabrication.

The interaction of focused ions at energies in the keV-MeV range with matter represents the ideal tool to achieve these goals. By means of MeV ion implantation it is possible to change the electrical and optical properties of diamond with great accuracy, as well as modify its structural properties through the damage-induced conversion to graphite. In particular, the conversion to the latter allotropic form (the stable form of carbon at room pressure and temperature) represents both a technique to create a sacrificial layer for selective etching and also a strategy to define electrically conductive paths in diamond based devices. Complementarily, the use of focused keV ions allows the direct milling of nanostructures with high spatial resolution.

In this talk, an overview will be given on the employment of focused keV-MeV ion beams to fabricate three-dimensional optical nano-structures in diamond and to functionalize the optical and electrical properties of the material for a range of devices of technological interest.

TUE-FIBP01-2 #52 - Invited Talk - Tuesday 1:00 PM - Post Oak

Ion Beam Analysis of Materials for Water Purification

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The polyamide active layers of reverse osmosis and nanofiltration membranes used for water purification are examples of a nanoscale functional materials that challenge the state-of-the-art of materials characterization. The active layer is only ~100 nm thick, and because the active layer is formed by a process of interfacial polymerization, the structure and composition of the membrane is highly inhomogeneous. Even such basic physical and chemical properties of the membrane as the atomic density, swelling in water, distribution of charged species, and the mobility of water and ions, are poorly understood. I will discuss our progress in the use of Rutherford backscattering spectrometry (RBS) to determine the composition and thickness of membrane; reveal the surprisingly high solubility of salt ions in the polymer active layer; analyze the acid-base chemistry of charged functional groups; and determine the degree of cross-linking.

TUE-FIBP01-3 #377 - Contributed Talk - Tuesday 1:00 PM - Post Oak

Optimal parameters of high energy ion microprobe systems comprised of Louisiana lenses

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High energy optimal ion microprobes comprised of new compact magnetic quadrupole lenses (Louisiana Quadrupole Lens) are numerically investigated. The smallest beam spot size and appropriate radii of object and divergence slits are presented for different emittances and compared with the corresponding parameters of the Oxford Triplet for the same total length. The parameters of the calculated microprobes include demagnification, the magnetic field in the lenses and the coefficients of spherical and chromatic aberrations for several quadrupole system configurations including the doublet, the Louisiana symmetric triplet, the Russian magnetic quadruplets and sextuplets.

TUE-FIBP01-4 #403 - Contributed Talk - Tuesday 1:00 PM - Post Oak

High Brightness Plasma FIB for Nanoscale and Microscale Milling Applications

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Conventional focused ion beams (FIB) employing liquid metal ion sources (LMIS) are commonly used to perform microscale and nanoscale milling operations. FIB tools are typically used to remove material with volumes from 0.1 cubic microns to 10000 cubic microns with a cross-section edge placement accuracy below 10nm. These tools are very effective for creating milled structures with dimensions below 25microns. Structures that are larger than 25microns are typically difficult to create with a conventional FIB because with a 10nA/30keV gallium beam the mill rate of silicon (normal incidence) is only 2.7cubic microns/s so mill volumes greater than 10000cubic microns can take more than an hour. For instance a 65micron x 65micron x 65micron (270000cubic microns) cross-section would take over 24 hours to complete with a 10nA/30keV gallium beam. Conventional LMIS tools are usually limited to beam currents below 50 nanoamperes because spherical aberrations significantly degrade the

current density of the probe and the spot quality as the current is increased. Applications involving Micro-Electro-Mechanical Systems (MEMS), biological structures, optical components, and semiconductor packaging materials often require large volumes of material to be removed (>million cubic microns) for further sub-surface material inspection or chemical analysis. A plasma ion source based FIB has been developed with a significantly enhanced milling rate with beam sizes comparable to a 10nA/30keV gallium beam. When mill rates greater than 10 cubic microns/s are required, the plasma source FIB offers a spot diameter that is smaller and better suited for milling large volumes than a standard gallium FIB. This plasma FIB operating with Xenon is capable of removing material almost 50X faster than a convention FIB when the beam probe size is 2 microns. The plasma source based FIB can also operate with a variety of ion species and has been operated with Xenon, Argon, Oxygen, and Helium.

TUE-FIBP01-5 #410 - Contributed Talk - Tuesday 1:00 PM - Post Oak

Growth of self-assembled epitaxial gold silicide structures on silicon surfaces: RBS Studies with an ion microprobe

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Growth of self-assembled equilateral triangle-shaped epitaxial gold silicide islands on Si(111) substrates and their shape transition to trapezoidal islands have been observed and explained in the light of theory of shape transition [1]. Gold silicide islands also grow on Si(110) surfaces. The twofold symmetry of the Si(110) surface leads to the growth of long straight wire-like islands [2], the growth aspects of which have been studied by Rutherford Backscattering Spectrometry using an ion microbeam (micro-RBS). We will present micro-RBS studies of growth features on Si(111) surfaces. Areas near the islands have been mapped by detecting Au RBS signals from various depths, Si RBS and Si PIXE signals. Point mode RBS results across the islands, show their height profiles. Outside the islands, in the flat regions, the presence of a thin gold silicide layer is revealed, conforming to a Stranski-Krastanov or layer-plus-island growth of gold silicide on silicon. Island heights of ~ 10-20 times the initial thickness of the deposited Au films have been observed. Gold silicide islands are formed up on annealing at the Au-Si eutectic temperature (363 0C). Si diffuses out into the Au layer to form Au4Si islands, which grow in height as additional Au diffuses to the islands by lateral diffusion of Au on the surface. This lateral diffusion of Au, additionally leads to fractal aggregation of Au [3]. We have imaged some of these fractal Au structures by micro-RBS mapping via detection of backscattering by Au. The importance of the ion micropobe in the study of growth mode will be elucidated.

[1] K. Sekar et al., Phys. Rev. B 51 (1995) 14330.
[2] B. Rout et al., J. Vac. Sci. Technol. B 18 (2000) 1847.
[3] K. Sekar et al., Solid State Commun. 96 (1995) 871.

TUE-FIBP01-6 #415 - Contributed Talk - Tuesday 1:00 PM - Post Oak

Molecular imaging with swift heavy ions (MeV-SIMS)

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Much effort has been made to increase the secondary molecular ion yields under ion bombardment. Desorption of large molecular ions under irradiation with MeV ions was first observed by Macfarlane et al. in 1974 [1], and plasma desorption mass spectrometry (PDMS) by using fission fragments from a 252Cf source has been used to detect bio-molecules up to 20 kDa. Unfortunately, with the emergence of other promising mass spectroscopy techniques, the number of PDMS studies has decreased. In the last decade there has been increased interest in molecular imaging of tissues and cells with mass spectrometry. We have proposed a SIMS analysis technique with swift heavy ions, termed MeV-SIMS here, and demonstrated that the molecular ion yield of varios bio-molecules was enhanced by a factor of 1000 compared with keV monomer ion irradiation. We have also successfully obtained MeV-SIMS imaging of peptide ions (GlyGlyGly-H-: 188 Da) with a lateral resolution of 10 ìm. The advantages and challenges of bio-molecular imaging with the MeV-SIMS technique will be discussed.

[1] DF. Torgerson, et al, Biochem. Biophys. Res. Commun. 60 (1974) 616.

TUE-FIBP01-7 #512 - Contributed Talk - Tuesday 1:00 PM - Post Oak

Lithography with MeV energy ions for biomedical applications: accelerator considerations

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MeV ion beam lithography becomes a very powerful technique for 3D direct writing of photoresist material such as PMMA, SU8, etc. The dependence of deposit energy and clearing dose for low and high energy has been investigated. Furthermore, coulomb scattering and range for ions and electrons are discussed here in details. Ion beams can be precisely defined deposition of energy on a nanometer scale in a material or biological cells. Therefore, the controlled energy deposition with MeV ion beam lithography can be acted as the basis of novel tools and being particularly useful for tailor making structures for cell- and sub-cellular level biomedical research and technology such as lab-on-chip systems for DNA, protein and cell separation, special cell-growth substrates with defined topography and microfluidic devices etc.

TUE-IBA02-1 #492 - Invited Talk - Tuesday 1:00 PM - Brazos II

Handbook of Modern Ion Beam Materials Analysis: The Second Edition

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The first edition of "Handbook of Modern Ion Beam Materials Analysis" was published by Materials Research Society (MRS) Publisher in 1995. The so-called Black Handbook has been popularly used by many students, ion beam researchers and accelerator laboratories in the world ever since. Over the last decade, steady advancements have occurred in many ion beam analysis related fields, including ion stopping, ion accelerator technology, particle detection systems, data reduction software development, and new ion beam techniques for materials characterization etc. According to the online search engine SearchPlus, well over 20,000 publications during the same period have used one or more of traditional ion beam analysis techniques. To capture these ion beam analysis advancements, we have initiated a process to produce a second edition for this useful handbook. In this presentation, we will give you an overview report on this project and more specifically, we will show you what improvements have been made to the existing chapters/appendix and what new chapters have been added in the new edition of the ion beam handbook.

TUE-IBA02-2 #263 - Invited Talk - Tuesday 1:00 PM - Brazos II

Physics of the interaction of charged particles with nuclei

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A chapter of the Ion Beam Materials Analysis Handbook devoted to the nuclear physics fundamentals of IBA is presented. The nuclear physics concepts and models relevant to IBA are discussed in this chapter. The chapter will begin with consideration of the formal quantum mechanical theory of scattering followed by review of mechanisms of the projectile-nucleus interaction. Models for dealing with different processes will be introduced and their application to the cross section evaluation will be presented. In addition sources of the nuclear data will be indicated and some examples will be given.

TUE-IBA02-3 #232 - Invited Talk - Tuesday 1:00 PM - Brazos II

Dechanneling in Rutherford Backscattering Spectrometry Analysis

Lin Shao
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This talk will focus on two issues in channeling Rutherford backscattering spectrometry analysis (RBS). One is the channel-depth conversion which needs to consider the stopping power difference between channeled and non-channeled ions. Another is the approach to separate dechanneling background. An iterative method, based on self consistency requirements of channeling theory, has been recently developed for obtaining more accurate displacement profiles. Furthermore, this method is able to extract dechanneling cross section. The extracted value, however, is larger than the prediction from classic theories. The difference suggests the importance to consider the strain relaxation around point defects. These two improvements on RBS analysis have been included in the new version of "Handbook of Modern Ion Beam Materials Analysis".

TUE-IBA02-4 #510 - Invited Talk - Tuesday 1:00 PM - Brazos II

Pitfalls in Ion Beam Analysis

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Accurate elemental depth profiling by IBA is of great value in many modern thin film technologies: it is particularly good at interfaces, and has an accuracy that is easily traceable to international standards, making it suitable for standards work. We will show in this chapter how to best capitalise on these strengths. Currently the best available absolute experimental accuracy is 0.6% (1 sigma), and we will consider a large number of pitfalls giving errors larger than about 0.25%, including beam events, fixed parameter calibration, algorithmic issues, uncertainty estimation and unwanted target-beam interactions. Methods of detection and solutions to the pitfalls will be proposed.

TUE-IBA02-5 #559 - Contributed Talk - Tuesday 1:00 PM - Brazos II

Investigation of Si and C disorder distributions and Pt-implanted profile in 6H-SiC

Weiming Zhang, Weilin Jiang, Zihua Z hu, Yanwen Zhang
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Silicon carbide (SiC) is a promising candidate for semiconductor devices and potential structural components in harsh environments, such as high radiation, high temperature, high power, or high frequency applications. Despite the excellent physical and chemical stability, radiation effect in SiC remains a key technical issue. In this work, Pt-implantation-induced Si and C disorder in 6H-SiC is studied. Specimens from the same 6H-SiC wafer were irradiated by 2 MeV Pt2+ ions at 150 K to fluences of 0.21 ions/nm2, 0.47 ions/nm2 and 22 ions/nm2. The Si and C damage distributions along the <0001> channel direction were measured using 3.5 MeV He ions to increase the scattering cross section of C. The distribution of the Pt ions in 6H-SiC was investigated both by Rutherford backscattering spectrometry using 2.0 MeV He ions for better depth resolution, and by secondary ion mass spectrometry (SIMS). The experimental results were compared with Monte Carlo simulation results, calculated by the Stopping and Range of Ions in Matter (SRIM) code, 2008 version, in a full cascade mode. The disorder profiles from the RBS measurements are over 30% deeper than the SRIM predicted profiles. Large overestimation of the stopping power by the SRIM predictions is also shown from the Pt distribution. The evidences indicate that electronic energy loss of Pt in 6H-SiC calculated by SRIM-2008 is inaccurate.

TUE-IBA02-6 #268 - Contributed Talk - Tuesday 1:00 PM - Brazos II

Recent developements at the IPNAS Cyclotron of Liege - Use of High-Energy Alpha and proton beams for RBS measurements

Grégoire Chêne[1,2], Henri Pierre Garnir[1], Thomas Dupuis[2], François Mathis[2], André Marchal[1], Michael Philippe[1], David Strivay[1,2]
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The depth profile resolution of RBS (Rutherford Back Scattering) analysis method is strongly dependent on the energy resolution of the probing beam. Therefore, we have reduced by a factor of 20 the natural dispersion of the Liege 20 MeV (proton) AVF (Azimuthal Varying Field) cyclotron by adapting a magnetic analyzer, consisting in two 90 left-right bending magnets forming an achromatic doublet. Measured by scanning and recording the resonance width of a 32S(p,p'g)32S (3,38MeV protons laboratory energy), the resolution achieved, with a value of DeltaE=±1,9keV is comparable to that of electrostatic accelerators and as it allows to reach higher energies, it opens new perspectives for "deeper surface" analysis for both proton and alpha beams.

Initially designed for the analysis of cultural heritage artifacts, this new extracted beam line will constitute an accurate tool, perfectly suited for the RBS analysis of thick layers such as corrosion or gilding layers, often observed on such artifacts.

First measurements to extend the use of alpha beams towards energies greater than 6 MeV, has shown, for such energies and ions conjunctions, great lacks in Non-Rutherford cross-sections knowledge and in the evaluation of its contribution to spectrums for quantitative RBS analysis by classical codes (SIMNRA, RUMP).

We will describe here our new high-energy extracted beam line, analyzing devices, and show first RBS results obtained with alpha beams from 6 to 14 MeV.

TUE-IBM06-1 #555 - Invited Talk - Tuesday 1:00 PM - Pecos II

Effects of Ionization on Ion-Beam-Induced Amorphization

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The effects of the ionizing component of energy loss on ion-beam damage accumulation can significantly affect the dynamics of recovery processes during irradiation in some materials. In such materials, the critical temperature for ion-beam induced amorphization can exhibit a strong dependence on electronic energy loss, and ionization-enhanced recovery and recrystallization due to electron beams is observed in some of these materials. Under irradiation with different ions, the ratio of electronic to nuclear stopping powers varies locally for both the primary ion and the secondary recoils produced. The local total ionization dose due to the primary ion and all secondary recoils can be determined, and the effects on the kinetics of damage accumulation in these materials can be quantified in terms of the ratio, R, of the local total ionization cross section to the total damage cross section. The results indicate that the critical temperature for amorphization increases linearly with the inverse of ln(R) until thermal processes dominate to define a unique critical temperature for these irradiation conditions. The current results demonstrate that the local rate of in-cascade ionization has a significant effect on the dynamic recovery processes that determines the critical temperature. Likewise, the results of this work show that the inverse critical dose for amorphization at a constant temperature increases linearly with the ratio R.

TUE-IBM06-2 #460 - Invited Talk - Tuesday 1:00 PM - Pecos II

Application of ion-solid interactions for reducing damage in FIB prepared specimens

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Focused ion beam (FIB) techniques have been used over the years to prepare specimens for characterization in a wide range of analytical instruments. Differential milling between materials is largely avoided due to the high glancing angle that is used (e.g., 88-89o) during the FIB process. One of the more popular uses of FIB is for the production of transmission electron microscopy (TEM) specimens. The advent of FIB for the preparation of specimens for 3D atom probe tomography (APT) allows for analysis of multi-phased and multi-layered materials which in the past would have been considered difficult or impossible due to specimen preparation constraints. In addition, FIB prepared surfaces are now routinely used for the acquisition of electron backscatter diffraction (EBSD) patterns. This technique has been extended to the acquisition of 3D crystallography in a DualBeam (FIB+SEM) instrument. Typical FIB instruments operating at 30 keV can result in sufficient lateral ion implantation and/or amorphization surface damage to hinder quantitative high resolution TEM results. Amorphization damage can also degrade the quality of the EBSD pattern such that the pattern cannot be resolved. In addition, 30 keV FIB milling can cause sufficient ion mixing which can destroy the chemical/elemental integrity of interfaces, rendering the 3D APT analysis useless. New advances in ion columns allow for imaging and FIB milling to take place down to 500 eV. Specimens can be prepared using the fine probe size of the high energy beam, and then polished with low energy ions which replace the high energy implantation damage with minimal damage from the low energy ions. These low energy FIB techniques allow for quantitative high resolution (S)TEM, improve the quality of the EBSD patterns, and allow for 3D APT without interferences from the Ga+ ion implantation.

TUE-IBM06-3 #428 - Invited Talk - Tuesday 1:00 PM - Pecos II

The Structure of Sapphire Implanted with Carbon at Room Temperature and 1000 C

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[(3)]Center for Materials Processing, University of Tennessee, 514 East Stadium Hall, Knoxville TN 37996-0750, United States

Carbon was implanted into sapphire single crystals at various temperatures as part of a study of the different defect structures produced by a series of light ion implantations. Implantations were made with 150 keV ions at fluences of 4e16, 1e17 and 1e17 ions/cm2 at RT and 1000 C. The defect structures were characterized using Rutherford backscattering-channel (RBS-C), transmission electron microscopy (TEM) and optical absorption. The stability of the defect structures was determined for samples annealed in vacuum at 1000 C. The RBS-C spectra indicated low residual disorder for implantation to the lowest fluence at RT, but disorder approaching the random value at the higher fluences. The TEM examination revealed a buried amorphous layer that contains embedded sapphire nanocrystals in the RT sample implanted with 1e17 ions/cm2. Damaged layers containing planar defects generally aligned parallel to the surface surrounded the amorphous region. The TEM micrographs showed only a highly damaged crystalline implanted layer for the sample implanted at 1000 C. The results will be compared to previously published observations on boron and nitrogen implanted sapphire.

TUE-IBM06-4 #361 - Invited Talk - Tuesday 1:00 PM - Pecos II

Ion Beam Nano-Engineering Opportunities in Industrial Applications

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Well-defined spatial localization (in 1-D, 2-D or 3-D) is an intrinsic characteristic of ion-solid interactions. By suitable choice of ion beam parameters, we can tailor features or arbitrary patterns with nanometer definition at resolution that can not be achieved by e-beam or photon induced processes.

Future industrial applications in which such nano-engineering could become enabling technology include: lithography for CMOS beyond the 22 nm node; high density 3-D chip integration; Terabit/sq.in. magnetic storage; multilayer functional nanopore membranes for gene sequencing; and patterned bio-activation of surfaces.

However, for successful application in such manufacturing modes, our ion beam techniques must be devised and implemented so as to satisfy commercial requirements for high reliability, high throughput, high performance, high flexibility, and acceptable cost.

In this paper, we review examples of progress recently made in these areas. And we point out some basic concerns still to be addressed, such as the need for new lithography processes, using new, thin resist layers and programmable masks; and potential problems of granularity and shot noise. We also note the potential for templated self-assembly in certain interesting applications.

TUE-IBM06-5 #9 - Invited Talk - Tuesday 1:00 PM - Pecos II

Coulomb heating of channeled C2 molecules in Si

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In a channeling motion, molecules undergo a break up process in the first monolayers of the crystal. The combination of these two motions, the channeling one and the Coulomb explosion of the molecule lead to the so-called Coulomb heating. Recently first quantitative Coulomb heating results were obtained for Hn molecules, however they are relative simples when compared with heavier clusters. Then, it is interesting to investigate if the experimental-theoretical approach used for Hn is valid for heavier clusters. In this abstract we report results of a Coulomb heating study produced by a C2 molecular beam. Our 3 MeV Tandetron has delivered C and C2 beams with energies ranging between 900 and 2200 keV/amu. The Si<100> samples were mounted on a goniometer in a vacuum better than 10-6 mbar.Then we performed with a C beam, an angular scan around the Si<100> axis detecting simultaneously the x-rays emitted from the Si target and the corresponding RBC/C spectra. After performing sweep around the center of the channel we changed to a C2 beam and repeated the operation. The obtained results show that at zero or near zero polar degree the x-ray yield induced by the C2 beam was 15% larger than the one induced by the C beam. In addition the RBS/C, C2 spectra show a stronger dechanneling as compared with the C one. Both features are clear signature of the Coulomb heating effect. In order to obtain quantitative results we have used the two beam model to fit simultaneously the x-ray yield and the RBS/C spectra. The obtaining results show that the heating values varies from 14 eV (900 kev/amu) up to 30 eV (2.2 MeV/amu). Finally, we were able to predict the experimental values by combining calculations and simulations being the experimental-theoretical agreement quite reasonable

TUE-MA03-1 #18 - Invited Talk - Tuesday 1:00 PM - West Fork

Acceleration of Protons by High-power Lasers for Clinical Applications: Current Challenges and Future Directions

Eugene Fourkal, Iavor Veltchev, Charlie Ma
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Recent developments in the field of laser engineering, specifically the invention of chirped pulse amplification technique made it possible to achieve laser light intensities reaching 10^{22} W/cm^2 range. In this review, we will show that such laser intensities are sufficient to accelerate protons to therapeutic energy ranges, provided that proper laser-target parameters are chosen. In the majority of recent laser-matter interaction experiments, the proton energy spectra coming out of the interaction chamber are thermal making it impossible to use these protons in hadron therapy. This necessitates the development of a particle selection device that would deliver quasi-monoenergetic particles suitable for medical applications. We will discuss earlier proposed particle selection system and show the dosimetric characteristics of protons coming out of this device. Using "real" patient data and physical characteristics (phase-space distribution) of selected particles we will discuss the inter-comparison studies between photon intensity-modulated plans on one hand and intensity-modulated plans based on laser-accelerated protons on the other. In concluding remarks, we will describe the current challenges facing the project and ways to resolve them.

TUE-MA03-2 #276 - Invited Talk - Tuesday 1:00 PM - West Fork

Design Features of an Integrated Proton Therapy Solution

J. Timmer, J. Conrad, H. Goebel, M. Grewe, J. Heese, F. Kubo, A. Langenegger, D. Murray, M. Petrillo, H. Roecken, M. Schillo, S. Schmidt, T. Stephani
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With Proton Therapy (PT), Varian Medical Systems provides an additional valuable tool in the ongoing fight against cancer. By supplying clinicians with these tools, patient treatment can be improved especially in the areas of dose control and optimized dose conformity. The Varian PT-system has been developed to provide the most advanced treatment modality by supplying pencil beam scanning which is delivered to a 360° rotating gantry or a fixed beam room. The nozzle with its diagnostics and scanning magnets, along with the superconducting proton accelerator, energy selection system and the beam transport system, are all designed and optimized for pencil beam scanning operation. By combining this state of the art proton delivery with advanced imaging and the Eclipse™ treatment planning system, an integrated proton therapy solution can be offered to the end customer. We report about the specifications and design features of the Varian accelerator, proton gantry, scanning system and integrated software tools.

TUE-MA03-3 #182 - Invited Talk - Tuesday 1:00 PM - West Fork

A Compact Linac for Intensity Modulated Proton Therapy Based on a Dielectric Wall Accelerator*

George J. Caporaso[1], Thomas R. Mackie[2,3], Stephen E. Sampayan[1], Yu-Jiuan Chen[1], Donald T. Blackfield[1], John R. Harris[1], Steven A. Hawkins[1], Clifford L. Holmes[1], Scott D. Nelson[1], Arthur C. Paul[1], Brian A. Poole[1], Mark A. Rhodes[1], Dave M. Sanders[1], Jim S. Sullivan[1], Li-Fang Wang[1], Jim A. Watson[1], Paul J. Reckwerdt[2], Richard Schmidt[2], Dave Pearson[2], Richard W. Flynn[3], Dennis L. Matthews[4], James Purdy[4]
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A novel compact CT-guided intensity modulated proton radiotherapy (IMPT) system is described. The system is being designed to deliver fast IMPT so that larger target volumes and motion management can be accomplished. The system will be ideal for large and complex target volumes in young patients.

The basis of the design is the dielectric wall accelerator (DWA) system being developed at the Lawrence Livermore National Laboratory (LLNL). The DWA uses fast switched high voltage transmission lines to generate pulsed electric fields on the inside of a high gradient insulating (HGI) acceleration tube. High electric field gradients are achieved by the use of alternating insulators and conductors and short pulse times. The system will produce individual pulses that can be varied in intensity, energy and spot width. The IMPT planning system will optimize delivery characteristics. The system will be capable of being sited in a conventional linac vault and provide intensity modulated rotational therapy.

Feasibility tests of an optimization system for selecting the position, energy, intensity and spot size for a collection of spots comprising the treatment are underway. A prototype is being designed and concept designs of the envelope and environmental needs of the unit are beginning. The status of the developmental new technologies that make the compact system possible will be reviewed. These include, high gradient vacuum insulators, solid dielectric materials, SiC photoconductive switches and compact proton sources.

*Patents Pending. Lawrence Livermore National Laboratory is operated by Lawrence Livermore National Security, LLC, for the U.S. Department of Energy, National Nuclear Security Administration under Contract DE-AC52-07NA27344.

TUE-MA03-4 #615 - Contributed Talk - Tuesday 1:00 PM - West Fork

Operating and Innovations in FFAGs for Proton and Ion Therapy

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A hybrid design for a Fixed-Field Alternating-Gradient (FFAG) accelerator has been invented which uses edge and alternating-gradient focusing principles applied in a specific configuration to a combined-function (CF) magnet to stabilize tunes through an acceleration cycle which extends over an order of magnitude in momentum. The final, extracted energy from this machine can attain 450 MeV/nucleon using either normal or superconducting elements depending on space constraints. By using fixed-fields, the machine proposed here has the high current advantage of the cyclotron yet retains important features of the synchrotron: smaller radial aperture, low losses, variable energy (no degrader for most applications), and both kicker-based and resonant

extraction. This machine, without modification, simultaneously supports a proton and a carbon ion beam in the energy range of interest for cancer therapy; i.e. multiple injection ports allow multiple ion sources with reconfiguration. Competing machines for this application include superconducting cyclotrons, synchrotrons, and, more recently, the more complex scaling FFAGs. As such this machine represents a broad innovation in therapy machines. A number of hadron and ion therapy facilities now exist or are under construction internationally based on scaling FFAGs. The current status of the operating and planned facilities will also be presented.

TUE-MA03-5 #620 - Invited Talk - Tuesday 1:00 PM - West Fork

The Still River Compact Proton Therapy System

Kenneth Gall, Townsend Zwart
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Still River Systems has developed a high magnetic field, superconducting cyclotron for proton therapy. The magnet for the system provides a peak field close to 12 Tesla, which is the key to the small size of the accelerator. Novel subsystem developments were needed to enable practical operation of the cyclotron, including the ion source and the radiofrequency system. The extraction of a beam from this high field cyclotron also posed design challenges. Additionally, the requirements for magnetic shielding of the high field needed to be met.

The compact size of the accelerator allows us to mount the cyclotron on a rotating gantry so that the emerging beam can be directed toward a patient from a range of angles. The cyclotron can produce a maximum beam energy of 250 MeV which, after accounting for the energy loss in the beam spreading devices, provides a treatment field with a depth of penetration of 32 cm in water. Using traditional scattering methods of proton beam shaping such as those described by Gottschalk, a uniform treatment field of up to 25 cm diameter is produced. The complete system is designed to fit within a single radiation shielded vault, with all power supplies, electronics and support devices housed inside the room.

TUE-MA03-6 #220 - Invited Talk - Tuesday 1:00 PM - West Fork

Development of Synchrotron-based Technology for Advanced Proton Therapy

Kazuo Hiramoto[1], Kazuyoshi Saito[1], Masumi Umezawa[1], Hideaki Nishiuchi[1], Satoshi Totake[1], Shinichirou Fujitaka[1], Hiroaki Sakurabata[2], Kunio Moriyama[3]
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[(3)]Information & Control Systems Division, Hitachi, Ltd., 2-1, Omika-chou, Hitachi Ibaraki 319-1293, Japan
It is expected that proton beam therapy can attain more conformal and accurate irradiation of tumor. In order to realize this expectation, Hitachi has developed new synchrotron-based technologies such as beam scanning, accelerator beam energy stacking, etc. The conformal irradiation can be achieved with combining the beam scanning and beam energy stacking for the range modualtion. For the beam scanning, Hitachi has developed new techniques for controlling the beam extraction from the synchrotron, where the beam extraction is switched on and off within 0.2 msec, and the spill time can be extended up to 5 s. In this control, Hitachi's original beam extraction scheme using transverse RF perturbation has been employed. The accelerated beam energy can be changed with pulse-to-pulse synchrotron operation cycle. Then, cooperating with the beam transport, the beam energy transported to the irradiation nozzle can be changed at every synchrotron operation cycle, and the range modulation can be done without using a conventional SOBP filter. By using these technologies, the pencil beam scanning with the energy stacking has become possible. The dose control of every irradiation spot is also possible. It is planned that this beam scanning will be applied to actual treatment in a hospital based proton therapy system this year. Furthermore, real time feedback control technology of the beam spill intensity has been developed for advanced and flexible operation. It has been confirmed experimentally that the average spill intensity can be controlled well. In order to reduce the number of the energy changes for the range modulation, that is, to increase treatment throughput, mini-ridge filter for spreading the pristine Bragg peak has been studied. It has been confirmed that a properly designed mini-ridge ridge filter can reduce significantly the number of the energy changes for the range modulation while keeping appropriate distal fall-off value.

TUE-MA03-7 #304 - Invited Talk - Tuesday 1:00 PM - West Fork

Rapid Cycling Synchrotrons for Cancer Therapy

Todd J Satogata, Stephen G Peggs
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The Rapid Cycling Medical Synchrotron (RCMS) is a second-generation synchrotron is designed to accelerate beams of 1.0e7-1.7e9 protons to energies of 70-250 MeV at 60 Hz, using strong focusing to maintain small beam size and resonant magnet cycling to lower facility cost. Beam energy and intensity are varied cycle by cycle; total dose to a one liter tumor can exceed 30

Gy/min. This capability can be used for 3D conformal spot scanning and dynamic response to patient respiration, eliminating gating inefficiency. This talk summarizes the technical design of the RCMS, and summarizes other rapid cycling synchrotrons that are being designed for proton and light ion medical therapy.

TUE-NP03-1 #372 - Invited Talk - Tuesday 1:00 PM - Brazos I

Neutron transfer reactions: surrogates for neutron capture for basic and applied nuclear science

Jolie A Cizewski
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Neutron-capture reactions on unstable nuclei are important for understanding nucleosynthesis, both slow and rapid neutron capture processes, as well as understanding the performance of nuclear reactors and nuclear weapons. However, direct measurements of neutron capture reactions are limited to relatively long-lived samples, with half lives of hundreds of days. We have recently demonstrated that the (d,p gamma) reaction is a surrogate for neutron capture reactions. We have initiated a program at the Holifield Radioactive Ion Beam Facility at Oak Ridge National Laboratory to study single-neutron transfer (d,p) reactions with beams of fission fragments to provide information on neutron-induced reactions of fission fragments far from stability. The techniques to measure gamma rays in coincidence with reaction protons have also been developed. This talk would provide an overview of the instruments, techniques, and initial results, as well as the potential impact on applied nuclear science. Work supported in part by U.S. Department of Energy and National Science Foundation.

TUE-NP03-2 #461 - Invited Talk - Tuesday 1:00 PM - Brazos I

The Global Nuclear Energy Partnership (GNEP) and the Need for Precision Nuclear Data

Tony S Hill
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The Global Nuclear Energy Partnership (GNEP) is a program funded by the DOE that seeks to develop worldwide consensus on enabling expanded use of economical, carbon-free nuclear energy and to build recycling technologies that enhance energy security in a safe and environmentally responsible manner, while simultaneously mitigating proliferation concerns. The envisioned fuel cycle will require advanced fast reactors, nuclear recycling facilities and enhanced safeguards technology. Nuclear Physics plays a central role in the development of these facilities and the uncertainties in the nuclear data propagate to uncertainties in integral and operational parameters. Nuclear data sensitivity calculations have been developed that are used to maximize the impact of GNEP nuclear physics R&D investment. Measurement programs are underway and others being developed to address the broad nuclear data needs of GNEP.

TUE-NP03-3 #481 - Invited Talk - Tuesday 1:00 PM - Brazos I

The Fission TPC Project

Mike Heffner
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New high-precision fission experiments have become a priority within the nuclear energy community due to a growing, world wide, interest in nuclear reactors. In particular, the design of the next generation reactors requires a reduction in the errors on a number of cross section measurements. Most of the required nuclear data has been measured over the last 50 years, although improvements in the accuracy of the data appear unlikely with the current technology. A potential breakthrough is the deployment of a detector developed within the particle physics community called the Time Projection Chamber (TPC). A group of 6 universities and 3 national laboratories have undertaken the task of building the first TPC for this purpose. In this talk I will present the fission TPC concept, and why we think we can make an improvement on 50 years of fission study.

TUE-NP03-4 #533 - Contributed Talk - Tuesday 1:00 PM - Brazos I

Photodisintegration Cross Section on ^{241}Am

A. P. Tonchev[1], S. Hammond[2], C. R. Howell[1], A. Hutcheson[1], H. J. Karwowski[2], J. H. Kelley[3], E. Kwan[1], G. Rusev[1], W. Tornow[1], J. B. Wilhelmy[4]
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Accurate neutron-induced reaction cross-section data are required for many practical applications, especially in the field of nuclear energy. The cross sections are needed, for example, to estimate the decay heat, activation of structural materials, and gas production in both present day fission and future fusion reactors. Improved neutron and gamma induced measurements on the minor actinides are desired for the Global Nuclear Energy Partnership, the transmutation of long-lived radioactive waste with advanced high neutron-energy reactors, and for establishing improved diagnostics for nuclear device performance. Here we concentrate on fast neutron and gamma induced reactions on the minor actinide ^{241}Am.

The photodisintegration cross section on radioactive ^{241}Am target has been measured for the first time using monoenergetic γ-ray beams from the HIGS facility. Induced activity from ^{240}Am produced via the (γ,n) reaction was measured by the activation technique using high resolution HPGe detectors. The (γ,n) cross section was determined both by measuring the absolute gamma-flux and by comparison to the ^{197}Au(γ,n) cross section used as a standard. In the following, we report new data for the excitation function of the ^{241}Am(γ,n) reaction from near threshold to 16 MeV incident γ-ray energy and we compare the data with statistical nuclear-model calculations performed with the GNASH, EMPIRE, and TALYS codes.

TUE-NP03-5 #316 - Contributed Talk - Tuesday 1:00 PM - Brazos I

Particle Identification in the Upgraded NIMROD-ISiS Detector

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Interest in the influence of the N/Z degree of freedom on multifragmentation has demanded an improvement in the capabilities of multi-detector arrays as well as the companion analysis methods. Towards this goal, the 4 pi detection array NIMROD has been recently upgraded. The upgrade increased granularity in the backward direction and improved Si coverage. NIMROD is now composed of 10 forward annular rings (3-90 degrees) and a hemisphere of the ISiS array (90- 167 degrees). Isotopic identification of particles is obtained through linearization of the deltaE-E data points. New algorithms allow for distance calculation between the points and the selected curves. Performance of the detector system and data analysis methods will be presented.

TUE-NP03-6 #189 - Contributed Talk - Tuesday 1:00 PM - Brazos I

Tri-axial Shape co-existence and a New Aligned Band in 178 Os

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The Os nuclei lie in the beginning of the transitional region between the well deformed rare earth and spherical lead isotopes. The nuclei in this region are believed to be soft to changes in gamma deformation due to the softness of nuclear potential and consequently may result in the shape coexistence. The neutron Fermi levels in Os nuclei from A=170 to A=186 lie in the middle of i13/2 orbital so that their shape in the ground state tends to take an appreciable prolate deformation. Hence collective bands with the well defined moment of inertia occur and the effect of different proton orbitals is observed as a modulation of the prolate structure. The anomalies in the yrast sequence, an effect attributed to change in moment of inertia of the ground state rotational band and the band crossing phenomena are very important and vary strongly with neutron number in case of Os nuclei.

The nuclear structure of 178 Os nucleus has been studied using the reaction 165Ho (20Ne, p6n) 178Os. Indian National Gamma Array (INGA) consisting of six Clover detectors with anti Compton shields was used for the detection of resulting gamma rays. The DCO ratio and Polarisation of gamma rays was measured to assign spin, parity and multipolarity of transitions. Twenty one new transitions belonging to the 178Os nucleus have been identified. The sudden and rather strong gain in aligned angular momentum is observed in the yrast band of 178 Os. A new aligned rotational band similar to 180Os is also discovered in this nucleus. This band exhibits a very complex decay pattern with a single linking transition of 1778 keV to the ground state band. The tri-axial shape co-existence is also observed in this nucleus at higher excitation. The experimental results are compared with the Microscopic Hartree-Fock model.

TUE-RE03-1 #568 - Invited Talk - Tuesday 1:00 PM - Trinity Central

The Near-Earth Radiation Environment

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This presentation discusses energetic radiation hazards present for devices and integrated circuits in the near-earth space environment. It is concerned with three categories of high-energy particle radiations in space. The first is particles trapped by the earth's magnetic field, i.e., the Van Allen Belts. The second is the comparatively low level flux of ions that originate outside our solar system called galactic cosmic rays. The third is bursts of radiation emitted by the sun, characterized by high fluxes of protons and heavy ions, referred to as solar particle events.

In order to have reliable, cost effective designs and implement new space technologies, the radiation environment must be understood and accurately modeled. Underestimating radiation levels can lead to excessive risk and can result in degraded system performance and loss of mission lifetime. Overestimating radiation levels can lead to excessive shielding, reduced payloads, over-design and increased cost.

An overview of the characteristics and some models of these space radiations will be given and compared to radiations available for accelerator research.

TUE-RE03-2 #586 - Invited Talk - Tuesday 1:00 PM - Trinity Central

Moore's Law vs. Soft Errors - Can Modeling Show the Way?

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Technology scaling past the 250nm fabrication node has proven to be a watershed event for single event effects and soft error circuit response. The unrelenting pursuit of Moore's Law has pushed physical feature size, noise margin, information storage energy, and switching frequency all in a direction that is deleterious to single-event radiation tolerance. It is conventional wisdom, almost to the point of cliché, that each new technology generation produces circuitry that is more sensitive to single event interactions than the previous. Yet, this is only part of the story.

While circuit features scale, ion tracks do not. The liberation of mobile charge in the wake of ionic penetration is dependent (to first order) on the ion species, energy, and target material; not the feature size of the unfortunate circuitry in its path. As such, the "region of influence" of a single event ion path relative to the lithographic features composing a "bit" of information increases with scaling. This is not only true spatially, but temporally as well.

Since crossing the 250nm threshold, we have observed a strong trend toward single event interactions that are not localized single-bit phenomenon, but prove to be regional effects, impacting groups of circuit nodes in ways that have been previously unobserved. These effects include charge sharing among sensitive nodes, regional debiasing of wells, parasitic responses disjoint from the strike location, and nuclear reactions in BEOL stacks generating showers of particles.

This presentation will address these unconventional single event effects; in particular the computer modeling of the physical attributes and circuit responses, as well as the experimental modeling of terrestrial and on-orbit error rates with heavy-ion and proton accelerators.

TUE-RE03-3 #582 - Invited Talk - Tuesday 1:00 PM - Trinity Central

Formation of Nanostructures on Semiconductor Surfaces using Focused-Ion Beams

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Recently, nanostructures have shown significant promise for various applications in electronics, optoelectronics, and photonics. For example, nanometer-sized metallic droplets often form on compound semiconductor surfaces during epitaxial growth, thermal annealing, and/or ion irradiation. Such metal droplets may be used for the growth of semiconductor nanowires, via the vapor-liquid-solid mode. For both cases, the nanostructure formation mechanisms are not well understood. Therefore, in this work, we have examined the formation of nanostructures during FIB irradiation of GaAs, GaSb, InAs, and InSb surfaces. On GaAs and GaSb surfaces, randomly distributed Ga droplets are observed to form at a critical dose. Subsequent ion beam irradiation of GaAs results in growth, motion, and coalescence of the droplets. On GaSb (InSb) surfaces, polycrystalline GaSb (InSb) nanowires with Ga(In) tips are formed initially. With continued irradiation, the Ga tips of GaSb nanowires coalesce to form large droplets; however, the analogous coalescence of In is not evident in the InSb case. On InAs surfaces, randomly distributed In nano-dots are observed. Interestingly, further irradiation of GaAs and GaSb surfaces leads to motion of the Ga

droplets, while on the InAs surfaces, the In nano-dots apparently remain static. A higher droplet velocity is observed on GaSb than on GaAs surfaces, suggesting that droplet motion is dependent on the energetics of the Ga-substrate interface. Detailed nanostructure formation mechanisms based upon ion-enhanced surface diffusion and sublimation will be discussed. In addition, strategies for fabrication of 3D nanocomposites will be presented.

This work is supported in part by AFOSR-MURI and ARO-DURIP.

TUE-RE03-4 #569 - Invited Talk - Tuesday 1:00 PM - Trinity Central

Hardening Commercial Technologies for Multiple Markets

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Texas Instruments HiRel Medical Defense and Aerospace organization leverages the large portfolio of TI semiconductor processes to provide HiRel products to the global marketplace. These HiRel applications demand reliable products that must tolerate many types of radiation, high temperature, and extended product life applications. It becomes critical to engage in a business strategy that not only addresses these markets in the United States, but also globally. In many cases by careful planning and execution, global markets can be addressed rather than point solutions. By applying a global mindset to semiconductor processes, entire product families can often become available then to the HiRel marketplace, rather than a single part solution. This presentation will describe global semiconductor process change techniques that can "fix" product families for HiRel applications in the global market place.

TUE-RE03-5 #226 - Contributed Talk - Tuesday 1:00 PM - Trinity Central

Amorphization Mechanism of Strained SiGe Alloys

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Previous studies have shown that ion-bombarded Si/SiGe strained layers have selective amorphization in strained regions. This suggests that the evolution to an amorphous phase might be different between strained Si (SiGe) and non-strained Si. It is unclear whether strained Si (SiGe) amorphizes directly or by overlapping of partially damaged regions. In this study, we have studied the radiation damage caused by small cluster ion bombardments of SiGe with strain compared to Si without strain. A strained SiGe structure which contains a 50 nm thick Si0.8Ge0.2 layer on the top of <100> Si was deposited by using molecular beam epitaxial growth. A 200 nm thick Si buffer layer was deposited between the Si0.8Ge0.2 layer and original Si substrate to avoid the effects from interfacial defects. The strained structure was bombarded with Agn clusters (n=1, 2, 3, and 4), where n represents the number of atoms contained in a cluster. Channeling Rutherford backscattering spectra show that damage accumulation in the Si0.8Ge0.2 layer as a function of cluster size did not follow the direct amorphization model. This study shows that the overlap model is the dominant amorphization mechanism in strained SiGe.

TUE-RE03-6 #203 - Contributed Talk - Tuesday 1:00 PM - Trinity Central

Diffusion of Antimony in Silicon in the Presence of Point Defects

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It has been known for quite some time that the diffusion of dopants in Si is strongly influenced by the presence of defects. In particular, the diffusion of Sb is enhanced by vacancies and suppressed by interstitials. Later on, Cowern et al [1] proposed a quantitative basis for the description of this phenomenon in terms of highly mobile defect-dopant complexes as crucial intermediaries, and demonstrated this concept in an application to the B-Si system. In this model, the diffusion coefficient is no longer the only materials parameter governing the process of diffusion. At least one other parameter, chosen here to be the mean ?free' path of the mobile complex in a single hop of the diffusing dopant, is involved and has to be considered. This mean free path is referred to as the migration length. Using this model, we have extracted the migration length for the diffusion of Sb in Si through a thorough analysis of the concentration profiles of Sb in Sb-delta-doped Si after diffusion of the Sb dopants was allowed to proceed for various time intervals and temperatures in the presence of excess vacancies previously created within the sample by high energy implantation of Si itself. The results for diffusion at 750 C were presented in CAARI 06. Here, we proceed to

present our results for a range of temperatures and discuss their implication on the underlying mechanism for the diffusion of Sb in Si at the atomic level.

[1] N. E. B. Cowern, K. T. F. Janssen, G. F. A. van de Walle and D. J. Gravesteijn, Physical Review Letters 65, 2434 (1990).

TUE-NHS - VTS-1 #550 - Invited Talk - Tuesday 3:30 PM - Pecos I

Today, Tomorrow and the Day After Tomorrow: Present and Future Trends in Imaging for National and Homeland Security

Richard C. Lanza
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Much of modern imaging for security purposes had its beginnings in the use of x-ray scanners for the detection of weapons in passenger baggage and was rapidly expanded to search for explosives especially after the bombing of Pan Am flight 103 on December 21, 1988. The simple x-ray systems of the ?80's rapidly evolved into the current state of the art in imaging using dual energy x-ray computerized tomography to detect explosives and contraband by the use of a variety of sophisticated detection algorithms. Larger systems using high energy linear accelerator sources are now standard for inspection of cargo containers.

The problem of identification of material beyond its x-ray transmission density still remains and a new generation of technology has been developed to deal with this problem as well as the concern over new threats such as nuclear weapons or radiological weapons, which require new tools beyond those developed for aircraft security. This next generation includes tools such as dual energy linac systems for identification of high-Z materials and the beginnings of the first non-x-ray approaches based on neutrons and combinations of neutrons and gammas. For the detection of nuclear materials, both active and passive methods are under consideration and the case of threat detection at a distance, "stand-off" detection remains a challenging problem, particularly with active methods.

For the more distant future, a number of new concepts may be brought to bear such as ultra-compact accelerators, tunable high energy gamma sources and long range imaging with sparse data and phase contrast imaging. Another approach may be to abandon the notion of deploying single large detection or imaging systems and instead to consider dispersed, autonomous and mobile "swarms" of detectors. Implicit in all of these methods will be the generally low (and diminishing) cost of computing in the future.

TUE-NHS - VTS-2 #391 - Invited Talk - Tuesday 3:30 PM - Pecos I

Neutron and Photon Active Inspection for Threat Materials - Principles and Applications

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The consequence of the detonation of a nuclear device in or near the USA is so severe that detection and interdiction of special nuclear material (SNM) in transport is one of the most critical security issues facing the United States in the recent years.

In principle, detection of nuclear materials is relatively easy because of their unique properties: all of them are radioactive and all emit some characteristic gamma rays. A few emit neutrons as well. These features are the basis for the passive non intrusive detection of nuclear materials. The low energy of the passively emitted radiations and the ability to shield them, especially when considering the large conveyance that would be used in the flow of commerce, necessitate additional means of detection and validation. These are provided by high energy x-rays radiography and active inspection based on inducing nuclear reaction in the nuclear materials.

Penetrating high energy x-ray imaging provides a two dimensional silhouette of the inspected object based on its areal density. Under certain conditions they provide some information on the presence of material with high atomic number (Z). While x-ray radiography is very helpful in the inspection process it cannot, however confirm the presence of nuclear materials.

Positive confirmation that a nuclear material is present or absent can be provided by interrogating the inspected object with a penetrating probing radiation, such as neutrons, photons or even mesons. These probes induce specific and unique nuclear reactions (such as fission) in the nuclear material yielding, in turn, penetrating signatures which can be detected outside the inspected object.

There are hosts of accelerators generating suitable neutrons or photons beams inducing nuclear reactions and signatures, which are been investigated and some implemented in commercial inspection systems. These will be described in the presentation.

TUE-NHS - VTS-3 #259 - Invited Talk - Tuesday 3:30 PM - Pecos I

New/Future Approaches to Explosive/Chemical Detection

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Threat to the security of people living anywhere on the globe can come from:

-Smuggling of sizable amounts of explosive (may-be in combination with radioactive or toxic element/compounds) preferable in the sea containers, tankers, trucks, etc.

- Huge amounts of explosives in the soil - landmines.
- Large amounts of the explosives and chemical warfare on the sea bottom.

It is very difficult to find out threat materials (explosive, chemical warfare, etc.) since they are usually contained within a small volume inside variable complex matrices. Large volumes prevent the proximity of sensor to the investigated material, large amounts of matrix around the investigated object generate huge backgrounds.

Therefore, any analytical technique applied has two assignments: penetration in (with a probe signal) and out of the matrix (with signal from the object). In addition, cross section for the process needs to be sizable (large). Nuclear analytical techniques are good candidates since they can be employed with electromagnetic radiation and charged or the neutral particles being both probe and detected signal.

Although there has been some reported progress in many systems (gamma in - gamma out, neutron in - neutron out) the most promising seems to be the use of tagged fast neutrons generated in d+t→α+n (Q= +17.6 MeV) nuclear reaction. Among others, EU - FP6 project EURITRACK has been a successful demonstration of the use of tagged neutrons for ship container inspections. It has been shown that the deployment of the same technology under-water is a feasibility to be realized in the near future (i.e. EU-FP7 project UNCOSS).

TUE-NHS - VTS-4 #489 - Invited Talk - Tuesday 3:30 PM - Pecos I

Radioactive Sources in Hydrocarbon Exploration and Production: Needs, risks and alternatives

Ahmed Badruzzaman
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The petroleum industry uses nuclear techniques, along with electrical, acoustic and magnetic resonance methods, for determining hydrocarbon reserves and making operational decisions. Chemical radiation sources are critical for current nuclear techniques, but their use has been threatened because of governmental concerns about security. Developing workable alternatives to chemical nuclear sources is of paramount importance to finding and developing the hydrocarbon resources needed today by the world's economies.

Devices with Am-Be and Cs-137 sources are used to compute the porosity and rock properties, either after a well has been drilled or while drilling. Various (n,gamma) reactions from D-T neutron generator-based devices are utilized to locate and quantify the remaining hydrocarbon.

Concerns have been raised about the dirty bomb potential of radioactive sources used in various industries, including those for petroleum exploration. The industry has safeguards to protect the sources from misuse, but such sources are highly mobile, transported across the world and often used in remote locations. Sources have been stuck down-hole and reported lost in transit. With a mandate from the US Congress, the National Academy of Sciences has prepared a report on the state of radioactive sources and their replacement. The Academy recommends replacing Am-Be sources used in characterizing reservoirs with either D-T neutron generators or Cf-252, while recognizing current lack of alternatives to the lower risk Cs-137 source. However, breaching of Cesium sources down-hole can contaminate reservoirs and thus remain of concern.

The presentation discusses the critical role of radioactive sources to petroleum exploration and production, alternatives the industry is considering to current chemical sources and the associated challenges. It notes that a partnership between the industry, national laboratories and universities for a timely transfer and adaptation of novel non-chemical sources would address the security and safety concerns related to an industry key to world economy.

TUE-NHS - VTS-5 #214 - Invited Talk - Tuesday 3:30 PM - Pecos I

Detection in Harsh Active Interrogation Environments

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Detecting well-shielded special nuclear material has necessitated the development of active inspection (AI) techniques to address the challenge. Active systems, however, often require operating detectors in environments for which they have not been designed and with sources for which they are not properly matched. Within these "harsh" environments detectors must extract useful signals from prolific radiation backgrounds both during and shortly after the source flash. AI can generate extremely high instantaneous count rates which often push detectors and associated data acquisition past their limits. Successful deployment of AI systems depends on mitigating the unique harsh environment through novel approaches to gating, shielding and data processing algorithms as well as properly matching detectors with the source to optimize performance. Anode and dynode gating circuits have been demonstrated with both LaBr3 and organic scintillators which mitigate photomultiplier saturation and are capable of recovery within 30 ns of the flash event. Compensation circuits embedded within these front-end electronics allow for cancellation of the long-lived (>1 us) light components, which are present in all scintillators, and can be problematic in high count rate environments. In liquid scintillators, tail cancellation allows for pulse shape discrimination (PSD) based on the 3 and 32 ns components rather than the longer 270 ns component. Utilizing only these components can reduce the time required for PSD to less than 100 ns. Ultra-fast (dt =125 ps) digitization of signals from a novel silicon carbide (SiC) detector has been used to extract neutron counts from a large gamma (>1.0E13g/s) backgrounds. SiC detectors have several inherent capabilities which make them attractive for use in AI environments. They are extremely gamma insensitive, fast (8 ns pulse width) and allow for PSD because of the inherent difference in charge collection time between neutron and gamma initiated events.

TUE-AP04-1 #TBD - Invited Talk - Tuesday 3:30 PM - Elm Fork

Excited Ions in Intense Femtosecond Laser Pulses

Ian Williams

TUE-AP04-2 #313 - Invited Talk - Tuesday 3:30 PM - Elm Fork

Interrogating molecular-ion beams by ultra-short intense laser pulses

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We have experimentally explored laser-induced dissociation and ionization of diatomic molecular ions, such as H_2^+, HD^+, N_2^+ and CO^+, using coincidence 3D momentum imaging. The vibrationally excited molecular-ion beam (4-9 keV) is crossed by an ultrafast intense laser beam (typical pulses 7-50 fs, 10^{13}-10^{16} W/cm^2 at 790 and 395 nm). The resulting fragments including neutral fragments are recorded in coincidence by a position-sensitive detector. Complete angular and kinetic energy release distributions are reconstructed from the measured momentum vectors of the fragments. Various effects due to the laser-dressed potential of H_2^+, such as bond-softening and above-threshold dissociation, have been observed. Ionization, which is separated experimentally from dissociation, was found to be strongly aligned along the laser polarization and exhibits peaks due to above-threshold Coulomb explosion. A few examples of the complex dissociation and ionization pathways of the many-electron targets will also be discussed.

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TUE-AP04-3 #210 - Invited Talk - Tuesday 3:30 PM - Elm Fork

FLASH photofragmenation of molecular ions

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Photofragment imaging experiments on molecular ions using dilute fast moving ion targets in the crossed beams geometry have proven feasible in the VUV and soft-X-ray spectral range [1] using the laser pulses of the Free-electron LASer in Hamburg (FLASH) [2] which operates at ~20-210 eV with extreme intensities of ~10^{13} photons within 30-50 fs. An ion-beam infrastructure that also allows for rovibrational cooling of the molecular ions by long time (ms-s) trapping in an electrostatic ion trap prior to the laser irradiation has been created for such experiments at the FLASH plane grating monochromator beam line. The dynamics on high-lying potential surfaces reached by energetic photons can thus be probed for a wide range of species and fragmentation channels that has so far been inaccessible, ranging from fundamental ionic molecules up to complex molecular and cluster systems. In particular for larger systems, numerous neutral fragment channels are expected even after multiple ionization by X-ray photons. Selected fundamental systems have recently been studied at FLASH; the benchmark system HeH^+ was probed at 32 nm (~39 eV) showing dissociation routes neither considered in theory nor in astrophysical models to be dominant [1], and very recently results on the photofragmentation of the astrophysically and atmospherically relevant H_3O^+ have been obtained at 92 eV (13.5 nm).

[1] H. B. Pedersen *et al.*, Phys. Rev. Lett. **98**, 223202 (2007).
[2] V. Ayvazan *et al*, Eur. Phys. J. D **37**, 297 (2006)

TUE-AP04-4 #58 - Invited Talk - Tuesday 3:30 PM - Elm Fork

Radiative Cooling of Small Aluminum Clusters

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The radiative cooling of small Al_n^- clusters (n=4-6) has been investigated using delayed electron emission as a temperature probe. Delayed electron emission is a process in which after absorbtion of a short (nsec) laser pulse, the clusters emit an electron hundreds of microseconds later. This process is shown to be sensitive to the initial temperature of the ions, and thus can be used for cluster thermometry. Using this tool the radiative cooling of small aluminum clusters produced in a Cs-sputter ion source, and trapped in an electrostatic ion beam trap is investigated. In addition a novel bent electrostatic trap has been used, enabling measurement of the competition between electron emission and fragmentation.

TUE-AT04-1 #41 - Invited Talk - Tuesday 3:30 PM - Bur Oak

Real-Time Dosimetry for Radiobiology Experiments Using 25 MeV LINAC

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The next generation of radiobiology research requires increasingly more complex radiation sources to address questions ranging from the effects of space-based radiation to the influence of dose rate on biological systems. The Idaho Accelerator Center (IAC) developed a unique radiobiology research facility to address some of these questions. The irradiation challenge is to deliver stable and reproducible conditions of beam uniformity, dose and dose rate under controlled temperature conditions and to limit the effects of any other uncontrollable variables.

We used a 25 MeV modified medical grade LINAC to obtain adjustable electron dose rate. To overcome electron beam drift we used a collimator that both assisted the LINAC's operator to steer the beam and ensured that even if the beam drifted, only the fixed collimated region would be exposed to the beam. In addition, we utilized a beam flattener to keep the beam variation as low as 3% at 2.5 cm from the beam's center, and 1 % variation between the sample tubes irradiated simultaneously. We also demonstrated that a segmented Faraday "cup" (FC) array provides a good beam scan and real-time beam monitoring system that is promising to implement real-time dosimetry.

This work was funded by the DOD, grant # FA8650-04-2-6541

TUE-AT04-2 #177 - Contributed Talk - Tuesday 3:30 PM - Bur Oak

Development and Testing of Gallium Arsenide Photoconductive Detectors for Ultra Fast, High Dose Rate Pulsed Electron and Bremsstrahlung Radiation Measurements

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During radiation applications where high dose rate radiation environments are used for testing electronic devices and/or biological agents, for example, real time radiation dose measurements are needed. The dosimetry needs in pulsed reactor fields and particle accelerator facilities require development of dosimeters with: 1) fast (10s of picoseconds) response to impulse radiation; 2) linear response over a wide range of dose rates (up to 1011 Gy/s); and 3) high resistance to radiation damage. Gallium arsenide photoconductive detectors (GaAs PCD) have been shown to exhibit less than 50 ps time resolution when using GaAs pre-irradiated by fission neutrons with fluences exceeding 1015 n/cm2 (1-MeV equivalent in Si). High-energy neutron irradiation introduces lattice defects, which decrease charge carrier mobility and lifetime, hence improving time resolution of a PCD at the expense of its sensitivity. Our objective is to develop, test, and characterize GaAs PCDs with response times of under 100 picoseconds and to determine their application limits in pulsed electron and gamma radiation dose measurements. A 23-MeV electron beam was used to produce a photoneutron spectrum in a tungsten target for GaAs pre-irradiation. The process was modeled with MCNPX and the simulation results were compared to the experimental measurements. PCDs with 0.6-mm electrode separation and active area of ~ 9 mm2 were fabricated from both pre-irradiated and unirradiated GaAs. The devices are tested in accelerator produced pulses of electron and bremsstrahlung radiation with various energy (3 to 44 MeV) and pulse length (50 ps to 4 μs). The results of the preliminary tests are presented together with an overview of the current effort to improve the PCD design and to optimize the electronic circuits in which the devices operate.

This work is funded by the DoD under contract # FA8650-04-2-6541. Special thanks to Nu-Trek Inc. for their contributions.

TUE-AT04-3 #356 - Contributed Talk - Tuesday 3:30 PM - Bur Oak

Performance of a small high-pressure xenon detector at sub-MeV photon energies with an example application to ion beam analysis

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Ion beam analysis (IBA) provides nondestructive compositional information of a sample. Many IBA techniques derive the information from high-energy photons produced by the interaction of the ion beam with the sample. The performance of a 1.5-inch diameter by 3-inch long high-pressure xenon (HPXe) detector is investigated at photon energies useful to IBA. The results for the HPXe detector are then used to predict the performance of larger HPXe detectors at those energies and recommendations are made for an HPXe system for IBA.

TUE-AT04-4 #89 - Contributed Talk - Tuesday 3:30 PM - Bur Oak

OSL vs. Radiochromic Film Response in a Pulsed Irradiation Environment

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Radiobiology research at the Idaho Accelerator Center (IAC) is conducted with pulsed Bremsstrahlung photons to study the persistence of E. coli and Bacillus spores with desiccated Deinococcus radiodurans as a control. Some of the challenges for these experiments include the control and measurement of dose, dose rate, dose uniformity, and real-time measurements,etc.

At the IAC, radiochromic films were the primary dosimeters that we have used in past radiobiology experiments. In this regard, we used the radiochromic films HD-810 (GEX product) to measure the delivered dose to the biospecimen using a pulsed 20 MV photon beam. Despite their good dosimetric properties, HD-810 cannot be easily used for calibration prior to the experiments because of their time-consuming development process (24 Hours).

In this work we developed a faster calibration method that used OSL (technology instead of HD-810. We also demonstrated that in a pulsed radiation environment, OSL response is highly comparable (correlated) to HD-810 radiochromic films. Hence, OSLs can be utilized for calibration prior to radiobiology experiments. In addition, we are developing real-time dosimetric method that enables better control of Bremsstrahlung irradiation conditions and beam monitoring.

TUE-AT04-5 #570 - Contributed Talk - Tuesday 3:30 PM - Bur Oak

Two dimensional neutron detection and some applications in Nuclear Physics Experiments

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The principles behind fast neutron detection are reviewed, with an emphasis on the use of plastic scintillating materials. Neutron detectors have been developed both at the Instituto de Física, UNAM and at the Tandem Accelerator Laboratory, ININ. We describe in detail our detectors and their characteristics. We also describe the three main local nuclear physics projects that are relying on the development of these detectors: 1) neutron elastic scattering studies, 2) nuclear decay by di-neutron emission and 3) nuclear studies with radioactive beams.

Recent results on the development of a large solid angle coverage position sensitive neutron detector in two dimensions will be finally discussed.

TUE-AT04-6 #515 - Contributed Talk - Tuesday 3:30 PM - Bur Oak

BrilLanCe(?)380 (LaBr3:Ce) scintillator with APD light sensor

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The BrilLanCe(TM) 380 (LaBr3:Ce) crystal scintillators are capable of 2.6% FWHM for 662keV photons(1) with PMT light sensors. Small devices applicable for stacking into arrays or for hand held probes have been problematic because small PMTs have poor performance and considerable length. PIN photo diodes and APD are more compact but have exhited poor performance to date. However, recent improvements in APDs make them an excellent light sensor for BrilLanCe™. It is now possible to achieve performance comparable to that of a PMT. We have measured 2.8% at 662keV using an APD for a light sensor on a 20mm long crystal of 1.6cc volume. APDs have advantages of compactness, ruggedness and minimal sensitivity to magnetic fields.

(1) Performance reported in SGC data sheet literature.

Protected under EU patent applications 0759555; 0850895

TUE-FIBP02-1 #589 - Invited Talk - Tuesday 3:30 PM - Post Oak

Single-Ion Implantation for Single-Dopant Controlled devices

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By 2016 transistor device size will be just 10 nanometers. However, a transistor that is doped at a typical concentration of 10^18 atoms/cm3 has only 1 dopant atom in the active channel region. Therefore, it can be predicted that conventional doping methods such as ion implantation and thermal diffusion will not be available 10 years from now, controlling the electrical properties of future nanoscale transistors will require the one-by-one controlled doping of single-dopant atoms. We have been developing a single-ion implantation (SII) method that enables us to implant dopant ions one-by-one into semiconductors until the desired number is reached. In this paper, the current status of the SII work will be shown and the future challenges discussed.

We have recently fabricated semiconductor devices with ordered dopant arrays by the SII. Electrical measurements of the resulting transistors revealed that there are fewer device-to-device fluctuations in the threshold voltage (Vth) of the devices with ordered dopant arrays than of those with conventional randomly doped distribution. We also found that the average value of Vth for the devices with ordered dopants is two times lower than that of the devices with a random distribution of dopants. We explain this pronounced difference in threshold voltage as follows: the uniformity of electrostatic potential lowers the voltage required to open the channel from source to drain, which allows for early turn-on in those parts of the channel that correspond to

the positioning of the implanted ions and results in the lower threshold voltage. The control of both the number and the positioning of the ions is essential for the future nanoscale devices. The SII is a more efficient method for studies of discrete dopant effects and the development of single-dopant controlled devices.

TUE-FIBP02-2 #87 - Invited Talk - Tuesday 3:30 PM - Post Oak

Single ion doping with high spacial resolution

Arun Persaud[1], Arunabh Batra[1], Jeff Bokor[2], Tzv Ivanov[3], Cheuk Chi Lo[2], Ivo W Rangelow[3], Andreas Schuh[1,3], Christoph D Weis[1,3], Thomas Schenkel[1]
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The ability to place single donor atoms at a precise location inside a target material opens the door to the fabrication of new devices. Our interest is in using this technique to build quantum computer test devices in silicon that will utilize the spin of single donor atoms. In this talk we will address the key issues of the single ion implantation process and also show results from recent experiments.

The main concerns in single ion implantation are alignment, spot size and single ion detection. We control the alignment of the sample to the implantation spot by integrating a scanning probe into our ion implanter. The spot size is controlled by using a small nano-sized aperture integrated into the cantilever of the scanning probe. This enables us to image the sample and align the aperture to the target with nanometer resolution. We will discuss the current state of the scanning probe setup and resolution limits.

Single ion detection is achieved by implanting into a pre-fabricated device (here a transistor) and monitoring the source-drain current. The implanted ion creates damage causing a change in the source-drain current that can be measured at room temperature. We will present data showing single ion hits and discuss integration of this technology with the scanning probe setup.

Furthermore, we will present a possible road to single spin readout using the above mentioned technology components and results from preliminary experiments.

This work was supported by LPS/NSA and by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231. The work on the AFM-probes was supported by the EU-Commission under the "PRONANO"- Project.

TUE-FIBP02-3 #453 - Invited Talk - Tuesday 3:30 PM - Post Oak

Advances in the nanoscale positioning of single ions

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The ultimate level of control in ion implantation is the precise nanoscale positioning and detection of every implanted ion. Interest is expanding in this field because pioneering classical and quantum devices in electronics and optics now require such a high degree of fabrication control. Examples of recent advances include single ion detection using charge collection [1], positioning using the nanostencil technique [2-3], and positioning using a focused ion beam [4].

This paper reports on initial proof-of-principle experiments that demonstrate positioning and detection of single ions in the keV and MeV energy regimes. Slotted nanoscale apertures in Si cantilevers were fabricated using a Ga focused ion beam with widths down to 20 nm. Ion beam positioning has been achieved by piezoelectric motion to drive the aperture position relative to the target. Ion beam induced charge mapping with 0.5 MeV He ions confined by a 100 nm wide aperture has been demonstrated; this technique is proposed to locate the beam on the target without the necessity of scanning probe imaging, as has been employed elsewhere [2,3]. Nanoscale lithography in PMMA resist with 14 keV Ar ions has demonstrated the fabrication of 20 nm features in the resist suggesting ion implantation at this precision will be feasible.

[1] C. Yang et al, Japanese Journal of Applied Physics 42 (2003) 4124.
[2] H. Guo et al, Applied Physics Letters 90 (1999) 093113.
[3] A. Persaud et al, Nano Letters 5 (2005) 1087.
[4] T. Shinada et.al, Nature 437 (2005) 1128.

TUE-FIBP02-4 #466 - Invited Talk - Tuesday 3:30 PM - Post Oak

Single ion detection with Geiger mode avalanche diodes for low ion energy detection

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We present experimental results and fabrication details of the first known single ion Geiger mode avalanche diode (SIGMA). The SIGMA detector extends Geiger mode operation of avalanche diodes initially developed by the single photon detection community, which requires sensitivity to a single electron-hole (e-h) pair generated by a single photon. Detection of very low energy ions requires a very low sensitivity threshold to e-h pair generation (i.e., less than 1000 e-h pairs). This work, furthermore, takes advantage of a complementary metal oxide semiconductor (CMOS) foundry to build these devices providing a path towards fabrication of novel single donor semiconductor devices. We observe single ion detection sensitivity for both room temperature and 77 K operation with the SIGMA detector to a 250 keV H+ beam using gated, passively quenched Geiger mode avalanche photodiodes. We determine the detector efficiency to be ~100% with a dark count probability of 15% at room temperature. The detector efficiency remains constant and the dark count dramatically reduces with decreasing temperature. The details of the measurement technique as well as the experimental setup will be presented. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

TUE-IBM04-1 #452 - Invited Talk - Tuesday 3:30 PM - Pecos II

Nanoscale Science with Ion Beams

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Materials science is a prime example of interdisciplinary research at its best. Extraordinary accomplishments have been recognized ranging from Nobel prizes in chemistry and physics to exciting applications. These accomplishments underpin the technology revolution that has driven societal changes for the last fifty years. Currently, the forefront of materials science is at the nano-scale. It is hoped that advances in nano-scale materials will contribute to the solutions of some of the dominant technological problems facing mankind---conservation of energy and environment, water purification and availability and propagating the information revolution.

Ion beam science makes substantial contributions to all of these burgeoning sciences. In general ion beam technology provides unique and exciting ways of modifying and creating new solids, controlling surface properties, adding beneficial impurities in the near-surface region, modifying the crystallinity, and providing a control and specificity that exceeds almost all other methods of surface modification. One fascinating example is the creation of a quantum computer requiring a collection of periodic impurity atoms (dopant) atoms strategically placed in a solid. Single ion implantation is one of the promising ways to create such a structure?an innovative use of ion beams unimaginable until recently.

This talk will illustrate the use of ion beam science in creating nanostructures and highlight the need for advances in ion beam technology for further advances in the field.

TUE-IBM04-2 #191 - Invited Talk - Tuesday 3:30 PM - Pecos II

MeV Au ion induced nanocrystal formation in amorphized Si layers

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We report some data on nanocrystal (NC) formation in Si using a double implantation technique. Si(100) samples, were first implanted with Si^-, Cu^-, Ag^- and Au^- ions in 15 to 50 keV range to fluences in the range of (0.01-1) e+17 cm^{-2} resulting in amorphized top layers of varied thickness. These samples were subsequently irradiated with 1.5 MeV Au^{2+} ions to a fluence of 1e+15 cm^{-2}. The samples were then characterised using Photoluminescence (PL), X-ray diffraction (XRD), Raman scattering, X-ray photoelectron spectroscopy and transmission electron microscopy (TEM). XRD measurements and TEM imaging confirmed the presence of Si NCs in the amorphized matrix. All samples, amorphized with metal ions to a fluence \\le 5e+15 cm^{-2} have been found to show PL at 1.7 eV, characteristic of Si NCs [1]. But the width of the PL band, ~ 0.02 eV, was found to be too small compared to earlier data. Similar results were also found in samples amorphized with self ions at 50 keV and 1 MeV respectively. This indicates that neither the presence of metal atoms nor the amorphous to crystalline interface play any role in NC formation. An additional study with increase in the MeV Au ion energy, showed a direct correlation between electronic energy loss and the PL intensity at 1.7 eV. However, no peak shift could be seen in line with the excitonic

recombination model. Further in case of Au^- ions, implantation to a fluence \\ge 1e+16 cm^{-2} was seen to result in silicide formation [2].

[1] T. S. Iwayama et al, Thin Solid Films 276, 104 (1996).
[2] G. Sahu et al Nanotechnology 18, 495702 (2007).

TUE-IBM04-3 #291 - Invited Talk - Tuesday 3:30 PM - Pecos II

Ion Beam Synthesis and Optical Properties of Ge, SiC, InN, and ZnO Nanoclusters

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There has been a great interest in semiconducting nanoparticles due to their prospective application in the field of microelectronic and optoelectronic. Ion Beam Synthesis (IBS) is a versatile technique for growing embedded nanoclusters (NCs) that can readily be integrated into well established Si technology. We have synthesized of Ge, SiC, InN and ZnO embedded NCs by a variety of IBS techniques and studied their optical properties. 300 keV Ge+ implantation onto thermally grown SiO2 films up to fluences of 3x10^16, 1x10^17 and 2x10^17 ions/cm^2 and subsequent thermal annealing at 800ºC in Argon atmosphere resulted in Ge NCs embedded in SiO2 matrix. PL spectra showed a peak at ~2.1 eV originating from Ge NCs and another peak at ~2.3 eV arising from ion-beam induced defects in the SiO2 matrix. 3C-SiC NCs were synthesized in Si (100) wafers by 300 keV C+ ion implantation up to a fluence of 2×10^17 ions/cm2 at elevated substrate temperatures of 550, 650 and 700 °C. XTEM studies showed 6 nm 3C-SiC nanoparticles uniformly distributed at a depth of 0.6 μm from the surface. Quantum confinement effect in 3C-SiC NCs has pushed the PL emission peak to 2.45 eV. InN phase formation was achieved by sequentially implanting Indium and Nitrogen ions ito Silica with 890 keV and 140 keV energy, respectively and followed by post-implantation annealing at 500°C in Nitrogen atmosphere. In addition to the diffraction pattern observed by GIXRD, both TO and LO vibrational modes of embedded InN NCs were observed in Raman spectroscopy. Embedded ZnO NCs in Silica matrix were synthesized by 400 keV Zinc ion implantation followed by post-implantation annealing at 420°C in oxidizing atmosphere. In this paper, the formation and growth of these NCs is discussed and optimum IBS conditions giving raise to efficient PL emission is identified.

TUE-IBM04-4 #29 - Invited Talk - Tuesday 3:30 PM - Pecos II

Investigation of strain in AlGaN/GaN Multi Quantum Wells by complementary techniques

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Al0.5Ga0.5N (15nm)/GaN (15nm) Multi Quantum Wells of 15 periods are grown on sapphire by MOCVD technique. GaN/AlN, each of thickness200nm and 20nm respectively, are used as buffer layers between substrate and epilayer to incorporate the strain in epilayers. It is well established technique to engineer the band gap in AlXGa1-x.N by adjusting alloy composition. These samples are used in visible & UV light emitters and high electron mobility devices. In our present study we employ RBS/Channeling technique to estimate the composition and thickness of AlGaN and GaN layers. Perpendicular and parallel strain is measured from High resolution X-ray diffraction and RBS/Channeling. We have also compared the ratio of perpendicular and parallel strains to investigate the elastic stiffness constant along crystallographic directions. Crystallinity and quality of interfaces have been studied by Rocking curve scan. Atomic force microscopy surface morphology shows larger hillocks, which is formed when the dislocations ends at the surface. The TD dislocations formed at the GaN buffer layer travel across the entire layers to the surface. Optical transmission studies shows very sharp GaN band edge at 3.4 eV as observed and reported by others, which shows that samples are free of point defects.

TUE-IBM04-5 #20 - Contributed Talk - Tuesday 3:30 PM - Pecos II

RBS/Channeling and HRXRD studies on swift heavy ion irradiated AlGaN/GaN heterostructures

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Epitaxial AlGaN/GaN layers grown by MBE on SiC substrates are irradiated with 150 MeV Ag ions at a fluence of 5x10^12 ions/cm^2. Samples used in this study are 50 nm thick AlGaN and 1 μm GaN layers. RBS/Channelling strain measurements were done along off normal axis of irradiated and unirradiated samples. In as grown samples AlGaN layer is partially relaxed with a small compressive strain. After irradiation this compressive strain increases by 0.22% in AlGaN layer. Incident ion energy dependence of dechannelling parameter shows E^1/2 dependence, which corresponds to the dislocations. Defect densities were calculated from the E^1/2 graph. As a result of irradiation, the defect density increased on both GaN and AlGaN layer. Contact mode AFM has been carried out to measure the surface morphology. As grown sample surfaces have hillocks and deep holes, which shows that both edge and screw dislocations are present in the sample. Irradiated sample shows similar morphology as unirradiated ones. The effect of irradiation induced-damages are analyzed as a function of material properties. Observed results from different characterization techniques like RBS/Channelling, HRXRD and AFM are compared and complemented with each other to deduce the information. Possible mechanisms responsible for the observations have been discussed in detail.

TUE-IBM04-6 #7 - Contributed Talk - Tuesday 3:30 PM - Pecos II

Fabrication of micron-size distributed Bragg reflectors in porous silicon

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One dimensional photonic structures based on alternating high and low porosity PSi layers have found applications as dielectric mirrors in the form of Distributed Bragg Reflectors, microcavities and waveguides. We have performed focused high-energy ion beam irradiation studies on heavily doped p-type silicon to precisely control the reflectivity and transmission of Bragg reflectors and microcavities fabricated in porous silicon. The nuclear microprobe facility at the National University of Singapore was used to focus 2 MeV protons to directly irradiate a desired pattern on silicon with micrometer resolution prior to electrochemical etching. The proton beam selectively creates lattice defects at the irradiated regions, where the porous formation occurs at a much reduced rate due to the increased resistivity during electrochemical etching. This reduces the optical thickness of each anodized layer, resulting in a Bragg reflector in which the peak reflected wavelength is linearly blue-shifted with increasing irradiation dose. This work demonstrates the ability of using ion irradiated PSi to selectively reflect different resonant wavelengths across the visible and infra-red spectrum. Micron-size reflective colour pixels of high density and reflectivity have also been successfully fabricated, raising the possibility of using PSi in many fields such as telecommunications and display applications.

TUE-MA04-1 #386 - Invited Talk - Tuesday 3:30 PM - West Fork

Planning for a Particle Therapy Facility at Mayo Clinic

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Particle therapy offers the potential to provide increased cancer cure rates without increasing side effects compared to conventional radiation therapy with X-Rays. Proton therapy is becoming more common worldwide, with over 50000 patients treated. Heavier particles such as Helium and Carbon offer not only the geometric improvements seen with protons, but also have a biological advantage. It is this combination that makes the heavier charged particles most appealing in terms of potential to improve radiation treatments.

Since 2002, the Department of Radiation Oncology has been deliberating and planning a strategy to construct a particle therapy facility to treat with protons, Helium ions and Carbon ions. The particle therapy facility will be developed and integrated into our practice as an additional modality to combat cancer. The process began with a thorough review of past and current scientific literature on proton therapy and heavier charged particle therapy. The summary of these data provided a strong clinical case to move forward. Based on existing facilities and capabilities, the projected development of technology for particle therapy delivery, and many visits with expert colleagues, a list of technical specifications for our facility was developed. This presentation will discuss the primary clinical requirements that drove the development of the technical requirements. An attempt

was made to develop the clinical qualities that parallel our conventional photon beam practice. Further, the specifications were developed to expose significant differences between competitive technologies. All this was done with the understanding that there are trade offs between cost, flexibility and degree of technical specification/perfection.

TUE-MA04-2 #318 - Invited Talk - Tuesday 3:30 PM - West Fork

Objective Considerations of a Particle Therapy Center

Xiaodong Wu
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The advance in radiation therapy technology has experienced at an unusual pace since the early 1990s. However, many decisive developments have been met with skepticism in their earlier initiatives. The IMRT as a pure technical advance is such an example. The clinical advantages of heavy-charged particles were foreseen in 1946 by Robert Wilson. Although their clinical application has been an ongoing, wide-spectrum research endeavor, the industrialization of heavy-particle therapy has been a rather slow and narrow process. The recent interest in the particle-therapy programs has reached such a markedly increased level that for many major institutions, the consideration for the particle-therapy program can no longer be neglected in their global strategic plans. The considerations of such a project in our institution include: 1. Clinical implications of particle therapy in the present and the future; 2. Maturity of the technology; 3. Choice of the particle(s), proton alone or with additional heavier ions, such as C-12; 4. Financial feasibility and model; 5. Scale and capacity of the facility; 6. Clinical operation model; 7. Research opportunities; and 8. Integrated effects in the whole institute. The project has not reached its conclusive stage. The thought process, rather than the conclusive opinions, will be discussed in this presentation.

TUE-MA04-3 #493 - Invited Talk - Tuesday 3:30 PM - West Fork

Ion Beam Therapy in Europe

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At present, two ion beam therapy facilities for the treatment of deep seated tumors are in operation in Europe at PSI, Villingen, Switzerland using protons and GSI, Darmstadt using carbon beams. Both facilities are experimental units operated in physics laboratories and have developed the technique of intensity modulated beam scanning in order to produce 3-D conformal target irradiation. (Beside these two facilities, there are also some low energy proton units for eye treatment that will not be discussed here.) There are 4 new proton centers under construction at Munich, Trento, Essen and Orsay. In order to reach a similarly good or better conformity as IMRT, all these centers want to use beam scanning for the beam preparation. In addition, the proton facility at PSI was equipped last year with a new accelerator with an isocentric gantry that is in commissioning phase at present.

Although the production of high energy heavy-ion beams, such as carbon, is more costly, the excellent clinical results at NIRS, Chiba and GSI, Darmstadt have triggered new heavy ion therapy projects.

Presently, there are four facilities for combined treatment with carbon and light ions under construction: Heidelberg Ion Beam Therapy (HIT) should start with patient operation in fall 2008. The CNAO center at Pavia will start at the end 2008 or beginning 2009. The cooperative therapy center (KITZ) at Marburg, a fully privately financed center, is scheduled to start patient treatment in 2010. Finally, at Kiel University, the groundbreaking ceremony for a comprehensive cancer center including ion beam therapy will be in July of this year.

In addition to these projects that are under construction, many projects are discussed and in a stage of preparation at different places. But it is not fully clear whether and when these projects will be completed.

TUE-MA04-4 #472 - Invited Talk - Tuesday 3:30 PM - West Fork

The Heidelberg Ion Therapy (HIT) Accelerator Coming into Operation

Carl M. Kleffner, David Ondreka, Udo Weinrich
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The Heidelberg Ion Therapy Facility (HIT) is the first dedicated proton and carbon therapy facility in Europe. It uses full three dimensional intensity-controlled raster scanning as basic treatment technique. The commissioning of the accelerator with beam was successfully finished for two fixed-beam treatment places in December 2007. Therefore, a library of 40,000 combinations of beam properties (ion type, treatment place, energy, intensity, beam size) is now offered to the treatment technique teams preparing the treatment systems for the clinical use.

The HIT facility also comprises a gantry with full scanning properties constituting the only carbon ion gantry worldwide. The gantry can be rotated by 360 degree, so that the beam may be aimed at the patient from arbitrary directions. Commissioning with beam of the gantry was started in January 2008 when the first beams were transported successfully into the treatment room.

The talk will report on experiences and results of the commissioning of the accelerator sections. It puts special emphasis on the subject of preparing the enormous variety of beam properties in an efficient and reliable way.

TUE-MA04-5 #181 - Invited Talk - Tuesday 3:30 PM - West Fork

Integration of Innovations for Particle Therapy Solutions

Dennis Falkenstein
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Particle therapy centers have been developed to provide the capability of delivering proton and heavier ions for the treatment of cancer. These require large capital investments which become difficult in an era of escalating healthcare costs. Current projects make use of a number of new innovations to enable a large number of patients to be treated in a cost effective solution. The innovations enable a patient friendly workflow to increase patient comfort, safety, and treatment delivery effectiveness.

Robotic positioners are refined for medical imaging and patient positioning in an automated process. Precise scanning beam control of the particle beam enables delivery of exacting treatment prescriptions. Scanning beam technology reduces the passive elements found in most treatment facilities today. Elimination of the passive devices obviates the need for human intervention between treatment fields during the daily treatment. These beams also result in reducing the amount of neutron generation, which has been shown to have possible long term harmful effects for the patient. Various examples of ongoing installations of these particle therapy solutions will be presented.

TUE-MA04-6 #474 - Contributed Talk - Tuesday 3:30 PM - West Fork

Development of the IBA Carbon/Proton Therapy System

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During the last three years, IBA has pursued the design of a combined carbon / proton beams therapy facility. This new facility uses as accelerator a superconducting isochronous cyclotron, able to accelerate ions having a charge to mass ratio of 0.5 up to a maximum energy of 400 MeV/u.

The physical design of the cyclotron is now complete. Most of the engineering and beam dynamics calculations have been carried by a team of accelerator physicists of the JINR in Dubna (Russia). In January 2007, an international review team made of specialists of isochronous cyclotrons from all around the world reviewed and validated the design. The prototype will be built and tested in Belgium, then installed to be tested and validated at a scientific partner. In February 2008, IBA signed a preliminary agreement with the ARCHADE group in located in Caen (France), next to the GANIL laboratory, to install there the prototype and be ready for treatment in experimental mode by the end of 2011.

An important feature of such a carbon therapy facility is having isocentric gantries. Conventional gantries with resistive magnets are exceedingly large, heavy and expensive. For this reason, IBA is also pursuing the design of a gantry for carbon ions based on a superconducting, rotating large bore 90° dipole magnet. The design of this new gantry will also be presented.

TUE-NBA02-1 #448 - Invited Talk - Tuesday 3:30 PM - Brazos II

New Plasma Tools for Antimatter Science

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Much progress has been made recently to create cold antimatter plasmas and to exploit them for a variety of fundamental scientific studies and technological applications. In particular, single-component plasmas are a unique medium with which to manipulate antimatter without the usual deleterious effect of annihilation with matter. Examples include efforts to create and trap antihydrogen, the recent creation of the first positronium molecules (i.e., Ps_2), positron interactions with atoms and molecules, and the use of positrons for characterization of materials. The work described here focuses on the development of new plasma tools for the trapping and manipulation of antimatter plasmas and beams, with immediate applications to positron science. Progress is described in three key areas: radial compression of single-component plasmas using rotating electric fields in a novel, strong-drive regime [1]; experiments and complementary theoretical modeling of the extraction of beams with small transverse

spatial extent from single-component plasmas [2]; and work to develop a multicell trap to increase by orders of magnitude the capacity for antiparticle storage [3]. Potential applications of these tools and challenges for future research are discussed.

This work is supported by the National Science Foundation grant PHY 07-13958, and is done in collaboration with T. R. Weber and C. M. Surko.

[1] J. R. Danielson, C. M. Surko, and T. M. O'Neil, Phys. Rev. Lett. 99, 135005 (2007).
[2] T. R. Weber, J. R. Danielson, and C. M. Surko, Phys. Plasmas 15, 012106 (2008).
[3] J. R. Danielson, T. R. Weber, and C. M. Surko, Phys. Plasmas 13, 123502 (2006).

TUE-NBA02-2 #116 - Invited Talk - Tuesday 3:30 PM - Brazos II

Projectile Charge Effects in Differential Ionization by Positrons and Electrons

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Total cross sections for single ionization by fast projectiles are known to scale with the square of the projectile charge. This means that identical cross sections are expected for intermediate and high energy electron and positron impact. However, because of post collision and trajectory effects, various theories have predicted differences in the differential electron emission. In the case of double ionization, experiments yield larger total cross sections for energetic electron impact than for positron impact. In this case, the differences are attributed to interference between the TS1 and TS2 double ionization mechanisms because the interference (cross) term is positive for negative particle impact and negative for positive particle impact. This talk will describe techniques we are using to probe these projectile charge effects. Our experiments employ intermediate to high energy positrons and electrons and generate doubly and triply differential ionization data. Examples illustrating charge differences in both the single and multiple ionization channels will be presented and discussed.

Work supported by the National Science Foundation

TUE-NBA02-3 #502 - Invited Talk - Tuesday 3:30 PM - Brazos II

Positron Annihilation Induced Auger and Gamma Spectroscopy

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The annihilation of positrons with core electrons results in unique signatures in the spectra of Auger-electron and annihilation-gamma rays that can be used to make clear chemical identification of atoms in the environment of the positron at the time of annihilation. Positrons implanted at low energies trap with high efficiency at an image-correlation just outside the top layer of atoms at the surface. This makes it is possible to use annihilation induced Auger and Gamma signals to probe the surfaces of solids with single atomic layer depth resolution. In this talk we will report recent applications of Positron Annihilation Induced Auger Electron Spectroscopy (PAES) and Auger-Gamma Coincidence Spectroscopy (AGCS) to the study of surface structure and surface chemistry. Our research has demonstrated that PAES can be used to obtain Auger spectra with the extremely low background, and increased surface sensitivity and can thus provide new information regarding the composition of the top-most atomic layer.1-8. The applicability of PAES to the study of Se passivated Si surfaces and catalytically important surfaces of oxides and wide band-gap semiconductors will be discussed in light of recent measurements. We will conclude with a discussion of the use of Auger-Gamma and Gamma-Gamma coincidence spectroscopy for in-situ studies of surfaces inside chemical reactors.

Research supported by the Welch Foundation Grant Number Y-1100

TUE-NBA02-4 #218 - Invited Talk - Tuesday 3:30 PM - Brazos II

The development and applications of an accelerator based positron source.

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For almost forty years slow positrons have been used as probes in solid state, surface, and atomic physics experiments. However, positron probes remain highly underutilized because the difficulties associated with creating useful beams has meant that such experiments have been carried out in only a relatively small number of laboratories by positron experts, and there has been very little application of these methods in the wider community. One of the main impediments to the general use of positrons has been that beams derived from radioactive sources are rather weak, with maximum currents in the pico-Ampere range. It is possible to

generate more intense positron sources via some high energy processes such as pair production, but this is in general prohibitively expensive and is not likely to be conducive to expanding the application of slow positron probes. Here we shall discuss the production of low energy positrons following the in situ creation of the beta emitting isotope 13N using a relatively low energy deuteron accelerator. Because of its short half life this isotope can be used to create more intense positron beams than are available using sources created ex situ, and by extracting gaseous 13N2 from the deuteron target a number of novel applications become possible.

TUE-NBA02-5 #390 - Contributed Talk - Tuesday 3:30 PM - Brazos II

The effects of surface reconstructions and electron-positron correlations on surface states and annihilation characteristics of positrons trapped at reconstructed semiconductor surfaces

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Theoretical studies of positrons trapped at semiconductor surfaces are necessary to derive the full power of the new surface positron spectroscopies. Such studies are also of intrinsic interest as positrons trapped at a semiconductor surface represent a system consisting of distinguishable quantum particles in a quasi 2d potential. In this talk, the effects of surface reconstructions and electron-positron correlations on positron surface states and annihilation characteristics are explored. Surface states and annihilation characteristics are calculated for Ge(100) surface with (2x1), (2x2), and (4x2) reconstructions, and for Ge(111) surface with c(2x8) reconstruction using different approximations to describe electron-positron correlations. The orientation-dependent variations of the atomic and electron densities associated with reconstructions are found to affect localization of the positron wave function at the reconstructed surface. Estimates of the positron binding energy and annihilation characteristics reveal their sensitivity to the specific atomic structure of the topmost layers of semiconductors and to approximations used to describe electron-positron correlations. The results of these theoretical studies are compared with the ones obtained for the reconstructed Si(100)-(2x1) and Si(111)-(7x7) surfaces, and for both As- and Ga-rich (100) surfaces of GaAs with c(2x8), (2x4), (2x6), and c(4x4) reconstructions. Theoretical annihilation probabilities of surface trapped positrons with relevant core electrons are used to analyze the results of studies of semiconductor surfaces using positron annihilation induced Auger electron spectroscopy (PAES). Comparison of positron annihilation probabilities computed for different reconstructed semiconductor surfaces with experimental ones estimated from the measured Auger peak intensities confirm that PAES intensities are sensitive to the crystal face, surface structure, and chemical composition of the semiconductor.

TUE-NP04-1 #622 - Invited Talk - Tuesday 3:30 PM - Brazos I

Physics with Radioactive Ion Beams: the European ISOL-based effort

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The field of Radioactive Ion Beams is rapidly expanding in Europe with a wealth of physics results coming from the running facilities such as e.g. GSI, ISOLDE and GANIL. Furthermore the construction of new facilities or major upgrade of existing facilities together with vigorous R&D for long-term projects assures the future of this research. An overview of recent highlights of the present facilities, mainly concentrating on the ISOL-based technique will be given. This will span the ultra-low energy sector of cooled and trapped ions over decay studies to reaction work with short-living isotopes. Next to the survey of physics results also an overview will be given of the experimental techniques especially tailored to the study of exotic nuclei. This contribution will end with an outlook on the new possibilities which will arise in the next five years at the different European facilities.

TUE-NP04-2 #458 - Invited Talk - Tuesday 3:30 PM - Brazos I

Gamma spectroscopy of neutron-rich nuclei with CLARA-PRISMA

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With the increase in efficiency and selectivity of the present generation gamma-spectroscopy set-ups, multi-nucleon transfer reactions and deep inelastic collisions have become an efficient tool to study medium- and high-spin states in neutron-rich nuclei far from the stability. Actually, before the planned Radioactive Ion Beam facilities start operation, these reaction mechanisms constitute the only possibility to populate such nuclei at beam energies near the Coulomb barrier and with sizeable cross sections, using the available combinations of stable beams and targets. In-beam spectroscopy of the nuclei populated in these reactions is however quite a challenge, given the wide range of reaction products, each of them having a broad velocity distribution. For this kind of studies, a highly efficient and granular array of germanium detectors is needed, coupled to additional devices identifying the reaction products and measuring their velocities.

One such example is the CLARA-PRISMA set-up, which completed its campaign of measurements to study medium-mass neutron-rich nuclei at the Laboratori Nazionali di Legnaro. The set-up consisted of the magnetic spectrometer PRISMA [1] coupled to the CLARA array [2] placed at the target position. The campaign of measurements focused on the properties of medium-mass neutron-rich nuclei in the vicinity of the shell closures, such as the stability of the $N = 50$ shell closure close to ^{78}Ni, the onset of deformation in the Cr-Fe region around $N = 40$ and the $N = 32$ shell closure around ^{48}Ca. Selected results are presented here. The CLARA array has recently been dismounted and the installation of the AGATA Demonstrator Array [3] is in progress. The perspectives offered by the AGATA+PRISMA setup are also discussed.

[1] A.M. Stefanini et al., Nucl. Phys. A701, 217c (2002)
[2] A.Gadea et al, Eur. Phys. J. A20, 193 (2004)
[3] J.Gerl and W. Korten (editors), AGATA Technical Proposal (2001)

TUE-NP04-3 #440 - Invited Talk - Tuesday 3:30 PM - Brazos I

Nuclear spectroscopy at RISING/GSI

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Experiments devoted to the study of the structure of nuclei with both N~Z and on the neutron-rich side of the nuclide chart have been performed at GSI, Darmstadt, within the Rare Isotopes Investigations at GSI (RISING) project.

Exotic nuclei were synthesised using projectile fragmentation of relativistic energy beams provided by the SIS synchrotron at GSI. The exotic fragments produced were separated and identified event-by-event using the GSI FRagment Separator (FRS). The final reaction products were stopped in layers of plastic, copper, or double-sided-silicon-strip detectors at the final focal point of the FRS and viewed by the high-efficiency, high granularity Stopped RISING gamma-ray spectrometer, consisting of 15 Euroball cluster Ge-detectors. Time-correlated gamma decays from individually identified nuclear species have been measured, allowing the clean identification of isomeric decays (passive stopper), and beta and conversion electron decays (active Si stopper).

Selected highlights of the experimental results from the highly successful experiments will be presented, with focus on heavy systems:

(i) observation of excited states in the N=126 closed-shell nuclei 203Ir, 204Pt, 205Au
(ii) observation of excited states in N>126, Z<82 nuclei
(iii) proton decay from an isomeric state in 54Ni
(iv) isomeric states in heavy N=Z nuclei
(v) internal decay in the r-process path nucleus 130Cd

The experimental setup, results and interpretations will be discussed.

TUE-NP04-4 #584 - Invited Talk - Tuesday 3:30 PM - Brazos I

MEASUREMENTS OF MAGNETIC MOMENTS OF SHORT-LIVED NUCLEAR STATES

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Magnetic moments of nuclear excited states yield fundamental information on the microscopic structure of these states. Experimental methods developed for abundant stable isotope beams have to be modified to meet the new challenges arising from the radioactive beam environment. In particular, high excitation probability, reasonably high intensity beams, efficient detection systems, low backgrounds, and very large hyperfine magnetic fields at the site of the nucleus of interest are crucial. The last three years have seen developments in both experimental technology and beam development.

It happens that, contrary to the situation with stable beams, for each radioactive isotope the experimental setup has to be optimized. Successful experiments have been carried out in light Ar and S nuclei, in heavier isotopes such as Kr, as well as in the A=132 region in a variety of techniques varying from low to intermediate energies at Oak Ridge National Laboratories, the 88-Inch Cyclotron Laboratory at Berkeley and the National Superconducting Cyclotron Laboratory at Michigan State University. These experiments will be described and future plans will be outlined.

TUE-NP04-5 #454 - Invited Talk - Tuesday 3:30 PM - Brazos I

Reinvestigation of direct two-proton radioactivity of $^{94}Ag^{m}$ ($J^{\pi} = 21^{+}$, 6.7 MeV)

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Both direct one-proton decay and direct two-proton decay of $^{94}Ag^{m}$ from this long-lived (0.4 s) isomeric state have been reported by Mukha et al. in experiments performed with the GSI on-line mass separator [1]. In the former decay, two proton groups with energies of 0.79 and 1.01 MeV were observed, each having a branching ratio of about 2%; in the latter decay, coincident events with a threshold energy of 0.4 MeV and a summed decay energy of 1.9 MeV were observed in coincidence with γ-decays in the ^{92}Rh daughter and were assigned to be coincident protons with a branching ratio of 0.5(3)%.

We have recently utilized our helium-jet system at the Berkeley 88-inch cyclotron to repeat this experiment, again employing the $^{58}Ni(^{40}Ca,p3n)$ reaction at 197 MeV. Reaction products were transported via a capillary to a detection area and collected on a slowly rotating wheel in front of an assembly of 24 ΔE_{gas} - ΔE_{gas} - E_{Si} detector telescopes with a threshold of 0.4 MeV for identifying protons. The beta-particle background is reduced enough in several of these telescopes to clearly observe the 0.79 MeV single proton decay from $^{94}Ag^{m}$. In the 240/276 identified proton coincidence combinations with low background, no proton-proton coincidences have been observed. Data analysis is continuing. A Monte Carlo analysis of our expected proton-proton coincidence yield will be presented.

[1]Mukha et al., Nature 439, 298 (2006) and references therein.

TUE-NP04-6 #375 - Invited Talk - Tuesday 3:30 PM - Brazos I

Single-neutron excitations in neutron-rich nuclei near 132Sn

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Understanding the origin of the elements heavier than iron is widely recognized as one of the most important outstanding astrophysics questions. Understanding the properties of atomic nuclei far from stability is an important effort in the quest to understand what binds neutrons and protons in all nuclei, both stable and unstable. In particular, nuclei near closed shells provide sensitive benchmarks for theory and neutron-rich N=50 and N=82 isotones are waiting points for the r-process of nucleosynthesis. We have recently completed the (d,p) reaction measurements with rare isotope beams of 132,130Sn and 134Te interacting with deuterated plastic targets. Reaction protons were measured in arrays of silicon-strip detectors, including an early implementation configuration of ORRUBA, a new barrel array of position-sensitive silicon strip detectors. Preliminary results of Q-value spectra and angular distributions of ground and excited states of the N=83 isotones, 133Sn and 135Te, and the 131Sn isotope will be presented. This work supported in part by the US Department of Energy and the National Science Foundation.

TUE-NP04-7 #618 - Contributed Talk - Tuesday 3:30 PM - Brazos I

Nuclear Structure Studies with Radioactive Ion Beams in the Mass A=80 Region.

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[(6)]National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing MI 48824, United States

An experimental program to measure spectroscopic properties of neutron-rich nuclei in the A=80 region is underway at the Holifield Radioactive Ion Beam Facility (HRIBF). Our approach has been to get a comprehensive picture of the shell structure in this region studying a series of properties (E (2+), B (E2), g-factors and Q). The beams, instrumentation and techniques developed at HRIBF specifically for this purpose have allowed us to systematically study the behavior of these observables along isotopic and isotonic chains using both stable and radioactive nuclei under almost identical experimental conditions. Highlights from three recent experiments will be presented. Namely, Coulomb Excitation of n-rich nuclei along the N=50 shell closure; the static quadrupole moment of the first 2+ in 78Ge and g-factor measurements of n-rich isotopes near N=50.

TUE-RE04-1 #571 - Invited Talk - Tuesday 3:30 PM - Trinity Central

Challenges in studying radiation response in complex materials

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The possibility of a renaissance of nuclear energy strongly depends on the perception by the general public that the technology is safe and that it generates waste that can be properly managed. The new generations of nuclear power plants will need to address these issues and in particular regarding the waste production, they must be much better in extracting more energy from the fuel and generate less volume of waste. These requirements call for deep burn up of fuels that poses harsh requirements to the materials that compose the fuel, the cladding, and the structural units of the reactor.

The development of new materials that will withstand these extreme conditions require the combination of experiments and modeling. Unfortunately the neutron sources in the world that would allow performing such experiments have neutron fluxes requiring many years of irradiation to reach adequate levels of damage. For that reason there is a renewed interest in conducting ion irradiations that would mimic the neutron environment. This implies multiple beams to add damage and adequate amounts of He and H, together with modeling to account for the differences between neutrons and ions.

In this talk I will address some of the issues the nuclear materials community is facing today, in particular those related to the behavior of ferritic steels in fast neutron spectra, and how the complexity of such material can be uncovered by multiple beam ion studies.

TUE-RE04-2 #439 - Invited Talk - Tuesday 3:30 PM - Trinity Central

Radiation Damage in UO2 by Molecular Dynamics Simulation

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We establish the methodology for simulating radiation damage in UO2 using molecular dynamics simulation. In particular, systematic studies of system-size, type of thermostat and the use of a variable time step algorithms are analyzed. The evolution of the number and type of defects are characterized as a function of PKA energies and temperature. Radiation damage in nanocrystalline UO2 is also analyzed, with particular emphasis on the interaction of the radiation cascade with the grain boundaries.

This work was funded by DOE-NERI Awards DE-FC07-05ID14649 and DE-FC07-05ID14647 and DE-FC07-07ID14833.

TUE-RE04-3 #421 - Invited Talk - Tuesday 3:30 PM - Trinity Central

A Comparison Between Radiation Damage Effects in Uranium Surrogates and Uranium Bearing Oxides with Delta-phase Structures

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To develop advanced nuclear fuel forms or waste forms, the search for radiation-tolerant materials has been an area of intense research in recent years.

The purpose of this study is to examine the radiation damage behavior of complex actinide oxides whose structures are derivatives of the fluorite structure which is the structure of UO2. The particular actinide compound of interest in this report is yttrium uranium oxides, Y6U1O12. In this study, we also consider two isostructural uranium surrogates Y6W1O12 and Yb6W1O12 for comparison to Y6U1O12. Y6U1O12 has a crystal structure known as the delta (d) phase, a structure belonging to space group in a rhombohedral symmetry, which is closely related to the cubic fluorite structure.

Polycrystalline Y6U1O12 and Y6W1O12, Yb6W1O12 samples were irradiated with 300 keV Kr++ ions to fluences up to 2´1020 ions/m2 at cryogenic temperature (100 K). Ion irradiation damage effects in these samples were examined using grazing incidence X-ray diffraction (GIXRD) and cross-sectional transmission electron microscopy (TEM). GIXRD and TEM observations reveal different radiation damage effects in these three compounds. The compound Y6U1O12 exhibits exceptional resistance to radiation-induced amorphization even at the highest radiation dose of 50 displacements per atom (dpa). On the other hand, ion irradiated d-Y6W1O12 and d-Yb6W1O12 both experience an ordered rhombohedral to disordered cubic fluorite

transformation by a displacement damage dose of ~12 dpa. Also both of these compounds become partially amorphous by a dose of ~50 dpa.

Density functional theory (DFT) calculations indicate that for the three compounds considered here, the lowest cation antisite formation energy occurs for Y6U1O12. Interestingly, however, we do not observe d-Y6U1O12 to undergo an ordered rhombohedral to disordered cubic fluorite transformation as readily as do the d-Y6W1O12 and d-Yb6W1O12 compounds. At present, we do not understand the disordering resistance of d-Y6U1O12.

TUE-RE04-4 #588 - Invited Talk - Tuesday 3:30 PM - Trinity Central

Molecular Dynamics Simulations of Radiation Induced Structure Changes during Ion Implantation in Oxide Ceramics

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Ion implantation is a promising method for rare earth ion doping in optical waveguides for the fabrication of waveguide lasers and amplifiers. It is well known that the spectral features of rare earth ions depend on their local coordination environments, which are however difficult to probe using experimental methods. Molecular Dynamics (MD) simulations have been shown to be able to provide detailed structural information in radiation effects in metals. Recently, MD simulations have been applied to complex crystalline or amorphous ceramic systems although where the long range Columbic interactions due to ionic nature in chemical bonding are computationally more demanding. Here we report comparative studies of erbium implantation in cristobalite (a high temperature polymorph of silica) and vitreous silica using molecular dynamics simulations with effective partial charge pair wise potentials. We focus our attention on the changes of the local environment around rare earth ions and the corresponding relaxation of the silicon-oxygen network structure in silica. The molecular structures of implanted glasses are compared with those formed by normal melt-quench process to understand the experimentally observed spectral differences. The results show that the silicon oxygen network has a strong tendency to recover from structural defects due to implantation and the medium range structure is minimally disturbed after erbium implantation.

TUE-RE04-5 #547 - Contributed Talk - Tuesday 3:30 PM - Trinity Central

AFM Characterization of Oxide Multilayer Surfaces Modified by Heavy Ion Beam Irradiation

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Tri-layer metal oxide films, composed of alternating layers of HfO_2 and MgO were grown at room temperature on Si(111) substrates, post-annealed, and pieces of the films irradiated with 10 MeV Au^{3+} ions at a range of fluences. The degree and nature of the modification of the surface structure of each of piece was characterized using atomic force topographic and phase imaging techniques to determine local changes in structure and mechanical properties as a function of fluence. Single-phase films the two materials were grown to the comparable thickest and irradiated for comparison. Details of the experiment and results will be presented.

TUE-RE04-6 #334 - Contributed Talk - Tuesday 3:30 PM - Trinity Central

Resistance of an Extreme Halophile to a Variety of Types of Radiation

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The model Archaeon *Halobacterium* sp. NRC-1 is an extreme halophile known for its resistance to multiple stressors, including ionizing and non-ionizing radiation. It is a well-developed system with a completely sequenced genome and extensive post-genomic tools for the study of a variety of biological processes. To further understand the mechanisms of *Halobacterium*'s radiation resistance, we have selected for multiple independent highly resistant mutants using repeated exposure to high doses of 18-20 MeV electrons using a medical S-band Linac. Molecular analysis of the transcriptional profile of several of these mutants revealed a single common change: upregulation of the *rfa3* operon. The three genes encode hypothetical proteins homologous to the large and medium subunits of eukaryotic Replication Protein A (RPA), a single-stranded DNA binding protein with major roles in DNA replication, recombination, and repair. This operon has also been implicated in a somewhat lesser role in resistance of wild type *Halobacterium* to ultraviolet radiation, suggesting common mechanisms for resistance. However, the radiation-resistant mutant strains do not display increased UV-C resistance, and in some cases are more sensitive than the parent strain.

The mutant strains were also tested using UV-A and UV-B, which are more likely to be encountered in a natural system and are therefore more biologically relevant. Continued testing of the mutants with high-energy photons will further determine the role of RPA in resistance to a variety of different types of radiation.

TUE-AP02-P1 #5 - Poster - Tuesday 5:30 PM - Rio Grande Room - Rio Grande Room

L X-ray cross sections for Fe, Cu, Zn, and Ge impacted by 75-300 keV protons

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L x-ray production from 75-300 keV proton impacts on thick targets of Fe, Cu, Zn, and Ge has been measured using a high-resolution Si(Li) detector equipped with an ultra-thin window. L x-ray production and L sub-shell ionization cross sections obtained from the data are compared with ECPSSR and ECPSSR-UA theory.

TUE-AP02-P2 #13 - Poster - Tuesday 5:30 PM - Rio Grande Room

Inelastic-collision cross sections for the interactions of H^+, He^{2+} and C^{6+} ions with liquid water.

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Monte Carlo codes for ion-nanodosimetry in tissue-like media require a detailed knowledge of the ionization cross sections. Secondary electron spectra play a main role in the radiobiological effectiveness of this kind of particles. The HKS and CDW-EIS formalisms are implemented to determine single ionization cross sections (SICS) corresponding to the impact of H^+, He^{2+} and C^{6+} ions on liquid water, for incident energies from 0.3 to 10 MeV/u. Corrected expressions for the HKS method have been used. The same kind of initial electron wave functions and binding energies have been used with both models, in order to compare the formalisms themselves. Double and single differential as well as total SICS of liquid water have been calculated by use of both methods and comparisons have been made between their theoretical predictions. Also, these results have been compared with experimental values reported previously for ionization of water vapor due to protons and alpha particles. Despite its sophistication, the CDW-EIS method does not show better results than the more simple HKS model when comparing liquid water single and double differential cross sections with experimental water vapor values. However, once the excitation cross sections are included to determine electronic stopping cross sections in liquid water, the results based on the CDW- EIS method provide the best agreement when compared with corresponding data published in ICRU reports, obtaining discrepancies of about 9 %, 16 % and 19% for incident protons, alpha particles and carbon ions respectively.

TUE-AP02-P3 #90 - Poster - Tuesday 5:30 PM - Rio Grande Room

Absolute differential and total cross sections for the production of neutral fragments from dissociative collisions of triatomic hydrogen like ions in He

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Neutral products of triatomic hydrogen like ions incident on He atoms were studied. Absolute differential and total cross sections are reported in the energy range of 1.25 and 5.00 keV for scattering angles between -5° and 5°. The total cross sections show no dependence on the projectile mass at equal velocity. The cross sections are between 4×10^{-17} cm^2 and 2×10^{-16} cm^2. A polynomial fit of fourth order with a maximum at 3.5 keV/amu, shows agreement with a previous work for H_3^+ at high energies. The differential cross sections have a decreasing behavior with a slight structure around 2°.

TUE-AP03-P1 #143 - Poster - Tuesday 5:30 PM - Rio Grande Room

DIELECTRONIC RECOMBINATION PROCESSES THROUGH DOUBLY-EXCITED STATES IN Ag-LIKE Xe IONS

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Ab initio calculations of dielectronic recombination processes from the ground states [Kr]4d10 of Xe8+ ion through doubly-excited states ([Kr]4d94fnl, [Kr]4d95l'nl, and [Kr]4d96lnl) of Xe7+ ions are calculated by the Hartree-Fock-Relativistic method

(Cowan code) and the relativistic many-body perturbation theory method (RMBPT code). Two codes are used to evaluate energy levels, radiative transition probabilities, and autoionization rates for [Kr]4d94fnl, [Kr]4d95l'nl, (n=5-8), and [Kr]4d96lnl (n =6-7) states in Ag-like xenon. Autoionizing levels above the threshold [Kr]4d10 are considered. It is found that configuration mixing [Kr]4d94fnl and [Kr]4d95l'nl play an important role for all atomic characteristics. Branching ratios relative to the first threshold and intensity factors are calculated for satellite lines, and dielectronic recombination (DR) rate coefficients are determined for the singly-excited [Kr]4d10nl (n=5-7), as well as doubly-excited [Kr]4d95s2, [Kr]4d95p2, [Kr]4d95s5d, [Kr]4d95s5p, [Kr]4d94f5s, and [Kr]4d94f5p states. The two-electron radiative transitions, such as 4d104f-4d95d2 and 4d105d-4d95p6d, are found to be important due to the strong correlation corrections. It is shown that the contribution of the highly-excited states is very important for calculation of total DR rates. Contributions from the doubly-excited states [Kr]4d94fnl and [Kr]4d95l'nl with n ¡Ý 8 to DR rate coefficients are estimated by extrapolation of all atomic parameters. The orbital angular momentum quantum number l distribution of the rate coefficients shows a peak at l =3. The total DR rate coefficient is derived as a function of electron temperature.

TUE-AP03-P2 #269 - Poster - Tuesday 5:30 PM - Rio Grande Room

The crystal structure in uniaxially polarized LiTaO3 and it's x-ray emission mechanism

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LiTaO3 is well known as a ferroelectric material and is used in polarization converters etc.. At temperatures below the Curie temperature Tc (Tc~930 K) of LiTaO3, the centres of positive and negative charges in a LiTaO3 crystal are separated spatially and the crystal is polarized. Brownridge et al. have reported x-ray emission during temperature changes of pyroelectric crystals like LiNbO3 or LiTaO3 under vacuum. Subsequently, their group and ours have independently investigated x-ray generation by ferroelectric crystals. Changing the temperature changes the absolute magnitude of polarization. Electrons in the crystal can be accelerated by an electric field due to the surface charges of the crystal formed upon temperature changes. X-rays are radiated as a result of the bremsstrahlung caused by the collision of charged particles with a target metal. The x-ray radiation rate becomes maximum at a gas pressure of approximately 5 Pa. Therefore, X-ray intensity is strongly dependent on the pressure of atmosphere gas and the type of atmosphere gas.

As there have been no reports on structural analysis in the high temperature range in which x-ray emission can be observed on the surface of the crystal, Nakanishi et al. carried out high temperature single crystal structure analysis of LiNbO3 and suggested that the valence electron in Nb changes in the compound and x-ray emission have a close relation to the electric charge of Nb in LiNbO3.

In present work, we executed the single crystal structure analysis of LiTaO3 in the temperature range between room temperature to about 440 K which x-ray emission can be observed, far below the phase transition, Tc in order to elucidate the mechanism of the x-ray emission in the pyroelectric crystals.

TUE-AT02-P1 #360 - Poster - Tuesday 5:30 PM - Rio Grande Room

Experimental Investigation and Simulations of Liquid Driven Pyroelectric Voltage Sources for Compact Accelerators

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Previous work with pyroelectric crystals in vacuum utilizing heaters has demonstrated voltage scaling greater than 100 kV using 3 cm diameter, 1 cm thick LiTaO3 crystals. These novel HV supplies were used to drive compact D-D neutron sources but suffer from breakdowns and slow thermal cycling times. Insulating liquids such as flouroinerts or Si oil offer the possibility of serving as both high voltage insulation and as a rapid heat transfer medium for these compact crystals based high voltage systems, potentially allowing for higher voltages and notably faster cycle times. Here, experimental setups and results involving 3 cm diameter LiTaO3 crystals up to 10 cm long quenched in flouroinert are discussed. Experiments with multiple crystals in parallel were also performed. Field probe diagnostic of the crystal voltage and direct measurement of the crystal current are provided. Electron acceleration is demonstrated by coupling a vacuum tube to the experiment. Voltages greater than 200 kV can be reliably obtained in cold quenches, and peak crystal currents in the ~100 nA range can be achieved in configurations with multiple crystals in parallel. Simulations of the system compared fairly with experiment. Ultimately, it is found that leakage currents in typical insulating liquids can limit the voltage in these liquid pyroelectric voltage sources.

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TUE-AT03-P1 #105 - Poster - Tuesday 5:30 PM - Rio Grande Room

Radiation of X-rays Using Uniaxially Polarized $LiNbO_3$ Single Crystal

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It is well known that by changing the temperature for the polarized hemimorphy single crystal, the electric field with high intensity is generated and then atmospheric gas atoms or molecules around the crystal are ionized. Using these phenomena, X-rays could be radiated by the bremsstrahlung radiation of electrons in low-pressure gas atmosphere. Therefore, X-ray intensity is strongly dependent on the pressure of atmosphere gas and the type of atmosphere gas. However, positive charges generated by the ionization of gas molecules near the crystal weaken the electric field strength. In a high vacuum, as the concentration of positive charges may decrease, the electric field strength is expected to become higher than that in a low vacuum. Thus, in this study, to enable X-ray radiation with a stable intensity, a source based on thermal electrons in high vacuum is employed and the enhancement of the X-ray radiation was examined by supplying electrons externally.

The -z plane of the congruent $LiNbO_3$ single crystal (5 mm thickness, 13×13 mm^2 area) polarized in the z-axis direction was opposed to the oxygen-free Cu target of a 10 μm thickness placed at a distance of 21 mm from the -z plane. The +z plane of a crystal was placed on a Peltier device. Filament of thorium-added-tungsten as a thermal electrons source was placed at a distance of 20 mm from the crystal side edge.

X-ray intensity, when thermal electrons were supplied, is more than 100 times of the intensity when no thermal electrons were supplied. This result shows that supplying of thermal electrons enhances the X-ray radiation. X-ray intensity became maximum, at which point high reproducibility was obtained, when the optimal number of thermal electrons was continuously supplied while increasing and decreasing the temperature of the crystal below approximately 5×10^{-2} Pa.

TUE-AT03-P2 #208 - Poster - Tuesday 5:30 PM - Rio Grande Room

Development of the RF System for the KIRAMS-30 Cyclotron

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Lab. of Particle Accelerator Development in KIRAMS developed KIRAMS-13, the 13MeV medical cyclotron, for Positron Emission Tomography (PET) in 2001. Now, KIRAMS-13 has spread to the provinces through the national project, "Development of Cyclotron and FDG Synthesis modules." But, there is just one cyclotron for Single Photon Emission Computed Tomography (SPECT) in Korea, which is made by IBA, Belgium. So, KIRAMS sat up a research project of 30MeV cyclotron development, named KIRAMS-30. It has high-performance compared with commercial cyclotrons and is installed in Advanced Radiation Technology Institute (ARTI) to product radioisotopes. ARTI will make use of KIRAMS-30 for radioisotopes production, industrial application, food and agriculture fields. The final object of KIRAMS-30 design is that 30MeV beam energy, 300ìA beam current and dual beam extraction. The RF system of KIRAMS-30 has vertical cylindrical stems just like other commercial cyclotrons. The power coupling method is capacitive coupling. A material of all most RF parts is Oxygen Free High Conductivity (OFHC) copper. In this paper, we describe the simulation results with Microwave Studio (MWS) and show mechanical drawings and manufactured the RF system of KIRAMS-30.

TUE-AT03-P3 #211 - Poster - Tuesday 5:30 PM - Rio Grande Room

On-site Real-Time Inspection System for Pump-impeller using X-band Linac X-ray Source

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The methods of nondestructive testing (NDT) are generally ultrasonic, neutron, eddy-current and X-ray etc. Nondestructive testing by using X-ray is particularly the most useful technique to inspect with higher resolution. We can especially evaluate corroded pipes of petrochemical complex, nuclear- and thermal-power plants by the high energy X-ray NDT system. We develop a portable X-ray NDT system with X-band Linac and magnetron. This system can generate 950keV electron beam. We are able to get some X-ray images of samples. We find out X-ray spatial resolution is about 1mm.This system can apply to the real time

inspection for impeller because Linac based X-ray sources are able to generate pulse X-ray. So, we can inspect the rotating impeller if the X-ray pulse rate is synchronized with rotating rate of impeller. This system helps in condition based maintenance of nuclear plants etc.

However, 950keV X-ray source can be only used for thin tubes of about 20 mm thickness. We start to design 3.95MeV X-band Linac for broader X-ray NDT application. We think that this X-ray NDT system will be used for corrosion wastage and cracking in thicker tubes at nuclear plants and impeller of larger pumps. This system consists of X-band linac, thermionic cathode electron gun, magnetron and waveguide components etc. For higher electric field works out, the 3.95 MeV X-band Linac structure is adopted side-coupled structure. This structure is more effective acceleration than 950 keV Linac with alternating periodic structure (APS). We adopt 1.3 MW magnetron for RF source. This accelerator system is about 30cm long. The beam current is about 150 mA, and X-ray dose rate is 10 Gy@1m/500 pps.

In this paper, the detail of the whole system concept and the electromagnetic field of designed linac structure will be reported.

TUE-AT03-P4 #465 - Poster - Tuesday 5:30 PM - Rio Grande Room

Proton Injector for CW-Mode Linear Accelerators

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Numerous applications exist for CW linear accelerators with final energies in the 0.5 to 4.0 MeV proton energy range. Typical proton current at the linac output energy is 20 mA. An important subsystem for the accelerator facility is a reliable dc mode proton injector. We present here design and laboratory results for a dc, 25-keV, 30-mA proton injector. The proton source is a 2.45-GHz microwave hydrogen ion source which operates with an 875-G axial magnetic field. Low emittance, high proton fraction (>85%), beams have been demonstrated from this source. The injector uses a novel dual-solenoid magnet for matching the injector beam into a radio frequency quadrupole (RFQ) linear accelerator. Recently, a dc ion-source development program has given up to 5 mA beam. Up-to-date dc ion source performance will be given at the conference. The dual solenoid is a compact and simple design utilizing tape-wound, edge-cooled coils. The low-energy beam transport design as well as 25-keV beam matching calculations to an RFQ will also be presented.

TUE-AT04-P1 #404 - Poster - Tuesday 5:30 PM - Rio Grande Room

Upgrade of the laser plasma cathode by external magnetic field of 1.0 T

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We are developing a laser plasma cathode based on Laser Wakefield Acceleration, which is expected to enable us to realize a compact high-quality electron accelerator.

Until now, significant enhancement of emittance and an increase of the total charge of femtosecond electron beams produced by laser plasma cathode were observed after applying a static magnetic field of 0.2T, directed along the axis of laser pulse propagation. Very high stability and reproducibility of the characteristics and position of well-collimated electron beams was detected, although in the energy distribution is a Maxwell-like.

The pre-plasma cavity was modified at the focus point by external static magnetic field. The pre-plasma had a two-cone structure with a density peak at the focus point. This can be explained by the fact that the plasma becomes magnetized only near the focus point; therefore a shock wave can propagate only in transverse direction, and there is no longitudinal shock wave. Because of a cone-like plasma density distribution at the front of the laser pulse, the diffraction is suppressed and therefore a much higher intensity is achieved at this steep density profile with very efficient self-injection.

We performed a hydrodynamics calculation to examine the growth process of the pre-plasma in a stronger magnetic field. As a result, we confirmed that an optical waveguide structure was made inside the gas jet in the pre-plasma growth process. From our experimental results, it is confirmed that quasi-monoenergetic electron beam is generated with a channel-like pre-plasma cavity. Therefore, we made a magnetic circuit, which has a strong magnetic field (B=1.0 T), and performed an experiment with this magnetic circuit to produce the channel-like pre-plasma cavity. The present report aims at presenting these experimental and analytical results.

TUE-AT04-P2 #557 - Poster - Tuesday 5:30 PM - Rio Grande Room

Electron Beam Quality Determination through the Fricke Xylenol Gel Dosimeter

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The high energy radiotherapic electron dosimetry is recommended to be done with parallel plate ionization chambers, following the AIEA TRS-398 protocol.

The dosimetry depth and R50, both obtained from the percentage depth dose curve, permit one to infer the electron beam average energy at the water phantom surface. In this work a chemical dosimeter, based on the Fe(II) to Fe (III) oxidation, was used to obtain the radiotherapic electron beam energies of nominal energies of 5, 7 and 10 MeV and compared with energies obtained through parallel plate ionization chamber, following the referred protocol. The results showed the applicability of the chemical dosimeter for this purpose.

TUE-FIBP01-P1 #198 - Poster - Tuesday 5:30 PM - Rio Grande Room

Microbeam Beam Heating Analysis of Thin Foils using Heat Conduction Theory

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The temperature distribution in and near the scan region of an ion microbeam is estimated using heat conduction theory. In the calculation, the energy deposited by a beam spot on a thin foil is treated as a point energy source. The spatial and time dependent temperature contributions from energy deposited by the ion beam rastering in a square scan pattern were then computed. The results showed that for poor conductors, the temperature of the material under the scan region can rise rapidly by up to two orders of magnitude, while that of good conductors remains virtually unchanged. The calculated results were consistent with experimental data where Mylar foils were scanned using an He microbeam, and the time for melt through was measured. Radiational cooling effects were also investigated and found to contribute little to the heat losses at typical microbeam beam powers of the order of less than 10^{-3} watts.

TUE-FIBP01-P2 #567 - Poster - Tuesday 5:30 PM - Rio Grande Room

Microfabrication with the high-energy heavy-ion nuclear microprobe at the University of North Texas

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Recently direct writing with high energy focused ion beams is proving to be an attractive and powerful maskless lithography technique for production of high aspect ratio 3-D microstructures in polymer resists and semiconductors [1-3]. The inclusion of direct writing with high energy proton micro-beam (P-beam) as one of the potential techniques in the fabrication of ultrafine structures roadmap in the Japanese Ministry of Economy Trade and Industry highlights the growing interest for industrial applications. In this presentation, we will be presenting recent progresses in the microfabrications using the high-energy heavy-ion nuclear microprobe facility at the University of North Texas.

[1] Three-Dimensional Microfabrication Using Maskless Irradiation with MeV Ion Beams: Proton-Beam Micromachining, F.Watt, J.A.van Kan, and T. Osipowicz, MRS Bulletin, 25(2), (2000) 33.

[2] Proton Beam Writing, Frank Watt, Mark B.H.Breese, Andrew A. Bettiol, and Jeroen A. van Kan, Materials Today, 10(6), (2007) 20-29.

[3] Fabrication of micro-structured tunnels in PMMA using P-beam writing, B. Rout, M. Kamal, A. D. Dymnikov, D. P. Zachry and G. A. Glass, Nucl. Inst. And Meth. B260 (2007) 366-371.

TUE-IBA02-P1 #110 - Poster - Tuesday 5:30 PM - Rio Grande Room

RBS Characterization of Yttrium Iron Garnet (YIG) Thin Films Elaborated by Radio Frequency Sputtering

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Magnetic materials such as yttrium iron garnet (YIG) present a great importance for its magneto-optic properties. It is a potential material used for applications in the domain of optical telecommunications. However, the need to integrate miniaturized optical and hyper-frequency electronic components is more and more important, so coating magneto-optic thin layers becomes very interesting. The deposition of thin films of YIG, on quartz or GGG (gadolinium gallium garnet) substrate, was elaborated using radio frequency magnetron non reactive sputtering technique. A post deposition annealing is needed to obtain crystallization of YIG films which is necessary to obtain the magneto-optical properties. Those properties depend on the substrate, the deposition parameters and the annealing conditions. Rutherford backscattering spectrometry (RBS) was used to characterize the performed layers (thickness and stoichiometry) in order to correlate the elaboration conditions with the quality of the final material. For this purpose, 2 MeV and 3.5 MeV alpha particle beams, depending on the layer thickness, were employed for the RBS measurements which showed close values to the expected stoichiometry of the YIG films.

TUE-IBA02-P2 #426 - Poster - Tuesday 5:30 PM - Rio Grande Room

IBA OF ZEOLITES EXCHANGED WITH LITHIUM FOR CO2 RETENTION.

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A great concern about the global climatic change partially due to industry CO2 expelled to the atmosphere has motivated the search of new materials capable to retain this gas. Clays, perovskites, zeolites and membranes have been utilized to trap the CO2. Zeolites are widely used as molecular sieves in different industrial processes related to gas purification and separation.

Zeolites exchanged with lithium have been proposed as potential materials to retain CO2. The lithium is retained through the formation of carbonate lithium compounds.

The lithium atomic determination in the zeolites is crucial. Zeolites with different lithium contents were prepared in order to study the CO2 retention. IBA of the samples was performed in order to obtain the lithium atomic concentration. The standard RBS method is not sensitive enough to be used. Instead, we used the 7Li (p, á)4He NR in order to perform the sample analyses. The NRA was performed using NR cross sections obtained from the IBANDL (http://www-nds.iaea.org/ibandl) in order to obtain the sample lithium concentrations.

TUE-IBA02-P3 #552 - Poster - Tuesday 5:30 PM - Rio Grande Room

Lattice site location and Defect centers of Silver in znO

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Structural and optical properties of Ag doped single crystal Zno are investigated. Ag by replacing Zn is a potential p type dopant in ZnO. The lattice site location of the dopants was studied by Rutherford backscattering/channeling. The optical properties were studied using PL luminescence. Single crystal ZnO was implanted with Ag at a dose of 4E15 with post implantation annealing. The implantation itself was done at 400 C at 4 different energies to form a uniformly doped thin layer of width 100 nm near the surface. Angular scans along both [0001] and [10-11] directions show that the best crystal recovery occurs around 1000 oC above which even though the crystal could recover more the silver could become very mobile and spread into the bulk. Our results indicate that around 30 % of silver is in the substitution site by annealing the implanted ZnO around 1000 oC. The change in band gap due to the Ag implantation in ZnO is studied by using Pl Spectroscopy.

TUE-IBM02-P1 #230 - Poster - Tuesday 5:30 PM - Rio Grande Room

Stability of Carbon Nanotubes under Electron and Ion Irradiation

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The stabilities of carbon nanotubes (CN) under electron and ion irradiation were investigated. Previous studies have shown that electron irradiation of CN results in dimensional changes and shrinkage. However, much less has been known about stability of CN under ion irradiation. In this study, we have used focused ion beam to study radiation response of CN as a function of fluencies of 30 keV Ga ions. In situ characterization by using scanning electron microscopy shows the shrinkage of multi-wall CNs within a short period of ion irradiation. However, the CN wall/forest does not experience noticeable degradation. Similar conclusion can be made for electron irradiated CN.

TUE-IBM02-P2 #611 - Poster - Tuesday 5:30 PM - Rio Grande Room

Damage characterization of graphene induced by ion beams

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There is increasing interest in studying the properties of both epitaxial and exfoliated graphene, as they might serve as platforms for carbon-based nanoelectronics. Here we are looking at generating and characterizing single-point defects in scotch-tape exfoliated graphene samples of thickness ranging from few to several tens of monolayers. The exact thickness of the samples will be measured using AFM. We are using accelerated ion beams (800 keV and 3 MeV protons, 30 keV and 150 keV N, 5 MeV Si) to create point defects at a density in the range of 1010 - 1011 cm-2 per graphene layer. In this study we are in particular interested at separating the defects due to nuclear stopping power and electronics stopping power, and study the change in the chemical bond breaking, additional bond formation, cross-linking, and other defects in the structure of the graphene using confocal micro-Raman, FTIR, XPS. The results will be presented during this meeting.

TUE-IBM04-P1 #21 - Poster - Tuesday 5:30 PM - Rio Grande Room

RBS/Channeling studies of swift heavy ion irradiated GaN layers

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Epitaxial GaN layers grown by MOCVD on c-plane sapphire substrates are irradiated with 150 MeV Ag ions at a ﬂuence of 5x10^12 ions/cm2. Samples used in this study are 2 µm thick GaN layers, with and without a thin AlN cap-layer. RBS/ Channeling measurements have been carried out on both irradiated and unirradiated samples. Energy dependent channeling for defects characterization and channeling angular scans on off normal axis for strain have been performed. Some theoretical aspects of the channeling in GaN hexagonal crystals have been discussed in detail. The effect of irradiation induced-damages are analyzed as a function of material properties. Observed results are compared and correlated with previous HRXRD, AFM and optical studies, and possible mechanisms responsible for the observations have been discussed.

TUE-IBM04-P2 #121 - Poster - Tuesday 5:30 PM - Rio Grande Room

Effect of swift heavy ions on the quantum-size light-emitting Si nanostructures

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Si nanostructures were prepared by implantation of 1017cm-2 140 keV Si ions in the 560nm-thick SiO2 layers on Si substrates. Two sets of the samples were irradiated with 130 MeV Xe ions with the doses ranging between 10*12cm-2 and 10*14cm-2. Such ions leave in the layers ~14 kev/nm with 99,8% of them being ionization losses. The first set was as-implanted layers, the second one- annealed at 1100oC for 30 min to form light-emitting quantum-size Si nanocrystals. Photoluminescence (PL) at 20oC was used for characterizations. In the samples of the first type irradiation with Xe ions stimulated formation of the structures, emitting weakly at ë=660nm. When annealed at 500oC in the passivating ambient (Ar + H2), the PL near ë=660nm vanished, and new band appeared at ë=770nm, inherent in Si nanocrystals. The intensity of that PL was found to grow with the ion dose. Strong PL

at ë=770nm in the samples of the second type proved formation of Si nanocrystals after 1100oC annealing. With growing of Xe ion dose PL was quenching and disappeared completely when the calculated probability to induce 1 displacement pro nanocrystal approached unity. Simultaneously, weak band at ë=660nm appeared and grew with the Xe dose. Post-bombardment passivation in Ar + H2 resulted in replacement the ë=660nm band by the weak ë=770nm band. The obtained results may be explained as follows. Because 500oC annealing could not provide crystallization, the band at ë=660nm seems to be stipulated by the damaged Si nanocrystals, which after passivation emit at ë=770nm. Irradiation with Xe ions stimulate formation of such nanocrystals in Si-implanted SiO2 layers. Taking in account that nuclear losses of Si ions is several orders greater than of Xe, high ionization losses of swift heavy ions play important role in formation of nanocrystals.

TUE-IBM06-P1 #561 - Poster - Tuesday 5:30 PM - Rio Grande Room

Synthesis and characterization of Ga doped ZnO films for scintillation applications

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There is a growing interest in developing new material systems with excellent energy resolutions at room temperature for radiation detection materials application. Recently, ZnO has received much attention in this direction due to its large band gap (3.37 eV), large exciton binding energy (60 meV) at room temperature and its ability to sustained radiation. In addition, increase in n-type conductivity was observed in Al and Ga doped ZnO samples. In this present work, we have investigated the ultra-low Ga (in ppm levels) doping in ZnO for possible scintillation application. For this, very thick (~ 10 micron) Ga doped ZnO films were grown on sapphire substrates using Pulsed Laser Deposition (PLD) method. We have used Rutherford backscattering spectrometry (RBS)/channeling, near-edge x-ray absorption fine structure (NEXAFS), x-ray photoelectron spectroscopy (XPS), secondary ion mass spectrometry (SIMS), focused ion beam (FIB) and x-ray diffraction (XRD) to characterize these samples. Specially developed time-of flight system was used to measure the scintillation responses of these samples to radiation (as a function of ions and energy). These results will be discussed along with the results from photoluminescence measurements.

TUE-MA03-P1 #237 - Poster - Tuesday 5:30 PM - Rio Grande Room

Simulation of the extraction of carbon ions from K120 superconducting cyclotron

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The K120 superconducting cyclotron is under design at KIRAMS, Korea. This cyclotron has about 3.13 tesla at the cyclotron center and accelerates the carbon 6+ ions upto 30 MeV/amu. TOSCA (OPERA3D) program generates 3-dimensional electric and magnetic field distribution of the electrostatic deflector, the cyclotron's main magnet, and the passive magnet channels. A conventional tracking method with Mathematica simulates the trajectories of carbon ion beam from the several turns before the deflector to the moment after extraction.

This paper shows the design parameters of the extraction system with an electrostatic deflector and passive magnetic channels and the simulation results of carbon ion beams.

TUE-MA03-P2 #376 - Poster - Tuesday 5:30 PM - Rio Grande Room

Feasibility studies of Parametric X-rays using existing medical technologies

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Parametric X-rays (PXR) were produced from the interaction of relativistic electrons with the periodic structure of crystal materials. Smooth x-ray energy tunability was achieved by rotating the crystal with respects to the electron beam direction. Experiments at the Rensselaer Polytechnic Institute 60-MeV LINAC have produced quasi-monochromatic x-rays (6-35 keV) from various target crystals to include highly oriented pyrolytic graphite (HOPG), LiF, Si, Ge, Cu, and W using electron beam currents up to 6 microamperes. These experiments demonstrated the first PXR images and some of the merits of thin metallic crystals. Recent experiments with a 100 micrometer-thick Cu crystal improved the Cu PXR (with energy ~12 keV) to Cu florescence ratio by a factor of 20 compared to a 1 mm-thick Cu crystal. Past RPI experiments were devoted to studies of crystal characteristics. This study investigated PXR feasibility using existing medical technologies for (1) the electron source and (2) x-ray detection. First, the Varian Clinac 2100 series 18 MV electron accelerator, widely used in hospitals for radiation therapy, was evaluated as an electron source for PXR generation using analytical and Monte Carlo techniques. The metrics for this evaluation

included PXR flux, electron beam scattering, crystal heating, and bremsstrahlung production. Second, PXR was analytically evaluated as a photon source interacting with gadolinium oxysulphide, the typical scintillator in computed tomography (CT) imaging. The metrics for this evaluation included PXR image contrast and patient dose due to a quasi-monochromatic source and image contrast due to an energy tunable x-ray source around the gadolinium k-edge 50 keV where the mass absorption coefficient changes by a factor of 5.

TUE-MA03-P3 #556 - Poster - Tuesday 5:30 PM - Rio Grande Room

Thermoplastic mask influence with electrons high energy radiotherapy

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Thermoplastic mask is used to immobilize the patient head. Doing that, the electron beam absorbed dose distribution is enhanced improving the radiotherapic treatment. In this work we investigate the influence of thermoplastic material in the surface and the target volume selected.

For the measurements a Fricke Xylenol Gel dosimeter, based on Fe(II) to Fe(III) oxidation, was used and their values compared with those from an Parallel Plate Ionization Chamber PTW/Markus 23343 of 0.055 cm3.

The values permitted to infer the depth absorbed dose distribution in the water phantom surface up to the build-up depth for electron beam energies of 5, 7 and 10 MeV. The results show that using the mask, this does not alterate significatively the patient surface dose distribution, making it usefull to be used in head and neck cancer treatment.

TUE-MA03-P4 #626 - Poster - Tuesday 5:30 PM - Rio Grande Room

Verification of Patient Positioning in Proton Therapy based on Digital X-ray Images

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To conduct the verification of the target position relative to the beam, a digital X-ray imaging apparatus by Konica Minolta Company has been installed at the Medico - Technical Complex. This method is applied instead of the old one with X-ray films.

This method presents the superposition of the X-ray image which is taken by the digitizer, with a digital reconstructed radiogram (DRR) calculated from the slices of the X-ray computer tomography. The application of this method allows less time for the proton beam therapy.

Two stages: First, the corresponding DRR of the patient is printed. Then the DRR contour is drawn out on transparent film. Also the target isocentre is marked at the DRR that defines the position of the beam axis relative to the patient on transparent film. Second, the digital X-ray image is loaded and displayed on the screen. Then the transparent film of the DRR is put on the screen. The drawn contour on the transparent film is superposed onto the X-ray image in the monitor.

After the superposition, the distance is measured from the center cross of the digital X-ray image to the target isocentre of the transparent film. Then, positioning the patient, the target isocentre is adjusted in the superposition to the axis of the beam.

Production of the digital X-ray image by digitizer of Konica Minolta Company takes 20 seconds. The old method with X-ray films, 3 minutes.

The application of the developed program together with the digital X-ray imaging technique will allow us to reduce the verification time down to one minute.

This program is the first version. In this version the superposition can't be made without an operator. The next version of the program is being written now and it will have a function for the automatic superposition.

TUE-NBA01-P1 #133 - Poster - Tuesday 5:30 PM - Rio Grande Room

Application of Positron Doppler Broadening Spectroscopy to the Measurement of the Uniformity of Composite Materials

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The uniformity of rubber-carbon black composite materials has been investigated with positron Doppler Broadening Spectroscopy (DBS). The number of grams of carbon black mixed into one hundred grams of rubber, phr, is used to characterize a sample. A typical concentration for rubber in tires is 50 phr. The S parameter measured by DBS has been found to depend on the phr of the sample as well as the type of rubber and carbon black. The variation in carbon black concentration within a surface area of about 5 mm diameter can be measured by moving a standard Na-22 or Ge-68 positron source over an extended sample. The precision of the concentration measurement depends on the dwell time at a point on the sample. The time required to determine uniformity over an extended sample can be reduced by running with much higher counting rate than is typical in DBS and correcting for the systematic variation of S parameter with counting rate. Variation in CB concentration with mixing time at the level of about 0.5% has been observed.

TUE-NBA01-P2 #264 - Poster - Tuesday 5:30 PM - Rio Grande Room

A high intensity positron source at Saclay: the SOPHI project.

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We are building the SOPHI experiment in Saclay, which is a device based on a small 5 MeV electron linac (1) to produce positrons via pair production on a tungsten target. This device should provide 108 slow e+/s, i.e. a factor 300 greater than the strongest activity Na22 based setups.

The SOPHI system has been finalized at the end of 2006 and the main components have been studied and built during 2007(2). The experiment is currently being assembled and first results are expected in June 2008.
The Linac, beam production and transport system will be presented, and first positron production rate measurements reported.

(1) Work supported in part by Conseil Général de l'Essonne under ASTRE 2006 funding
(2) Work supported in part by Research National Agency under contract number ANR-05-BLAN-0380-01

TUE-NBA01-P3 #560 - Poster - Tuesday 5:30 PM - Rio Grande Room

Status and perspectives for a slow positron beam facility at the HH-NIPNE Bucharest

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The development of a positron annihilation spectroscopy laboratory at the HH-NIPNE Bucharest- to be used for material studies and applications was started in the last 10 years. In the framework of a national research project extended over the last 3 years, was designed a lower energy positron accelerator, as a high-vacuum dedicated beam line with two options: a 25 mCi ^{22}NaCl source and in line with the NIPNE-cyclotron or a new intense compact cyclotron. The construction of the beam line was planned as a sequence of modules: source- moderator system; magnetical filter for fast positrons in order to select the positrons energies in the range 0.8 - 1 keV; a modular system for focusing, transport and acceleration of monoenegetic positrons in the energy range 0.8 - 50 keV and a CDBS analysis chamber. The moderator proposed - is tungsten as a foil of about 3μm prepared at the Optoelectronics Institute were put into a thermal treatment vacuum chamber and bombarded with electrons from a 100W electron gun .After the treatment, they were tested for changes of elemental composition of the surface and structure at the Polytechnic University. The structure tests were performed on a DRON 3M diffractometer, with a Co tube ($\lambda_{K\alpha}$=1.7903 A) - the angular regions studied were around 34^0 (1 0 0) and 69^0 (2 0 0). In the present time, the traiectories of the positron are going to be simulated with dedicated software (an ion and electron optics simulator). For the coincidence measurements (CDBS) set-up we used a home-made ^{22}NaCl source, by separation without carrier from a metallic Mg target irradiated with 12 MeV protons and separated by columnar cation exchange. A home- made biparametric system for CDBS measurements will be reported, also.

TUE-NBA01-P4 #612 - Poster - Tuesday 5:30 PM - Rio Grande Room

Positron Annihilation Lifetime Studies of ZnO Nanopowders

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Zinc oxide reveals numerous properties beneficial for applications in optoelectronics, spintronics, high temperature/high power microelectronics, and nanotechnology. For many of these applications, and especially for the nanoscale-based, the condition of the surface and the subsurface region is a key performance-defining factor. Current understanding of the relationship between the morphology of the ZnO nanostructures and their defect properties is still largely inadequate. The nature of the surface and sub-surface defect states is still ambiguous and only in a small number of studies in the past few years attempts were made to correlate properties of these states with the morphology of the nanocrystals themselves.

We employed positron lifetime (LT) measurements on a range of commercially available ZnO nanopowders (along with bulk single crystal ZnO as a reference). Positron annihilation spectra of the nanopowders reveal two major LT components, somewhat similar to the bulk lifetimes - a shorter one, most likely related to bulk recombination, and a longer one, associated with defect-related free volume. However, in all the nanopowders the defect-related LT component has a substantially higher relative intensity, indicating a significant abundance of defects. Moreover, we observe a correlation between the relative intensities and the values of the defect-mediated LT on the one hand and the average nanocrystal size on the other. Compression of the powders into pellets yields further modifications of the LT parameters. Our results indicate that substantial increase of the free surface in the nanopowder samples generates higher concentration of defects, consistent with the model of a crystal with defect-rich surface and subsurface layers.

TUE-NBA01-P5 #284 - Poster - Tuesday 5:30 PM - Rio Grande Room

Investigation of Normal Brain Section and Brain Section with Glioma Derived from a Rat Glioma Model Using Positron Annihilation Spectroscopy

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The application of positron annihilation lifetime spectroscopy (PALS) to the study of animal or human tissue has only recently been reported [1]. We have initiated a study samples of normal brain section and brain section with glioma derived from a rat glioma model. The preliminary results on samples fixed in 4% formalin show a decrease in o-Ps lifetime between the normal brain section and brain section with glioma. This suggests a reduction in mobility and thus free volume in the glioma. The change in lifetime is somewhat smaller than that reported for skin cancer samples [1]. Tissue samples are heterogeneous and this needs to be carefully considered if PALS is to become a useful tool in distinguishing tissue samples. The variation in o-Ps lifetime among normal samples and the effect of differences in formalin absorption in samples is also being investigated.

[1] G. Liu, et al. phys. stat. sol. (C) 4, Nos. 10, 3912-3915 (2007).

TUE-NBA02-P1 #395 - Poster - Tuesday 5:30 PM - Rio Grande Room

Studies of oxidation of the Cu (100) surface using a low energy positron beam

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Positron probes of surfaces of semiconductors and transition-metal oxides that play a fundamental role in modern science and technology are capable to non-destructively provide information that is both unique to the probe and complimentary to that extracted using other more standard techniques. We discuss the results of studies of oxidation of the Cu (100) surface using positron-annihilation-induced Auger-electron spectroscopy (PAES). PAES measurements show a large increase in the intensity of the annihilation induced Cu M2,3VV Auger peak as the sample is subjected to a series of isochronal anneals in vacuum up to annealing temperature 300º C. The intensity then decreases monotonically as the annealing temperature is increase to ~600º C. Experimental PAES results are analyzed by performing calculations of positron surface states and annihilation probabilities of surface-trapped positrons with relevant core electrons taking into account the charge redistribution at the surface, surface reconstructions, and electron-positron correlations effects. The effects of oxygen adsorption and defects on localization of positron surface state wave functions and annihilation characteristics are also analyzed. Possible explanations are provided for the observed behavior of the intensity of positron annihilation induced Cu M2,3VV Auger peak with changes of the annealing temperature.

TUE-NBA02-P2 #398 - Poster - Tuesday 5:30 PM - Rio Grande Room

Positron trapping at quantum-dot like particles on metal surfaces

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The physical and chemical properties of quantum dot structures have been the subject of extensive studies because of the prospects of an ever increasing range of their applications in semiconductor electronics, quantum communications, biological imaging, and cell technology. Measurements of the positron annihilation induced Auger electron (PAES) spectra from the Fe-Cu alloy surfaces with quantum-dot like Cu nanoparticles embedded in Fe reveal a large enhancement of the Cu PAES signal for surfaces created by enriching the Cu content of the Fe-Cu alloy. The observed large enhancement of the Cu PAES signal for the vacuum annealed surfaces is similar to that seen for the PAES signal of Au deposited on Cu [1]. In this talk we analyze these experimental results by performing calculations of positron surface states and annihilation characteristics at the Fe(100) surface with quantum-dot like Cu nanoparticles embedded in the top atomic layers of the host substrate. Positron surface states and annihilation characteristics also explored for the (100) and (111) surfaces of Cu with deposited Au. Estimates of the positron binding energy and annihilation characteristics reveal their strong sensitivity to the nanoparticle and adsorbate coverages. Theoretical core annihilation probabilities are compared with experimental ones estimated from the measured Auger peak intensities.

[1] K. Lee, G. Yang, A.R. Koymen, K.O. Jensen, A.H. Weiss, Phys. Rev. Lett., 72, 1866, (1994).

TUE-NP02-P1 #113 - Poster - Tuesday 5:30 PM - Rio Grande Room

Microscopic Calculations of the Dynamics of Peripheral Collisions at Fermi Energies and the Nuclear Equation of State

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A systematic study of quasi-elastic and deep-inelastic collisions at Fermi energies has been undertaken at Texas A&M aiming at obtaining information on the mechanism of nucleon exchange and the course towards N/Z equilibration [1,2]. We hope to get insight in the dynamics and the nuclear equation of state by comparing our experimental heavy residue data to detailed calculations using microscopic models of quantum molecular dynamics (QMD) type. At present, we have performed detailed calculations using the code CoMD (Constrained Molecular Dynamics) of A. Bonasera and M. Papa [3]. The code implements an effective interaction with a nuclear-matter compressibility of K=200 (soft EOS) with several forms of the density dependence of the nucleon-nucleon symmetry potential. CoMD imposes a constraint in the phase space occupation for each nucleon, effectively restoring the Pauli principle at each time step of the collision. Results of the calculations and comparisons with our residue data will be presented and implications concerning the isospin part of the nuclear equation of state will be discussed.

[1] G.A. Souliotis et al, Phys. Rev. Lett. 91, 022701 (2003).
[2] G.A. Souliotis et al, Phys. Lett. B 588, 35 (2004).
[3] M. Papa et al, Phys. Rev. C 64, 024612 (2001).

TUE-NP02-P2 #151 - Poster - Tuesday 5:30 PM - Rio Grande Room

Isoscaling and symmetry energy studies of reconstructed quasiprojectiles from collisions in Fermi energy regime

S. Galanopoulos, G. A. Souliotis, A. L. Keksis, M. Veselsky, M. Jandel, D. V. Shetty, Z. Kohley, S. Soisson, B. Stein, S. Wuenschel, S. J. Yennello
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Recent studies on heavy ion reactions have shown that the fragment yield ratios from a neutron rich and a neutron deficient fragmenting system follows an exponential dependence with respect to the neutron and proton number of the fragments, an effect known as isoscaling [1]. In this work, we measure the isoscaling parameter α and the nuclear temperature T as functions of the excitation energy of the reconstructed quasiprojectiles in $^{40}Ca+^{112,124}Sn$ reactions at the beam energy of 45 MeV/u. The measurements were performed at the K500 Cyclotron accelerator of Texas A&M University and the projectile fragments were detected using the Forward Array Using Silicon Technology (FAUST) [2,3]. Since the nuclear temperature and the isoscaling parameter are related to the nuclear symmetry energy [1], it is possible to determine the symmetry energy with respect to the excitation energy [4,5]. The results will be compared with the predictions of theoretical models.

[1] A.S. Botvina et al, Phys. Rev. C 65, 044610 (2002).
[2] F. Gimeno-Nogues et al, Nucl. Instr. Meth. A 399, 94 (1997).
[3] A.L. Keksis, PhD, dissertation (2007), Cyclotron Institute, Texas A&M University.
[4] G.A. Souliotis et al, C 75, 011601(R) (2007).
[5] D.V. Shetty et al, Phys. Rev. C 75, 034602 (2007).

TUE-NP02-P3 #336 - Poster - Tuesday 5:30 PM - Rio Grande Room

Cross sections of 116Sn, 114Sn, 64Zn and 46Ti at astrophysically relevant energies

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This is a continuation of Famiano et al. 2008, in which the total (p,g) cross sections of 116Sn, 114Sn, 64Zn and 46Ti were measured. An activation technique was used with proton center-of-mass energies of 1-4 MeV. Data was taken during the fall of 2006 using the tandem accelerator facility at Western Michigan University.

However, this project is looking for additional p-process reactions: the (a,n) and (p,n) reactions for all the nuclei listed above. The data will be reanalyzed to determine the cross sections of these reactions, from which we can then calculate the astrophysical S-factors. These will then be compared to the NON-SMOKER and MOST statistical model calculations. The isotopes in this experiment are of particular astrophysical importance because they are what is called "beta blocked" and cannot be produced by standard r- and s-processes.

TUE-NP03-P1 #19 - Poster - Tuesday 5:30 PM - Rio Grande Room

Generalized mass energy equation in universal equality of masses of nucleons and binding energy of nucleus

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There are two inherent observations; firstly masses of nucleons are fundamental constants, i.e., same universally (inside and outside the nucleus in all cases) and secondly nuclei possess BE ('DELTA' mc2) due to mass defect. To explain these observations of deuteron (BE = 2.2244MeV), the difference in masses of nucleons must be 0.002388 u or about 0.11854% of masses of nucleons outside nucleus. Thus theoretically masses of nucleons must be less in nucleus, which is not justified as all data is based upon equality of masses of protons and neutrons in all cases. If the applications of the generalized equation 'DELTA' E = Ac2 'DELTA' m are speculated in this regard, then it is capable of explaining both the observations simultaneously, i.e., equality of masses of nuclei (assuming infinitesimally small mass defect) and binding energy. As according to 'DELTA' E = Ac2 'DELTA' m even due to infinitesimally small mass defect (2.388×10^-14 u , say) the binding energy of deuteron can be 2.2244MeV due to presence of conversion factor A.

TUE-RE02-P1 #332 - Poster - Tuesday 5:30 PM - Rio Grande Room

Dose-dependent radiation damage in He ion irradiated Cu/V nanolayers

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Sputtered Cu/V nanolayers with individual layer thickness (h) of 1 to 100 nm were subjected to helium ion irradiation with a peak dose of 0.5-10 dpa. The effects of radiation dose on evolution of microstructure and mechanical properties have been investigated. A similar hardening trend has been observed in specimens radiated with different doses, i.e., radiation hardening decreases with decreasing layer thickness. Radiation hardening seems to reach saturation when peak dose is 5 dpa. Hardening is negligible for fine (h smaller than 2.5 nm) nanolayers at all dose levels. Evolution of microstructure as a function of dose and layer thickness is investigated. Potential mechanisms of interface-defect (induced by radiations) interactions under the context of length scale will be discussed.

TUE-RE02-P2 #480 - Poster - Tuesday 5:30 PM - Rio Grande Room

Study of Effective Atomic Number in Compounds Using Gamma-Ray Interaction

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In view of the applications of mass and mass-energy attenuation coefficients of gamma radiation in shielding design and medical diagnostic respectively [1&2], we have made an attempt to carry out the experimental and theoretical works on mass attenuation coefficients and effective atomic number (Zeff) for various NH4Cl, KCl, and CdO compounds.

The experimental setup followed is for a narrow geometry. We have used Na-22 (511, 1274), Cs-137 (661.6), Mn-54 (835), Co-60 (1173, 1332 keV) as gamma sources and NH4Cl, KCl, and CdO as target compounds. The integral intensities of the beam before and after passing through the sample are measured for sufficient time. The experimental mass attenuation coefficient of the sample is then estimated by the known relation.

The theoretical mass attenuation coefficient has been estimated by the known mixture rule and from the knowledge of the mass attenuation coefficients of all the elements (whose values may be obtained from XCOM data [3]) present in a molecule of the sample. Both experimental and theoretical Zeff of the compound sample have been estimated from the knowledge of mass attenuation coefficient, Molecular, Atomic and the Electronic cross sections.

Both experimental and theoretical mass attenuation coefficient as well as Zeff of all the samples have been tabulated and their variations with photon energy have been shown in figures.All kinds of errors arise in the experiments have been discussed. The experimental and theoretical results show a fairly good agreement and energy dependence. The results obtained in the present study are found to be useful for future dosimetry and radiation shielding applications.

[1] Hubbell J H, Phys.Med. Biol. 44 (1999) 1.
[2] Hubbell J H, Phys.Med. Biol. 51 (2006) 245.
[3] Berger M. J, Hubbell J.H, XCOM Data, NBSIR 87 (1987) 359 .

TUE-RE02-P3 #617 - Poster - Tuesday 5:30 PM - Rio Grande Room

Defect Kinetics and Magnetic Studies of Ion-Irradiated FePt Nanoparticles

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FePt nanoparticles have acquired interest as possible candidates for obtaining large magnetic storage capacities. The 4 nm FePt nanoparticles with uniform size distribution are synthesized by simultaneous polyol reduction of platinum acetylacetonate and iron chloride in the presence of organic surfactants. Chemically synthesized FePt particles usually are in the FCC phase and they need to be thermally annealed above 500 °C to transform to the L10 phase that has high magnetic anisotropy and large magnetic coercivity. In order to avoid particle aggregation and sintering during high temperature annealing, we used 300 keV Al+-irradiation [NIM-B241 (2005) 583] and 1 MeV proton-irradiation [ANS Proc. 2007, pp319-325] to obtain vacancy-defects enhanced phase transformation at lower temperatures (~200 °C due to the migration of vacancies). SRIM-2003 computer code is used to estimate the depth profile, the energy loss, and the defect creation in FePt nanoparticles. Low temperature annealing showed promising results, but further annealing higher temperatures showed detrimental effects due to lattice strain produced by larger defect clusters. The detrimental effects are more prominent in proton-irradiation compared to Al+-irradiation and the effects of vacancy clusters seam to remain stronger even at higher temperatures. The magnetization results indicate the dissociation of vacancy clusters at annealing temperatures above 600 °C. The magnetization studies of 700 °C annealed particles aged for one year at room temperature showed defect strain release over time.

TUE-RE03-P1 #126 - Poster - Tuesday 5:30 PM - Rio Grande Room

Early stages of the ion irradiation tests for space application devices at the Centro Nacional de Aceleradores (Spain)

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Particle radiation effects are a fundamental trouble in the use of numerous devices for space appli-cations, which is aggravated with the technology shrinking towards smaller and smaller scales. The suitability of low-energy accelerators for irradiation testing is being considered nowadays. The facilities at the Centro Nacional de Aceleradores (CNA), typically used for ion beam characterization of materials, are a valuable tool to perform prevalidation tasks. Indeed, our 3 MV Tandem accelerator can supply protons and other heavy ions to do experiments in the low LET region. Moreover, the possibility to use a nuclear micro-probe, with a lateral resolution of a few microns, allows us to evaluate the behavior under ion irradiation of specific elements in an electronic device. On the other hand, the installation of an external beam line in our Cyclone 18/9 cyclotron turns this accelerator into the highest energy facility in Spain for materials irradia-tion using protons. This accelerator provides protons at 18 MeV, while the accepted threshold for significant chip radiation damage is located at 20 MeV.

The energies of the particles supplied by our accelerators are not high enough to achieve certified tests as stated by the ESA requirements. However, during the device's design process, some experimental difficulties can be surmounted performing previous tests at low cost. In this work, the main elements of our laboratory will be briefly described and the first examples of ion irradiation tests in our Centre will be presented.

TUE-RE03-P2 #223 - Poster - Tuesday 5:30 PM - Rio Grande Room

Effects of Radiation Damage on Void Evolution in He-implanted SiC

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Understanding of Ostwald ripening of voids in SiC is important for fabrication of high temperature and high frequency devices. SiC has also been proposed as structural materials in next generation high temperature reactor concepts. Recent studies suggested that gas-filled voids will release their stress by absorbing vacancies, thus growing in their sizes. This suggests that void densities and sizes in gas atom implanted SiC should be affected by the amount of damage introduced. However, there is a lack of systematical studies in which radiation damage is separated from gas atom implantation. Such a study is expected to provide insights into the phenomena and validate the existing empirical formula. In this study, we pre-implanted SiC with 1 MeV Si self ions to different fluencies. He ions were then introduced, followed by furnace annealing under different conditions. Voids formed in SiC were investigated by using transmission electron microscopy (TEM). Void evolution has been studied and compared with the existing model.

TUE-RE03-P3 #231 - Poster - Tuesday 5:30 PM - Rio Grande Room

Effects of Void Formation on Electron Transport in Si

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We have studied the effect of void formation on electron transport in Si. Ultra high fluence He ion implantation, followed by furnace annealing, is used to form voids in monocrystalline Si. With increasing thermal budget in annealing, defects are removed and voids are left inside Si. Characterization of voids is realized by using transmission electron microscopy. Selected samples are characterized by using spreading resistance analysis. The depth profile of resistivity changes reflects the efficiency in electron transport. The study is driven by the needs to fabricate advanced electronic devices and detectors.

TUE-RE03-P4 #248 - Poster - Tuesday 5:30 PM - Rio Grande Room

Reduction of effective carrier density and charge collection efficiency in SIC devices due to radiations

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The particle detectors operating in high radiation environments like J-PARC (Japan Proton Accelerator Complex), super-LHC (Large Hadron Collider), and space must exhibit radiation hardness. In these radiation environments, Silicon (Si) is applied to a particle detector at present. However, it is considered that Si detectors do not have enough radiation tolerance. Therefore, developing new particle detectors with superior radiation tolerance is required. Since, Silicon carbide (SiC) is regarded as one of the candidate materials for electronic devices with radiation hardness, we have developed the SiC particle detectors. In this study, we evaluate the radiation hardness of the SiC detectors from the point of view of the Charge Collection Efficiency (CCE) degradation. CCE is one of the most important physical parameters indicating the performance of particle detectors. Since CCE is strongly affected by the effective carrier density, then, we also evaluate the degradation of the effective carrier density. 6H-SiC diodes are fabricated and irradiated with Co-60 gamma rays, 1MeV electrons, 65MeV protons at Japan Atomic Energy Agency (JAEA) Takasaki. After the radiation damages are introduced in devices, the CCE is evaluated by using Transient Ion Beam Induced Current (TIBIC) system connected with the Tandem accelerator at JAEA Takasaki. The effective carrier density is evaluated from C-V (Capacitance-Voltage) characteristics. It is found that both the CCE and the effective carrier density decrease with increasing the fluence. We discuss whether Non-Ionizing Energy Loss (NIEL) analysis can be applied to these degradation behaviors. The concept of NIEL has gained considerable acceptance in describing radiation effects in devices. According to this concept, the observed degradation is independent of the radiation sources and energies. Results from this study suggest that the degradation of the CCE and the effective carrier density can be predicted for any ion species and energy using the concept of NIEL.

TUE-RE03-P5 #249 - Poster - Tuesday 5:30 PM - Rio Grande Room

Change in Ion Beam Induced Current from Si Metal-Oxide-Semiconductor Capacitors after Gamma-Ray Irradiation

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Metal-Oxide-Semiconductor (MOS) capacitors were fabricated on both n- and p-type Si substrates (n-MOS, and p-MOS). These MOS capacitors were irradiated with gamma-rays at a dose rate of 6.3 kGy (SiO2)/h for 1 hour at room temperature. During irradiation, 0.3 MV/cm electric field was applied to gate oxide. The capacitance-voltage characteristics for MOS capacitors were measured before and after irradiation. The flat band shift for n-MOS and p-MOS capacitors due to gamma-ray irradiation at 6.3 kGy(SiO2) was -12.3 V and -15.2 V, respectively. As for the generation of interface traps (DDit), the values for n-MOS and p-MOS capacitors were estimated to be 0.5x1011 /cm2 and 1.7x1011 /cm2, respectively. Transient Ion Beam Induced Current (TIBIC) obtained from these MOS capacitors were compared before and after gamma-ray irradiation. For n-MOS capacitors, the peak height of TIBIC signals decreased after gamma-ray irradiation. On the other hand, the peak height of TIBIC signals for p-MOS capacitors increased after gamma-ray irradiation. The applied bias dependence of the peak height of TIBIC signals for MOS capacitors irradiated with gamma-rays can be mathced to that for ones before gamma-rays irradiation by shifting the voltage by -13 V for n-MOS capacitors and by -15 V for p-MOS capacitors. These voltage values are in good agreement with the flat band voltage shifts due to gamma-ray irradiation. Since flat band shift occurs due to the generation of positive charge trapped in gate oxide, the change in TIBIC signals observed for MOS capacitors due to gamma-ray irradiation can be interpreted in terms of positive charge generated in oxide. No significant effects of interface traps generated by gamma-ray irradiation on TIBIC signals are observed from MOS capacitors when the value of DDit is in the order of 1011 /cm2.

Sandia is a multiprogram Laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

TUE-RE03-P6 #262 - Poster - Tuesday 5:30 PM - Rio Grande Room

Study of defects by self-ion implanted Si using TEM

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Defects in self-ion irradiated silicon were studied by using a transmission electron microscopy. The Si (100) samples were implanted with 1 MeV Si^+ ions and fluences from 1×10^{15} to 1×10^{16} ions/cm^2. The implanted samples were annealed from 600 to 1000°C for 30 minutes. A layer of defects could be observed in the as-implanted sample with a fluence of 1×10^{15} ions/cm^2. However, a continuous and amorphous buried-layer was formed with a fluence of 5×10^{15} ions/cm^2. The amorphous layer was lying 1.0μm from the surface and was about 0.7μm width. It should be noticed that no obvious defects were observed in the region between the surface and the buried layer for the as-implanted samples. We found that there were fewer EOR (end of range) damage observed in the 1×10^{16} ions/cm^2 sample than the one in the 1×10^{15} ions/cm^2 sample at 1000°C, 30 min. annealing condition. It means that a better crystalline recovery may be achieved with the annealing treatment as a fully amorphous layer is formed during the ion implantation.

TUE-RE03-P7 #384 - Poster - Tuesday 5:30 PM - Rio Grande Room

A Broad, Uniform Flux Alpha-Particle Beam for Accelerated SEU Testing

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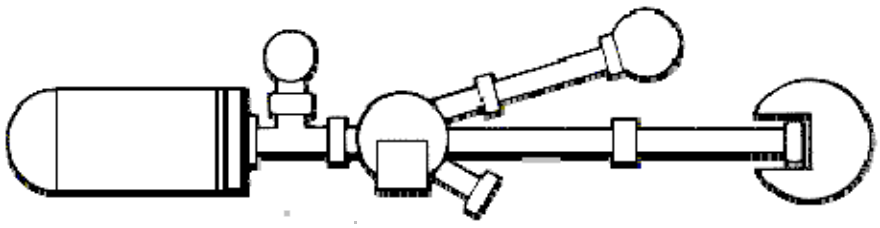
The use of radioactive alpha particle sources (e.g. Am-241, Th-228) of several micro Curie activity for the single event upset (SEU) testing of memory devices is common practice. However, the fixed energy nature of these sources and the distributed angle of incidence resulting from their point-source-like irradiation geometry leaves researchers wanting a collimated, broad-beam accelerator driven source for such work. The University of North Texas (UNT) Ion Beam Modification and Analysis Laboratory (IBMAL) has developed an SEU testing chamber that uses a broad beam of collimated alpha particles with uniform density over an area of at least 1.5" diameter. These alpha particles can be produced at energies from 1 to 9 MeV, and at fluxes ranging from 100 to 100,000 (alpha/sq. cm)/s. This flux can uniformly irradiate a 512 Mbit SRAM memory array and four PIN diodes that surround the array, which measure dose coincidently with upsets. Measured SEU/dose rates of the 512 Mbit arrays using 5.5 MeV alphas in the broad-beam testing chamber agree with rates measured using a 10uCi Am-241 source. Further discussion of the use of the 3MV tandem accelerator and SNICSII ion source of IBMAL to produce multi-MeV beams of Si, Mg and other SEU relevant ions at low intensity and broad area uniformity will also be presented.



WEDNESDAY

WED-AP05-1 #97 - Invited Talk - Wednesday 8:30 AM - Elm Fork

Measurement of Polarization for Radiative Electron Capture Transistions in Highly Charged Ions

Harald Braeuning[1], Sebastian Hess[1], Uwe Spillmann[1], Christophor Kozhuharov[1], Thomas Krings[2], D. Protic[2], Martino Trassinelli[3], Serge Trotsenko[1], Guenter Weber[1], Regina Reuschl[1], Sabrina Geyer[1], Renate Maertin[1], Thomas Stoehlker[1]
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Radiative electron capture (REC) is the time inverse process of photoionization and thus the radiation is strongly polarized. In relativistic collisions with highly charged ions, the presence of spin-flip effects leads to a depolarisation of the x-ray emission particularly in the forward direction. Experimentally only very few studies of the polarisation properties for REC especially in the x-ray regime are available.

We will report on recent measurements using a new position and energy sensitive Si(Li) detector with an active area of 64x64 mm^2 as a dedicated Compton polarimeter. Such detectors employ the sensitivity of the azimuthal Compton scattering angle to the polarisation of the incoming photon. Simulations as well as tests with radiation of known polarisation show, that these detectors can operate as nearly perfect polarimeters.

New data on the polarisation of K-REC into U^{91+} at 44 MeV/u and Xe^{54+} at 120 MeV/u will be presented. The high degree of polarisation compares well with theoretical predictions. In the case of U^{91+} for the first time also the polarisation of the two L-REC lines (capture into the $2p_{1/2}$ and $2p_{3/2}$ state) could be obtained. Finally an outlook will be given to current experiments trying to measure the predicted depolarization at high energies under forward emission angles.

WED-AP05-2 #111 - Invited Talk - Wednesday 8:30 AM - Elm Fork

Electron transfer to continuum in near relativistic ion-atom collisions

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Theories for electron transfer to the continuum have encountered considerable difficulties to take into account the intrinsic many-electron processes in the capture channel. This may partially be attributed to large momentum transfers involved and thus collision systems are mostly not in the realm of first order perturbation theories. For this reason we have studied simultaneously competing electron transfer processes, like radiative(RECC) and non-radiative electron capture to continuum (ECC) in the relativistic domain where one or two active electrons are involved; here the projectile electron loss to continuum (ELC) permits additionally to study the dynamics of ionization very close to threshold. We have studied these electron transfer processes in forward electron emission in two systems of different projectile Compton profile, U88+ + N2 and Sn47+ + N2 collisions using the forward electron spectrometer at the supersonic jet-target of the ESR storage ring.We report first results and compare with theory.

WED-AP05-3 #513 - Invited Talk - Wednesday 8:30 AM - Elm Fork

Atomic physics involving antiprotonic complex: antihydrogen atoms and antiprotonic atoms

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We have been developing intense ultra-slow antiproton beams to synthesize cold antihydrogen atoms and to study collision dynamics of antiprotonic atom formation processes. Syntheses of antihydrogen atoms, the antimatter counterpart of hydrogen, are in itself quite interesting, which involves three body recombination processes of antiproton and positron at several K under strong magnetic field. What is more, the most important aspect is the fact that it is the essential first step to make high precision comparison of hydrogen and antihydrogen atoms, providing a stringent test scheme of the CPT symmetry in the hadron sector as well as the lepton sector. From the atomic collision physics point of view, antiproton provides a chance to study collision dynamics of "negative proton" or a "heavy electron". In contrast to proton impacts, antiprotons do not capture electron, which simplifies the overall collision processes, and greatly helps our understanding on the collision dynamics of heavy charged

particles with atoms/molecules. On the other hand, at low energies, antiproton itself can be captured by atoms/molecules via exchange collisions with initially bound electron(s), an antiprotonic formation process. This resonant reaction channel opens only for heavy negatively-charged particles with kinetic energies lower than the bound electrons in the center of mass frame. At the conference, I will present the latest results on the antihydrogen formation and trapping experiments as well as ionization and antiprotonic atom formation experiments.

WED-AP05-4 #306 - Invited Talk - Wednesday 8:30 AM - Elm Fork

A Resonant Ionization Laser Ion Source for Radioactive Ion Beams

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The availability of beams of exotic nuclei far from stability offers unique and exciting opportunities to study the structure of the nucleus, the stellar processes which power the universe, and the fundamental laws of physics. However, the purity of the radioactive ion beams is of crucial importance for many experiments. One of the laser-based beam purification techniques being developed at the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory is resonant laser ionization. A resonant ionization laser ion source based on all-solid-state, tunable Ti:Sapphire lasers is being developed at HRIBF. In such an ion source, atomic species can be selectively ionized by laser radiation via stepwise atomic resonant excitations followed by ionization in the last transition. In order to yield useful intensities of radioactive ion beams, maximum ionization efficiency is required. The ionization efficiency is often limited by insufficient laser power to saturate the ionization step. It is thus important to find ionization schemes that lead to ionizing an excited atom through an auto-ionization or Rydberg state, which are much more efficient than non-resonant transitions to the continuum. Spectroscopic studies on the ionization schemes for numerous elements of interest are being carried out. Three-photon resonant ionization of selected elements including Sn, Ni, Ge, Cu, Mn, Fe, Co, Ho, Tb, and Dy has been demonstrated. The overall efficiency of the laser ion source for some of these elements has been measured to be 2-40%.

WED-FIBP03-1 #482 - Invited Talk - Wednesday 8:30 AM - Post Oak

Evaluation of Lá x-ray production cross sections for PIXE applications

Gregory Lapicki
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Empirical fits for L-subshell ionization [1], updated on the basis of semi-empirical corrections [2] in [3,4] for Lα x-ray production in Z2=47-92 elements by protons up to 4 MeV, are evaluated in terms of the ECPSSR theory [5] and its modifications for the united atom and DHS wavefunction effects [6]. Also discussed are the role of intra-shell coupling and the choice of atomic parameters for conversion of ionization theories to x-ray data.

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WED-FIBP03-2 #106 - Invited Talk - Wednesday 8:30 AM - Post Oak

Some new results on stopping power for fast ions

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Using our large collection of experimental stopping power data, we compare these data statistically with various theories and stopping codes, in order to judge the quality of both data and theories.

We discuss the influence of the state of aggregation of the target upon stopping power, and the importance of choosing the best value of the ionization potential of the target for medical applications.

WED-FIBP03-3 #137 - Invited Talk - Wednesday 8:30 AM - Post Oak

Developments in the external beam setups at LABEC, Florence

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Except for very specific cases, the Florence group of applied nuclear physics has always been working with external beams for PIXE and IBA in general: in the past twenty five years they have been routinely used for all applications to Cultural Heritage, environmental studies, geology, material science.

Since 2004, with the installation of a new laboratory (named LABEC) based on a 3 MV Tandetron accelerator, additional beam lines were built up for IBA and all setups were significantly improved. At present, three independent external beam lines, dedicated to different applications, are in operation: one with a scanning micro-beam and two with a collimated-beam.

The talk will review various technical aspects, focusing on recent developments in instrumentation and available techniques that extend the information provided by PIXE and improve its quality.

In particular, the external scanning microbeam will be shortly described, where an effective beam size of less than 10 micron on target can be achieved. The traditional setup for PIXE (two detectors) and PIGE has been supplemented with the instrumentation for back- and forward- scattering analysis; lately, also IBIL and IBIC are possible. With all techniques, the extra advantage of space-resolved analysis can be exploited.

The solutions adopted to improve the standard PIXE setups at the external collimated beam lines will also be illustrated, with particular attention to the innovative X-ray detection system currently under development, based on a Silicon Drift Detector chip coupled to a slightly focusing polycapillary lens.

WED-FIBP03-4 #324 - Contributed Talk - Wednesday 8:30 AM - Post Oak

Measurement of K-L radiative vacancy transfer probabilities in rare earth elements bombarded with 12C and 16O ions

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In a previous work, the measurement of radiative vacancy transfer probabilities from the K shell to the L sub-shells were measured, when rare earth elements were irradiated with 3 MeV - 4 MeV protons. It was found that those probabilities did not depend on the ion energy and there was a close agreement with theoretical predictions. Therefore, in this work the K-shell X-ray intensity ratios for rare-earth elements have been measured following irradiation with 12C and 16O ion beams. From the X-ray intensity ratios, the radiative vacancy transfer probabilities from the shell K to the L sub-shells were determined. The experimental data were compared to theoretical predictions, such as the Scofield theoretical predictions for these probabilities. The results showed a good agreement between theory and experiment, and did not show a dependence with the ion incident energy.

WED-FIBP03-5 #308 - Contributed Talk - Wednesday 8:30 AM - Post Oak

Analysis of textile fibers by in-air PIXE

David Jezersek[1], Sabina Jakomin, Ziga Smit[1,2]
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[(2)]Faculty of Mathematics and Physics, University of Ljubljana, Jadranska 19, Ljubljana SI-1001, Slovenia

Trace elements in textile fibers were analyzed by the in-air PIXE method. A single fiber was positioned in the beam and used as a target, as our aim was also to analyze small amounts of material, which may be the case in forensic studies. For quantification of the concentrations, the X-ray production was assumed to occur in thin cylindrical target which was only partly hit by the beam. In the model we calculated the irradiated volume and the distribution of X-ray escape lengths. The beam intensity was calculated as a convolution of the step function in a cylindrical geometry and a Gaussian distribution which described lateral straggling of the projectiles; however, due to the small exit window, the beam profile at the target was practically Gaussian. For normalization, the argon signal induced in the neighboring air was used. The beam parameters were determined experimentally by scanning the beam profiles for different exit windows. The calibration parameters were tested by the analysis of thin metal wires.

WED-FIBP03-6 #246 - Contributed Talk - Wednesday 8:30 AM - Post Oak

Middle energy PIXE preliminary experiments

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The "Institut de Physique Nucléaire, Atomique et de Spectroscopie" (IPNAS) has a CGR MeV 520 Cyclotron almost entirely devoted to archaeometry and cultural heritage research. The laboratory, in collaboration with the "Centre Européen d'Archéométrie" (European Archaeometry Center, CEA), is mainly active in material analysis by means of IBA techniques: PIXE, PIGE and RBS. A new beam line is under development to analyze simultaneously cultural heritage objects with these three techniques. Our accelerator allows us to produce middle energy protons or alpha particles beam (up to 20 MeV) with high resolution. Several experiments have been done on some standard samples to highlight the advantages and the disadvantages of middle energy PIXE.

In this poster the results of those preliminary experiments will be shown, focusing on the one hand on middle energy proton beam and on the other hand on middle energy alpha particle beam.

It aims, first, to explore the potentials of alpha particles induced X-ray emission (alpha-PIXE) using 6, 8.7 and 12 MeV beams and to compare its performance with conventional 3 MeV proton PIXE. The peak signal-to-noise ratio of the X-rays will be compared for those different energies. Secondly, the peak signal-to-noise ratio and the ratio between the intensities of the K X-ray and the L X-ray for object containing heavy metals (Au, Pb,...), in the case of middle energy protons beam (3, 6 and 8 MeV), will be also compared.

WED-IBM08-1 #33 - Invited Talk - Wednesday 8:30 AM - Pecos II

Modification of Polymer Materials by Ion Bombardment

Dariusz Marian Bieliñski[1,2], Jacek Jagielski[3,4], Piotr Lipiñski[2], Diana Pieczyñska[1], Urszula Ostaszewska[1], Anna Piatkowska[3]
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[(3)]Institute for Electronic Materials Technology, Wolczynska 133, Warsaw 01-919, Poland
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Application of ion bombardment for modification of polymer materials has relatively short history in comparison to metals or ceramics. Contrary to general concern on possible material degradation, proper selection of ion mass, chemical reactivity towards target, ion fluence and beam energy, makes possible not only to improve durability of polymers but to produce materials of interesting characteristics. The paper presents results of structural and functional investigations: infrared spectroscopy, RBS and NRA, nanoindentation, contact angle, surface geometry, tribological and conductivity tests for wide range of polymer materials. Special attention has been devoted to the possible reduction of friction by application of ion bombardment. The most significant example is a carbon black filled nitrile rubber (NBR) bombarded with light ions, for which the coefficient of friction could be reduced up to 5 times. The effect is explained by the modification of surface composition, structure and geometry, which in turn reflect hardness and surface energy of polymer materials. Application of ion bombardment can significantly modify surface wettability. For PE materials ion implantation usually leads to increased wettability, whereas in the case of PTFE it was possible to obtain a super hydrophobic surface. General hardening of the surface layer, being the result of ion bombardment improves wear resistance of polymer materials. Limited depth of the modification is an advantage in terms of dynamic applications. Hard skin is thin enough not to adversely affect cracking resistance, what is a problem for polymers subjected to conventional chemical treatment. Contrary to chlorination or sulfonation, ion beam bombardment works even in the case of materials resistant to the modification, e.g. silicone rubber or polyolefines.

WED-IBM08-2 #471 - Invited Talk - Wednesday 8:30 AM - Pecos II

Ion-Beam Surface Modification for Implantable Biomaterials

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Implantable medical devises require (1)Safety(lifelong antithrombogenesity and good biocompatibility), (2)Reliability and Durability and (3) Effectiveness. It is widely recognized that heparin and/or polymer coatings demonstrate significant anti-thrombogenic effects for hours up to several days. However, implantable biomaterial requires a more prolonged coating life of several years and possibly being permanent ideally. Recently, we developed a new nanotechnology of ion-beam surface modification which permanently produces an anti-thrombogenic surface property.

In-Vitro and In-Vivo studies were performed to verify the ability of this new technology. Biomaterials including Polystyrene(PS), ePTFE, Titanium(Ti) and Ti-Ni alloy were coated with type-1 collagen and then irradiated by He^+ ion-beam with fluencies between 1 x 10^{13} and 1 x 10^{16} ions/cm^2. The results of platelet adhesion and cell attachment In-Vitro tests demonstrated that platelet adhesion was depressed at fluencies of 1 x 10^{13} ions/cm^2 (Ti, Ti-Ni alloy), 1 x 10^{14} ions/cm^2(PS, ePTFE) while endothelial cell attachments remained. Twenty Ti-Ni alloy stents (4 x 25mm) which underwent He^+ ion-beam surface modification were implanted into the femoral artery of ten canine. One month patency was 80% with no anti-thrombogenic drugs. Ten stents are still patent after two years with no drugs. These results revealed that a new nanotechnology of ion-beam surface modification is able to maintain anti-thrombogenic effects on implantable biomaterials for longer time periods without anti-coagulant and anti-platelet drugs.

WED-IBM08-3 #578 - Invited Talk - Wednesday 8:30 AM - Pecos II

ION BEAM PROCESSING OF POLYMERS: BASICS AND APPLICATIONS

A Leslie Evelyn
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The convergence of two chronological events, the advancing use of plastics and the proliferation in radiation environments, has resulted in basically two emergent technologies: the development of polymers for use in radiation environments and the use of radiation to develop and modify polymer materials for specialized applications. The types of radiation found in radioactive environments include energetic photons, thermal neutrons, fast neutrons, light ions and heavy ions. Chemical changes are produced in plastics by the ionizing radiation interacting with the polymer material resulting in the liberation of electrons from the atoms of the polymers. Radiation induces modifying processes in the polymer chains that produce chemical changes in the materials' properties. These processes can occur separately or in combination with one another and, depending on the nature of the material, one or more can occur simultaneously. Molecular excitations may be transmitted through the material as phonons or excitons which may cause bonds to break and produce scission, and cross-linking of the polymer chains. In many cases, dissociated hydrogen atoms and other small molecules move through the material and diffuse out as volatile species are formed. Dehydrogenation or the liberation of hydrogen atoms produces dangling bonds which eventually saturate and results in cross-linking. Other molecular emission processes, double bond formation, triple bond formation, dipole formation and precipitate formation by self clustering of the injected species can also occur. Our studies have revealed the effects on the polymers by radiation using energetic ion beams and have allowed us to modify the polymers as a result. This is a review paper of our work on the ion beam interaction with polymers, published as a chapter in the book, Advanced Functional Molecules and Polymers Vol. 4, Gordon and Breach Science, Japan, (2001).

WED-IBM08-4 #255 - Contributed Talk - Wednesday 8:30 AM - Pecos II

Structural and optical characterization of 60 MeV Si5+ ion irradiated PoT-PVC blends

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Organic semiconductors have attracted enormous research because of their potential applications as sensors, Field effect transistors, LEDs and Solar cells etc. The conduction mechanism and other properties of organic semiconductors have not been understood completely. Poly (o-toluidine) (PoT), a derivative of polyaniline, which is relatively environmental stable, is chosen for the present study. PoT powder is prepared by chemical oxidation polymerization and is blended with PVC to achieve self supported films. These Poly (o-toluidine)-PVC blend films are irradiated by 60 MeV Si5+ ions at different fluences. Pre and post irradiation FTIR, UV-Visible and XRD studies are carried out on these films to observe the changes in structural and optical properties. FTIR studies show a decrease in the intensity of vibrational modes indicating some changes in the structural properties. XRD studies show formation of two new crystalline peaks with fluence. The optical band gap calculated from UV-Visible absorption spectra show an increase in optical band gap with fluence. In polymers bond breaking and chain scissoring take place due to irradiation, which lead to molecular rearrangements. These re-arrangements cause the formation of new bonds and crystallite zones in polymers lead to the changes in optical and electrical properties. The paper discusses detailed experimental studies on these irradiated samples.

WED-IBM08-5 #337 - Contributed Talk - Wednesday 8:30 AM - Pecos II

Enhanced stiffness of GPC composites by MeV Ion bombardment

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As air travel continues to grow, the drive for new advanced material keeps increasing. Materials designed for aerospace structures must obey the most extreme property demands. Devices made from Glassy Polymeric Carbon GPC have proven to meet these physical, chemical, thermal and mechanical property requirements. Indeed, GPC is a lightweight material that can maintain dimensional and chemical stability in adverse environment. At Alabama A&M University (AAMU), we are developing higher-performance materials that would improve durability and designed stiffness by combining GPC and nano "powdered" materials and by bombarding composites with high energy ions.

WED-MA05-1 #500 - Invited Talk - Wednesday 8:30 AM - West Fork

Clinical Ion Beam Application: Planning, Application, Quality Control

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The most essential part of ion beam therapy is the interface between accelerator and patient i.e. the treatment planning and beam application system and its control. Intensity Modulated Radio-Therapy (IMRT) with photons has outdated the 50 year old passive application technology concerning field precision and neutron-induced secondary tumors.

Therefore, the new technique of active beam delivery has been developed that uses a fine pencil beam to paint a net of some 10 to 50 000 pixels distributed in 3 dimensions over the target volume. Because of the nonlinear geometry of the particle depth-dose curves and the normally more complex field geometry, each pixel has to receive a particle number different from its neighbour in order to achieve a homogeneous effect over the complete tumor. In case of the heavier carbon ions, the variation of the RBE over the target field has to be included. For "particle IMPT" with simultaneous multifield optimization, the coverage of the treatment field with particles becomes even more complicated.

In order to control the position-exact delivery of the fluence, fast online detectors have to monitor the beam in real time proximal to the patient. In addition, the accelerator has to deliver all the requests on Multiple Energy, Focus and Intensity (MEFI) settings. For an additional quality control, the decay of radioactive Positron emitters created in nuclear reactions of the fast ions with tissue is monitored using an online PET camera. This in-beam PET allows monitoring of the beam penetration.

Modern ion beam therapy has become a very complex but also very successful technique, producing tumor control rates better than 80%, even for difficult cases.

WED-MA05-2 #494 - Invited Talk - Wednesday 8:30 AM - West Fork

Scanned Carbon Pencil Beams for Tumor Therapy

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At GSI, a fully active beam application has been developed for tumor therapy with carbon ions. In this so-called rasterscan system, the tumor volume is split into ~60 slices of iso-energies ranging from ~90-430 MeV/u (range: 1.8-30.7 cm) which can be combined with variable beam diameters and intensities. For each iso-energy slice, beam is requested from the synchrotron and delivered as a narrow pencil beam (beam's full width at half maximum 3-10 mm). For lateral target coverage, this pencil beam is deflected to hundreds of grid positions per iso-energy slice by orthogonal dipole magnets. At each grid position, an optimized number of particles is deposited intensity-controlled, i.e. ionization chambers monitor the dose deposition and trigger deflection to the next grid position once the required dose level is achieved. This method allows intensity-modulated treatment fields necessary to deposit a uniform biological effective dose, but also enables parallel optimization of multiple fields that allows better sparing of organs at risk in the vicinity of the tumor volume.

Scanned-beam delivery facilitates target conformal and homogeneous dose delivery for stationary targets. For tumors located in the head & neck, as well as tumors in the pelvic region, very promising results were achieved in the carbon therapy pilot therapy project started at GSI in 1993. A comparable project is conducted at Paul-Scherrer-Institut (PSI) in Switzerland with a scanned proton beam. One of the current research topics is the treatment of moving targets, such as lung tumors. Scanned-beam delivery requires but also offers possibilities to conformally irradiate moving target sites.

WED-MA05-3 #469 - Invited Talk - Wednesday 8:30 AM - West Fork

Application of Positron Emission Tomography for Radiotherapy Monitoring

Georgy Shakirin[1], Fine Fiedler[1], Daniela Möckel[1], Katia Parodi[2], Jörg Pawelke[1,3], Marlen Priegnitz[1], Wolfgang Enghardt[1,3]
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Positron emission tomography (PET) is used for independent monitoring of dose delivery in ion therapy. An in-beam PET scanner registers the annihilation γ-rays following the decay of minor amounts of β^+ radioactive nuclei, which are produced via nuclear reactions between the ions of the therapeutic beam and the atomic nuclei of the irradiated tissue. From a comparison of the reconstructed activity distributions with those predicted from the treatment plan, deviations between the prescribed and the applied dose distributions can be detected. In-beam PET, therefore, allows verification of the physical beam model used in the treatment planning, to detect patient dislocations and density changes in the irradiated tissue. Treatment of more than 400 patients has been monitored by means of in-beam PET at Gesellschaft für Schwerionenforschung (GSI), Darmstadt, Germany. The in-beam PET method demonstrated a positive clinical impact as an *in vivo*, *in situ*, non-invasive technique for independent monitoring of dose application.

WED-MA05-4 #477 - Contributed Talk - Wednesday 8:30 AM - West Fork

Development of Pencil Beam Scanning for Proton Therapy

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Scanning methods are in the vogue today. In particular, pencil beam scanning modality allows very conformal dose deposition while reducing the dose to healthy tissue and organs at risks. Over the last years, IBA continued expanding its treatment delivery modes. More specifically, based on its existing system, IBA designed a state-of-the-art pencil beam scanning solution.

Pencil beam scanning imposes special performance requirements, like beam optics, the beam current regulation and beam control of a proton therapy system. In order to fulfill these requirements, new equipment has been designed, tested and integrated in the system.

Also, the measurement of scanning beams has requirements distinct from double-scattering beams. Additionally, dedicated measurement methods for the routine quality assurance of scanning systems have been developed.

During the last year, a broad range of new results have been obtained at our different operational sites. The various technical challenges, solutions and the results will be presented.

WED-MA05-5 #595 - Contributed Talk - Wednesday 8:30 AM - West Fork

Development of Proton Computed Tomography for Applications in Proton Therapy

Vladimir A Bashkirov[1], Reinhard W Schulte[1], George Coutrakon[1], Bela Erdelyi[2], Kent Wong[2], Hartmut Sadrozinski[3], Scott Penfold[4], Anatoly Rosenfeld[4], Scott McAllister[5], Keith Schubert[5]
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Determination of the Bragg peak position in proton therapy requires accurate knowledge of the electron density and ratio of effective atomic number and mass (Z/A) of the body tissues traversed. While the Z/A ratio is fairly constant for human tissues, the density of tissues varies significantly. One possibility to obtain accurate electron density information of tissues is to use protons of sufficient energy to penetrate the patient and measure their energy loss. From these transmission measurements, it is possible to reconstruct a three-dimensional map of electron densities using algebraic techniques. The interest in proton computed tomography (pCT) has considerably increased in recent years due to the more common use of proton accelerators for cancer treatment world-wide, and a modern design concept based on current high-energy physics technology has been suggested. This contribution gives a status update on the pCT project carried out by the pCT Collaboration, a group of institutions sharing interest and expertise in the development of pCT. We will present updated imaging data obtained with a small pCT prototype developed in collaboration with the Santa Cruz Institute of Particle Physics and installed on the proton research beam line at Loma Linda University Medical Center. We will discuss hardware decisions regarding the next-generation pCT scanner, which will permit scanning of head-sized objects. Progress has also been made in the formulation of the most likely path of protons through an

object and parallelizable iterative reconstruction algorithms that can be implemented on general-purpose commodity graphics processing units. Finally, we will present simulation studies for utilizing pCT technology for on-line proton dose verification and tumor imaging with positron emission tomography (PET).

WED-NHS01-1 #10 - Invited Talk - Wednesday 8:30 AM - Brazos II

Imaging and Radiography with Nuclear Resonance Fluorescence and Effective-Z (EZ-3D^{TM}) Determination

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Three new technologies have been developed for use in non-intrusive inspection systems to detect nuclear materials, explosives and contraband. Nuclear Resonance Fluorescence (NRF) provides a three dimensional image of the isotopic content of a container. NRF determines the isotopic composition of any region and specifies the isotopic structure of the neighboring regions, thus providing the detailed structure of any threat. In transmission mode, NRF provides a two dimensional projection of the isotopic content of a container, much as standard X-ray radiography provides for density. In this mode, NRF also signals the presence of materials that may be of interest. The effective-Z method (EZ-3D^{TM}) uses standard electromagnetic processes to yield a three dimensional map of the effective-Z in a container. The EZ-3D^{TM} method allows for a rapid discrimination of dangerous cargo, such as materials with high Z, as well as specifying regions of interest for other contraband. These three new technologies can be used singly or together to automatically determine the presence of dangerous materials or contraband. They can also be combined with other technologies to provide added specificity.

WED-NHS01-2 #501 - Invited Talk - Wednesday 8:30 AM - Brazos II

Low Dose Gamma Ray Transmission Radiography for Detection of SNM using Monoenergetic Gamma Rays

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The detection of nuclear materials requires both the localization of the potential threat and confirmation of its nuclear properties. The use of monoenergetic high energy gamma rays for transmission imaging provides a means for high contrast imaging of shielded SNM and the means to confirm the fissile nature of the material. This relies on the large difference between the pair production cross-section for mid and low-Z material and for high-Z materials and subsequently, the large difference in absorption at high energies. An estimate based on the use of monoenergetic gamma rays of 4.4 MeV and 15.1 MeV, confirmed by MCNPX simulations, shows that a transmission image using this approach easily separates a 100 cc cube of U behind 25 cm of steel with doses which are orders of magnitude below those of other approaches.

The radiation is easily produced using low energy nuclear reactions. which reduces the dose to cargo and potential stowaways by orders of magnitude compared to traditional techniques (e.g. radiography from high energy linacs). By selecting nuclear reactions with large positive Q values, small accelerators producing 3 to 10 MeV protons or deuterons can simultaneously produce fast neutrons and high energy (> 10 MeV) monoenergetic gammas. One such reaction is d(11B,n)12C. Using 3 MeV deuterons, this reaction produces fast neutrons peaking at around 16 MeV with a broad distribution at lower energies and intense gamma rays at 4.4 and 15.1 MeV. The fast neutrons also can be used to produce fission and, the 15.1 MeV gamma ray line is also near the peak in the photofission cross-section for U. Thus, with a single accelerator we are thus able to produce transmission images as well as prompt and delayed neutrons and gammas that can be quantified using standard detection methods.

WED-NHS01-3 #102 - Invited Talk - Wednesday 8:30 AM - Brazos II

X-Ray Cargo Inspection: Status and Trends

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Over the past few years, x-ray cargo inspection has experienced tremendous world wide growth. Based on data from Varian Medical Systems' field service organization, there are several hundred systems in use world wide and a few new units are installed every week. The spatial resolution of these systems is typically 3-5mm, penetration ranges from under 200mm to 450mm of steel and contrast sensitivity is typically 1-4% at half of the maximum penetration. Inspection throughput ranges from about 20 trucks per hour to 200 trucks per hour. The majority of systems are powered by a 3-4MV or 6MV Linac x-ray source. Fielded systems are mostly located in north and west Africa, Mideast, Europe, east Asia, and South America. The United States

of America has started to show some interest in these systems. Currently the systems are primarily used to fight import tax evasion and smuggling of controlled substances.

A variety of systems have been developed to fit different needs and there are a few clear trends. The first trend is better imaging performance, represented by spatial resolution, contrast sensitivity and penetration. The second trend is a need for high throughput system, even with slightly degraded imaging performance. Drive-through portal systems handle large volume at border crossings. Another trend is material discrimination, or even identification and automatic detection. Material discrimination is achieved with dual energy x-rays and is the foundation of material identification and automatic detection. The last, but not least trend is a shift to security applications. The US government has launched major efforts such as CAARS and JINII to fight nuclear threat and systems that can automatically detect a small amount of high atomic number materials are being developed. Threat from conventional explosives, especially in air cargo environment, remains a challenge to this community.

WED-NHS01-4 #59 - Invited Talk - Wednesday 8:30 AM - Brazos II

Distinguishing illicit materials using a Compton Imager

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In the past decade a rapidly growing and important research area has been established which utilises new and novel techniques and technologies to rapidly assess possible security threats and risks.

The UK DISTINGUISH project aims to determine the presence and concentrations of any illicit or hazardous materials present in domestic or international cargo using digital Pulsed Fast Neutron Analysis (PFNA) [1]. A pulsed neutron beam will be employed to initiate a prompt gamma emission from inelastic scattering (n,n') or neutron capture (n,gamma) from any light elements present in the cargo. The detected gamma rays will provide a fingerprint of the explosive or narcotic material present in the container.

The location of the contraband within the unit can be found using a gamma-ray imager that operates using the Compton camera [2] principle. For this process the incident emitted gamma ray must interact with a sensor depositing some of its energy and scattering in to a second sensing element. A cone beam is generated from this process. As the cone beams from each such event overlap the position of the emittance can be identified. For the Distinguish system the gamma rays emitted will be detected by a segmented High Purity Germanium (HPGe) planar detector and pixellated CsI composite system that utilises digital pulse processing techniques. This system will produce tomographic images that provide the origin of these emissions using Compton kinematics. A liquid scintillator will detect the elastic scattered neutrons, providing data for inversion to tomographic images.

Pulse shape analysis (PSA) [3] methods for use with this system will be discussed. Results from the characterisation of these detectors along with the Compton images produced will be presented.

[1] NIM A422 (1999) 895
[2] NIM B99 (1995) 674
[3] NIM A452 (2000) 223

WED-NHS01-5 #54 - Invited Talk - Wednesday 8:30 AM - Brazos II

Automated detection with high energy radiation

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Automated detection of objects in images requires identification of the object in an image together with some type of physics tag such as effective atomic number, density or elemental content. This technique has been well established using a pair attenuation images created with ~100 keV x-rays. We discuss how sets of attenuation images generated from neutrons or photons at the MeV scale can generate useful physics tags, providing a basis for automated detection.

WED-NHS01-6 #205 - Contributed Talk - Wednesday 8:30 AM - Brazos II

THE PULSED ELECTRON BEAM COMPRESSION FOR RADIOGRAPHY

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Radiography using pulsed electron accelerators with X-ray targets can be a superior analytical method for research and applications. One major challenge of this technique is the difficulty of forming high current electron beams with a small cross section. The use of a High Temperature Superconductor (HTS) tube to compress a charge-compensated electron beam is a simple and effective solution to this problem. This technique can provide pulsed high-current electron beams with diameters as small as 2 mm. New approaches for forming of pulsed high density electron beams with small diameter using HTS tubes of new geometry are considered in this paper. Simulation results for the compression of nanosecond relativistic high current electron beams are presented.

WED-NP05-1 #84 - Invited Talk - Wednesday 8:30 AM - Brazos I

An Active Target Time Projection Chamber for Nuclear Structure and Reactions Experiments

Abigail Bickley
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Time projection chambers (TPC's) are powerful devices for studying charged particles produced in nuclear collisions. The high resolution and large angular acceptances of these devices permits 4pi event reconstruction providing ample event characterization for nuclear structure and reaction experiments. In conjunction with a magnetic field, TPC's can be used to identify diverse particle species ranging from pions to light charged fragments in intermediate energy collisions. This particle identification capability is suitable for nuclear reactions studies of the density dependence of the symmetry energy in the nuclear equation of state. By varying the gas with which the detector chamber is filled, a TPC can be used as an active target in which the fill gas acts as both the target and detector. This will allow low threshold processes relevant to nuclear structure, fission and nuclear astrophysics to be studied in inverse kinematics. The scientific and technical plans for implementing an active target time projection chamber to be used with the radioactive ion beams at the National Superconducting Cyclotron Laboratory will be discussed.

WED-NP05-2 #31 - Invited Talk - Wednesday 8:30 AM - Brazos I

Nuclear Resonance Fluorescence and Isotopic Mapping of Containers

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National security programs have expressed interest in developing systems to isotopically map shipping containers, fuel assemblies, and waste barrels for special nuclear material (SNM). Current systems such as radiographs offer no more than an ambiguous density silhouette of a container's contents. In this talk I will present a system being developed at LLNL to isotopically map containers using nuclear resonance fluorescence (NRF). Recent experimental measurements on NRF strengths in SNM will be presented. Experimental results on the feasibility of such a system will also be presented.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

WED-NP05-3 #55 - Invited Talk - Wednesday 8:30 AM - Brazos I

Neutron time-of-flight measurements at n_TOF, CERN

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Neutron induced reaction cross sections play an important role in a wide variety of research fields, ranging from stellar nucleosynthesis, symmetry breaking effects in compound nuclei, the investigation of nuclear level density studies, to applications of nuclear technology, including the transmutation of nuclear waste, accelerator driven systems and nuclear fuel cycle investigations.

Several new experimental activitives in this field have been developed world-wide in the last few years. One important contribution has been the construction of the time-of-flight facility n_TOF at CERN. This neutron spallation source with a pulsed 20 GeV/c proton beam is at present undergoing an upgrade of the lead spallation target.

After a first phase of data taking during the period 2001-2004, the facility is foreseen to be operational again by the end of 2008. The new design of the spallation target and the cooling system are optimized for a long-term performance. The target is also compatible with a possible future extension of the facility with a secondary short flight path.

Measurements have been planned for the second phase of n_TOF, mainly neutron capture and fission experiments on a variety of isotopes of interest for nuclear astrophysics, advanced nuclear technologies, and for basic nuclear physics. The status of the facility, its instrumentation, and the upcoming experimental programme will be discussed.

WED-NP05-4 #53 - Invited Talk - Wednesday 8:30 AM - Brazos I

Study of the photon strength functions for Gadolinium isotopes with the DANCE array

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The gadolinium isotopes are interesting for reactor applications as well as for medicine and astrophysics. There are seven stable isotopes of gadolinium with varying deformation. Decay gamma rays following neutron capture on Gd isotopes are detected by the DANCE array, which is located at flight path 14 at the Lujan Neutron Scattering Center at Los Alamos National Laboratory.

The high segmentation and close packing of the detector array enable gamma-ray multiplicity measurements. The calorimetric property of the DANCE array coupled with the neutron time-of-flight technique enables one to gate on a specific resonance of a specific isotope in the time-of-flight spectrum and obtain the summed energy spectrum for that isotope. The singles gamma-ray spectrum for each multiplicity can be separated by their DANCE cluster multiplicity. Various photon strength function models are used for comparison with experimentally measured DANCE data and provide insight for understanding the statistical decay properties of deformed nuclei.

WED-NP05-5 #235 - Contributed Talk - Wednesday 8:30 AM - Brazos I

Searching for resonances in the unbound 6Be nucleus

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Understanding the evolution of the light elements (such as D, 3He, 4He, and 7Li) from the big bang to the present is crucial for testing the Big Bang Nucleosynthesis (BBN) predictions for the primeval abundances [1, 2]. By comparing the predicted and observed abundances of the light elements, the baryon density had been constrained to the range of 1.7*10^31 ~ 4.1*10^31 g/cm3[3]. Knowledge of the 3He(3He,2p)4He reaction is, therefore, essential for constraining BBN models and the baryon density. The reaction also strongly affects the calculated neutrino luminosity from the sun.

Previous measurements have found a surprisingly large rise in the cross section at low energies that could be due to a low energy resonance in the 3He + 3He (6Be) system or electron screening. In the 6Be nucleus, however, no excited states have been observed above the first 2+ state at Ex = 1.67 MeV up to 23 MeV, even though several are expected.

The d(7Be,t)6Be reaction has been studied for the first time to search for resonances in the 6Be nucleus that may affect our understanding of the 3He(3He,2p)4He reaction. A 100-MeV 7Be beam from the Holifield Radioactive Ion Beam Facility (HRIBF) was used to bombard CD2 targets, and tritons were detected by the Silicon Detector Array (SIDAR). Details of the experiment and a report of the current stage of the analysis will be presented.

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[2] D. N. Schramm and M. S. Turner, Rev. Mod. Phys. 70, 303 (1998).
[3] C. J. Copi, D. N. Schramm, and M. S. Turner, Science 267, 192 (1995).

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WED-NP05-6 #152 - Contributed Talk - Wednesday 8:30 AM - Brazos I

Systematic investigation of caloric curves of reconstructed quasiprojectiles from collisions in the Fermi energy regime

S. Galanopoulos, G. A. Souliotis, A. L. Keksis, M.Veselsky, M. Jandel, D. V. Shetty, Z. Kohley, S. Soisson, B. Stein, S Wuenschel, S. J. Yennello
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In this work we study the excitation energy dependence of the nuclear temperatures, usually noted by the term caloric curve, in the ^{40,48}Ca, ^{40}Ar + ^{112,124}Sn reacting systems at the beam energy of 45 MeV/u. The measurements were performed at the K500 Cyclotron accelerator of Texas A&M University and the projectile fragments were detected using the FAUST multi-detector array [1,2]. For each reacting system, the double isotopic yield ratio method was implemented to derive temperatures at each excitation energy bin using isotopic yields from a neutron rich and a neutron deficient region of the reacting system. The results will be compared with model calculations and the experimental temperature compilation of Ref. [3].

[1] F. Gimeno-Nogues et al, Nucl. Instr.and Meth. A 399, 94 (1997).
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WED-RE05-1 #432 - Invited Talk - Wednesday 8:30 AM - Trinity Central

Ion tracks in silica

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The intense electronic excitation that heavy, high energetic ions generate when penetrating matter can produce narrow cylindrical defect regions, so called ion tracks. Discovered in the late 1950's a boom in ion track research was stimulated by numerous applications in a variety of disciplines including materials science and engineering, nuclear physics, geochronology, archaeology, and interplanetary science. The development of large heavy ion accelerators in the 1980's enabled more systematic studies as much higher excitation and ionization densities became easier accessible. By now tracks have been observed in many crystalline and amorphous materials including semiconductors, insulators and various metals. Structural investigation of ion tracks, however, still remains extremely challenging as they comprise embedded objects which are generally characterized by subtle differences in structure and density between track and matrix material. This lack of contrast leaves the complex structure of ion tracks inaccessible with most experimental techniques, in particular in amorphous materials. Consequently, more detailed measurements are required to resolve still existing discrepancies in both experimental observations and theoretical descriptions of ion track formation. In this presentation we will give an overview of ion track formation with a focus on silica, arguably one of the technologically most important and most studied materials. We will present the current status and report on new results providing direct evidence of a fine structure in ion tracks in amorphous silica. Synchrotron small angle x-ray scattering measurements and molecular dynamics simulations reveal that the ion tracks consist of a low density core surrounded by a high density shell. The structure is consistent with a frozen-in pressure wave originating from the center of the ion track resulting from a thermal spike. The results are discussed in the framework of existing models and in view of their applicability to other materials.

WED-RE05-2 #457 - Invited Talk - Wednesday 8:30 AM - Trinity Central

Properties of Vacancy defects induced by irradiation in SiC

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Due to its physical and chemical stability, its relatively good resistance to radiation, its low activation, silicon carbide, SiC, is considered as a good candidate for the conception of the new nuclear reactors. In the fusion reactors SiC or SiC/SiC composites are under consideration for the conception of new structural components. In the helium cooled reactors of the fourth generation (Generation IV), SiC is envisaged for the nuclear fuel encapsulating. The understanding of the behavior of this material under irradiation is of first importance to evaluate its availability in nuclear applications.

In this work, we have used positron annihilation spectroscopy (PAS) to determine the properties of vacancy defects created in SiC by irradiations performed in different conditions. Both 22Na based positron lifetime spectroscopy (PALS) and slow positron beam based Doppler annihilation-ray broadening spectrometry (SPBDB) have been used to characterize respectively the bulk and the first micron under the surface of 3C-SiC or 6H-SiC single crystals. In some special cases defects characterization has been supplemented by EPR measurements.

These studies have allowed to determine several properties of the vacancy defects in SiC. The displacement energy threshold in the Si sublattice has been determined to be 25 and 20 eV respectively in 3C and 6H SiC polytypes. It has been shown that the nature and the electrical activity of the vacancy defects that are created can change as a function of the nature and the energy of the incident irradiating particles. Finally some recombination steps leading to the evolution of the nature of the defects have been pointed out after annealing in the 150 to 1300°C temperature range.

WED-RE05-3 #455 - Invited Talk - Wednesday 8:30 AM - Trinity Central

Orientation dependence of disorder accumulation and recovery in silicon carbide

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6H- and 3C-SiC single crystals were irradiated with Au2+ ions to a range of ion fluences at low temperatures and were subsequently annealed at various higher temperatures. The relative disorder on both the Si and C sublattices has been determined simultaneously using in-situ ion-channeling methods along the major axes. In general, a strong anisotropy of both disorder accumulation and recovery in the materials is revealed. The disordering rate on the Si sublattice in 3C-SiC follows the decreasing order as observed along the <111>, <100> and <110> axes, while that on the C sublattice shows comparable values. Similar levels of Si and C disorder are observed along the <111> axis in the applied dose range. However, a higher level of C disorder is observed along the <100> and <110> axes. In 6H-SiC, there is a preferential C disordering and more C interstitials are aligned with <0001>. A higher disordering rate is observed on both the Si and C sublattices along the <2-201> than <0001>. Room-temperature recovery occurs for both the sublattices in the 3C-SiC along <111> and in the 6H-SiC along <2-201> due to close-pair recombination. Significant recovery takes place along all directions in the two polytypes during thermal annealing at 500 K and above, which is attributed to uncorrelated annihilation of interstitials, and possibly also to epitaxial recrystallization of embedded amorphous domains or highly disordered defect clusters.

WED-RE05-4 #393 - Invited Talk - Wednesday 8:30 AM - Trinity Central

Damage accumulation in gallium nitride and silicon carbide irradiated with energetic heavy ions

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In this paper we present in the follows our recent study of damage accumulation in GaN and SiC irradiated with energetic heavy ions.

1: A study of the damage production in gallium nitride (GaN, a compound semiconductor) via inelastic collision process (strongly electronic excitation) using different heavy ions is presented. Specimens of GaN crystal were irradiated with slow highly-charged heavy ions (Xe^{n+} and Pb^{n+} ions, with the charge state n ranging from 9 to 35) and swift heavy ions (Xe^{26+} and Pb^{27+} ions of 1.1-2.3 MeV/u). Damage production/accumulation at the surface and in the bulk as a function of irradiation dose was studied, and a comparison with ordinary mono-charged heavy ions was given. Enhanced surface erosion and amorphization due to inelastic energy loss was found, indicating that damage production in GaN is more sensitive to electronic excitation and ionization than elastic energy loss via nuclear collision. An explanation based on the Coulomb explosion model is given.

2: A study of defect production in silicon carbide crystal (4H-SiC) irradiated with energetic heavy inert-gas ions (Ne and Xe) to different doses is presented. The microstructures of the annealed specimens Ne-ion or Xe-ion irradiated are characterized by the formation of dislocation loops around the estimated damage peak, as well gas bubbles in high density. The density and size of dislocation loops show a strong dependence on dose and ion species. A comparison with the microstructure of helium-implanted SiC and spinel crystals was made.

WED-RE05-5 #75 - Contributed Talk - Wednesday 8:30 AM - Trinity Central

Stress depth profiles in Al2O3:Cr irradiated by swift heavy ions

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Depth profiles of the residual stress in Al2O3: Cr single crystals irradiated with (1-3) MeV/amu Kr, Xe and Bi ions has been studied by using laser confocal scanning microscopy (LCSM) technique. The residual stress profiles and stress tensor components through the irradiated layer were determined from depth-resolved photostimulated R-lines spectra. It was found that stresses are compressive in basal plane and tensile in perpendicular direction in all samples irradiated with high energy ions. The role of radiation damage created via electronic excitation in stress generation is discussed in the framework of model, considering the Cr3+ atoms as individual piezosensors.

WED-RE05-6 #49 - Contributed Talk - Wednesday 8:30 AM - Trinity Central

Ion Irradiation Effects in Nanolayered Nitride Coatings

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Nitride bulk materials and coatings have attracted extensive interests for various applications in advanced nuclear reactor concepts due to their unique combination of physical, mechanical and chemical properties, including high temperature stability, excellent corrosion resistance, superior mechanical property and high thermal conductivity. Recently, nanostructured nitride materials have demonstrated enhanced radiation tolerance and diffusion barrier properties. In this talk, the ion irradiation effects in TiN/TaN nanolayer coatings as a function of layer thickness will be reported. TiN/TaN nanolayers (over 500nm in total film thickness) with various thickness combinations (40nm/5nm, 20nm/5nm, 15nm/5nm and 5nm/5nm) were prepared on TiN buffered Si (001) substrates by a pulsed laser deposition technique. All the samples were irradiated with 4He+ ions to high fluences at 100K and room temperature. Following ion irradiation, transmission electron microscopy (TEM), high resolution TEM and scanning transmission electron microscopy (STEM) were used to compare the microstructural characteristics of the as-deposited and post-irradiated samples. Nanolayer structures retained after radiation and no obvious layer intermixing were detected. Electrical resistivity measurement and nanoindentation were conducted to explore radiation effects on the evolution of electrical and mechanical properties. Besides the radiation tolerance study, preliminary results on the corrosion resistance and thermal stability of these nanolayers will also be presented.

WED-ED – VTS-1 #265 – Invited Talk - Wednesday 11:00 AM – Pecos I

Accelerator-Based Laboratory Activities at USNA

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The Naval Academy Tandem Accelerator Laboratory is dedicated to providing educational experiences for undergraduates. This facility is comprised of a CAMAC-based instrumentation lab and a National Electrostatics Pelletron 5SDH-1. The accelerator features a dual SNICS/ Alphatross injector and two beamlines. The microprobe beamline has an endstation for PIXE, PIGE, and RBS investigations. The other beamline contains a large scattering chamber appropriate for nuclear and accelerator-based atomic physics investigations using an array of surface barrier detectors or an electron spectrometer. Recent experiences with the facility will be discussed. Examples from the nuclear physics course, independent study projects, and community service projects will be presented.

WED-ED – VTS-2 #134 - Invited Talk - Wednesday 11:00 AM – Pecos I

Using accelerators for teaching electromagnetism to high-school students

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A programme was developed in 1999 by FAPERJ (a Brazilian State funding agency) for high-school students interested in natural sciences, with the aim of introducing them to the daily activities of scientists in universities and research institutes. The aim of this work is to describe physical experiments in which high school students may become invoved. The objetice of the experiments, which are suitable for sênior high-school students, is to demonstrate the principles of electromagnetism. Some experiments, requiring the use of the 1.7 MV Pelletron accelerator, are described.

Work supported in part by FAPERJ and CNPq.

[1] D. A . Sinflorio, P.Fonseca, L. F. S. Coelho, and A C. F. Santos, Phys. Ed. 41, 539 (2006).

WED-ED – VTS-3 #168 - Invited Talk - Wednesday 11:00 AM – Pecos I

Undergraduate Research Experiences in Positron Beams at St. Olaf

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At St. Olaf College we have recently begun the construction of a slow positron beam for the eventual purpose of creating a beam of positronium atoms. This work is motivated by recent results which demonstrate that certain highly structured nanoporous material should produce positronium in a very directional manner. This talk will cover the fundamentals of how such a beam is constructed and operated. St. Olaf is an entirely undergraduate institution and thus undergraduates have participated in all aspects of the design and construction of this beam. Examples will be presented for the types of projects students have work on such as ion beam modeling, various machining projects, and pulsing electronics. The guiding principles used in generating these projects will also be discussed.

WED-NSF - VTS-1 #365 - Invited Talk - Wednesday 1:00 PM - Pecos I

Few-Nanometer Patterning of Surfaces, Thin Films and Resists -- Issues and New Approaches

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Ion beam modification of surfaces and structures can, in principle, be used to impose arbitrary patterns having feature resolution and definition in the few-nm range (or sub-nm range for purely ballistic recoil processes). However, in order to achieve such resolution in practice, the beam parameters and the nature of the receiving medium or surface need to be tailored with care.

In this paper, we discuss options for future device lithography and resists, to minimize granularity or shot noise within a feature, and minimize line edge roughness. We also examine options for patterned functionalization of surfaces, and templating ALD growth of 3-D features. Examples of patterning results will be shown, including bit patterns for multilayer magnetic storage media, response of thin polymer resists, and patterned surfaces.

WED-NSF - VTS-2 #243 - Invited Talk - Wednesday 1:00 PM - Pecos I

Research on High-Resolution High-Throughput Ion Beam Lithography and Imaging Based on Plasma Ion Sources

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An inductively coupled plasma (ICP) ion source can generate a high-brightness and low-energy-spread ion beam. Different ICP ion sources have been developed for various applications, such as ion beam projection lithography and focused ion beam micromachining and imaging. Compared with photons or electrons, ions have higher mass, which results in negligible diffraction and smaller material interaction volume. Therefore, the ion beam has the potential to achieve higher resolution in lithography and imaging than a photon beam or electron beam. Projection ion beam lithography has been investigated as one of the candidates for next generation lithography. To further eliminate the recurring cost of masks in advanced lithography processes, maskless ion

beam lithography has also been researched. For focused ion beam (FIB) systems, a traditional FIB utilizes liquid gallium ions, which cause contamination for some applications. Plasma ion sources can generate various gas phase ion species including inert gases such as helium and argon. A focused ion beam system based on mini plasma ion sources is being developed in Lawrence Berkeley National Laboratory.

Even though various ion beam lithography and imaging tools have been developed both in research institutes and in industry, none of them are readily available for high-throughput lithography and defect inspection processes in the semiconductor industry. The status of these researches will be reviewed in this presentation. To meet the high-throughput requirement for the semiconductor industry, challenges in optics design and ion source development will be discussed.

WED-NSF - VTS-3 #303 - Invited Talk - Wednesday 1:00 PM - Pecos I

Ion Projection Technology System

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The concept of Ion Projection Technology (IPT) was developed by IMS - Ion Microfabrication Systems GmbH. An IPT System with 9x ion-optical reduction was realized by IMS for Fraunhofer Society in 1988. This system was re-installed at BIONT in March 2008. The system parameters before and after re-installation are compared. The reason for the new installation - nano-particles formation for nano-medicine research - is described together with necessary system improvements. Generally, the BIONT-IPT-System can serve for cooperative research for a large variety of nanotechnology applications. It offers multi-beam parallel feature writing on a 4 inch wafer with a single exposure field of 2x2 mm^2 with demagnification from stencil mask to wafer of 9:1 and physical limit of feature size 20 nm.

WED-NSF - VTS-4 #496 - Invited Talk - Wednesday 1:00 PM - Pecos I

The Helium Ion Microscope for Sub-nanometer Imaging and Analysis

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The scanning helium ion microscope (HIM) is now installed in several major research facilities. It displays sub-nanometer resolution using ion induced secondary electron (SE) mode and back scattered ion (RBI) mode imaging. In addition to its long working distance and sub-nanometer resolution, the helium ion microscope in RBI mode provides contrast that is material Z dependent on a nanometer scale. By employing charge neutralizing electrons, the helium ion microscope can image dielectric materials at full beam energy and maximum resolution without the need for sample coating.

This paper will describe the physics of the subatomic virtual source, the system's ion optics, the types of detectors used and the substrate interactions involved with SE and RBI imaging. As the mean energy of the secondary electrons collected for imaging is around 2 eV, their range in most materials is around 1 nm, so that SE mode image information comes from the top nanometer volume of any sample. The implications of this low secondary electron energy and its consequent surface sensitivity will be reviewed.

We will cover the current system's helium ion Rutherford backscattering spectrometry (RBS) methods for determining thin film and small particle dimensions and constituents. Other analytical possibilities will be introduced. And we will conclude the talk with a review of the more popular applications for the helium ion microscope with examples from the semiconductor, magnetic storage, metallurgical and polymer sciences.

WED-NSF - VTS-5 #520 - Invited Talk - Wednesday 1:00 PM - Pecos I

ionLiNE - a New Tool Concept for Nanofabrication

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The Raith *ionLiNE* is an advanced focused ion-beam nanofabrication instrument designed and characterized to meet lithography tool standards. The unique components are the patented NanoFIB column, the high speed pattern generator, the laser interferometer stage, and a complete lithography software package, all integrated into one system to enable advanced ion-beam patterning. The ion-beam source and column produce the beam stability required for automated advanced lithography. With a small beam diameter and nominal beam tails, the focused ion-beam offers high lateral selectivity, enabling fabricated feature sizes of 10 nanometers and below. Exposures are made in a variety of scan modes using a high speed 16-bit pattern generator.

The pattern generator technology enables nanosecond ion dose control and 3D grey level patterning. For applications covering areas larger than a single exposure field, the laser interferometer stage provides positioning resolution of 1 nm. With these unique features, the *ionLiNE* delivers critical lithography specifications, such as stitching and overlay accuracies. The lithography software permits the generation or import of complex patterns in the widely accepted GDSII data format, job automation for overnight patterning without user interaction, automated dose control, metrology, and automated focus control via height sensing schemes. Fixed Beam Moving Stage (FBMS), a zero stitching error writing mode for the seamless exposure of extended structures, completes the advanced patterning of the *ionLiNE*. Additional options, such as a gas-injection system and nanomanipulators, can be added to allow unique nanofabrication and nanoengineering capabilities. The *ionLiNE* workstation is a flexible, multi-user platform designed to enable a wide variety of focused ion-beam applications, from the traditional milling, drilling, and cutting to the advanced high-accuracy lithography that was never possible before.

WED-AP06-1 #172 - Invited Talk - Wednesday 1:00 PM - Elm Fork

Bond rearrangement following collisions between fast ions and ammonia or methane

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The production of H_2^+ and H_3^+ fragments upon dissociation of ammonia and methane molecules involves rearrangements of the molecular bonds. Using fast ions to ionize these molecules, electrons can be removed on a time scale of 10 attoseconds, thus freezing the nuclear motion. The production of H_3^+ ionic fragments require the cleavage and formation of a larger number of bonds during the fast process. The ground state H_3^+ molecular ions form an equilateral triangle. This geometry matches the configuration of the hydrogen atoms in both parent molecules, therefore increasing the odds for H_3^+ formation. We find, however, that H_3^+ production is more likely to occur from an ammonia target than a methane one, despite the fact that one would expect methane to be geometrically favored, as it has more initial H_3 triangles. We are currently exploring this behavior theoretically. Measurements of D_2^+ and D_3^+ fragments from CD_4 and ND_3 tend to support the conclusion that the bond rearrangement process is very rapid. Our earlier experimental results of H_2^+ formation upon dissociation of water molecules by fast ion impact showed a strong isotopic dependence. With ammonia and methane targets, differences in triangle size result in vibrational excitation and may cause the observed isotopic differences.

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WED-AP06-2 #222 - Invited Talk - Wednesday 1:00 PM - Elm Fork

Ion induced dissociation dynamics of acetylene

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We report the results of dissociation dynamics of multiply charged acetylene molecules formed in collision with 1.2 MeV Ar^{8+} projectiles. Using the coincidence map, we found the evidence for molecular deformation due to a vibrationally active transition state of multiply charged C_2H_2 under the impact of low energy projectiles. 'Butterfly-like' structures are observed in the coincidence spectra between hydrogen and carbon ionic fragments. Such structures can be generated by numerical simulations and are found to originate from the bending motion of the dissociating molecule. From the measured slopes of the coincidence islands for carbon atomic fragments and theoretical values determined from the charge and momentum distribution of the correlated particles, we observe a diatom-like behavior of the C-C charged complex during dissociation of multiply charged acetylene. This is a signature of sequentiality in the breakup dynamics of this multiply charged molecular species.

WED-AP06-3 #544 - Invited Talk - Wednesday 1:00 PM - Elm Fork

Collision Induced Dissociation for 1.5 keV/amu HeH^+ Impact on Argon

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Collision induced dissociation [CID, e.g. HeH^+ + Ar -> H+ + He] is measured for 1.5 keV/amu HeH^+ on argon using 3D momentum imaging techniques. In contrast to H_2^+, HeH^+ dissociation is dominated by vibrationally excited rather than electronically excited CID. This experimental difference is explained in terms of the larger energy gap between the ground and excited states in HeH^+. An asymmetry in dissociation channels between H^+ and He^+ products will also be discussed. This

work is supported by the Chemical Sciences, Geosciences, and Biosciences Division, Office of Basic Energy Sciences, Office of Science, U.S. Department of Energy.

WED-AP06-4 #135 - Contributed Talk - Wednesday 1:00 PM - Elm Fork

Dissociative and non-dissociative ionization of the O2 molecule by the impact of 0.75-3.5 MeV He+

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Total projectile electron loss and absolute dissociative and non-dissociative ionisation cross sections of the O2 molecule in coincidence with the final projectile charge states have been measured for the impact of 0.75-3.5 MeV He+. Comparison is made with proton, He+, and electron impact data available in the literature for the direct ionisation channels. The fragmentation fractions for singly-charged products follow a scaling law indicating that the main dynamical variables behind that fractions are the momentum transfer at intermediate velocities and the energy transfer at high velocities.

Work supported in part by FAPERJ and CNPq.

WED-AT06-1 #122 - Invited Talk - Wednesday 1:00 PM - Bur Oak

Review of cluster ion beam facility and technology

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The paper reviews the development of cluster ion beam technology, including historical background, fundamental characteristics of cluster ion to solid surface interactions, emerging industrial applications, and identification of some of the significant events which occurred as the technology has evolved into what it is today.

Processes employing ions of clusters comprised of a few hundred to many thousand atoms are now being developed into a new field of ion beam technology. Cluster-surface collisions produce important non-linear effects which are being applied to shallow junction formation, to etching and smoothing of semiconductors, metals, and dielectrics, to assisted formation of thin films with nano-scale accuracy, and to other surface modification applications.

WED-AT06-2 #77 - Invited Talk - Wednesday 1:00 PM - Bur Oak

Extremely low damage SIMS by using size-selected gas cluster ion beam

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When a gas cluster ion, consisting of thousands of atoms, collides with a solid surface, several types of reactions are uniquely induced at the surface. Firstly, the average kinetic energy (Ek) of a constituent atom of the cluster is provided by dividing the acceleration energy (Ea) by the number of constituent atoms (N). As a result, extremely low-energy bombardment (< 10eV) is easily achieved by using large gas cluster ions. Secondly, multiple scattering occurs among constituent atoms and surface atoms, which can provide high sputtering yield. We have developed the apparatus for secondary ion mass spectrometry (SIMS) by using gas cluster ion beam (GCIB) as a primary ion beam. Argon (Ar) gas clusters produced by supersonic expansion were ionized by electron impact. The Ar cluster ions were separated by the number of the constituent atoms (cluster size) by using a time of flight technique. The size-selected GCIB in the range of 500~4000 atoms/cluster bombarded the target samples. Target samples were the thin films of organic molecules and polymers such as rhodamine B, homo peptide (6 mer of aspartic acid, (asp)6), and polystyrene (PS) made on a silicon substrate. The mass spectra of the secondary ions were dramatically changed by the cluster size of incident Ar-GCIB. On the whole, the yield of the secondary ions having larger mass (less fragmented) relatively enhanced as the cluster size increased. The intact molecular ions of rhodamine B (Mw: 479) and (asp) 6 (Mw: 709) were detected by the bombardment with Ar-GCIB with the size of 1400 atoms/cluster at 5keV acceleration energy (Ek: 3.6 eV), those are never detected by the bombardment with mono atomic Ar+ ions. Present results indicate that gas cluster ion is a strong candidate as a projectile for extremely low damage SIMS.

WED-AT06-3 #414 - Invited Talk - Wednesday 1:00 PM - Bur Oak

Secondary ion emission under large cluster ion irradiation

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Secondary ions emitted from solid surfaces with atomic ion incidence have been studied in order to explore sputtering phenomena. The emission mechanisms of these particles, however, are still not fully understood. It is of great interest for secondary ion emission under cluster ion irradiation, due to the high ionization efficiency which is a key parameter to improve detection limit in SIMS. In previous studies, we have investigated Si cluster emission from Si surfaces under irradiation of Ar cluster ions[1]. The secondary ion spectra from Si surface under Ar cluster ion irradiation strongly depend on the energy and the size of cluster ions. It was found that secondary cluster ion emission was governed by the incident cluster ion velocity, when the size of incident cluster ions is more than 100 atoms/ion. Recent progress in cluster size effect of secondary ion emission and related topics will be presented.

[1] S. Ninomiya, Y. Nakata, K. Ichiki, T. Seki, T. Aoki and J. Matsuo, Nucl. Instr.and and Meth. B 256 493 (2007).

WED-AT06-4 #542 - Invited Talk - Wednesday 1:00 PM - Bur Oak

Advanced surface polishing for accelerator technology using ion beams

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A review has been made of surface erosion problems common in the development of TeV accelerators; fusion and fission reactors; semiconductor, optical, and magnetic storage devices; and extreme ultra-violet lithography devices. Nanoscale surface roughness in rf-linacs and contamination cause field emission of electrons that can lead to high-voltage breakdown of electrodes. These are limiting factors in the development of high-gradient RF technology and are expected to be important for developing future TeV accelerators. Analyses were conducted of various models and mechanisms of energy transfer into a solid target by accelerated cluster ions, highly charged ion (HCI), and swift-heavy ion, such as plasma and hollow atom formation, Coulomb explosion, space charge screening, charge neutralization, shock wave generation, crater formation, and sputtering. A few mechanisms of nanoscale surface fracture under a high-gradient electric field were developed and will be discussed. A new plasma model of space charge neutralization based on impact ionization of semiconductors at high electric fields was developed and applied to analyze ion impacts on Si and W. Surface erosions and modifications caused by GCIB, HCI bombardments, and low-energy He+ and H+ ions typical for fission and fusion devices were studied by using molecular dynamics and mesoscale simulations. Experimental results for smoothing electrode materials using gas cluster ion beams were analyzed and will be presented. A dramatic reduction in the number of field emission sites on Nb coupons treated with GCIB has been seen by using a scanning field emission microscope. The GCIB surface treatment can significantly reduce the dark current and possibly mitigate the high-gradient vacuum breakdown of metal rf-cavities. The GCIB surface smoothing technique can also mitigate Q-slope drops in superconducting Nb-cavities. Moreover, it has recently been recognized that GCIB can also be used to determine the basic mechanisms of the Q-slope, another serious problem for high-gradient linacs.

WED-AT06-5 #163 - Invited Talk - Wednesday 1:00 PM - Bur Oak

Precise silicon wafer fabrication process using gas cluster ion beams

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Gas cluster ion beam (GCIB) is a promising technique for precise surface etching and planarization of silicon wafers. We have studied a precise fabrication process of a silicon wafer using GCIB. This paper describes the current results of our investigation, especially, relation between the irradiation condition and the damage at silicon surface, and the recovery of a surface damaged at various annealing temperatures. The irradiation damage is composed from an amorphous Si (a-Si) layer, a transition layer, and a surface roughness. These irradiation damages are varied by the species of the source gas and acceleration energy. Moreover, the damage is influenced on the electron acceleration energy used for ionization of the neutral gas cluster. It is suggested that the size and charge of a gas cluster ion are changed by the collision to the electron. The irradiation damage can recover completely and atomically smooth surface are formed after high-temperature annealing. This process is able to preserve the thickness uniformity of the wafer which is precise etched by GCIB irradiation.

WED-AT06-6 #156 - Invited Talk - Wednesday 1:00 PM - Bur Oak

Energy loss and beam transport properties of gas cluster ion beams

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The energy loss and beam characteristics of gas cluster ion beam (GCIB) after collisions with residual gases were studied. As the collision cross-section of gas cluster ion is large compared to that of monomer ions, influence of the residual gases in the beam line is not negligible. Thus the GCIB sometimes shows different irradiation effects under the different vacuum systems. In this study, the energy loss and beam transport properties of the size-selected GCIB were studied using a collision cell and the energy and mass analyzer. From the energy distribution of Ar-GCIB after the collision cell, an Ar cluster ion which was accelerated at high voltage (30 kV) was easier to lose its kinetic energy than that accelerated at low voltage (5 kV). Also, at the same acceleration voltage, the smaller Ar cluster ion lost its energy rapidly than a larger one. In addition, the energy loss of CO2-GCIB was gentle compared to that of Ar-GCIB at the same cluster size. However, the velocity of GCIB was always the same as that of before collisions. These results indicated that the energy loss mainly occurs by the decrease of its cluster size and the number of the reduction of cluster size is determined by the energy / atom and the cohesive energy of the gas.

WED-FIBP04-1 #112 - Invited Talk - Wednesday 1:00 PM - Post Oak

PIXE applied to Cultural Heritage: recent studies at LABEC, Florence

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The importance of PIXE for the non-destructive analysis of art objects is widely acknowledged. The Florence group of applied nuclear physics has a long-time tradition in this field, since the middle of Eighties. This activity increased in 2004 with the installation of LABEC (Laboratorio di tecniche nucleari per i Beni Culturali) based on a new 3MV Tandetron accelerator funded by the National Institute of Nuclear Physics.

The presentation will focus on recent measurements performed at the external beamlines of LABEC for the analysis of different works of art. Special emphasis will be given to the investigation of paintings by famous Italian artists (Antonello da Messina, Giorgio Vasari, Filippino Lippi?) carried out in the framework of collaborations with Museums and Institutions for restoration and conservation. The essential role played by variants or refinements of PIXE such as differential PIXE and scanning mode analysis in the study of such complex and unique works will be demonstrated through the examples proposed.

WED-FIBP04-2 #479 - Invited Talk - Wednesday 1:00 PM - Post Oak

PIXE TECHNIQUE CONTRIBUTION IN ARCHAEOMETALLURGICAL STUDIES

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PIXE (Proton Induced X-Ray Emission) is a well established analytical technique that allows the determination of the elemental composition of irradiated samples. It is clear that PIXE can provide useful quantitative data for research in the fields of the Archaeology and Cultural Heritage, especially when an external set-up is employed since non destructive analysis is possible even in the case of irregular shapes. Metals are ideal samples for PIXE because they are usually composed of medium and heavy elements and, thus their composition and traces can be quantified with precision in just one spectra acquired within some minutes. No damage can be done with the proton beam on these types of samples allowing high intensities and small spots. Only the corrosion appearing on most of the metals can cause trouble if polishing is not permitted.

In this work, several examples of measurements on ancient metallic artefacts from South Iberian Peninsula are included. The analyses have been performed at the 3 MV Pelletron accelerator of the CNA in Sevilla (Spain). From the elemental composition some inferences can be drawn and their contributions to the archaeological studies are pointed out: object characterization, identification of antique technologies: alloys, repairs, gildings, periods, etc.

WED-FIBP04-3 #43 - Contributed Talk - Wednesday 1:00 PM - Post Oak

PIXE-PIGE analysis of Carolingian glass from Slovenia

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The glass technology changed in the 9th century AD. The Egyptian sources of natron (soda), extensively exploited for massive production of Roman glass, became unavailable due to contemporary political events, and the plant ash resumed the role of the glass flux. Analytical studies of glass from this period are therefore important, as they contribute to the dating and better understanding of this switching period. In Slovenia, several glass products (mainly pin heads and beads, but also ingots) were discovered in a fortress site that experienced an abrupt military event in the 9th century. Due to smallness of the objects and their rarity, only nondestructive analytical procedures were allowed. The analysis of 44 objects was performed by a combined PIXE-PIGE analysis, using proton beam in the air. The results show that the majority of objects were composed of glass that still shows Roman tradition, and the primary material can be associated with the Levantine origin. The similarities between ingots and objects indicate a local production center.

WED-FIBP04-4 #167 - Contributed Talk - Wednesday 1:00 PM - Post Oak

PIXE Analysis of Metal Hull Bolts from HMB DeBraak

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HMB DeBraak was a 16-gun British brig-sloop that sank in a squall on May 25 1798 off Cape Henlopen, Delaware. Silt apparently covered the wooden hull shortly after it sank, largely preserving it and its contents until DeBraak was salvaged in 1984. The many items recovered from the ship include copper-alloy bolts that held the hull together as well as copper hull sheathing and sheathing nails. They constitute a valuable record of the materials and techniques used in the construction of naval vessels in the late 18th century. We used PIXE to measure the composition of 45 of the hull bolts. One of the bolts is stamped with the word FORBES, presumably referring to William Forbes, an 18th-century English industrialist who pioneered the use of mechanically hardened copper bolts. Other marks stamped on some bolts include the Broad Arrow, which identifies an object as Crown property, and various Roman numerals whose significance is unknown. We found that the bolts we studied are nearly pure copper (98.37% on average), with most also containing small amounts of iron (0.88%), nickel (0.04%), arsenic (0.42%), silver (0.08%), lead (0.18%) and bismuth (0.11%). Some contain a little tin (0.05%), but few contain zinc above the detection limit. The compositions of these bolts are similar to those reported for 18th-century English copper, but quite different from those of several copper alloys that are often reported to have been used to make hull bolts, including bronze, brass, Muntz metal or Kier metal. We conclude that, when DeBraak was last fitted out in about 1795 - 1797, the Royal Navy was continuing to use Forbes's mechanically hardened "pure" copper bolts. Forbes's process represents the successful innovation and application of new technology in Royal Navy ships during the wars of the late 18th century.

WED-FIBP04-5 #108 - Contributed Talk - Wednesday 1:00 PM - Post Oak

PIXE protocols for cluster analysis of archeological samples: the funny filter case

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Ion Beam Analysis techniques were developed and utilized for applications in the domain of archeology at the accelerator laboratory of the Lebanese Atomic Energy Commission. In order to have accurate and relatively fast measurements for analysis studies of archaeological objects, mainly ceramics, different experimental protocols were tested and established, using "Proton Induced X-ray Emission" technique. The first experimental protocol was done using two runs at 1 MeV and 3 MeV. The second one was more advantageous since it is time consuming by using just one run at 3 MeV with a pinhole filter as x-ray absorber. Hence, a classification study based on the elemental composition and on multivariate statistical techniques could be performed for provenance studies of archaeological objects. The performed protocols were applied and checked on standard reference materials such as DRN, BEN from Geo-standard and SRM-679 brick clay from NIST.

WED-IBM05-1 #408 - Invited Talk - Wednesday 1:00 PM - Pecos II

Ion beam synthesis of transition metal nanoclusters in silicon

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The synthesis of materials combining ferromagnetism and semiconducting properties is of great interest for the development of devices for future electronics. Possible implementations of adding the spin degree of freedom to conventional semiconductors are the formation of diluted magnetic semiconductors (DMSs) and the synthesis of magnetic clusters embedded in semiconducting matrices. Despite the technological importance of Si, the former research has mostly been focused on II-VI, III-V and other compound semiconductors.

Beside various layer deposition techniques, ion implantation in combination with subsequent thermal treatment is an excellent way to introduce the necessary high concentration of foreign atoms into the substrate. Especially the formation of magnetic clusters in semiconductors or DMS layers is of great interest because they offer the possibility to achieve Curie temperatures above room temperature, which is a common drawback of common DMS structures.

The synthesis of transition metal-related nanoclusters in Si has been studied by implanting high fluences of Mn, Sb and As, either individually or in combination. In order to prevent amorphization, the implantations were performed at 200°C or 350°C. Subsequently the samples were subjected to a rapid thermal annealing at temperatures from 900-1350°C for 30 to 120 s. Radiation damage, distribution of foreign atoms as well as structure and composition of the nanoclusters were analysed using RBS and TEM. To characterize the magnetic properties of the samples, SQUID magnetometry and ferromagnetic resonance (FMR) measurements were carried out.

It is shown that in certain windows of the implantation and annealing parameters both Mn and As or Mn and Sb rich crystalline nanoclusters are formed that are partly phase-separated. The influence of the formation parameters on the number, size, size distribution and composition of the nanocrystals as well as the role of atom diffusion will be discussed. Results of magnetic analyses will be presented as well.

WED-IBM05-2 #373 - Invited Talk - Wednesday 1:00 PM - Pecos II

Response of Materials to Single Ion Events

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Knowledge of ion-solid interactions is of fundamental and practical importance for rapidly expanding applications in nuclear reactors, fusion technology, radiation detection, electronic device performance in high radiation fields, and single ion impact on sub-100 nm electronics in space and missile applications. Materials respond uniquely to ion energy deposition and associated secondary processes, such as photo emission and electron-hole production.

This presentation provides a review on the recently developments based on single ion-solid interaction. From on single ion events, the electronic energy deposition of each charged particle in nanometer films is determined over a wide energy range, which provides critical data for validating and refining stopping theories. The scintillation response to single ion excitation is discussed in terms of light yield, nonlinearity and energy resolution, which provide material properties relevant to radiation detector performance and may serve as a fast screening technique to identify possible candidate scintillator materials.

WED-IBM05-3 #295 - Invited Talk - Wednesday 1:00 PM - Pecos II

Ion Beam Modification at the molecular level: Comparison of molecular target and molecular projectile fragmentation

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The study of the dissociation of biomolecules by collisions is crucial to the understanding of processes such as cell damage, dosimetry and atmospheric pollution. From the theoretical point of view, the problem is complex due to the coupling of the electronic and nuclear degrees of freedom, thus few theoretical approaches exist that can be compared directly with experiment. In this talk, a study of the fragmentation of a molecular target induced by an atomic ion, as well as the fragmentation of a

molecular ion induced by an atomic target is presented. The first case corresponds to slow alpha particles colliding with Glycine where the fragmentation is induced by the dominant double electron capture by the projectile. The second case is the fragmentation of CO2+ molecular ion when colliding with Helium target atoms where we look into the collision induced fragmentation and its similarities between the already known photo dissociation. We present results for the total and differential cross section for electron capture, as well as a study of the angular distributions of the fragments and kinetic energy releases. Finally, comparisons to the experiment are presented and discussed.

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WED-IBM05-4 #290 - Invited Talk - Wednesday 1:00 PM - Pecos II

Radiation Effects in Fluorite-type Nuclear Oxides

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Binary metal oxides possessing the fluorite-type crystal structure are well known to be amongst the most radiation tolerant materials. Such a crucial property led to the early use of uranium dioxide as nuclear fuel and to recent studies devoted to the development of the so-called inert matrix fuels for in-reactor actinide transmutation (actinide cations partially substitute regular cations). Whilst radiation-induced structural modifications due to low-energy ions, i.e. in the nuclear stopping regime, were extensively investigated, specific irradiation effects due to electronic stopping of penetrating ions are still much debated. This work focuses on the radiation stability of fluorite-type canonical systems, namely urania and yttria-stabilized cubic zirconia single crystals, irradiated with high-energy heavy ions. Several analytical techniques, which probe the material at various depth scales, were used (e.g. RBS in the channelling mode, XRD, TEM) to gain information on the nature of the created damage (depth distribution, disordering kinetics, occurrence of structural and micro-structural modifications) at fluences ranging from the formation of isolated ion tracks up to complete surface recovery. Damage formation is interpreted in terms of the huge electronic excitations created in the wake of the ion's path. The melting of the material in the core of tracks, via a thermal spike mechanism, leads to the creation of large hillocks at the surface of the crystals. The overlapping of ion tracks at high fluence induces a severe transformation of the microstructure of single crystals. The formation of subdivided grains slightly disoriented from the main crystallographic direction occurs, with a mean size decreasing with increasing irradiation fluence.

WED-MA06-1 #573 - Invited Talk - Wednesday 1:00 PM - West Fork

The Clinical Practice of Proton Radiotherapy: Overview and Recent Developments

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Clinical proton radiotherapy (PRT) is demonstrating worldwide a rapid introduction into clinical practice. The paradigm of the 90's was the transfer of PRT from physics research institutes to hospital-based facilities. This paradigm has shifted towards availability of PRT to a maximum number of cancer care facilities by reduction of size and costs.

With >50,000 patients treated over three decades, PRT has passed all reasonable safety and efficacy requirements. However, use in clinical practice varies between countries, ranging from deliberately exchanging photons with protons (example: USA) to a more restricted use based on published medical evidence (example: some Europe).

Long term data are available on initial disease sites used as tumor model to prove the hypothesis that PRT could be safely used as a high dose tool. Those indications are uveal melanomas, tumors of the skull base with close proximity of vital normal structures, as well as paraspinal tumors. Subsequently, clinical indications were introduced, emphasizing PRT's reduction of the irradiated normal tissues. The primary goal in those circumstances was reduction of acute or late toxicity. Examples are the treatment of prostate cancer and of childhood malignancies. Several world-renowned Cancer Centers will gain access to proton radiotherapy within the next several years. Important additional clinical indications will be undergoing academic evaluation. The "list of indications" for proton radiotherapy and medical evidence in support of proton radiotherapy is expected to increase dramatically over the next several years.

Historically, PRT relies on passive scanning technology. Spot scanning based treatment, as introduced at the Paul Scherrer Institut for >10 years, will be presented in detail. More than 350 patients have been treated with five year outcomes data available in >100 patients. This is arguably the most advanced treatment delivery technology, and will become a major component of new equipment designs.

WED-MA06-2 #532 - Invited Talk - Wednesday 1:00 PM - West Fork

Proton Conformal Radiation Therapy and Radiosurgery of Intracranial Lesions: Dubna Experience

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Proton radiation therapy started in the former USSR in 1967, when the first patient was irradiated in Dubna. Later, two more proton centers started clinical work: ITEP in Moscow (1968); and LINP near Leningrad in 1975. At the beginning of the 21st century, new 3D CT and MRI based proton treatment planning and realization of the proton therapy technique was developed in Dubna. Technique was clinically tested on more then 200 patients, mainly with cerebral arteriovenous malformations and intracranial tumors. Description of the irradiation method and some clinical and imaging results will be presented.

WED-MA06-3 #628 - Contributed Talk - Wednesday 1:00 PM - West Fork

Proton Beam Radiotherapy in Uppsala: Past, Present and Future

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Past: The first proton beam treatment given directly to a cancer was performed in 23rd Nov, 1957 at the Gustav Werner Institute (GWI) in Uppsala. A total of 73 patients with a variety of tumors were treated up to 1971 with a 185 MeV fixed proton beam. Imported technical developments were made with constructions of fixatures and stereotactic localizing equipment. The "Gammaknife" was born at the institute as a part of this activity.

Present: Proton beam therapy restarted at the The Svedberg Laboratory (former GWI) in 1989. The beam energy has been gradually escalated from 72 MeV to 180 MeV in 1994. Treatments are given with a fixed beam mainly to targets in the brain, skull base, facial skeleton and the prostate. At the end of 2007, 823 patients were treated. The treatments are planned to continue to 2011.

Future: Preparations are ongoing for a new national facility located in Uppsala, the "Scandion Clinic", based on cooperation between all counties with university hospitals in Sweden. The facility will be built and operated by a jointly owned company. The preparations for treatments, including dose planning, will be performed at the departments of oncology at the collaborating university hospitals. Both dose plans and patients will then be transferred for treatment and patient care at the Scandion Clinic. The basic concept is that of "distributed competence" with physicians, physicists and nurses involved at the "home hospitals." A maximal number of 2.500 patients per year will be possible to treat. Proton beam treatments will be given with at least two gantries with scanned beams. Treatments are planned to take off in 2011 (2012?).

WED-MA06-4 #631 - Invited Talk - Wednesday 1:00 PM - West Fork

The Role of Protons in Pediatric Malignancies

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Proton (P+) radiation therapy (RT) has been used in the treatment of pediatric malignancies for over 30 years, but relatively recently, there has been a surge of interest in this radiation modality. Currently, there are 5 operating proton therapy facilities in the United States, with 2 others presently being constructed and scheduled for opening in 2009.

The advantageous physical characteristics of proton radiation over photon radiation have been well documented. The lower entrance dose and near complete absence of an exit dose (also called the Bragg peak) allow for much lower dose to the non-target tissues for a patient. This is desirable in all patient populations, but especially in children. Children would, hopefully, have a long life expectancy, and thus be at greater risk of developing late RT effects over the course of their lives than older patients. Late RT effects, especially second malignant neoplasms (SMN) are correlated with the volume of tissue receiving high dose of RT, and thus decreasing RT dose to non-target tissues is a goal for all radiation oncologists.

Currently, most P+ RT is used in sites where the motion of the target is either fixed or can be accounted for. For example, brain tumors and para-spinal tumors are a common indication for P+ RT.

The goal of this presentation will be to highlight the differences in radiation dose to non-target tissue when using P+ versus photon RT.

At the end, the participant should be able to: understand the importance of decreasing dose to non-target tissues; and understand how protons can decrease the dose to non-target tissues versus photons

WED-MA06-5 #633 - Invited Talk - Wednesday 1:00 PM - West Fork

Patch Field Technique in Proton Beam Radiation Therapy for Selective Tissue Avoidance

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Radiation therapy is a long-established modality in the treatment of malignancies. However, the dose distribution of conventional radiation therapy makes it extremely difficult to obtain a strongly concave dose distribution in the situation where a tumor surrounds a critical normal structure. These situations often arise with tumors of the base of skull and spinal canal. Proton beam radiation therapy's unique characteristic allows such concave dose distributions with high doses while selectively minimizing dose to the critical normal structure. Unlike conventional radiation therapy with x-rays or gamma rays which are exponentially attenuated, proton beam radiation therapy has no exit dose after the Bragg peak. The width of the peak as well as its depth in tissue can be precisely modulated with a variety of compensators. The laterality of the field can be easily tailored similar to conventional radiation therapy. Patch field combinations consist of multiple fields of proton beam radiation therapy that take advantage of this unique stopping ability of proton radiation. These field combinations typically consist of a single or multiple "patch" fields which are modified such that its distal edge abuts onto the lateral edge of a "long" field. Multiple sets of patch field combinations can be used to deliver high doses of radiation to target volumes while minimizing dose to normal tissue structures. This allows highly conformal radiation therapy to elegantly treat tumors surrounding or encasing critical normal tissue.

WED-MA06-6 #629 - Invited Talk - Wednesday 1:00 PM - West Fork

Proton Beam Therapy for Prostate Cancer

Andrew K Lee
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Proton therapy is considered a relatively new modality in the treatment of cancer; however, it has been used clinically for over 50 years in the U.S. The characteristic Bragg Peak of proton beams allows better control of distal doses beyond the target compared to conventional photon (x-ray) therapy, but the complexity and cost of proton therapy units has led to only a limited number of clinical centers. Proton therapy in the past has relied on the available technology of the time, but just as radiation oncology has seen significant advances in the photon therapy over the past 20 years, these same advances will improve the state of the art for proton therapy as well.

This presentation will summarize the various clinical sites that proton therapy may be useful with an emphasis on prostate cancer, and provide a rationale for why it may provide a benefit. In the U.S., prostate cancer has an estimated incidence exceeding 200,000 new cases per year, and this is one of the most common sites that can be treated with proton therapy. Other established sites include uveal melanomas, CNS tumors, and pediatric tumors. Emerging sites include lung cancer and gastrointestinal malignancies.

Despite the long history of proton therapy in the U.S., there is a relative paucity of clinical data compared to photon therapy, largely due to the limited number of centers. Selected historical clinical data (both retrospective and prospective) will be presented with a discussion of its potential relevance to modern proton therapy. This presentation also will discuss ongoing clinical trials involving proton therapy with an emphasis on trials conducted at M.D. Anderson, and a discussion of the potential of proton therapy to improve clinical outcomes.

WED-NHS02-1 #518 - Invited Talk - Wednesday 1:00 PM - Brazos II

Active Interrogation Technologies for Nuclear Detection - Overview

R. Leon Feinstein
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The challenge of protecting our homeland against nuclear threats requires significant investment in and innovation from the entire research and development community - private industry, academia and national/government labs. In an environment filled with dense material and normally occurring radioactive substances, the detection of illicit nuclear material in commerce and in transit requires new solutions that will dramatically improve detection sensitivity, discrimination and verification. The Domestic Nuclear Detection Office (DNDO) has been tasked by the Department of Homeland Security to ensure the United States remains safe from attack by the illicit importation, development, or procurement of nuclear material and devices. Under the Transformational and Applied Research Directorate (TARD), an aggressive R&D program is underway to make significant advances in radiography and active interrogation technology. A brief overview of the DNDO R&D implementation strategy will be discussed.

WED-NHS02-2 #434 - Invited Talk - Wednesday 1:00 PM - Brazos II

Conventional and Non-Conventional Nuclear Material Signatures

Tsahi Gozani
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The detection and interdiction of concealed special nuclear material (SNM) in transport is one of the most critical security issues facing the United States.

In principle, detection of nuclear materials is relatively easy because of their unique properties: all of them are radioactive and all emit some characteristic gamma rays. A few emit neutrons as well. These signatures are the basis for the passive non intrusive detection of nuclear materials. The low energy of the radiations necessitates additional means of detection and validation. These are provided by high energy x-rays radiography and by active inspection based on inducing nuclear reaction in the nuclear materials.

Positive confirmation that a nuclear material is present or absent can be provided by interrogation of the inspected object with a penetrating probing radiation, such as neutrons and photons. The radiation induces specific reactions in the nuclear material yielding, in turn, penetrating signatures which can be detected outside the inspected object.

The ¡°conventional¡± signatures are first and foremost fission signatures: prompt and delayed neutrons and gamma rays. Their intensity (number per fission) and the fact that they have broad energy (non discrete) distribution and certain temporal behavior are key to their use. The prompt radiations have also high multiplicities (typical 3 for neutrons and 7 for photons). The ¡°non conventional¡± signatures are not related to fission but to the unique nuclear structure of each element/isotope in nature. This can be accessed through the excitation of isotopic nuclear levels (discrete and continuum) by neutron inelastic scattering or gamma resonance fluorescence. Finally there is an atomic signature-high atomic number (Z¡Ý 74), which obviously includes the nuclear materials. The presence of such a high Z elements can be inferred by techniques using high x-rays.

These signatures and some of their current and potential use will be discussed.

WED-NHS02-3 #194 - Invited Talk - Wednesday 1:00 PM - Brazos II

A Novel Electron Accelerator for non-Intrusive Interrogation Applications

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The importance and utility of high duty cycle accelerators for various inspection technologies such as transmission radiography, Nuclear Resonance Fluorescence and Effective-Z (EZ-3D?) will be discussed. An overview of existing accelerator technologies with respect to the different inspection techniques will be provided. A novel, high duty cycle accelerator being designed by Passport Systems will be presented. The accelerator operates in the 3-10 MeV range at currents up to approximately 1 mA. Compared to existing high duty cycle accelerators with these operating parameters the accelerator is compact, lower cost and lower power. The impact of this accelerator on various inspection technologies will be discussed.

WED-NHS02-4 #507 - Invited Talk - Wednesday 1:00 PM - Brazos II

Tunable, Monochromatic X-rays in Interrogation - Production and Use

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Beams of mono-energetic gamma-rays can efficiently excite nuclear resonance fluorescence (NRF) and thus can be used for isotope-specific detection and imaging of well shielded materials. Material detection is possible either by observing the scattered NRF radiation from an interrogated object or by observing the absence of NRF resonant photons in a gamma-ray beam that passes through an object. The creation of ultra-bright beams of gamma-rays can be accomplished by the collision of short duration laser pulses with relativistic beams of electrons, i.e. via Thomson or inverse Compton scattering. At the Lawrence Livermore National Laboratory, a 775 keV Thomson-Radiated Extreme X-ray (T-REX) source has been constructed specifically for proof of principle, NRF-based, isotope (U238) detection and imaging demonstrations. A review of the laser, accelerator and detector design considerations for homeland security and non-proliferation applications of laser-based gamma-ray sources will be presented.

WED-NHS02-5 #463 - Invited Talk - Wednesday 1:00 PM - Brazos II

Development of a source of quasi-monochromatic MeV energy photons for detection of special nuclear materials

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We discuss a high-brightness, nearly monoenergetic, laser-driven electron accelerator, and preliminary results on the use of this accelerator for the generation of quasi-monochromatic x-rays. A laser pulse with 40-50 TW of peak power is focused on a supersonic helium nozzle to drive a relativistic plasma wave. Electron beams with energies of are accelerated by means of laser wakefield acceleration. The electron beam is measured to have an angular spread of 5 mrad with a charge of 100 pC. Remarkably, the acceleration region is only 4 mm in length. The use of a stable and well-characterized laser system, in conjunction with high-contrast and adaptive optical correction, results in highly reproducible electron beams, both in terms of energy and pointing stability. Operation in the resonant regime, where the spatial and temporal dimensions of the laser pulse equals the plasma wavelength and period, respectively, is also found to dramatically improve beam brightness and reproducibility. We also report preliminary results on an experimental demonstration of MeV-energy x-ray generation by means of all-optical Thomson scattering. When a lower power, independent laser pulse (from the same laser system) is focused onto the above-mentioned electron beam, it is Doppler-shifted in energy from 1.5-eV to > 1 MeV. Comparisons will be made with theory, which predicts that up to 4.5x10^7 photons per laser shot can be produced. The development of a source of tunable, collimated, monochromatic, MeV-energy photons may enable the practical implementation of the technique of nuclear resonance fluorescence (NRF) spectroscopy for active interrogation of cargo containers. Because of the extremely narrow energy widths of NRF lines, polychromatic sources (such as from Bremsstrahlung) are inefficient for this purpose because most of the photons they produce are below the resonant density of interest, resulting in wasted radiation dosage and undesired background noise.

WED-NHS02-6 #389 - Contributed Talk - Wednesday 1:00 PM - Brazos II

Fissile Material Detection by Differential Die Away Analysis

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Detection and interdiction of Special Nuclear Material (SNM) in transportation is one of the most critical security issues facing the United States. SNM naturally emits gamma rays, which forms the basis for passive SNM detection. However, natural gamma rays are low in energy and readily shielded. X-ray systems are effective in detecting the presence of anomalies, which may or may not be SNM. Fortunately, inducing fission in fissile nuclear materials, such as 235U and 239Pu, provides several strong and unique signatures that make the detection of concealed nuclear materials technically very feasible. Differential Die-Away Analysis (D2A2) is a very efficient, active neutron-based technique that uses the abundant prompt fission neutrons signature (average 2.4-2.9 n/fission). It benefits from high penetrability of the probing and signature neutrons, high fission cross section, high detection sensitivity, ease of deployment and relatively low cost. D2A2 can use any neutron source or energy as long as it can be suitably pulsed (e.g., tens to hundreds of microseconds at .1-1 kHz). Typically it uses 14 MeV (d,T) neutrons, because of their very high penetrability and low cost. The neutron generator produces pulses of neutrons that are directed into a cargo. As each pulse passes through the cargo, the neutrons are thermalized and absorbed. If SNM is present, the thermalized neutrons create a new source of (fission) neutrons with a distinctive time profile.

An efficient laboratory system was designed, fabricated and tested under a US Government DHS DNDO contract. It was shown that a small uranium sample can be detected in a large variety of cargo types and configurations within practical measurement times using commercial compact (d,T) sources. Using stronger sources and wider detector distribution will further cut inspection time. The system can validate or clear alarms from a primary inspection system such as an automated x-ray system.

WED-NP06-1 #541 - Invited Talk - Wednesday 1:00 PM - Brazos I

First Results with TIGRESS and Accelerated Radioactive Ion Beams from ISAC

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The TRIUMF-ISAC Gamma-Ray Escape Suppressed Spectrometer (TIGRESS) is a state-of-the-art new gamma-ray spectrometer being constructed at the ISAC-II radioactive ion beam facility at TRIUMF in Vancouver, Canada. TIGRESS will be comprised of twelve 32-fold segmented high-purity germanium (HPGe) clover-type gamma-ray detectors, with BGO/CSI(Tl) Compton suppression shields, and is currently operational at ISAC-II in an early-implementation configuration of six detectors. This presentation will discuss results of the first accelerated radioactive ion beam experiments with TIGRESS, including Coulomb excitation studies of neutron-deficient 20,21Na important for the breakout of the hot CNO cycle into the astrophysical rp-process,

Coulomb excitation of neutron-rich 29Na and the transition to the "island-of-inversion" around 32Mg, and studies of the 12Be halo nucleus via 11Be(d,p)12Be with an accelerated radioactive beam of 11Be.

WED-NP06-2 #587 - Invited Talk - Wednesday 1:00 PM - Brazos I

The GRETINA Spectrometer

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GRETINA (Gamma-Ray Energy Tracking In-Beam Nuclear Array) is a large segmented HPGe detector array developed to carry out a wide range of gamma-ray spectroscopic measurements. Unlike previous arrays, GRETINA can track the scattering path of gamma-rays through the germanium crystal with an RMS position resolution < 2 mm. This is done using the new technology of highly segmented HPGe detectors in conjunction with high speed digital electronics and newly developed signal processing algorithms. The ability to track gamma rays through the crystal eliminates the need for Compton suppression shields allowing the crystals to be close-packed giving the detector array dramatically higher efficiency. Additionally, one can carry out precision Doppler correction on an event-by-event basis enabling high-resolution measurements at radioactive beam facilities where the source can have a high velocity. A discussion of the motivation, technical developments and current status of the project will be given. GRETINA is a national facility developed by Lawrence Berkeley National Laboratory with the participation of Oak Ridge National Laboratory, Argonne National Laboratory, Michigan State University and Washington University and is scheduled to start operations in 2011.

WED-NP06-3 #574 - Contributed Talk - Wednesday 1:00 PM - Brazos I

The Advanced GAmma Tracking Array, AGATA

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The 4pi Advanced GAmma Tracking Array, AGATA, is being constructed by an European collaboration, which currently consists of over 40 partners from 12 countries.

The new challenges for nuclear spectroscopy, which provides the scientific impetus for AGATA, are emerging principally from the new generation of high-intensity Radioactive Ion Beam (RIB) facilities currently being developed worldwide. This array will facilitate the study of the rarest reaction channels populated by these RIBs.

The 4pi array will consist of 180 tapered High Purity Germanium (HPGe) hexaconical crystals which can be grouped into 60 identical triple clusters. To maximise the solid-angle coverage three slightly different irregular shapes are required to make up a triple cluster. The outer contact of each of the Canberra Eurisys crystals are electrically segmented in to 6 rings each having 6 individual segments producing 36-fold segmentation with a central contact ?seeing' the entire crystal.

The AGATA array will utilise digital electronics, Pulse Shape Analysis (PSA) and Gamma-Ray Tracking (GRT). PSA will be used to accurately identify the position of a photon interaction to within ~2mm whilst GRT algorithms will be employed to reconstruct Compton scattered events producing a greater Peak-to-Total ratio and absolute efficiencies.

The full array will be realised in phases. An AGATA demonstrator will consist of 15 detectors assembled in triple clusters plus a symmetric prototype triple cluster. This demonstrator will be commissioned with a series of experiments at the stable-beam facility at Legnaro National Laboratory in Italy starting in the autumn of 2008.

As this array evolves into a 45-detector (1pi) system it will be positioned at GANIL, France and then at GSI, Germany to fully exploit the new and exciting nuclear physics and astrophysics information that such a spectrometer affords .

A report on the current status of the project will be presented.

WED-NP06-4 #300 - Contributed Talk - Wednesday 1:00 PM - Brazos I

Measurement of the Efficiency of the Modular Neutron Array (MONA) at the NSCL

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The efficiency of the Modular Neutron Array (MoNA), recently assembled at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University, was measured and compared to simulations. The Coulomb excitation of a 90 MeV/u beam of 11Be from a gold target was used to produce a calculable flux of neutrons. I will present experimental details and discuss data analysis that incorporates the virtual photon method and Monte Carlo simulations. Both, experimental data and simulation show that the 144-module array, when arranged nine layers deep, is over 70% efficient to 90 MeV neutrons.

WED-NP06-5 #169 - Contributed Talk - Wednesday 1:00 PM - Brazos I

The Development of a Versatile Array of Neutron Detectors at Low Energy

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The development of radioactive ion beams of fission fragments at the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory allows the study of many neutron- and proton-rich nuclei relevant to nuclear astrophysics. On the proton-rich side the doubly-magic 56Ni is a waiting-point in the rp-process, which occurs at the high temperatures and densities present in x-ray bursts and x-ray pulsars. A measurement of the 2H(56Ni,n)57Cu reaction cross section to populate astrophysically important levels would allow the first direct determination of the 56Ni(p,gamma)57Cu reaction rate. The beta decay properties of neutron-rich nuclei are important in the modeling of astrophysical nucleosynthesis processes, such as the rapid neutron capture process. We propose measurements of the decay strength in nuclei near 78Ni and 132Sn to determine beta decay lifetimes, branching ratios and investigate the role of forbidden decays.

The Versatile Array of Neutron Detectors at Low Energy (VANDLE) is a new array of plastic scintillator bars under development at ORNL. The array is highly modular allowing the configuration of the individual elements to be optimized for particular experimental requirements. We propose two configurations: one optimized for beta-delayed neutron emission studies and one optimized for (d,n) reaction in inverse kinematics using radioactive ion beams at energies near Coulomb barrier. Details of the testing and design of the array will be presented.

This work is supported in part by the U.S. Department of Energy under contract numbers DE-FC03-3NA00143 (ORAU), DE-FG52-03NA00143 (Rutgers), and DE-AC05-00OR22725 (ORNL).

WED-NP06-6 #35 - Contributed Talk - Wednesday 1:00 PM - Brazos I

Effect of signal noise on the learning capability of an artificial neural network

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Digital Pulse Shape Analysis (DPSA) by artificial neural networks (ANN) is becoming an important tool to extract relevant information from digitized signals in different areas. In this paper, we present systematic evidence of how the concomitant noise

that distorts the signals or patterns to be identified by an ANN set limits to its learning capability. Also we present evidence that explain overtraining as a competition between the patterns relevant features, on the one side, against the signal noise, on the other side, as the main cause defining the shape of the error surface in link space and, consequently, determining the steepest descent path that controls the ANN adaptation process.

WED-NP06-7 #298 - Contributed Talk - Wednesday 1:00 PM - Brazos I

Improved Energy Resolution of Radioactive Beams at the UM-UND \\emph{TwinSol} Facility

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Making a radioactive ion beam typically requires bombarding a primary target with a stable accelerated (primary) beam. Specific secondary radioactive ions can then be selected for use in various scattering experiments by a focusing magnetic field. These secondary beams often have rather poor energy resolution (e.g. 1 MeV) which limits their use in nuclear reaction studies. One method to compensate for this is to use the time-of-flight (TOF) method with a temporally bunched primary beam (FWHM$\\sim$2 ns) has been used to determine the energy of the secondary beam.

To facilitate this, the UM-UND low-energy radioactive beam facility (\\emph{TwinSol}) operated at the University of Notre Dame FN tandem accelerator has been extended with an added TOF beam line and a new chamber. In the current work this and other methods for non-destructive event-by-event timing measurements which will improve on this situation are presented. Several approaches involving foil \\& multi-channel plates (MCPs), parallel plate proportional counters (PPACs) and thin scintillators are examined. The main challenges for these systems are to operate at count rates typical for secondary radioactive beams (10^5-10^6 per second) and to produce limited energy dispersion in the secondary beam. Results of in-beam tests will be presented.

WED-RE06-1 #357 - Invited Talk - Wednesday 1:00 PM - Trinity Central

Nano-composite based radiation detectors for beam experiments

Ernst I Esch[1], Aaron J Couture[1], Rico E Del Sesto[1], Robert D Gilbertson[1], Luiz G Jacobsohn[1], T. Mark McCleskey[1], Edward A McKigney[1], Ross E Muenchausen[1], Denisse Ortiz-Acosta[1], Rene Reifarth[2], Sy Stange[1], Felicia L Taw[1], Fredrik K Tovesson[1]
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Experiments in accelerator physics today have ever growing demands on radiation detector hardware. With larger applications and less budget for experiments, it is important for radiation detectors to be ideally suited for the task and to be cost efficient. This paper outlines two detector development projects currently carried out at Los Alamos National Laboratory. The first one is the development of a neutron-hardened gamma detector material based on nanocomposites. Stewardship, technological, and astrophysical programs require neutron induced reaction rates for isotopes with half-lives down to a few days. In order to investigate the desired neutron capture rates, higher neutron fluxes are necessary than are currently in use. This necessitates detection systems that can handle higher count rates and have faster recovery times. Presently available materials are either not suitable or cannot be produced in volumes necessary for a calorimetric detection. Scintillator crystals made of nanoparticles embedded in a matrix of secondary material might offer a viable replacement to mono-crystalline material. This would allow the cost-effective production of detectors with the desired material in large volumes.

The second project involves the development of a neutron fission detector to monitor neutron flux at beam lines or reactors. Neutron flux monitors are commonly used in a variety of nuclear physics applications. In nuclear reaction measurements, for example, the neutron flux is needed in order to determine the reaction cross section. Recent research on nanocomposite based γ-scintillator development, pioneered at Los Alamos, indicates that this approach can be extended to load fissionable nanomaterial into a matrix of scintillator material, with up to three orders of magnitude higher fissionable material loading than typical fission chambers. This will result in a rugged, cost efficient fission detector with high efficiency, short signal rise time and the ability to be used in low neutron-flux environments.

WED-RE06-2 #422 - Invited Talk - Wednesday 1:00 PM - Trinity Central

Accelerating Discovery of Improved Radiation Detection Materials

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This presentation will describe the approach and progress over the last 3 years of a research thrust at Pacific Northwest National Laboratory (PNNL) focused on accelerating the discovery of new and improved radiation detection media. This research initiative was begun in response to a range of national needs, particularly those in homeland security, counter-proliferation, and defense. These motivations led to a focus on energy resolution in gamma detectors. One key theme of this effort is an improved understanding of important detector material properties through a better understanding of the fundamental mechanisms and processes responsible for the performance of radiation detectors. The second key theme is accelerating identification of new candidate detector materials that are worth the investment needed to grow single crystals large enough for testing with gamma-rays up to about 1 MeV, which requires crystal volumes of approximately 1 cm^3. To achieve this goal, PNNL is investigating use of material informatics to identify promising new material systems and use of thin films for synthesis, doping optimization and performance screening. In particular, PNNL is investigating use of ion beams to screen thin films of potential scintillators for brightness, timing, and non-proportionality.

WED-RE06-3 #487 - Invited Talk - Wednesday 1:00 PM - Trinity Central

Radioluminescence investigation of ion-irradiated phosphors

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Phosphors are materials that emit light under the excitation of incoming radiation. This property is used, among other applications, in radiation detection. In many cases, energetic particles are generated in radioactive decay, and the interaction of these energetic particles with phosphors induces luminescence. Efficient energy transfer from the ionization track to the luminescent centers must occur to yield significant light output. Besides, the investigation of the effects of ion irradiation on the luminescence of phosphors is comparatively unexplored. In this work, we summarize radioluminescence (RL) investigation of ion-irradiated phosphors and oxides, with particular focus on materials of technological interest, namely Lu2SiO5 (LSO), a host for rare earth activators, and the intrinsic phosphor Bi4Ge3O12 (BGO). Commercial crystals were irradiated with H+ and He+ ions with fluences up to 2x1016 atoms/cm2, and the irradiation effects characterized by means of RL measurements as a function of temperature, from 10 K to room temperature, and optical absorption measurements. Additionally, luminescence thermal quenching was analyzed by means of the two-level Mott-Seitz model, yielding the effects of ion irradiation on the activation energy of this process. At low temperatures, in the case of LSO, H+ irradiation leads to an unexpected two-fold increase of the self-trapped luminescence, while for BGO luminescence decreases 15%.

WED-RE06-4 #580 - Invited Talk - Wednesday 1:00 PM - Trinity Central

Heavy Charged Particle Effect on Al2O3:C Radiation Detectors

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The Optically Stimulated Luminescence technique is now routinely used in personal dosimetry, but its range of application can also be extended to medical, space dosimetry, and accident dosimetry, as well as homeland security (forensics). Al2O3:C, the most successful OSL detector, has been extensively characterized for proton radiotherapy and space dosimetry applications using heavy charged particles (HCPs) from proton to xenon, with energies from 7 to 1000 MeV per nucleon. This talk reviews the effect of HCPs on the OSL properties of Al2O3:C, particularly the linear energy transfer (LET) dependence of the luminescence efficiency and how this dependence is affected by experimental parameters. We demonstrate that the ionization density created by the HCPs affect the luminescence emission bands of Al2O3:C, providing extra information about the radiation field. So far, this dependence has been observed for HCPs of different LETs with energies of relevance for space dosimetry. However, there is also the potential to use this effect in proton and neutron dosimetry, in the latter case using new neutron-sensitive Al2O3:C dosimeters recently developed. Potential application in forensics will also be discussed.

WED-RE06-5 #443 - Contributed Talk - Wednesday 1:00 PM - Trinity Central

Development of Nanocomposite Scintillators for Gamma-Ray Measurement

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Accurate measurements of the neutron capture cross-sections of a number of short-lived isotopes are needed to advance research in nuclear astrophysics, the nuclear fuel cycle, and weapons physics. The large decay rate of short-lived samples and the high neutron flux required for the measurement call for a detector with a fast signal decay time. Current neutron capture cross-section experiments are unable to conduct these measurements. Cerium fluoride (CeF3) has been identified as a suitable scintillator for

these measurements; however, CeF3 crystals are not currently available in the necessary sizes and quantities. One potential solution is the fabrication of nanocomposite scintillators, consisting of nanoscale CeF3 particles dispersed in a matrix material. We have successfully fabricated CeF3 nanoparticles with sizes < 10 nm, dispersed them in organic matrices, and characterized their optical properties and radiation response. We will present the manufacturing process and characterization of these detectors.

WED-AP01 - VTS-1 #444 - Invited Talk - Wednesday 3:30 PM – Pecos I

Evolution of quantum systems from microscopic to macroscopic scales

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Even though the static properties of quantum systems have been known since the early days of quantum mechanics, accurate simulation of dynamical break-up or ionization remains a theoretical challenge despite our complete knowledge of the relevant interactions. The simulations are challenging because of highly oscillatory exponential phase factors in the electronic wave function and the infinitesimally small values of the continuum components of electronic probability density at large times after the collision. The approach we recently developed, so-called, the regularized time-dependent Schrödinger equation method, has addressed these difficulties by removing the diverging phase factors and transforming the time-dependent Schrödinger equation to an expanding space. The evolution of the electronic wave function was followed to internuclear distances of R = 100,000 a.u. or 5 microns, which is of the order of the diameter of a human hair. Our calculations also revealed unexpected presence of free vortices in the electronic wave function. The discovered vortices also bring new light on the mechanism of transferring of the angular momentum from an external to internal motion. The connection between the observable momentum distribution and the time-dependent wave function implies that vortices in the wave function at large times are imaged in the momentum distribution.

WED-AP – VTS-2 #TBD - Invited Talk - Wednesday 3:30 PM – Pecos I

WED-AP – VTS-3 #TBD - Invited Talk - Wednesday 3:30 PM – Pecos I

WED-AT07-1 #157 - Invited Talk - Wednesday 3:30 PM - Bur Oak

Electron Cyclotron Resonance ion sources for highly charged ion beams

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Electron Cyclotron Resonance (ECR) ion sources are used for several different applications. Mostly they are used for the production of highly charged ion beams for the nuclear physics experiments but they are also used for example for medical applications and for the tests of space electronics. Strong requirements have been introduced towards the higher beam intensities and new exotic, even radioactive, ion beams. Due to the requirements more powerful ECR ion sources and new methods for the beam production are needed. In order to meet the beam intensity requirements several superconducting ion sources have recently been built or are under construction in Asia, Europe and USA. The development work of the ion beam quality and metal ion beams are also playing a crucial role. In this article a general overview concerning the challenges involving in the most powerful ECR ion sources and beam production will be given.

WED-AT07-2 #565 - Invited Talk - Wednesday 3:30 PM - Bur Oak

Ramping Up the SNS Beam Power with the LBNL Baseline H- Source

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To deliver the promised neutron yields, SNS is aggressively ramping up the rep rate, pulse length and the beam current during the initial seven productions runs spanning over a three year period. This challenges and strains most of the equipment including the Front-end with the H- source designed and built by Lawrence Berkeley National Laboratory. After the second production run, the low-energy beam transport had to be modified for supporting >0.2% duty factors with high availability. Before the forth production run, the H- source needed to be modified for routinely producing the required 25 mA LINAC beam current during the ~0.4 ms long pulses at 60 Hz. Ion source modifications continue to be implemented to routinely produce the 30 mA LINAC beam current during the 0.8 ms long pulses at 60 Hz required by 6/1/08. The final 1.4 MW target power requires 38 mA LINAC

beam current, which was demonstrated for 4 hours on 12/24/07. We continue to prepare improvements that are likely needed to routinely meet the 38 mA requirement during the 1 ms long LINAC beam pulses at 60 Hz with 99.5% availability. Encountered problems and implemented mitigations will be discussed.

WED-AT07-3 #285 - Invited Talk - Wednesday 3:30 PM - Bur Oak

Study on various plasma Ion sources for focused ion beam

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Focused ion beam (FIB) has been widely used for the industrial field of nanofabrication. Ion source is an essential part of the performance for the FIB since its current determines the process yield and the emittance controls the resolution. Most commercial FIB systems utilize liquid metal ion source (LMIS) using gallium because of its high brightness, typically on the order of 106 in amperes/cm2sr. However, various drawbacks such as gallium contaminations have been continuously reported, requiring new types of ion sources for other ion species such as inert gas, hydrogen, and oxygen. Also, the need for a multi-beam ion source to accommodate quasi-parallel processes has been grown, but the LMIS is not appropriate to make more than a single ion beam. Accordingly, alternative ion sources substituting the LMIS have been required and the plasma ion source could be one of the most attractive candidates due to its desirable characteristics for FIB such as possibilities of various operable species and multi-beam extraction. In SNU, a novel plasma ion source using a bias electrode has been introduced, which makes it possible to extract high current ion beam even through a small aperture. Positive voltages on bias electrode trigger generation of additional dense plasma near aperture and thus increase ion beam current drastically. Based on this bias method, several types of plasma ion sources for FIB have been investigated. Characteristics including brightness of these sources will be presented and the feasibility to the FIB system will be addressed.

WED-AT07-4 #76 - Invited Talk - Wednesday 3:30 PM - Bur Oak

Charge breeding applications of EBIS/T devices

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The demand of highly charged ions of isotopes from all mass regions of the nuclear chart for low energy experiment of for the post acceleration has driven the development of different charge breeding methods. Charge state breeder employ high charge state ion sources like the Electron Beam Ion Source/Trap (EBIS/T) and the Electron Cyclotron Resonance Ion Source (ECRIS). Existing radioactive beam facilities like REX-ISOLDE or ISAC (TRIUMF) are already using charge state boosters for the post acceleration of radioactive ions. Facilities like SPIRAL II, EURISOL and MATS within the FAIR project have identified the need of a breeding system because of the demand for highly charged ions at low energies and because of the available budget. Charge state breeding with EBIS/T devices requires several steps, which need to be optimized. A beam of singly charged ions must be prepared prior to injection into an EBIS/T in order to match the acceptance of the electron beam. An efficient injection and short breeding times are required as well as a high abundance in one specific charge state, which can be manipulated in EBIS/T devices. Further issues of charge breeder development are extraction and purification of the wanted highly charged ion species. The present paper will review the efforts of the EBIS/T community and will give an overview of the planned and running facilities.

WED-AT07-5 #406 - Contributed Talk - Wednesday 3:30 PM - Bur Oak

High Brightness Inductively Coupled Plasma Source for Accelerator Applications

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A new inductively coupled plasma ion source has been developed for ion microbeam applications. This radio frequency ion source is well suited to accelerator applications because it has a high brightness and long lifetime. The source has been designed to have a very low ion temperature (0.1electron-volts) so it will have high brightness at moderate extraction current density (100-200 mA/square cm). This source can operate with a variety of positive ions and has been tested with Xenon, Argon, Oxygen, and Helium. The source has a very low wear rate even with heavy ions and should have a lifetime greater than 2000 hours with Xenon. This source has an axial energy spread of less than 6eV. Experimental testing on a 30KeV microprobe column has demonstrated a reduced brightness that is 10X greater than the Duoplasmatron ion source. The performance of this source in several accelerator applications is modeled and shows the source to be well matched for accelerator based microprobe applications.

WED-AT07-6 #371 - Contributed Talk - Wednesday 3:30 PM - Bur Oak

BRIGHTNESS STUDIES OF THE ION BEAMS PRODUCED BY SUSI - THE SUPERCONDUCTING SOURCE FOR IONS

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The NSCL/MSU operates the Coupled Cyclotron Facility (CCF) mainly for production of rare isotopes by fragmentation of fast stable ions. These rare, short-lived isotopes are used in fundamental nuclear research. In order to increase the available secondary beam intensity one possibility is to increase the accelerated primary beam intensity. To accomplish this task, we designed and constructed a new, completely superconducting Electron Cyclotron Resonance Ion Source (ECRIS) called SuSI, operating at 18+14.5 GHz microwave frequencies [1]. Besides the increased intensities, this ECRIS was designed with several adjustable parameters in order to allow the optimization of the extracted ion beam brightness: magnetic field (axial magnetic peak position and magnitude, radial magnetic field magnitude), plasma chamber length, bias disc position and voltage, extraction electrode (puller) position and voltage and bias voltage on the beamline. The accelerated beam intensity out of the CCF is determined not only by the available ion beam intensity from the ECRIS but also by emittance of the ion beam and its proper match to the cyclotron acceptance. The emittance of the extracted ions was measured with an Allison-type emittance scanner. We will present the general performance of SuSI as well as results from beam studies on the influence of the tunable ion source parameters on the intensity and emittance of the extracted ion beams. Emphasis will be on the results for the medium charge states needed for the CCF operation. The performance obtained will be compared to similar data from the ARTEMIS ECRIS used presently in the CCF operations [2].

* Work supported by NSF under grant PHY-0110253 and by MSU.

[1] P.A. Zavodszky et al., Rev. Sci. Instr. 79, 02A302 (2008).
[2] M. Doleans et al. Proceedings of the 18th International Conference on Cyclotrons and their Applications, October 1-5, 2007, Giardini Naxos, Italy, paper FRYCR02.

WED-AT07-7 #369 - Contributed Talk - Wednesday 3:30 PM - Bur Oak

Opto-Electric Characterisation of an AC Field Controlled Electrospray

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Electrospray is successfully used as an ionization method for large biological molecules. The droplet dynamics and coulombic fission are key factors in the ionization efficiency of an electrospray ion source (ESI). We investigate droplet dynamics of an electrospay controlled by a transversal electric field generated by a high voltage amplifier driven by an arbitrary wave generator. A high speed camera is used for image acquisition of droplet dynamics. Disk-like counter electrodes of different diameters are employed in our studies. Our measurements show that the electrode radius influences the onset voltage. The electrospray current is investigated as a function of electric field magnitude frequency, signal wave shape, and field structure in the electrospray electrode gap, while the fluid flow rates are controlled by a syringe pump. The current variations are related to the transversally controlled droplet dynamics and coulombic fission.

WED-AT07-8 #234 - Contributed Talk - Wednesday 3:30 PM - Bur Oak

The Solubility and Diffusivity of Helium in Mercury with Applications to the Spallation Neutron Source

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The Spallation Neutron Source (SNS) is one of the largest science projects in the United States, with total cost near 1.7 Billion Dollars. The limiting factor of the facility had always been assumed to be the lifetime of the target window due to radiation damage. After further investigation, the lifetime of the target was determined not to be limited by radiation damage but by cavitation damage.

The cavitation damage derives from pressure waves caused by the beam energy deposition. Vapor bubbles form when low to negative pressures occur in the mercury near the stainless steel target window due to wave interaction with the structure. Collapse of these bubbles can focus wave energy in small liquid jets that erode the window surface. Compressibility of the mercury can be enhanced to reduce the amplitude of the pressure wave caused by the beam energy deposition. Two methods to

enhance compressibility have been devised?small (10 to 30 micron diameter) gas bubble injection into the bulk mercury through out the target and a gas layer injected near the window in the region most vulnerable to damage. Solubility and diffusivity parameters of inert gas in mercury are required for a complete mechanical simulation and engineering of these strategies.

Using current theoretical models, one obtains a theoretical Henry coefficient of helium in mercury on the order of 3.9E15 Pa-molHg/molHe at 300 K. This low solubility was confirmed by a direct experimental method. Mercury was charged with helium and any pressure change was recorded. Any pressure change was attributed to gas going into solution. Therefore, with the sensitivity of the experiment, a lower limit of 9E12 Pa-molHg/molHe was placed on the mercury-helium system. These values guarantee a stable bubble lifetime needed within the SNS mercury target to mitigate cavitation issues.

WED-FIBP05-1 #202 - Invited Talk - Wednesday 3:30 PM - Post Oak

PIXE's role in understanding emission characteristics and composition of dust aerosols in western Texas (USA)

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The arid Chihuahuan Desert and semiarid Southern High Plains in western Texas (USA) are frequent source areas of dust and sand storms. Mineral aerosols from western Texas and the surrounding areas are regularly transported long distances, impacting visibility and air quality in cities and ecologically protected areas far downwind. Aerosols collected on filters, dust falling in dry-deposition monitors, sediment traps, and in rain, and bulk samples of dust storm source materials, have been obtained from various locations in the region and analyzed by PIXE.

Analytical results provide some of the only known compositional data on these materials, which will be useful for source apportionment and understanding the environmental impacts of west Texas dusts. Elemental concentrations and ratios of Southern High Plains dusts are compositionally similar to local soils, although certain elements such as Fe are enriched in the aerosolized materials, probably as a result of the intense wind erosion process. In the Salt Basin of the Chihuahuan Desert, PIXE analyses revealed a compositional fractionation in blowing sand and dust, with the coarser, horizontally-transported particles closest to the ground and nearest to the source being enriched in Na, Mg, Ca, and S (salts), with the finer, vertically-settling particles higher above the ground and farthest from the source being enriched in Si, Al, K, and Fe (crustal elements). Dust-emitting soils from other sites in the Chihuahuan Desert were revealed to contain enrichments of metals such as As, Ni, and Pb: in some sites, the enriched metal concentrations may be related to runoff from agricultural and mining activities.

WED-FIBP05-2 #497 - Invited Talk - Wednesday 3:30 PM - Post Oak

Innovation of microcapsules that enables drug targeting through radiotherapy

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We developed fluoroscopically detectable liquid-core microcapsules with a high affinity for radiation-induced P-selectin that release anticancer drugs on radiation. By treating Meth A fibrosarcoma in BALB/c mice with 2 radiotherapy sessions, we tested the microcapsules' ability to target the anticancer drug and increase the antitumor effect via synergistic effect in combination of targeted anticancer drugs with radiation.

The microcapsules were prepared by spraying a mixture of 3% hyaluronic acid and 2% alginate, supplemented with 0.2 mmol carboplatin on 0.5 mol/l FeCl₂ containing 0.1 µmol/l P-selectin glycoprotein ligand-1 and FcSv antibody to P-selectin. To induce P-selectin, the tumor was radiated with 5 or 10 Gy ⁶⁰Co γ rays. Next, 1 x 10¹⁰microcapsules were injected i.v. 1 h before the P-selectin level peaked and were allowed to interact with P-selectin for 1-6 h postradiation. Then the 2nd sessions were conducted, identical to the 1st session. P-selectin was detected by in situ hybridization and western blotting. The distribution of carboplatin was imaged and quantified using particle-induced X-ray emission.

The microcapsules were 20.3 ± 3.8 µmφ, with a 19.7 &plusmn 1.2 µmφliquid core. The 1st session proximally induced P-selectin, which peaked 6 h postradiation; P-selectin was expressed in 78.1±6.7% and 93.4

± 7.8% endothelial cells after 5 Gy and 10 Gy radiations, respectively. The microcapsules were injected 5 h after the 1st session and could be traced fluoroscopically. Maximum accumulations were observed 6.2 ±1.7 h postinjection, as in the microscopic study. After the 2nd session, the accumulated microcapsules released the carboplatin and gelatinized their outer shell. The released carboplatin increased the antitumor effect via synergistic effect with radiation.

Our microcapsules will provide new potential to radiation through drug localization limited to the irradiated area. These factors will bring about better tumor control and a decrease in the adverse effects.

WED-FIBP05-3 #188 - Contributed Talk - Wednesday 3:30 PM - Post Oak

Regional PIXE facility at Chandigarh (India) and trace element analysis of Aerosol and Medical samples

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A regional Proton induced X-ray Emission (PIXE) facility is newly developed using 3 Mev Proton beam from Variable Energy Cyclotron, Panjab University, Chandigarh (India). A new target chamber has been designed to cater for Proton Induced Gamma Emission (PIGE) and Rutherford Back Scattering (RBS) along with PIXE measurements. The HPGe x-ray detector, the Ge (Li) gamma-ray detector and a silicon surface barrier (SSB) detector can be mounted simultaneously in the chamber for this purpose. A remotely controlled stepper motor is provided to move the target wheel holding 12/24 samples at a time. This facility is now routinely used for the detection of trace elements in the aerosol, medical and forensic science samples.

The paper presents the analysis of Aerosol samples collected from highly polluted steel city of Mandi Govindgarh in Punjab state and relatively clean city of Jammu in Jammu & Kashmir region. The results from the analysis of these samples show some basic differences in the trace element profile of the two cities. The paper also describes the trace element analysis of fly ash in the vicinity of Ropar Thermal Power plant in Punjab. The scope of this study was to determine the concentration and composition of atmospheric particulate matter (PM) in the vicinity of coal-fired thermal power plants in India. The data taken for the Medical and Forensic samples will also be discussed.

WED-FIBP05-4 #488 - Contributed Talk - Wednesday 3:30 PM - Post Oak

HEAVY METALS INPUTS FROM ATMOSPHERIC DEPOSITION AND WASTEWATER IRRIGATION TO AGRICULTURAL SOILS IN THE MEZQUITAL VALLEY IN CENTRAL MEXICO

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The Mezquital valley in Central Mexico is one of the most studied areas in Mexico in terms of metal contamination because it has been receiving, the residual waters of Mexico City for nearly 100 years. It is located close to the Tula-Vito-Apasco industrial corridor, a critical zone by the polluting agents emitted to the atmosphere. Intense research, in particular the effects heavy metals in soil and crop products have been done. However there are limited studies of other sources like the atmospheric deposition. This work presents a comprehensive study in the Mezquital area where heavy metals such as Fe, Cu, Zn and Pb present in irrigation water and aerosols sampled are investigated to determine the relative importance of these sources of metals to agriculture soils. Water samples collected from irrigation channels in 2004 were pre-concentrated with metal-carbamates and collected into filters. Coarse PM10 were collected in Tlaxcoapan, Hidalgo on Polycarbonate filters exposed every 2 days for 24 hours, from June to December 2007. PIXE was applied to determine the metals in aerosols and water at the 3 MV Peletron accelerator of the Institute of Physics of the National Autonomous University of Mexico. X-ray detection of elements was conducted with a Canberra low-energy Ge detector and a 38 m Al foil. The concentrations of elements were calculated using the GUPIX software package. Calibration was performed using MicroMatter films. The results obtained relative to the metal concentration in wastewater and aerosols as well as their possible relationship with the metal concentration in soils is discussed in this paper.

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WED-FIBP05-5 #322 - Invited Talk - Wednesday 3:30 PM - Post Oak

Studies of Hard and Soft Tissue Elemental Compositions in Mice and Rats Subjected to Simulated Microgravity*

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The effects of micro-gravity on mammalian physiology are not thoroughly known. To further investigate these effects, groups of mice and rats were subjected to simulated micro-gravity via NASA validated Hind-limb suspension (HLS). Animals were hind limb suspended for 1, 2, 4 and 14 days while the control groups were maintained without suspension for the same duration as of HLS animals. Some groups were also fed on special diet with defined composition to study the effect of diet. At term the animals were sacrificed and the tibia, femur, and parietal and interparietal bones from the cranium were collected. In addition, pancreatic tissues and muscle tissue from the buccinator muscle from the rats was also collected. All of the bones and tissues samples were cleaned, dried and then sputter coated with gold-palladium for quantitative analysis using Energy Dispersive Spectroscopy (EDS) equipped on a Scanning Electron Microscope (SEM). In the EDS, 10-20 keV electrons bombarded the samples and a Si(Li) detector with a resolution of 144 eV at 5.9 keV measured K-, L- and M-shell x-rays. Independently, X-Ray Fluorescence (XRF) provided the data for comparison and normalization. Flame software, with Fuzzy Logic, was used to form elemental ratios. Elemental analysis of bone samples indicated a variation in the compositional ratios of calcium, potassium, oxygen and carbon in the leg bones and skulls of the HLS versus control specimens. These variations showed dependence on sample position in the bone. In the soft tissue samples some correlation is seen between the weight percent of carbon and the diet composition consumed by the animals.

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WED-IBA03-1 #456 - Invited Talk - Wednesday 3:30 PM - Brazos II

Ion beam Analysis of Technologically Important Oxides

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Metal oxides are unique in their breadth of properties and they represent a very important class of materials. These materials demonstrate range of properties including electronic properties ranging from superconducting to insulating, magnetic properties ranging from ferromagnetic to antiferromagnetic, dielectric properties ranging from low-k to high k, and surface chemical reactivity ranging from active to inert. As a result, oxides have applications not only in fascinating fundamental science issues, but also in significant importance for current and future technologies. Current and future technologies require new materials systems encompassing these properties that are fabricated with a high degree of control. Oxide materials show an increasing demand for capabilities that can be effectively used to meet the challenges associated with quantitative characterization. Ion beam analysis which includes several powerful ion beam capabilities can be effectively used to characterize various aspects of these materials. In this discussion, we will focus on the applications of ion beam analysis in characterizing several technologically important oxides including, doped titanium dioxide materials for catalysis/photocatalysis area relevant to clean energy production, doped dilute magnetic semiconducting oxides for spintronics applications, and the characterization of high K thin films that were grown on silicon. Effective use of RBS, nuclear reaction analysis (NRA), and PIXE along the channeling and random geometries to locate the dopant and impurity registries and profiles, to determine crystalline quality of thin films, to carry out the defect analysis, and to investigate the structure and stability of interfaces will be discussed along with other surface and bulk sensitive capabilities which played major roles in addressing the scientific issues in these materials in combination with ion beam capabilities.

WED-IBA03-2 #323 - Invited Talk - Wednesday 3:30 PM - Brazos II

OXIDE FILMS AND SURFACES FOR OPTICAL AND ELECTRICAL DEVICE APPLICATIONS - ION BEAM ANALYSIS AND SURFACE MODIFICATION

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Oxide thin films, surfaces, and interfaces play a significant role in micro/nano-electronics, integrated optics, and optoelectronics. Understanding the chemical and geometric structures of thin oxide films is, therefore, very important in order to optimize the

growth conditions to produce high-quality materials to meet the requirements of enhanced device performances. The talk will focus on the chemical and structural characteristics of MOx (M = Ti, Mo, V, and W) thin films studied using ion-beam analytical techniques. The application of the Rutherford backscattering spectrometry (RBS) and nuclear reaction analysis (NRA) methods, which employ the high-energy (MeV) ion-beam probe for analysis, along with other surface-specific techniques will be discussed to establish the microstructure of thin oxide films as a function of the growth temperature (30-500 oC). The effect of microstructure on the electrical and optical properties will be discussed. The low-energy (keV) Ar+ ion-induced surface modification of the nonlinear optical crystal surfaces, KTiOAsO4 (001) and KY(WO3)2 (010), will also be discussed to demonstrate the alteration of <As-O>, <Ti-O>, and <W-O> bonds and their possible effects on the optical properties of the respective crystals.

WED-IBA03-3 #36 - Invited Talk - Wednesday 3:30 PM - Brazos II

High temperature thermal stability and oxidation resistance for magnetron-sputtered CrAlON coatings on 430 steel

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The requirements of low cost and high-temperature corrosion resistance for bipolar interconnect plates in solid oxide fuel cell stacks has directed attention to the use of metal plates with oxidation resistant coatings. We have investigated the performance of steel plates with homogenous coatings of CrAlON (oxynitrides). The coatings were deposited using RF magnetron sputtering, with Ar as a sputtering gas. Oxygen in these coatings was not intentionally added. Oxygen might have come through contaminated nitrogen gas bottle, leak in the chamber or from the partial pressure of water vapors. Nitrogen was added during the growth process to get oxynitride coating. The Cr/Al composition ratio in the coatings was varied in a combinatorial approach. The coatings were subsequently annealed in air for up to 25 hours at 800 oC. The composition of the coated plates and the rate of oxidation were characterized using Rutherford backscattering (RBS) and nuclear reaction analysis (NRA). Surface of the coatings were characterized using Atomic force Microscopy (AFM). From our results, we conclude that Al rich coatings are more susceptible to oxidation than Cr rich coatings.

WED-IBA03-4 #317 - Invited Talk - Wednesday 3:30 PM - Brazos II

Interface Mixing of Fe-Al Interface and role of Ti, V and Zr as a Stabilizing Interlayer at the Interface

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There is considerable interest in fabricating thin film multilayer structures with sharp interfaces for a wide variety of applications. Interface intermixing may degrade the desired physical properties of a structure, but this may be reduced in some cases using stabilizing interlayers at the interface. Model calculations for the Fe-Al interface, a system well known for considerable intermixing at room temperature, predict that both V and Ti will be effective stabilizing interlayers where as, in contrast, predict Zr to have the opposite effect. We have used X-ray reflectometry (XRR) and Rutherford backscattering spectrometry (RBS) to characterize bilayers and tri-layers of the Fe-TM-Al (TM=Ti, V, Zr) systems prepared using dc magnetron sputtering.

WED-IBA03-5 #293 - Invited Talk - Wednesday 3:30 PM - Brazos II

Ion beam analysis on Cr retention and oxidation resistance of coatings on SS430 interconnect for solid oxide fuel cells application

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Chromia forming ferritic stainless steels are being considered for application as interconnects for planar solid oxide fuel cells (SOFC) because of their low cost and flexibility. Many SOFC designs will operate at temperatures exceeding 700 ◦C. At these temperatures, ferritic steels lack environmental stability in the SOFC environment, and as a result may degrade the performance of the SOFC. In this study, an effective, dense and well adherent TiCrAlYO coating was deposited on 430SS using

filtered arc deposition technique. XRD indicates that nanocrystalline spinel is the dominant crystal structure in the coating. Rutherford backscattering with He+ and non-Rutherford scattering with H+ were used to characterize the composition and the thermal stability of the coatings. The chromium volatility of the coated steel plates at 800 oC was measured using ion beam analysis. Significant reductions in oxidation rates as well as reduced Cr volatility were observed for the coated alloys.

WED-IBA03-6 #160 - Contributed Talk - Wednesday 3:30 PM - Brazos II

The analysis of very thin SiON layers, a TOF-ERD approach.

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In the development of new materials related to micro-electronics, simple analysis techniques with fast turnover times are necessary. Currently, SiON layers are of great interest in recent memory devices. Total thickness is rated at 6 nm, very often composed of a three layer stack of SiO2, SiN and SiON-layers. Most of these thin films were analyzed with angular resolved XPS as it is full wafer compatible and non-destructive. With the decreasing dimensions of the dielectric films, this approach starts to faille as the AR-XPS becomes unable to clearly identify the respective layer structure and is not able to detect H at all.

In this paper an alternative approach based on Time-of-Flight Elastic Recoil Detection (TOF-ERD) is explored. Notwithstanding its intrinsic limitations, one can obtain, through a careful optimization of the beam species, beam energy and geometry, sufficient depth resolution and mass resolution for the (background free) analysis of very thin films (< 10 nm).

This optimization is illustrated in the present study on the thin SiON-films (<6 nm). By choosing a 4.5 MeV Chlorine beam with optimized geometry (exit angle 5 degrees, recoil angle 39 degrees) sufficient depth resolution was obtained enabling to identify the 3 layer structure. When compared to the AR-XPS depth profiles, the improved depth resolution can clearly be illustrated. In addition thicker films have also been analyzed whereby higher beam energies (9 MeV Chlorine) with larger exit angles (19 degrees) are used. The results obtained between thick and thin samples were in total agreement and additional measurements with FTIR on the thick samples confirm the obtained LE-TOF-ERD data.

Finally we will demonstrate that the H-detection represents an additional advantage relative to the XPS-data, as the H-profiles obtained with LE-TOF-ERD are consistent with the variations in process conditions and their impact on the electrical properties.

WED-IBM07-2 #445 - Invited Talk - Wednesday 3:30 PM - Pecos II

Scanning Ion Conductance Microscopy of Ion Tracked Membranes

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Scanning Ion Conductance Microscopy (SICM) is an underutilized form of scanning probe microscopy that measures surface induced changes in conductivity at the tip of an oscillating micro or nanopipette. An advantage of SICM is it is optimized to perform in ionic solutions, making it well-suited for the study of conductivities and properties of nanoporous materials. In this presentation, SICM has been used to image both conical and cylindrical nanopores etched into polymeric membranes via the track-etch process. We will compare images obtained with SICM with results obtained from scanning electron microscopy and atomic force microscopy.

WED-IBM07-3 #459 - Invited Talk - Wednesday 3:30 PM - Pecos II

Nanowires synthesised in ion track-etched membranes

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In recent years, quasi-one-dimensional nanostructures such as nanopores, nanotubes, and nanowires have moved more and more into the focus of intensive research owing to their fascinating properties and their potential application as electronic, sensoric, opto-electronic, and thermoelectric components in future nanoscale devices. Among the various fabrication techniques, the ion track-etching method is frequently employed because it allows the control of both size and shape of the nanostructures within a wide range. For this purpose, polymer foils are irradiated with swift heavy ions and subsequently etched resulting in nanoporous membranes. Thereafter, metal is deposited electrochemically inside the pores leading to the formation of nanowires.

By this approach, nanowires with diameters from 20 nm up to the micrometer range can be created. Furthermore, it allows the growth of cylindrical as well as of conical nanowires where the cone angle is adjusted by the etching parameters. The wire crystallinity is controlled by the electrochemical deposition conditions (temperature and overvoltage). Studies of the transport properties of single nanowires revealed that the electrical resistivity is affected by finite-size effects, i.e., additional electron

scattering both at the wire surface and at inner grain boundaries. For instance, Bi nanowires show a non-monotonic resistance vs. temperature behaviour due to the aforementioned effects.

Wires of few ten nanometers in diameter fragment into chains of nanospheres at temperatures of few hundred degrees Celsius far below the bulk melting temperature. This decay results from the Rayleigh instability whose driving force is the minimization of surface energy.

WED-IBM07-4 #409 - Invited Talk - Wednesday 3:30 PM - Pecos II

Fabrication of multi-level micro-tunnels in SU-8 using High Energy Ion Beam Lithography

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Multi-level, three-dimensional micro-tunnel microstructures in polymers have many applications as sensors, as heat exchangers for fuel cells, and as components for Micro-Electro-Mechanical-Systems (MEMS). Fabrication of these multi-level microstructures with a minimum number of process steps has always been one of the primary challenges in this technology. The polymer SU-8 offers two distinct advantages as a negative photoresists in this regard: (1) the extremely low exposure requirements, particularly when using high energy ion beams, results in a significantly reduced exposure time, and (2) the thickness of single or multi-layer spin coatings on substrates can be easily and precisely controlled over a wide range.

Examples of multi-level structures fabricated in SU-8 using the high energy focused ion beams will be presented and a novel sequential exposure and developing process will also be illustrated.

WED-IBM07-5 #499 - Invited Talk - Wednesday 3:30 PM - Pecos II

Writing with Nanotubes

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We will show in this talk a novel method for the patterning and deposition of chemical and biochemical molecules onto flat surfaces with resolution at the submicron level. In this method, conical nanotubes are embedded in an impervious glass matrix and they act as "pens" for the deposition of biomolecules on flat surfaces. Multiple nanotubes containing conical nanopores are prepared in our lab. The deposition and patterning of nucleic acids and protein molecules were performed using electrophoresis transport mechanism onto a flat surface by applying appropriate sign and magnitude of a potential between molecules in the nanotubes and surface. The distance between the nanotubes and surface are kept small (<200 nm) to minimize the diffusion of molecules in a lateral direction once they leave the nanotube tips. We will show simultaneous deposition of two charged molecules onto glass substrates using this technique. In principle, many molecules can be simultaneously deposited by providing appropriate reservoir for each molecule. The proposed system may find many potential applications in the fields of life, materials and biomedical sciences.

WED-MA07-1 #413 - Invited Talk - Wednesday 3:30 PM - West Fork

Overview of Carbon and Other Heavier-ion Therapy

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Carbon and other heavier-ions possess biologic and physical advantages over X rays. Biologically, they reduce OER and increase RBE. Cells irradiated by them show less variation in cell cycle related radiosensitivity and decreased repair of radiation injury. Their physical behavior allows precise delivery of high doses to tumors while minimizing irradiation of normal tissues. The most beneficial aspect of ion beams lies on the fact that as they travel deeper inside the body, the RBE becomes larger with depth.

In 1975, heavy particle therapy was first started at LBL using neon ions to irradiate tumors for which cure by conventional modalities was difficult. By 1988, a total of 239 patients had received a minimum neon physical dose of 1000 cGy. In 1994, carbon ion therapy was started at NIRS, and subsequently two other facilities started this therapy. Almost 4,000 patients have been treated at NIRS, and more than 300 patients have undergone therapy at GSI in Germany since 1997. In 2004, the third facility started operation in Hyogo, Japan, where about 300 patients have been treated. Still more are under construction or in planning, including three in Germany, and one each in Italy, France and Japan.

Carbon ion therapy is effective in such tumors of the head and neck, skull base, lung, liver, prostate, bone/soft tissue and pelvic recurrence of rectal cancer, as well as adenocarcinoma, adenoid cystic carcinoma, and sarcomas. Carbon ions have demonstrated a therapeutic advantage in permitting a hypofractionated radiotherapy. When compared with photon and proton therapy, a significant reduction of overall treatment time and fractions has been accomplished without enhancing toxicities. This means that the carbon therapy facility can be operated more efficiently, treating a larger number of patients than is possible with other modalities over the same period of time.

WED-MA07-2 #282 - Invited Talk - Wednesday 3:30 PM - West Fork

Carbon Ion Therapy at NIRS

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High LET charged particle therapy with carbon ions has been of interest in the treatment of malignant tumors because of better dose localization in the tumor volume and greater biologic effectiveness. Between June 1994 and August 2007, a total of 3,452 patients were treated by carbon ion radiotherapy at NIRS. They consisted of 564 patients with prostate cancer, 488 patients with non small cell lung cancer (NSCLC), 432 patients with head and neck cancer (H&N), 374 patients with bone and soft tissue (B&S) sarcomas, and so on. They also consisted of 1,561 patients of phase I/II dose escalation study and 1,891 patients of phase II clinical study.

For the patients with prostate, H&N and B&S sarcomas, the results of phase II study with the dose fractionation methods of 16~20 fractions through 4~5 weeks showed good local control and acceptable late normal tissue morbidity. For the patients with hepatic cell carcinoma, phase II study by two fractions is ongoing. For the patients with NSCLC, phase I/II dose escalation study of one day fraction is undergoing.

The results of phase II clinical studies and preliminary results of phase I/II studies showed acceptable normal tissue reactions and good local control of the irradiated sites. In mucosal malignant melanoma of the H&N, the phase II study had achieved a satisfactory local control rate (75% at 5 years), but the survival rate was not commensurate (36% at 5 years) with this favorable local control rate. In view of this, a new protocol was commenced for the purpose of verifying the validity of preventive chemotherapy against distant metastasis, the major cause of death in this malignancy. As a preliminary result of this combined therapy, the five-year local control rate was 87% and the five-year overall survival rate was 48%.

WED-MA07-3 #94 - Invited Talk - Wednesday 3:30 PM - West Fork

Proton and Carbon-Ion Beam therapy in Hyogo Ion Beam Medical Center (HIBMC)

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Introduction: On April 1, 2001, Hyogo Ion Beam Medical Center (HIBMC) was opened as the first facility in the world to provide ion beam therapy using 2 types of beams, proton and carbon-ion. To investigate the efficacy and safety of the treatment of proton and carbon-ion beams at HIBMC, we have conducted a clinical phase I/II study from 2001 to 2002. After clinical study, we started general practice of proton therapy on April 1, 2003 and carbon-ion therapy on March 17, 2005. In the present article, we will report the results of our experience.

Patients and Results: Between April, 2001 and December, 2007, 1897 patients were treated with ion-beams. The clinical study of proton therapy was performed for 30 patients in 2001 and that of carbon-ion beam also for 30 patients in 2002. After the clinical studies, the number of patients have been increasing year after year. Almost all (99.8%) of the patients could complete their planned treatment. This shows that the ion-beam treatment is very gentle and safe for the patient with cancer. During the treatment period, some patients go playing golf.

Before the start of carbon-ion treatment for general practice, some patients with radio-resistant tumors were treated with proton beams. From this experience, carbon-ion may not be always necessary to control radio-resistant tumors. However, the basic studies including the irradiation of cultured cells by using proton and carbon-ion beams will be needed. We have just started these basic studies.

Conclusion: The ion-beam treatment is a new type of cancer treatment. The results of the treatment are very excellent. In the future, we expect to see even more excellent results by using proton and carbon-ion.

WED-MA07-4 #604 - Invited Talk - Wednesday 3:30 PM - West Fork

Carbon Ion Radiotherapy Using Intensity-Controlled Active Rasterscanning - The Heidelberg Results

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Over recent years, high precision radiotherapy has been implemented widely into clinical routine. Modern techniques such as fractionated steretoactic radiotherapy (FSRT) and intensity modulated radiotherapy (IMRT) have enabled the Radiation Oncologist to apply high doses of radiation to defined target volumes while sparing normal tissues, especially organs at risk. Thus, is was possible to increase the total tumor dose and subsequently increase local control rates, while the risk for radiation induced side effects can be minimized.

However, in certain tumor entities, overall treatment results still remain unsatisfying. Therefore, particle therapy seems to be a promising alternative. One main benefit of particle therapy is the inverted dose profile. With carbon ion radiotherapy, this physical privilege is accompanied by distinct radiobiological effects within the tissue, resulting in a higher relative biological effectiveness (RBE). Therefore, an increase in local tumor control and subsequently improvement of overall survival can be expected.

We have shown in a number of studies that radioresistant tumors such as chordomas, chondrosarcomas and adenoidcystic carcinomas certainly benefit from carbon ion RT. Other extracranial tumors, including sacral chordomas, lung cancer and sarcomas, have been treated with carbon ion RT effectively.

Carbon ion therapy is currently available in a few centers in Japan. At the University of Heidelberg, we perform treatment with carbon ions at the Gesellschaft für Schwerionenforschung (GSI) in Heidelberg. In Heidelberg, the Heidelberg Ion Therapy Center (HIT) has been built offering carbon ion and proton radiotherapy for over 1300 patients per year. The facility offers three treatment rooms, two equipped with horizontal beamlines, and one with a carbon ion gantry. The facility is directly attached to the existing Department of Radiation Oncology, and offers the unique possibility to perform pre-clinical as well as clinicial studies.

WED-MA07-5 #253 - Invited Talk - Wednesday 3:30 PM - West Fork

Indications of Carbon Ion Therapy at CNAO

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CNAO will be a dual center capable of providing therapeutic beams of protons and carbon ions with maximum energy of 400 MeV/u. At the beginning, it will be equipped with three treatment rooms with fixed horizontal and vertical beam lines. In a subsequent phase, two more rooms with a rotating gantry are foreseen. An active spot scanning dose delivery system will be employed. Initially, 80% of the treatments will be carried out with carbon ions. All patients will be treated within clinical trials to assess carbon ion indications with an evidence-based methodology. Seven disease-specific working groups have been developed: lung tumors, liver tumors, sarcomas, head and neck tumors, central nervous system lesions, eye tumors and paediatric tumors. The last two groups will be treated mainly with protons. In the first phase, CNAO will focus on head and neck cancers, treating inoperable, residual or recurrent malignant salivary gland tumors, mucosal melanoma, adenocarcinoma and unfavourably located SCC (nasal and paranasal sinuses). Carbon ions will be employed as a boost in the treatment of locally advanced, poor prognosis, SCC of the hypopharynx and tongue base. Bone and soft tissue sarcomas of the extremity will be treated with a limb-sparing approach, and trunk sarcomas will be treated with exclusive or post-operative irradiation. Skull base tumors (chordoma and chondrosarcoma), recurrent or malignant meningioma and glial tumors will be treated with carbon ions.

After sufficient expertise has been gained in coping with organ motion, CNAO will start treating thoracic and abdominal targets. HCC will be treated in inoperable patients with one or more lesions that can be included in a single CTV. Early stage NSCLC will be treated. In the second phase, two more groups on gynaecological malignancies and digestive tumors (esophageal cancer, rectal cancer, pancreatic cancer) will be created.

WED-MA07-6 #522 - Contributed Talk - Wednesday 3:30 PM - West Fork

Estimating the Need for Particle Beam Radiotherapy in Japanese Cancer Patients

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Purpose: To estimate the number of cancer patients in Japan who will be candidate for particle beam radiotherapy (RT).

Materials and methods: An estimation model was constructed as follows. (1) The total number of patients in each cancer site was estimated based on the Japanese cancer registration in 1999. (2) Indicated cancer sites and clinical attributes for particle RT were reviewed from the literatures and clinical data of more than 3,800 patients treated with carbon ion RT at NIRS. (3) A proportion of the corresponding clinical attributes (stage, tumor size, histology, etc) in each site was calculated by using regular structure surveys by cancer society, cancer registration, published papers, and textbook. Regarding the process, Japanese data around 1999 were quoted as much as possible. (4) The number of patients indicated for particle beam RT in each cancer site was calculated.

Results: A total number of Japanese cancer patients in 1999 was 529,523. According to the estimation model, particle RT was indicated for 59,092 (11%) patients. If the patients were divided into four categories based on their probability of indication for particle RT in comparison with other treatment modalities with clinical evidence (80%, 50%, 25%, and 5%), particle beam RT was indicated for 21,928 (4.1%) patients.

Conclusions: The current estimation provides appropriate rate of particle RT application and may be useful for the future planning for allocation of particle RT facilities.

WED-NBA03-1 #355 - Invited Talk - Wednesday 3:30 PM - Brazos I

Crystal Driven Neutron Source: A New Paradigm for Miniature Neutron Sources

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Neutron interrogation techniques have specific advantages for detection of hidden, shielded, or buried threats over other detection modalities in that neutrons readily penetrate most materials providing backscattered gammas indicative of the elemental composition of the potential threat. Such techniques have broad application to military and homeland security needs. Present neutron sources and interrogation systems are expensive and relatively bulky, thereby making widespread use of this technique impractical. Development of a compact, high intensity crystal driven neutron source will be described. The crystal driven neutron source approach has been previously demonstrated using pyroelectric crystals that generate extremely high voltages when thermal cycled [1-4]. Placement of a sharpened needle on the positively polarized surface of the pyroelectric crystal results in sufficient field intensification to field ionize background deuterium molecules in a test chamber, and subsequently accelerate the ions to energies in excess of 80-100 KeV, sufficient for either D-D or D-T fusion reactions with appropriate target materials.

Further increase in ion beam current can be achieved through optimization of crystal thermal ramping, ion source and crystal accelerator configuration, and methods for introducing the gas species for ionization. The advantage of such a system is the compact size along with elimination of large, high voltage power supplies. A novel implementation to be discussed incorporates an independently controlled ion source in order to provide pulsed neutron operation having microsecond pulse width.

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WED-NBA03-2 #117 - Invited Talk - Wednesday 3:30 PM - Brazos I

Commercial Electronic Neutron Generator Technology and Applications

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Neutron generators are used in a variety of research, educational, and industrial settings because of the their unique operating characteristics and versatility. Since they can be turned off when not in use, and because nuclear regulators and other authorities prefer these devices over other options, their use is also expanding and they are being acquired as replacements for conventional radioisotope neutron sources. Recent developments in the underlying and supporting technologies used in neutron generators have improved their ease of use, increased their performance margins, and expanded their range of applicability over previous generation instruments. Applications using neutron generators are growing and diversifying, primarily in relation to their use in contraband and special nuclear material detection systems. This paper presents a review of current neutron generator research and development efforts and a survey of some recent neutron generator application development programs in the area of active interrogation and security screening.

WED-NBA03-3 #525 - Contributed Talk - Wednesday 3:30 PM - Brazos I

High Intensity, Pulsed, D-D Neutron Generator

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RF-plasma generators are a laboratory source of intense, pulsed neutron beams. The continuous and pulsed operation of such a neutron generator capable of producing 10e9 n/s using the deuterium-deuterium fusion reaction are reported. The neutron beam can be pulsed both by varying the RF field and by the use of gate electrodes to switch the ion beam.

Neutrons have applications in radiography, crystallography and, of course, spectroscopy -- the primary scientific/industrial use of neutrons. Prompt Gamma Activation Analysis (PGAA) is a technique to non-destructively detect trace and major elements in bulk materials, independent of chemical matrix and without the need for sample preparation. High-output neutron generators extend this useful application to home laboratory operations. Using a database of PGAA spectra for each element, a simply-equipped facility can perform economical, real-environment analysis of many complex materials, identifying the presence and quantity of multiple elements within a sample.

WED-NBA03-4 #437 - Contributed Talk - Wednesday 3:30 PM - Brazos I

Temporal Enhancement of Material Signatures in Pulsed Neutron Sources Applications

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A pulsed 14-MeV neutron generator accelerator source allows for the measurement of different elemental signatures through three primary neutron-induced reactions. This paper will present data from the study of optimizing the time gate used to collect the thermal, fast, and activation spectra for explosive detection. The study showed that the performance improved when different time windows were used for collecting the neutron capture gamma rays. Specifically, the choice of different time windows could be optimized based on the type of cargo in the interrogation area. The cargo type(s) is determined by the very same system, which then automatically can select the optimal temporal parameters to use.

WED-NBA03-5 #149 - Contributed Talk - Wednesday 3:30 PM - Brazos I

Characterization of a Pulse Neutron Source Yield under Field Conditions

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Accelerator-based neutron sources such as pulse d-T neutron generators are widely used in non-destructive measurements in nuclear geophysics, homeland security, radiation biophysics, and other applications. The measurements are based on detection of neutrons and/or gamma-rays produced in nuclear reactions induced by neutrons emitted by the generator. These applications entail real world conditions, usually outdoor environment. It is important to know the yield of the neutron source and the time structure of its pulses, and also to evaluate the neutron and photon fluxes near the irradiated objects.

We have developed a technique of rapid evaluation of a pulse neutron sources under field conditions. The lightweight sensor, a phoswich detector consisting of lithium-loaded glass and a BC501 liquid scintillator cell mounted on a single PMT, is used for the simultaneous detection of fast and thermal neutrons, and photons. The BC501 has time constant for scintillation from gamma-scattered Compton electrons of ~4 ns, and has high efficiency for fast neutrons emitting light with time constant 30 ns. The 6-Li glass provides high efficiency for thermal neutrons and has a time constant for scintillation of 60 ns. The pulse-shape discrimination techniques were used for separation of detector signals into three distinct groups thus allowing simultaneous fast and thermal neutron counting. The time structure of the neutron generator output has been obtained for microsecond time scale using a Time-to-Amplitude Converter. The MCA was used to evaluate both the neutron/photon counting rates and the time structure of fast neutrons only. To calibrate the sensor for quick field measurements, activation neutron detectors (thin aluminum foils) were used together with the phoswich in the same geometry to measure the neutron source yield in the laboratory conditions.

WED-NBA03-6 #311 - Contributed Talk - Wednesday 3:30 PM - Brazos I

Novel generation method of 24-keV monoenergetic neutrons using accelerators

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In the radiation protection field, monoenergetic neutrons of keV-energy region are important in measuring energy responses of neutron dosimeters. In particular, 24 keV is a reference energy point specified in ISO-8529-1. These neutrons are usually produced by the 45Sc(p,n)45Ti or the 7Li(p,n)7Be reaction with an accelerator. There are however disadvantages that a neutron yield is small for the 45Sc(p,n)45Ti reaction and a neutron spectrum is broad for the 7Li(p,n)7Be reaction. In the present study, we suggest a generation method of the 24-keV monoenergetic neutrons by combining the 7Li(p,n) 7Be reaction and an iron filtering.

Experiment was performed using a proton beam from a 4-MV Pelletron accelerator at NMIJ/AIST. A neutron source was composed of a lithium evaporated tantalum disk surrounded by an iron block of 10.0-cm thickness. The proton energy was 1.903 MeV, 22 keV above the threshold energy of the 7Li(p,n)7Be reaction. At this proton energy, neutrons in the energy range from 2 to 90 keV are emitted from the lithium target within about 50¢[a] with respect to the proton-beam direction by kinematics. The 24-keV neutrons corresponding to deep minimum in the total cross section of 56Fe are extracted by the thick iron filter additionally placed in the neutron path. The neutron spectrum is almost same as during measurement. The neutrons were measured with a 3He proportional counter (4 atm 3He + 2 atm Ar) calibrated with thermal neutrons and an Si detector with a 6LiF evaporation foil in the experiment. Measurements were also performed for other 24-keV neutron source due to the 45Sc(p,n)45Ti reaction with the accelerator or the iron filter method in a fast reactor, YAYOI. These results are reported in this presentation.

WED-NBA03-7 #634 - Invited Talk - Wednesday 3:30 PM - Brazos I

ON THE DEVELOPMENT OF A MINIATURE NEUTRON GENERATOR FOR THE BRACHYTHERAPY TREAMENT OF CANCER

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Brachytherapy refers to application of an irradiation source within a tumor. Cf-252 needles used in brachytherapy have been successful when applied to treatment of some of the most virulent cancers but it is doubtful that it will be widely used because of difficulty in dealing with unwanted dose (source cannot be turned off) and in adhering to stringent NRC regulations that have been exacerbated in our post 911 environment. We have been working on the development of a miniature neutron generator with the reaction target placed at the end of a needle (tube) for brachytherapy applications. Orifice geometries are most amenable, e.g. rectum and cervix, but interstitial use is possible with microsurgery. In this talk, I will review the results of a 30 watt DD neutron generator SBU project that demonstrates that sufficient hydrogen isotope current can be delivered down a small diameter needle required for a DT neutron treatment device, and, will summarize the progress of building a commercial device pursued by the All Russian Institute for Automatics (VNIIA) supported by the DOE's Industrial Proliferation Prevention Program (IPP).

It is known that most of the FN beam cancer treatment facilities have been closed down. It appears that the major limitation in the use of FN beams has been damage to healthy tissue, which is relatively insensitive to photons, but this problem is alleviated by brachytherapy. Moreover, recent clinical results indicate that fast neutrons (FN) in the boost mode are most highly effective in treating large, hypoxic, and rapidly repopulating diseases. It appears that early boost application of FN may halt angiogenesis (development and repair of tumor vascular system) and shrink the tumor resulting in lower hypoxia. The boost brachytherapy application of a small, low cost neutron generator holds promise of significant contribution to the treatment of cancer.

WED-NBA03-8 #174 - Contributed Talk - Wednesday 3:30 PM - Brazos I

14 MeV Neutron Generator as Thermal Neutron Source

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One of the most important applications of the general purpose Monte Carlo N-Particle (MCNP5)) code is neutron shield design. We employed this capability of MCNP5 to simulate the shield design of a 14-MeV neutron generator to be used as a thermal neutron source for testing large area neutron detectors, developed for protein crystallography and also useful for national security applications.

As a starting point we simulated the neutron flux distribution of an existing Am-Be source surrounded by a paraffin wax thermalizer cylinder and Cadmium and Borated polyethylene beads and sheets for fast and thermal neutron shielding, and having a large collimator for thermal neutrons. The simulation accurately predicts the measured thermal neutron flux at the collimator, and the measured flux at the side of the shielding. It also provides useful data for the flux spatial distribution.

The 14-MeV neutron generator is orders of magnitude stronger, and therefore it requires a heavier shielding. As a starting point we performed a simulation for the 14-MeV generator with the shield geometry of the Am-Be source. The simulation shows the effectiveness of the paraffin thermalizer and the thermal neutron shield. In order to bring the thermal and fast neutron background below acceptable level in the surrounding areas we will need to increase the shielding thickness considerably. We will present detailed simulation results which will explore the required modification of the present geometry and also describe possible novel arrangements.

WED-NSF01-1 #495 - Invited Talk - Wednesday 3:30 PM - Trinity Central

NSL Masks: New Ways of Forming Surface Nanopatterns with Ion Beams

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Regular surface patterns with nanoscale dimensions are a key element to functionalize materials surfaces for optical, electronic, sensoric, medical and many other applications. As conventional lithography based patterning techniques are limited in either spatial resolution, pattern writing speed or cost efficiency, alternative approaches are being developed to allow for inexpensive and materials general nanopattern generation at surfaces. Among these approaches, nanosphere lithography (NSL) is a particularly promising technique to form such patterns. NSL exploits the self-organization of nanospheres from a colloidal suspension on a surface to generate mostly hexagonally close packed monolayers of spheres, which can serve as a stencil mask for the deposition of small amounts of materials on the surface.

While the control on self-organized nanomasks is still limited, it is particularly interesting to combine NSL masking with a highly controllable though most flexible and well-established materials modification technique such as ion irradiation. In this talk it will be shown that ion beams can be most beneficially employed to (a) modify NSL masks with respect to the shape of mask openings, resulting in more flexibility in nanopattern design, (b) interlink nanospheres and substrate for improved mask stability and adhesion, and (c) generate a zoo of useful novel nanopatterns at the surface and in the near-surface region of materials. For the latter issue, well established effects such as ion beam induced amorphization, precipitation and swelling are utilized, however, restricted to the area under the mask openings with just a few tens of nanometers width. Various mechanisms contributing to morphological changes of the NSL masks, including the ion beam induced sintering (IBSI) of nanoscale objects and the ion hammering effect will be discussed.

WED-NSF01-2 #585 - Contributed Talk - Wednesday 3:30 PM - Trinity Central

Energetic Neutral Particle Lithography for Sub-50 nm Array Fabrication

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Neutral particle lithography (NPL) is a proximity exposure technique where a broad beam of energetic neutral atoms floods a stencil mask and transmitted beamlets transfer the mask pattern to resist on a substrate. It preserves the advantages of ion beam lithography including extremely large depth-of-field, sub-5 nm resist scattering, and the near absence of diffraction, yet is intrinsically free of charge-related image artifacts. This paper reports progress toward a practical NPL technology for fabricating dense nanostructure arrays.

The approach is aperture array lithography where multiple offset exposures of a mask containing a periodic field of apertures is used to write the unit cells of an array in parallel. Energetic atoms are created by neutralizing an ion beam by charge transfer scattering at a crossover. The exposure tool incorporates a multi-cusp ion source and a three-electrode accelerating lens to form

the crossover. We expect PMMA exposure times in the 2-10 second range, penumbral blur near 2 nm (FWHM) for a 75 micron proximity gap, and ±10% uniformity over a 6 cm field. The offset exposures will be made using a simple nanostepping concept where the mask, a gap-setting spacer, and the wafer are clamped together and the entire stack mechanically inclined with respect to the beam. The rigid clamping of the mask to the substrate makes the process remarkably insensitive to vibration and thermal drift.

The silicon masks are fabricated using the DRAM film stack. Structures written by electron beam lithography in PMMA resist are transferred to a thin sputtered SiO_2 layer by RIE and then into a thick SiO_2 layer using C_2F_6/C_4F_8. This SiO_2 pattern is then transferred into the silicon membrane with HBr. A backside coating of amorphous carbon protects the mask from ion implantation damage.

WED-NSF01-3 #468 - Invited Talk - Wednesday 3:30 PM - Trinity Central

Nano-cell Fabrication using the Behavior of Point Defects Induced by Ion Irradiation

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This nano-fabrication is based on the authors' discovery that a cellular structure is formed on the ion implanted GaSb surface. Numerous Frenkel pairs, vacancies and interstitials in GaSb, are induced by ion irradiation. Though most of these pairs are annihilated by recombination, some of these point defects survive and form cells with fine dimensions (about 30 nm diameter, 300 nm depth and 10 nm thick partitioning walls) self-organizationally.
The authors' proposed nano-fabrication technique utilizes this phenomenon. It consists of two procedures, the top down and the bottom-up. The top-down procedure is to create a two-dimensional lattice of voids under the semiconductor surface by the precisely positioned irradiation of focused ion beam. The voids are created at the irradiated points where the irradiation-induced-vacancies are oversaturated. After that, a bottom-up procedure is performed, where point defects are created near the surface by ion irradiation and they develop the voids to the cells (the vacancies and the interstitials are absorbed by the voids and the partitioning walls, respectively).

The nano-cell fabrication experiments were performed for GaSb, InSb and Ge using FIB, and investigated the possible cell dimensions under variation of the ion acceleration voltage, the ion dose, the substrate temperature and the lattice type. The results obtained show that this novel technique is very promising as a tool for nano-fabrication.

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WED-NSF01-4 #464 - Invited Talk - Wednesday 3:30 PM - Trinity Central

Nanopantography: A Method for Parallel Writing of Etched and Deposited Nano-patterns

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Nanopantography is a radically different approach for parallel writing of pre-selected nanopatterns over large areas. Standard photolithography, thin film deposition, and etching are used to fabricate arrays of ion-focusing micro-lenses (e.g., small round holes through a metal/insulator structure) on a substrate such as a silicon wafer. The substrate is then placed in a vacuum chamber, and a broad area ion beam impinges on it. Electric potentials are applied to the lens arrays such that the ions focus at the bottoms of the holes on the wafer surface. When the wafer is tilted off normal with respect to the ion beam axis, the focal points in each hole are laterally displaced, allowing the focused beamlets to be rastered across the hole bottoms. Thus the desired pattern is replicated simultaneously in many closely spaced holes over a large area. With the proper choice of ions and downstream gaseous ambient, the method can be used to deposit or etch materials. Etching was demonstrated with simultaneous impingement of an Ar ion beam and a chlorine effusive beam. Using an array of 950 nm dia. lenses, 10 nm dia. ~100 nm deep holes were etched into Si. The substrate was also continuously tilted about x and y axes. With tilting in one direction, 15 nm full width at half maximum trenches 45 nm deep were etched into the Si wafer. T-shaped patterns were etched by tilting the substrates in two directions. 10 nm dia. nickel nano-dots were also deposited with a Ni ion beam. Nano-pantography could become a viable method for rapid, large-scale fabrication of virtually any shape and material nanostructure. Unlike other focused ion or electron beam writing techniques, this self aligned method is virtually unaffected by vibrations, thermal expansion, and other alignment problems because the ion focusing optics are on the wafer.

WED-NSF01-5 #266 - Contributed Talk - Wednesday 3:30 PM - Trinity Central

Ion Beam Etching: Replication of Nanostructured 3D Stencils

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Ion beam LIGA allows the etching of 3D nano-structures by direct writing with a nano-sized beam. However, this is a relatively time consuming process. We propose another approach for etching nano-sized structures on large surfaces and much faster, compared to the direct writing process. This approach consists of replicating 3D structured masks, by scanning an unfocused ion beam. A polymer substrate is placed behind the mask, as in UV photolithography. But the main advantage is that the 3D structure of the mask can be replicated into the polymer. For that purpose, the masks (developed at LMIS1, EPFL) are made of a silicon nitride membrane 100 nm thick, on which 3D gold structures up to 200 nm thick, are deposited. The 3D Au structures are made with the nanostencil method, based on the successive gold deposition on selected regions.

The IMA institute owns a High Voltage Engineering 1.7MV Tandetron with both solid and gaseous ion sources, able to generate ions from almost every chemical element in a broad range of energies comprised between 400 keV and 7.1 MeV. The accelerated ion type and the beam energy are chosen in such a way, that ions lose a significant fraction of their energy when passing through the thickest regions of the mask. Ions passing through thinner regions of the mask lose a smaller fraction of their energy and etch the polymer with larger thicknesses, allowing a replication of the mask into the polymer.

For our trials, a carbon beam of 500 keV was used. The beam was slightly focussed with a diameter of 5mm, in order to avoid border effects and thus ensure a homogeneous dose distribution on the beam diameter. The feasibility of this technique has been demonstrated, allowing industrial applications for micro-mould fabrication, 3D nanostructured elements for micro-fluidics and micro-optics.

WED-NSF01-6 #161 - Invited Talk - Wednesday 3:30 PM - Trinity Central

Magnetic Patterns Induced by Restricted Ion Irradiation through Different Masks

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Regular nano- and micro-patterns are of great interest due to their potential technological application in data storage, displays, biological sensors or photonic crystals. One way of creating regular structures, or an array of modulated physical properties, is by ion beam-based projection methods. Ion beams are ideal instruments to modify material properties in a controlled way, and very suitable for fabrication and tailoring of e.g. magnetic patterns. In the projection method the ion impact is restricted by a mask or template, enabling a parallel formation of well-ordered and localized material modification yielding structures with well-defined features and interesting material properties.

The masks used as templates in the present work were commercial TEM grids and porous anodic alumina membranes. Energetic heavy ions were applied in order to transfer a given pattern defined by a mask to a substrate. The structures are formed via the deposited ion energy or by the implanted ion species themselves. Energies from a few tens of MeV to some tens of keV were used for restricted ion implantation.

We will present some examples of regular micro- and nano-structures having interesting magnetic properties in a wide variety of materials induced by ion irradiation through different mask. The studied materials range from oxides like TiO2 and ZnO, to magnetic materials such as FePt and amorphous ribbons. ZnO and TiO2 are oxide semiconductors with both suitable characteristics in electronic and optical applications. Ion implantation of magnetic ions confers ferromagnetic behavior to these non magnetic materials. FePt thin films and amorphous magnetic ribbons are different magnetic materials with direct applications in magnetic recording and sensing. The irradiation with heavy ions allows tuning of their magnetic properties. Advantages and disadvantages using the present technique will be discussed.

WED-RE07-1 #519 - Invited Talk - Wednesday 3:30 PM - Elm Fork

Gain-Defect Correlations in Ion and Neutron Irradiated Silicon Bipolar Transistors

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Displacement defects near the emitter-base junction of bipolar transistors increase minority carrier recombination in the depletion zone of emitter-base junction and also decrease the minority carrier lifetime in the neutral base. Historically, this problem has been attacked by (1) studies of fundamental point defects in silicon typically introduced by electron irradiation at ~ 1 MeV or (2) semi-empirical descriptions of the performance of devices following irradiation without directly measuring defects. In the Qualification Alternatives to the Sandia Pulsed Reactor (QASPR) program, we are interested in uniting these two approaches and describing the performance of bipolar transistors in terms of the basic defect properties. Our goal is to use ion damage as a proxy for neutron damage and to predict the performance of silicon bipolar transistors following fast neutron damage by looking a data from ion damaged devices and perhaps damage from conventional neutron sources. A complete solution of this extraordinarily complex problem will require extensive modeling of damage mechanisms. We have used deep level transient spectroscopy (DLTS) and gain measurements to combine the two approaches described above. We show that the same point defect spectra seen in fundamental studies can be used to predict the gain of devices following neutron or ion irradiation where the damage is highly clustered. This provides additional confirmation to establish that the same spectra of defects seen after fast neutron damage is produced after ion damage and it also shows that the gain at times long after the irradiation can be inferred by comparing numbers of defects derived from DLTS spectra.

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

WED-RE07-2 #451 - Invited Talk - Wednesday 3:30 PM - Elm Fork

Damage Relationships between the QASPR Relevant Facilities

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We present the initial results of an on-going effort to understand and relate damage in Silicon bipolar junction transistors across a wide range of irradiation conditions. We consider both ion and neutron irradiations from a variety of sources accessible to Qualification Alternatives to the Sandia Pulsed Reactor (QASPR) program. These include: the Sandia Pulsed Reactor (SPR-III), Annular Core Research Reactor (ACRR), White Sands Missile Range Fast Burst Reactor (WSMR FBR), Los Alamos Neutron Science Center (LANSCE) and the Ion Beam Laboratory (IBL) at Sandia National Laboratories. Using four experimental metrics (late-time gain, deep level transient spectroscopy (DLTS), cryogenic irradiation and active gain measurements) we have developed a series of damage relationships to address the comparison between the QASPR relevant facilities. Of particular interest are the type, number and evolution of the initial defect concentrations across the irradiation facilities. To address these issues we use late-time gain degradation as a metric for relating ion-to-neutron irradiations and DLTS to identify and quantify the defect concentrations that are responsible for the late-time gain degradation. Finally, cryogenic irradiations and room temperature early-time active gain studies are used to determine the defect evolution. Combined these metrics allow us to present a description of damage relationships between the QASPR relevant facilities.

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

WED-RE07-3 #450 - Invited Talk - Wednesday 3:30 PM - Elm Fork

Displacement Damage-Induced Electrical and Structural Changes in Gallium Arsenide Photovoltaic Devices Following Ion Irradiation

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Electrical and structural changes in GaAs solar cells were monitored following irradiation with various ions. We characterized the radiation-induced defects using illuminated current-voltage, dark current-voltage, deep level transient spectroscopy (DLTS) and electron beam induced current (EBIC) measurements. The structural changes were monitored using transmission electron microscopy (TEM). The EBIC micrographs showed the existence of radiation induced active recombination centers or localized defects following high energy proton (E ¡Ý 10 MeV) and 22 MeV silicon ion irradiations, which were not observed following 1 MeV electron or lower energy proton irradiations. The TEM images revealed strain related defects that correspond to the same

ion energy for which the localized defects were observed, and therefore, the defects seen in the TEM images are associated with those seen in the EBIC images. These defects were not observed prior to irradiation so the lattice strain in the material is definitely associated with irradiation-induced lattice defects. High resolution transmission electron microscopy (HRTEM) results suggest the defects are voids, which could also be clusters of vacancies. The formation of the U-band defect as determined by DLTS seems to evolve under the same irradiation conditions as the defects in the images. This very broad U-band peak is consistent with what would be expected from defect clusters. From analysis of the recoil spectra, we can conclude the defects are produced by high energy recoils and are independent of the total displacement damage energy deposited.

WED-RE07-4 #288 - Invited Talk - Wednesday 3:30 PM - Elm Fork

Evolution of implantation induced damage under further ion irradiation: influence of damage type

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Different types of radiation damages were formed in silicon using hydrogen, helium and silicon ion implantations: Frenkel defects and defect clusters in Si-implanted Si or He-implanted Si and H-stabilized defects (platelets) in H-implanted Si. These ion implanted Si samples were then irradiated with higher energy proton beams to study the influence of damage type on the defect evolution under additional ion irradiation. Rutherford Backscattering Spectrometry - Channeling (RBS-C) measurements of these implantation induced damage along <100> and <110> directions suggest that the damage that gives rise to the direct backscattering was formed after hydrogen implantation either at liquid nitrogen temperature or room temperature, and helium or silicon implantation (Doses were chosen to generate similar displaced atoms (DPA) to H implantation) only at liquid nitrogen temperature. However, their defect evolution behaviors were different when exposed to the additional ion irradiation. For damage introduced by helium or silicon ion implantation, a following-up ion irradiation with 110 keV H (its range much greater than the original damage depth) at room temperature resulted in a decrease in the direct backscattering yield, but no change in the direct backscattering was observed when irradiated at liquid nitrogen temperature. In contrast, the H implantation damage peak was observed to increase under the same irradiation at both room temperature and liquid nitrogen temperature. In addition, the channeling yield along the <110> direction was higher than that along <100> for the H- implanted Si while the opposite trend was observed for the helium implanted Si, and the trend for the silicon implanted Si fell in between. These observations on defect evolutions will be discussed based on the different defect complexes in these implanted samples along with the additional influence of the following-up ion irradiations.

WED-RE07-5 #170 - Contributed Talk - Wednesday 3:30 PM - Elm Fork

RADIATION EFFECTS IN BINARY AND MULTICOMPONENT SOLIDS

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The report deals with damage kinetics, defect evolution and radiation response of binary and multicomponent solids irradiated with MeV electrons. We have studied such systems as metallic alloys, semiconductors, high-Tc superconductors and bulk metallic glasses. The common features of the studies consist in the efficient use of MeV dc electron beams as generators of point-like defects in solids, precise low-temperature (5 - 80 K) irradiation conditions, and, as a rule, in situ measurements of irradiated material parameters. To exemplify, successful investigations on the following topics are reported here.

(1) Annealing of radiation defects in binary zirconium-base alloys. The alloying atoms of rare earth have been found to interact effectively with point defects in the zirconium matrix. The observed processes have a pronounced effect on annihilation and redistribution of radiation defects and, therefore, must be taken into account in the development of radiation resistant zirconium-base alloys.

(2) Impact of defect density on electronic properties of nanocrystalline hydrogenated silicon. The important findings of the studies are the effective use of low-temperature electron irradiation as a method of increasing the defect density in thin-film silicon without changing its microstructure, and the elucidation of the role of defects in electron transport in the material. The results are of importance for improving the silicon-based thin-film device production technology.

(3) Pinning process in high-Tc YBaCuO single crystals irradiated with MeV electrons. It has been first demonstrated here that point defects generated by the MeV electron beam are the effective pinning centers of magnetic vortices in high-Tc crystals, and this determines a substantial rise in the critical current density in irradiated superconductors.

(4) Accumulation and recovery kinetics of radiation defects were investigated in ZrTiCuNiBe and ZrTiCuNiAl bulk metallic glasses exposed to 2.5 MeV electrons. The resulting data demonstrate existence of stable point defects in such amorphous systems.

WED-RE07-6 #368 - Contributed Talk - Wednesday 3:30 PM - Elm Fork

Optical Restoration of Damaged Lead Fluoride Crystals

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Due to its relatively high resistance to high radiation, lead fluoride (PbF2) crystals are becoming an increasingly popular material of choice for electromagnetic calorimetry, such as for experiments requiring the measurement of high-energy decay products in Hall A of Jefferson Lab. For our studies we irradiated the PbF2 crystals using an electron linear accelerator (LINAC) followed by exposing the crystals to blue light so as to restore the nominal optical properties. This technique of optical bleaching with blue light affords an efficient and low-cost means for reversing the deleterious effects of optical transmission loss in radiation-damaged lead fluoride crystals. Whereas earlier experiments irradiated the PbF2 samples with the 1.17 MeV and 1.33 MeV gammas arising from 60Co, we used pulsed beams of energetic electrons from the tunable 25-MeV LINAC at the Idaho Accelerator Center of Idaho State University in Pocatello, Idaho. A 20-MeV beam of electrons was targeted onto four separate 30 x 30 x 185-mm3 samples of lead fluoride over periods of 1, 2, and 4 hours yielding doses between 8.5 kGy and 35 kGy. Samples were then bleached with blue light of wavelength 410 - 450 nm for periods between 19.5 and 24 hours. We performed this process twice - radiation, bleaching, radiation, and then followed by bleaching again - for each of these four PbF2 samples. We shall discuss the efficacy of UV curing on samples that had undergone the cycle of electron irradiation and optical bleaching.

WED-AP05-P1 #15 - Poster - Wednesday 5:30 pm - Rio Grande Room

Multiple ionization of fast heavy ions by neutral atoms in the energy deposition model

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Multiple ionization of heavy low-charged ions (Xe18+, U10+, U28+, Pb25+) in collisions with H, He, N, Ne, Ar, Kr and Xe atoms are considered in the energy range of 1 - 100 MeV/u using the energy deposition model and the Russek-Meli statistical probabilities for m-electron ionization of projectile ions. The corresponding cross sections are of a great interest for the future FAIR/GSI project when the design parameters for the rest-gas vacuum and beam lifetimes are strongly required. Calculations of the m-fold and total ionization cross sections were performed using a new DEPOSIT computer code which employs the Slater wave functions for the projectile ions and the sum of Yukawa potentials for the field of neutral atoms. A comparison of the present calculations of m-fold and the total ionization cross sections with available experimental data, obtained at GSI facility and the Texas A & M cyclotron, and with the nCTMC calculations by Olson show that the suggested model can be applied for estimation of multiple ionization cross sections of fast heavy ions colliding with neutral atoms with an accuracy of a factor of 1.5 - 2.

The work was performed under the INTAS grant Nr. 06-1000012-8530.

WED-AP05-P2 #16 - Poster - Wednesday 5:30 PM - Rio Grande Room

Electron capture of heavy low-charged ions on neutral atoms

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Single-electron capture of heavy low-charged ions (Xe18+, U5+, U10+, U28+) in collisions with H, C, N, O and Ar atoms are considered in the energy range of 1 - 100 MeV/u using the CDW, CAPTURE codes and the Schlachter semi-empirical formula. The corresponding electron-capture cross sections are of a great interest for the future FAIR/GSI project when the design parameters for the rest-gas vacuum and beam lifetimes are strongly required. A comparison of the present calculations with available experimental data, obtained at GSI facility, and CTMC calculations by Olson is given. On the basis of the available

experimental data and calculations, the recommended data for electron-capture cross sections are presented in the form of the universal curve with a few fitting parameters.

The work was performed under the INTAS grant Nr. 06-1000012-8530.

WED-AP05-P3 #449 - Poster - Wednesday 5:30 PM - Rio Grande Room

Experimental study of single electron capture in slow collision of Ne+ and Ne2+ ions with Ne atomic gas

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One-electron transfer processes resulting from Ne+ and Ne2+collisions with Ne atomic gas have been studied using the time-of-flight technique for energy range of 0.6 to 2 keV. The dependence of the total single-electron capture cross sections on the incident laboratory energy has been reported. The present Ne2+-Ne measurements and earlier high-energy data are compared. Extrapolation of the present low-energy data to the high-energy regime exhibits good agreement. These data were compared with the theoretical calculations. The data agree qualitatively with the theory.

The energy dependence of single-electron-capture cross section has been studied for both for Ne+-Ne and Ne2+ + Ne systems. The total single-electrons captured cross sections exhibit similar behavior to those experimental studies of single electron capture cross sections in collision of Ar+-Ne, Kr+-Kr and Kr+-Xe reported by Martinez1. To best of our knowledge, these are the first measurements to be reported for this system.

Previously, Kase2, Suk3, Flacks4 and Bloemen5 measured the total single-electron-capture cross sections in the energy range of 5 keV - 3 MeV. Extrapolation of the present low-energy data to the high-energy regime exhibits good agreement.

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WED-AP06-P1 #136 - Poster - Wednesday 5:30 PM - Rio Grande Room

A multi-coincidence study of the single and multiple photoionization and fragmentation of the Tetramethyl Silane Molecule around Si 1s edge

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Photoionization of the Si[CH3]4 molecule has been studied around the Si 1s edge, using time-of-flight mass spectrometry, photoelectron-photoion coincidence techniques (PEPICO, PE2PICO and PE3PICO) and synchrotron radiation. Partial ion yields have been recorded as a function of the photon energy. Strong fragmentation of the molecule is observed and singly charged species (H+, H2+, C+, and CHn+) dominate the spectra, with the H+ ion being the most abundant fragment. Mean values for the translational kinetic energy of the fragments have also been determined. Although the contribution of stable doubly and triply charged species was not significant in the measured spectra, intense double and triple ionization of the molecule was demonstrated below and above the Si 1s edge, through PE2PICO and PE3PICO measurements

Work supported in part by FAPERJ and CNPq.

WED-AT07-P2 #183 - Poster - Wednesday 5:30 PM - Rio Grande Room

Neutron Yield With a Pulsed Surface Flashover Deuterium Source

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As a step towards developing an ultra compact D-D neutron source for various defense and homeland security applications, a compact, low average power ion source is needed. Towards that end, we are testing a high current, pulsed surface flashover ion source, with deuterated titanium as the spark contacts. Neutron yield and source lifetime data will be presented using a low voltage (<100 kV) deuterated target. With 20 ns spark drive pulses we have shown >106 neutrons/s with 1 kHz PRF.

This work was supported by the Defense Advanced Research Projects under contract 1026419 with the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344.

WED-AT07-P4 #345 - Poster - Wednesday 5:30 PM - Rio Grande Room

Characterization of a Surface-Flashover Ion Source with 10 - 250 ns Pulse Widths

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As a step towards developing an ultra compact D-D neutron source for various defense and homeland security applications, a compact ion source is needed. Towards that end, we are testing a pulsed surface flashover ion source, with deuterated titanium films deposited on alumina substrates as the electrodes. As the duration of the arc current is varied, it was observed that the integrated deuteron ion current per pulse initially increases rapidly, then reaches a maximum near a pulse length of 100 ns. Thin film patterning techniques and deuteration parameters will be discussed.

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WED-AT07-P5 #363 - Poster - Wednesday 5:30 PM - Rio Grande Room

Nano-structure ion sources for neutron production

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Nano-structure deuterium ion sources based on both field emission and field ionization are investigated for neutron sources. These structures, such as arrays of gated tips or devices based on multi-wall carbon nanotubes, have the potential to be more compact, lower power, and produce better beam mix then conventional gas sources. Experimental and simulation results from such field emission and field ionization devices are presented. Neutron and ion beam production measurements are discussed. It is found that micro-amps of ion current can be easily extracted from nano-structure devices smaller than 0.25 cm-squared.

WED-FIBP03-P1 #383 - Poster - Wednesday 5:30 PM - Rio Grande Room

Ion microprobe endstation at the Louisiana Accelerator Center

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A versatile new endstation has recently been installed on the Louisiana Accelerator Center (LAC) high energy focused ion beam system. A 3-D computer controlled motorized translation stage inside a 30 cm diameter, 30 cm tall cylindrical vacuum chamber can be used to position samples for either microanalysis or microfabrication applications with submicron resolution. Microanalysis techniques available include PIXE, STIM and secondary electron imaging while microfabrication of microstructures in resists and other substrates can be performed using a combination of beam scanning and stage movement.

Movement of the sample + or - 7.5 cm in both planes mutually perpendicular to the beam direction is possible while up to + or - 7.5 cm adjustment parallel to the beam direction can be used to optimize the position of the target plane.

WED-FIBP03-P2 #531 - Poster - Wednesday 5:30 PM - Rio Grande Room

Thorium and uranium M-shell x-ray production by bombardment with 0.3-4.0 MeV protons and 0.3-6.0 MeV helium ions

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M-shell x-ray production cross sections for thorium and uranium have been measured for protons of energy 0.3 to 4.0 MeV and helium ions of energy 0.3-6.0 MeV. The measured x-ray production cross sections are compared to the predictions of the PWBA [1] and ECPSSR [2] theories. The efficiency of the x-ray detector was measured using the Kα transitions of selected elements from Si to Cu bombarded with helium ions at 1.5 MeV. The K-shell fluorescence yields were taken from Krause [3], the average fluorescence yield from Öz et al. [4], the M-subshell fluorescence yields and Coster-Kronig yields from Chen et al.[5,6], and the probabilities of radiative transitions from Chen et al.[7]. Our results are also compared with the measurements of other authors.

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WED-FIBP03-P3 #613 - Poster - Wednesday 5:30 PM - Rio Grande Room

A procedure to quantify contributions to the total cross section by mechanisms competing to the direct ionization

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Determination of ionization cross sections is important for the understanding of the mechanism of atomic interaction. This is also important to improve results in quantitative analysis with the technique Particle Induced X-ray Emission, PIXE. In quantitative PIXE analysis, matrix effects become a fundamental question. Bulk material affects the examination of the specific elements in a sample. Depending on the analyzed element, the projectile particle type and its energy; components of the bulk material can produce a major effect on the X-ray production yields. Specifically, the ionization cross sections could be affected by the previous state of the projectile, conditioned by the passage in the material producing multiple ionizations and vacancies in its electronic orbitals. It has been reported that some projectiles can acquire 2p vacancies by the passage in sample and share this with the target atom. Then, the vacancy in the projectile ion modifies the normally expected mechanism of ionization in a specific target atom. A procedure is proposed to quantify a mechanism competing to the direct ionization, like the mechanism of sharing of 2p vacancies to the target. This is by the construction of a rate equation based on the X-ray results in variable thickness sample irradiations. According to the estimated life time of a 2p vacancy in a projectile, the typical thickness to observe this effect is inferred.

WED-FIBP04-P1 #107 - Poster - Wednesday 5:30 PM – Rio Grande Room

PIXE characterization of Lebanese excavated amphorae from Jiyeh archeological site

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Archaeological excavations were undertaken in the Jiyeh archeological site which is located north of Sidon, identified as the Greco-Roman Porphyreon. The first investigations raised suspicions about a probable pottery production centre. About 40 sherds were analyzed by Proton Induce X-ray Emission technique PIXE in order to identify and characterize the elemental composition of four types of amphorae, using the 1.7 MV tandem accelerator in Beirut. The analysis protocol provided almost 24 elements in one spectrum, including majors, minors and traces. The elemental composition provided by PIXE and based on 12 most abundant elements, ranging from Mg to Zr, was used in a multivariate statistical program and consequently the studied objects were classify into well defined groups.

WED-FIBP05-P1 #69 - Poster - Wednesday 5:30 PM – Rio Grande Room

Trace Elements in Diabetic Blood Serum: Comparison of Fasting and PP Samples

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Diabetes Mellitus (DM) is a metabolic disorder where in human body does not produce or properly uses insulin, a hormone that is required to convert sugar, starches, and other food into energy. Human body has to maintain the blood glucose level at a very narrow range, which is done with insulin and glucagons. Over the past many years, numerous studies have found alterations in micronutrient status of patients with diabetes and in some studies deficiency of certain minerals has been correlated with presence of diabetes. Establishing links between the trace elemental compositions in blood and diabetes can thus be a useful study.

This report carries results from the preliminary study of the elemental concentrations in Diabetic blood-serum samples using the PIXE technique. Diabetes mellitus is usually diagnosed by the level of Blood glucose. This test is done in fasting and 2 hours after breakfast (PP). While the accepted blood-sugar level varies for these two categories, alterations in the trace levels of the elements have not been studied. This study consists of comparison of the elemental characterization of diabetic blood-serum for samples collected before (fasting) and after food (PP).

Blood samples from 30 patients were collected and serum was separated. 2 MeV (15 nA) proton beam from the Tandetron Accelerator available at the Indira Gandhi Center for Atomic Research (IGCAR), Kalpakkam, India, was used for conducting the PIXE experiment on these samples. Elemental analysis was carried out by using the software WINGUPIX. The preliminary results reveal that the trace levels of the elements like Sulphur, Potassium, Manganese, Iron, Copper and Zinc are comparable in both fasting and PP samples. A thorough study on the role of trace elements in diabetes is achieved by comparison of the trace levels in non-diabetic blood and linking the effect of altered levels with insulin action.

WED-FIBP05-P2 #109 - Poster - Wednesday 5:30 PM – Rio Grande Room

PIXE identification of fine and coarse particles of aerosol samples from Beirut

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Beirut is a cross road for several meteorological phenomena during the year, thus the transport of pollution over the different seasons and storm episodes was studied, by simultaneous sampling of PM10 and PM2.5. The collection of fine and coarse particles on Teflon filters was carried out once a month, for a period of 24 hours, during a whole year between February 2004 and January 2005, using a dichotomous sampler. The characterization of the elemental content of the two fraction mode, fine and coarse particles, were analyzed using proton induced X-ray emission (PIXE). The use of 75 μm of Kapton filter, as x-ray absorber, with a 3 MeV proton beam delivered by the 1.7 MV Tandem-Pelletron accelerator of the LAEC facility, allowed the simultaneous determination of Si, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn and Pb. Furthermore, PIXE study and the calculation of the enrichment factor showed the differentiation, of pollution sources, between anthropogenic versus natural emissions. Finally, the results of PIXE analysis of the NIST SRM 2783 will be showed.

WED-FIBP05-P3 #171 - Poster - Wednesday 5:30 PM – Rio Grande Room

Single detector PIGE and PIXE analysis of dental composites

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PIGE is widely used for analyzing light elements as a complementary method to PIXE. In particular, fluorine is analyzed by the 110 and 197 keV γ radiation from the 19F(p, p'γ)19F reaction at energies around 3 MeV. Fluorine helps the maturation and protection of teeth, and added in dental composites prevents secondary caries. We examined the feasibility of detecting fluorine by PIGE together with heavier elements by PIXE using protons and a single low energy HP Ge detector, and we tested it on F-rich dental composites. Flat samples of the composites Ariston and Tetric Ceram (Ivoclar-Vivadent, Liechtenstein), and reference materials including Teflon, NaF and metallic Al were analyzed. The samples were irradiated at 45° and at 3.0 MeV for PIXE, and for PIGE also at 3.20, 3.37 and 4.19 MeV, where the cross-section of F lines show maxima [1].

The composites evidenced mainly Ca, Zr, Ba and Yb, and traces of Fe, Se, Sr, Sm and Hf by PIXE, and F by PIGE. In addition, their PIGE spectra collected between 0 and 300 keV showed a weak line at ~171 keV, due to 27Al(p, p'g)27Al; Al was confirmed by higher energy lines, and was best observed with 3.0 MeV protons. A weak γ line at 122-123 keV could be attributed to Sm and/or Hf. The PIGE detection limit for F was of ~0.2% with 3.0 MeV protons and of ~500 ppm with 4.19 MeV protons. The cross-sections were material dependent. In the composites, F and Al arise as YbF3, and Ca fluorosilicate glass and Ba fluoroaluminosilicate glass, respectively. As shown by the lower Ba and Al/F ratio, Ariston contained less of the latter glass than Tetric. The ratio F(198)/F(110) was slightly different in the composites, suggesting granularity differences.

[1] A. Caciolli et al, NIMB 249 (2006) 98-100.

WED-FIBP05-P4 #187 - Poster - Wednesday 5:30 PM – Rio Grande Room

Angle-resolved PIXE analysis of natural Hydroxyapatite films

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Hydroxyapatite thin films deposited on different substrates, used for dental and orthopedical implants, are optimum experimental model for PIXE studies. Hydroxyapatite samples in the form of a pellet (HA1) and of a film deposited on silicon substrate (HA2) were irradiated at different angles between 0-45° with 3.0 MeV protons from a tandem van de Graaff accelerator and PIXE spectra were collected with a HP Ge detector. The PIXE spectra of thick sample HA1 acquired with and without additional absorber (Al foil of 40 μm) at 45° highlight Ca as the major element, and traces of Ba, Fe, Cu, Zn and Sr. Some of these trace elements - Fe, Zn, Sr - were also evidenced in the spectrum of HA2 film, but the lines of these traces were less visible than in thick sample. At 45° the HA2 spectrum (thin layer) differs from HA1 (thick target) by the absence of pile-up lines, but especially by a more intense background, resulting in a difficult visualization of the trace elements lines. By measuring HA2 spectra at different angles, the lines of the trace elements were highly increased in intensity. Thus Zn was evidenced more clearly at 30-20-10° by its Kα line, while both K lines of Zn and Fe were evidenced at 5°. Close to about 0° the relative amplitude of Ca lines was decreased and, instead, besides Zn and Fe intense lines, many other traces of the transitional metals (V, Cr, Mn, Co, Ni, Cu) as well as Ga and As/Pb lines were evidenced. In addition to improved sensitivity, angle-resolved PIXE could also serve for assessing of the Hydroxyapatite deposition thickness, thus helping to characterize also structurally this type of medical implants.

WED-FIBP05-P5 #321 - Poster - Wednesday 5:30 PM – Rio Grande Room

PIXE/ASV Analysis of Heavy Metals in Water

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The most important and often the rate-limiting step in the chemical analysis of trace heavy metal ions in environmental samples such as domestic and natural water is sample preparation. Anodic Stripping Voltammetry (ASV) is capable of analyzing trace metals in water samples at parts per billion or better with little or no sample preparation. Particle Induced X-Ray Emission Spectroscopy (PIXE) is capable of performing the qualitative analysis of multiple elements in a single scan, lacking in ASV, but requires a preconcentration/separation step prior to analysis of water samples. This step, beneficial to both techniques, refers to the enrichment of heavy metal ions for improved sensitivity and limits of detection and separation from organic impurities, alkaline and alkaline earth ions to reduce background and matrix effects. Materials necessary for preconcentration/separation are solid support sorbents that may be used directly or modified by heavy metal-ligand complex forming agents. These agents may be either immobilized or chemically bonded to the solid support. This enrichment process is generally referred to as Solid-Phase Extraction (SPE) by column or batch method. Sorbents include inorganic resins, organic and/or chelating resins, nanomaterials and microorganisms. Our study proposes to utilize an offline SPE step in method development and analysis of heavy metal ions in water samples by PIXE/ASV.

WED-FIBP05-P6 #607 - Poster - Wednesday 5:30 PM – Rio Grande Room

Multi-Elemental Analysis of Coastal Sediment Samples by PIXE Method

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The quantative analyses of multielements for coastal sediment samples were collected from Pondicherry to Porto-Novo, East Coast of Tamilnadu, India. The elemental analyses were carried out using particle induced X-ray emission (PIXE) technique with the proton energy of 2 MeV obtained from 1.7 MV tandem accelerator. The validation of the technique is assessed using standard reference material (SRM) NIST 1646a estuarine sediment and the result shows the good agreement with certified ones. The emitted characteristic X-ray spectrum shown multi elements in a fingerprint mode namely K, P, Ca, Ti, Fe, Cr, Co, Zn, Mn, Ni, Cu, As, Zr, Hf, Pb and Hg etc were detected and the results are discussed. The conclusion is drawn from the result.

WED-IBM05-P1 #56 - Poster - Wednesday 5:30 PM – Rio Grande Room

A channel for modification of materials with post-accelerated or decelerated ion beams from an ECRIS

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At present, heavy ion beams from the electron cyclotron resonance ion source (ECRIS) in the Laboratory of Physics of the Vinca Institute of Nuclear Sciences, Belgrade, Serbia, are used in the channel for surface modification of materials. The source and the channel were commissioned in 1998, and have been used since that time by a number of user groups from the Vinca Institute and other scientific and educational institutions in Serbia. However, since the maximum extraction voltage of the source is 25 kV, sometimes the extracted beams do not have the sufficiently high energies for the required applications. Therefore, in order to solve this problem, we have decided to construct a new channel, to be used for deeper modification of materials. The beams obtained from the source will be post-accelerated by biasing the target to be irradiated to the negative potentials of down to -100 kV. For example, we shall be able to bombard a target with the Xe24+ beam of the energy of up to 3 MeV, instead of up to 600 keV, which is now the case. An additional possibility will be to bias the target to the positive potentials of up to 25 kV and thus decelerate the beams extracted from the source down to the energies of about 1 keV. Consequently, one will be able to modify materials with the beams in a wide energy range - from about 1 keV to about 3 MeV, which is rarely met at similar experimental set-ups. It must be noted that changing the post-accelerated or decelerated beam energy in the new channel will be performed simply by adjusting the power supply of the biasing system, without any adjustments of the source or the elements along the transport line.

WED-IBM05-P2 #176 - Poster - Wednesday 5:30 PM – Rio Grande Room

HIGH ENERGY SI IONS BOMBARDMENT AND TEMPERATURE EFFECTS ON THE THERMOELECTRIC PROPERTIES OF GdFe4Sb6-y Gey THIN FILMS

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We have deposited two single layers of GdFe4Sb6-y Gey (y = 2,4) thin films on Si, C and silica substrates with varying thickness of 220 nm and 235 nm respectively using Ion Beam Assisting Deposition (IBAD) technique. The high-energy (5 MeV) Si ion bombardments were performed on samples with 5 different fluences between 5E13 - 5E15 ions/cm2. The thermopower and thermal conductivity measurements were performed at room temperature while electrical resistivity measurements in 300-580 K temperature range before and after the Si ions bombardment of samples. The dimensionless figure of merit, ZT values were calculated for virgin and bombarded samples by thermoelectric parameters. The Si ions bombardment caused mainly positive changes on the thermoelectric properties of films. Rutherford Backscattering Spectrometry (RBS) was used to analyze the elemental composition of deposited materials. The thickness of films were determined the by optical interferometer, too.

WED-IBM05-P3 #178 - Poster - Wednesday 5:30 PM – Rio Grande Room

THERMOELECTRIC PROPERTIES OF SEQUENTIALLY DEPOSITED SiO2/GdFe4Sb8Ge4 NANOLAYERS MODIFIED BY 5 MEV Si IONS BOMBARDMENT

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We have grown a thin film of 82 alternating nano-layers of SiO2/GdFe4Sb8Ge4 super-lattice system. The total thickness of film was determined as 283 nm by optical interferometer. The layers in the periodic structure are between 3-5 nm thick, each. The super-lattices were bombarded by 5 MeV Si ions at 4 different fluences ranging from 5E13 to 1E15 ions/cm2. Rutherford Backscattering Spectrometry (RBS) specified the stoichiometry of the thin film. We measured electrical resistivity values of virgin and bombarded samples in the temperature range of 300-580 K. The other thermoelectric properties were specified by Seebeck coefficient and thermal conductivity experiments at room temperature before and after 5 MeV Si ion bombardments again. The electrical conductivity increased due to Si ion bombardment, while and thermal conductivity values, Seebeck coefficients decreased except the fluence of 1×1015 ions/cm2. The dimensionless figure of merit ZT has been affected positively by the ion bombardment.

WED-IBM05-P4 #179 - Poster - Wednesday 5:30 PM – Rio Grande Room

THERMOELECTRIC PROPERTIES of YbBiPt and YBiPt THIN FILMS

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Single layer thin films of YBiPt and YbBiPt were produced in house with 394 nm and 560 nm thickness respectively and their thermoelectric properties were measured before and after 5 MeV Si ion bombardments. The energy of the Si ions was chosen such that the bombarding ions could stop in the silicon substrate. The bombardment by MeV Si ions at various fluences changed the homogeneity as well as reducing the internal stress in the films thus affecting the thermal, electrical and Seebeck coefficient of thin films. The stoichiometry of the thin films was determined using Rutherford Backscattering Spectrometry, the thickness has been measured using interferometry and the electrical conductivity was measured using Van der Pauw method. Thermal conductivity of the thin films was measured using an in-house built 3w-thermal conductivity measurement system. Using the measured Seebeck coefficient, thermal conductivity and electrical conductivity values we calculated the dimensionless figure of merit (ZT). We will report our findings of change in the measured ZT as a function of bombardment fluence.

WED-IBM05-P5 #196 - Poster - Wednesday 5:30 PM – Rio Grande Room

Characterization of MeV Ion Bombardment Modified p-Ge / n-Si photovoltaic device

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In p-Ge/n-Si photovoltaic device, the p-Ge layer is formed by MBE and electron beam gun deposition respectively. The nanoscale clusters formed by MeV Si ion beam bombardment modification in depletion region of n type Si substrate increase the absorption of photon, increasing the multiple exciton generation and Auger impact ionization, increasing photocurrent. the miniband formed in quantum dots provide intermediate band and make absorption of sub- bandgap photon possible, the amorphous Si and nanocrystalline Si formed by ion bombardment modification also yield photon absorption in wide spectrum, test result indicate that the short circuit current and fill factor increase with the fluence of ion bombardment .

WED-IBM05-P6 #197 - Poster - Wednesday 5:30 PM – Rio Grande Room

Thermoelectric Properties of MeV Si Ion bombardment modified Bi2Te3/ Sb2Te3 Superlattice Deposited by Magnetron Sputtering

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In order to keep the stoichiometry of Bi2Te3 and Sb2Te3 so as to keep the electrical and thermal conductivity advantage of the layered structure of bulk Bi2Te3 and Sb2Te3 in each period of the superlattice, magnetron sputtering, which is operated at relatively low temperature, was used to deposit multilayer Bi2Te3/ Sb2Te3 thermoelectric superlattice device. In addition to the effect of quantum well confinement of the phonon transmission, the nanoscale clusters produced by the bombardment of ion beam further adversely affect the thermal conductivity, The increase of the electron density of states in the miniband of nanoscale cluster quantum dot-like structure formed by bombardment also increases the Seebeck coefficient and the electrical conductivity. Eventually, the thermoelectric figure of merit of superlattice films increases.

WED-IBM05-P7 #206 - Poster - Wednesday 5:30 PM – Rio Grande Room

Effects of MeV Si ions Bombardment on the Thermoelectric Properties of Zn4Sb3/CeFe(4-x)CoxSb12 Nano-layered Superlattices

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We prepared multilayers of superlattice system consisting of 50 periodic nano-layers of semiconducting half heusler â-Zn4Sb3 and skutterudites CeFe2Co2Sb12 compound thin films using ion beam assisted deposition (IBAD) system with Au layers deposited on both sides as metal contacts. The deposited multi-layer films have alternating layers of 5 nm thick. The total thickness of the multilayer system is 275 nm. The superlattices were then bombarded by 5 MeV Si ions at six different fluences to form nano-cluster structures. The film thicknesses and stoichiometry were monitored by Rutherford backscattering spectrometry (RBS) before and after MeV ion bombardments. We measured the thermoelectric efficiency of the fabricated device by measuring the cross plane thermal conductivity by the 3rd harmonic method, the cross plane Seebeck coefficient, and the electrical conductivity using the Van Der Pauw method before and after the MeV ion bombardments.

WED-IBM05-P8 #207 - Poster - Wednesday 5:30 PM - Rio Grande Room

MEV Si ION BOMBARDMENT EFFECTS ON THE THERMOELECTRIC GENERATORS FROM AgBiTe and AgSbTe THIN FILMS

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The ternary chalcogenides AgBiTe2 and AgSbTe2 belong to family of semiconductors with disordered NaCl cubic structure in which silver and antimony occupy metal sublattice. Both compounds are very interesting due to their thermoelectric properties. We have grown the monolayers of AgBiTe and AgSbTe thin films on silicon and silica substrates using Ion Beam Assisted Deposition (IBAD) system. The high-energy (MeV) Si ion bombardments were performed on samples at 5 different fluences between 5×1013-5×1015 ions/cm2. The Si ions bombardment caused changes on the thermoelectric and optical properties of the thin films. The optical absorption behaviors of AgBiTe2 and AgSbTe2 thin films were studied. We measured the thermoelectric efficiency (figure of merit, ZT) of the fabricated device by measuring the cross plane thermal conductivity by the 3rd harmonic method, the cross plane Seebeck coefficient, and the electrical conductivity using the Van Der Pauw method before and after the MeV ion bombardments. Rutherford Backscattering Spectrometry (RBS) was used to analyze the elemental composition and thickness of deposited materials.

WED-IBM05-P9 #294 - Poster - Wednesday 5:30 PM - Rio Grande Room

(Ga,Mn)As fabricated by ion implantation and irradiation

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(Ga,Mn)As thin films were fabricated by Mn+ implantation and following He+ ion irradiation. The crystalline quality of Mn+ implanted layer was investigated using the high resolution X-ray diffraction (HRXRD) and transmission electron microscopy (TEM). The results show there are no known second phases in the samples. The changes of lattice constant of Mn+ implanted layer with He+ ion irradiating dosage were observed in HRXRD measurements.

WED-IBM05-P10 #407 - Poster - Wednesday 5:30 PM - Rio Grande Room

Irradiation effects on Li:ZnO thin films

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Deposition of ZnO thin films were carried out by resistive heating method and pulsed laser deposition (PLD) technique on Si and quartz substrates. The depositions of films by PLD were carried out using KrF laser (248 nm) as a source in oxygen atmosphere. ZnO target was used for deposition of ZnO thin films by resistive heating method. Films have been doped with Lithium (Li) ions using ion-implantation technique. Irradiation has been done by swift heavy ions on doped samples. Irradiated samples have been characterized by atomic force microscopy (AFM), UV-Visible absorption spectroscopy, Photoluminescence (PL), x-ray diffraction (XRD) and Fourier transform infrared spectroscopy (FTIR). Result of systematic studies on the optical, electrical and structural properties of film will be presented.

WED-IBM05-P11 #476 - Poster - Wednesday 5:30 PM - Rio Grande Room

Effect of C+H and C+H+Ar hybrid ion implantation on UHMWPE samples

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UHMWPE samples were C+H and C+H+Ar hybrid ion implanted by using MEVVA ion implantation technique. Samples were implanted with an extraction voltage of 30 kV and the fluence of 1017 ions/cm2. Surface characterization of implanted samples were compared to unimplanted ones. ATR- FTIR chemical characterisation analysis was used to see if any new chemical bonds formed 2 microns deep at the surface. It was found that cis- and trans- geometric isomerism occured and C-H bond concentration decreased after C+H and C+H+Ar implantation, which was thought to be caused by crosslink formation on the surface. Alkyne triple bond characteristics were better observed with C+H implanted samples than C+H+Ar implanted samples. Considering bio-medical application, pin on disk wear tests and contact angle measurements of implanted samples were done. Although, hydrophilicity of implanted samples decreased, pin on disk measurements showed that wear resistance of implanted of Polymers.

WED-IBM05-P12 #491 - Poster - Wednesday 5:30 PM - Rio Grande Room

Surface Characterization of Ti+C Hybrid Ion Implanted UltraHigh Molecular Weight Polyethylene (UHMWPE) Samples

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UHMWPE samples were Ti+C hybrid ion implanted by using MEVVA ion implantation technique. Samples were implanted with an extraction voltage of 30 kV and the fluence of 1017 ions/cm2 . Characterization of implanted samples with ATR- FTIR, UV-Vis-NIR and RBS were compared to unimplanted ones.

WED-IBM08-P1 #93 - Poster – Wednesday 5:30 PM – Rio Grande Room

Selective cell adhesion on ion implanted poly(bisphenol A carbonate) film

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For biomedical applications, conventional polymers must undergo a surface modification by using different methods including chemical and physical processes due to their poor biocompatibility such as an undesirable protein adsorption and cell adhesion. Ion implantation is an efficient and useful technique for an improvement of polymer surface properties such as biocompatibility, hardness, wear resistance, and conductivity with the bulk properties of the polymer remaining.

In this paper, we investigated the biocompatibility of poly (bisphenol A carbonate) (PC) films implanted with Ar+ ions with an energy of 100 keV. The surface chemical characteristics, wettability, and biocompatibility were observed by using X-ray photoelectron spectroscopy, FT-IR spectroscopy, water contact angle measurement, and cell culture test.

The results showed the disappearance of carbonate groups and the generation of hydrophilic groups such as hydroxyl and carboxylic acid by ion implantation. The oxygen to carbon atomic ratio of the ion implanted PC films increased with increasing ion fluence. The surface wettability of the Ar+-implanted PC films was improved when compared with the pristine one. The HaCaT cells were well adhered and proliferated on the ion implanted regions of PC films.

WED-IBM08-P2 #162 - Poster - Wednesday 5:30 PM - Rio Grande Room

Enhanced Polymerization of PF-Resin by MeV Si Ion bombardment

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Glassy Polymeric Carbon (GPC) is a technologically important material obtained by the polymerization of a phenol-formaldehyde precursor at high temperature (up to 3000°C). GPC's structure consists of long ribbon-like of graphene sheets that are arranged randomly in space. The formation of aromatic carbon usually appeared around 525°C. In this work, in order to enhance the degree of graphitization, we used MeV silicon ions to deposit thermal energy in a GPC sample that was heat treated to 1000°C. We monitored changes in the material's structure using Raman spectroscopy, FTIR as well as scanning electron microscopy (SEM) and transmission electron microscopy (TEM).

WED-IBM08-P3 #346 - Poster - Wednesday 5:30 PM - Rio Grande Room

Studying the destruction caused by 1. 3. 5 MeV He ions on PTFE, PVDC, and PE polymers

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The discrepancy between the high chemical and thermal stability of polytetrafluoroethylene (PTFE) and other fluoropolymer variants and their very low radiation stability remains a subject of discussion. PTFE has been described as a "very radiation-unstable synthetic polymer material". In contrast, short chain linear perfluoroalkanes (the low-molecular analogues of PTFE)

have greater radiation stability (G = (1-5) molecules destruction per 100 eV adsorbed radiation energy) than their hydrocarbon analogues (G = (6-10)). The radiation-chemical stability of PTFE is one order greater than that of polyethylene and two orders greater than those for cellulose and polysulfones. PVDC was also chosen for this study as an "intermediary/transition chemical" between PTFE and PE. We used residual gas analysis to monitor the gaseous species emitted from the various polymer samples (PTFE, PVDC, PE) during the 1, 3, 5 MeV He ions bombardment. Comparative results among these polymers are presented here.

WED-MA05-P1 #132 - Poster - Wednesday 5:30 PM - Rio Grande Room

Performance of a motion tracking system during cyberknife robotic radiosurgery

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Cyberknife (Accuracy, Ca) is a robotic radiosurgery system invented at Stanford in the nineties, which includes a robotic arm to aim at any part of the body from any angle. Mounted on the robot is a compact electron linac that delivers 800 cGy/minute of "6 MV" X-rays. An essential tool is the guidance system based on x-ray imaging cameras located on supports around the patient. A Cyberknife is operational at the Italian Vicenza Hospital for years, mainly for treating tumors and ArteriorVenousMalformations. In radiotherapy, delivery of high doses to targets that move with respiration is challenging because of possible spatial inaccuracies. The purpose of this work was to estimate the accuracy of the prediction algorithm used to compensate for system latency in our real-time respiratory tracking system ("Synchrony"), which is based on the correlation between the position of LED markers, detected in real time, and the position of internal markers, sampled through x-ray imaging. The position of the external LED signals, though read in real time, must be predicted to compensate for a 120 ms time lag in the feedback loop that redirects the beam to the current target position. We have analyzed respiratory signals of 23 patients who had lung or liver Cyberknife treatments. These signals were described through their frequency power spectrum, as recently proposed by other authors. Prediction errors above 2 mm, lasting longer than 5 seconds were observed for irregular breathers. These episodes correlate to the presence of a bimodal distribution in the power spectral density, and of very low frequencies contribution. Eventually a more effective strategy has been invented. Data of three patients were collected with a modified adaptive predictor based on fuzzy logic. Results showed a much smaller inaccuracy, with prediction errors above 1 mm typically lasting for less than 1 second.

WED-MA05-P2 #242 - Poster - Wednesday 5:30 PM - Rio Grande Room

Fabrication of Proton Beam Modulation for Proton Therapy

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We constructed a proton beam modulation system for proton therapy, which will be applied to one of the beam line from MC-50 cyclotron at Korea Institute of Radiological and Medical Sciences (KIRAMS). We developed a dose measurement method using GAF film to evaluate the generated dose distribution by the beam modulator in phantom. The modulator was applied in method of rotating wheel where different thickness wheels can be formed the same effects from the several layers of decelerating objects. Generally, wheel type modulators were used to adjust a rotation width of a specific plan thickness in order to give a weight on the range of beam in phantom. Unlikely the above method, a multi-level frame having the same rotation width is used in this study. And then, the weight of a dedicated range is reflected by changing its rotation speed corresponding to the congruent thickness layer. The image analysis method with GAF film is applied to estimate a dose distribution deposited in phantom. To measure the dose distribution at different depth in phantom, we employed a color index analysis of the proton-irradiated GAF film, which is attached to the backward of acrylic target shaped triangle pillar. The color index analysis of the film is analyzed RGB of digitalized images, which is scanned by a general optical scanner. With this method, two dimensional dose distributions can be easily obtained without using very expensive 2D scan dose equipments. We conclude the dose distribution generated by fabricated modulator is satisfied by showing that the flatness of beam is within 5 % of density variation and the slope in SOBP boundary (defined as the distance of points of 90 % and 10 % of SOBP region) is within 1mm.

WED-MA05-P3 #594 - Poster - Wednesday 5:30 PM - Rio Grande Room

Path Reconstruction for Proton Computed Tomography

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Maintaining a high degree of spatial resolution in proton computed tomography (pCT) is a challenge due to the statistical nature of the proton path through the object. Recent work has focused on the formulation of the most likely path (MLP) of protons through a homogeneous water object [1] and the accuracy of this approach has been tested experimentally with a homogeneous PMMA phantom [2]. Inhomogeneities inside the phantom, consisting of, for example, air and bone will lead to unavoidable inaccuracies of this approach. The purpose of this ongoing work is to characterize systematic errors that are introduced by regions of bone and air density and how this affects the accuracy of proton CT in surrounding voxels both in terms of spatial and density reconstruction accuracy. Phantoms containing tissue-equivalent inhomogeneities have been designed and proton transport through them has been simulated with the GEANT 4.9.0 Monte Carlo tool kit. Various iterative reconstruction techniques, including the classical algebraic reconstruction technique (ART), fully sequential, and block-iterative techniques are currently being tested, and we will select the most accurate method for this study. We will also investigate new MLP formulations that take into account updated knowledge of the phantom from a first run of iterative reconstruction. Although this will increase, the computing time, it is expected to lead to a substantial improvement in image quality and accuracy for proton treatment planning.

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WED-NHS01-P1 #80 - Poster - Wednesday 5:30 PM – Rio Grande Room

Beam Focusing Strategies at AIRIX Facility

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High intensity electron beam focusing is a key issue for the successful development of flash radiography at hydro test facilities. AIRIX is a 2 kA, 19 MeV, 60 ns, single shot linear accelerator that produces X-rays from the interaction between relativistic electrons and a Tantalum solid target (Ta). A simulation tool has been developed to model the pulsed-beam dynamics through the accelerator from the cathode to the target. In this work, different beam focusing strategies at AIRIX Facility have been investigated on both experimental and theoretical approaches.

WED-NHS02-P1 #81 - Poster – Wednesday 5:30 PM – Rio Grande Room

Pulsed DD Neutron Generator Measurements for HEU Oxide Fuel Pins

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Pulsed neutron interrogation measurements have been performed on HEU oxide fuel pins and DU metal with a D-D neutron generator (10^6 n/s) at the Idaho National Laboratory Power Burst Facility. These measurements demonstrate the ability to distinguish HEU from DU by coincidence counting using a pulsed source. The neutrons were counted during and after the pulse with the Nuclear Material Identification System (NMIS) and used to calculate the neutron coincidence time distributions. The amounts of HEU measured were 4 kg and 8 kg compared to 31 kg of DU in sealed 55-gallon drums. These measurements utilized moderated He-3 tubes to evaluate the ability to detect the presence of HEU. This paper presents results from the measurements.

WED-NHS02-P2 #119 - Poster - Wednesday 5:30 PM – Rio Grande Room

Capabilities of the INL ZPPR to Support Active Interrogation Research Utilizing SNM

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For over 40 years Idaho National Laboratory (INL) and its predecessor organizations have maintained and operated the Zero-Power Physics Reactor (ZPPR) as a test bed for studying reactor physics and nuclear reactor design. Although the ZPPR is no longer operated as an active research reactor, it's infrastructure (radiation shielding, safety systems, physical safeguards) and special nuclear material (SNM) inventory (variably enriched uranium and plutonium fuels available in metallic, oxide, alloy, and other forms) still make the facility a unique national resource for research and development activities involving the use of SNM. Recently INL has utilized this resource to serve as a test and evaluation facility for active interrogation research and development. This facility is currently hosting scoping experiments using neutron and x-ray radiation sources to characterize SNM active interrogation signatures and to develop tools and techniques to detect and identify shielded SNM. This paper presents an overview of the facility's infrastructure and assets and describes recent active interrogation experiments that have taken place using high-energy x-ray sources and compact electronic neutron generators.

WED-NHS02-P3 #385 - Poster - Wednesday 5:30 PM – Rio Grande Room

Identifying Nuclear Material via Prompt Photo-Neutron Multiplicity Measurements

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Prompt neutron emissions from photonuclear interrogation are more numerous by orders of magnitude than beta-delayed neutrons from fission fragments. However, prompt neutrons have not been used for the purpose of identifying the presence of nuclear material in part because of the difficulty in discriminating between neutrons originating from fissionable and fissile materials and neutrons originating from other high-atomic-number materials. In the present work, proof-of-principle multiplicity measurements of prompt neutron emissions were performed, both for depleted uranium (DU) metal and Pb. The present work has shown that photo-fission neutrons can be distinguished from photo-detachment neutrons, via multiplicity techniques, for the purpose of identifying nuclear material under circumstances where the neutrons are already naturally bunched in time by the pulsed nature of the accelerator. These techniques work for bremsstrahlung endpoint energies up to 20 MeV, where fission yields are dramatically improved compared to 10 MeV endpoint energies, but where neutron energy discrimination techniques fail. Measurements with the 44 MeV short-pulse accelerator at the Idaho Accelerator Center indicate that such measurements can be performed rapidly with a high-repetition-rate accelerator, and hold promise for distinguishing HEU and DU by the sensitivity of multiplicity techniques to multiplication.

WED-NHS02-P4 #486 - Poster - Wednesday 5:30 PM – Rio Grande Room

Production of an Associated Particle Neutron Generator with ZnO:Ga Alpha-Detector

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An associated particle neutron generator (APNG) capable of 10^9 neutrons/second has been produced with an alpha particle detector made of ZnO:Ga phosphor with decay time of approximately 1 nanosecond. Fast 14 MeV neutrons and 3.5 MeV alpha particles are produced through a deuterium-tritium fusion reaction and travel in opposite directions to conserve linear momentum. The alpha particle transducer was found to yield a mean light output of 35 photoelectrons and a detection efficiency of 94%, using a bialkali photocathode. The neutron generator provides high rate capability, excellent nanosecond time resolution, and a large solid-angle with an acceptance of 8%. Using a NaI detector to measure the return gamma ray spectrum, a significant reduction in the signal to noise ratio is found. The noise reduction is presented as a function of the generator's neutron production. The possibility of using the noise reduction capability of the APNG to search cargo for special nuclear materials (SNM) is discussed. The detection of prompt fission gamma rays in coincidence with the segemented alpha detector signal from the APNG can greatly suppress backgrounds and help located SNM within a container.

WED-NP06-P1 #301 - Poster - Wednesday 5:30 PM – Rio Grande Room

Elemental discrimination of low-energy ions using risetime analysis of silicon-strip detector signals

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The availability of intense reaccelerated radioactive beams has made possible the direct measurements of reaction cross sections of importance to explosive burning such as in novae and X-ray bursts. Often times, however, the required beams are contaminated by other isobars making it difficult to distinguish the events of interest from those induced by the contaminants. For measurements at typical astrophysical energies, the reaction products are usually too low in energy to identify using standard energy-loss techniques with silicon-strip detectors, and so other solutions have been explored such as purifying the beam by fully stripping or reconstructing the Q-value of the reaction from the measured energies and angles of reaction products. These techniques are not always ideal, and a possible further constraint can be obtained by measuring the risetimes of the signals in silicon-strip detectors induced by the low energy reaction products. Sensitivity to the proton number of the detected particles has been demonstrated at higher energies (> 4 MeV/u), but rarely has it been applied to energies typical for astrophysics (~0.5 MeV/u) or to silicon-strip detectors. We have constructed a simple electronics scheme to measure the risetimes of 10 MeV 16O and 14N beams scattered from carbon targets into an annular silicon-strip detector. By gating on a fixed ion energy, we find partial discrimination of the detected beam ions based upon risetime alone. The method and results will be presented.

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WED-NP06-P2 #302 - Poster - Wednesday 5:30 PM – Rio Grande Room

Quantitative Low-Energy Ion Beam Profile Measurement with Gafchromic$^\\text{\\textregistered}$ Film

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It is often necessary in the initial set up and testing of new accelerator beam lines and/or new ion-optical devices to do multiple beam-profile imaging. This is especially true for producing and utilizing secondary radioactive beams. While electronic position-sensitive detectors are obviously suitable for this, they often cannot be easily used in some situations and in certain locations due to space or other constraints. While conventional radiographic (x-ray) film and plastic track-sensitive films (e.g. CR39) have been used in these instances, they can be difficult to use as they are either light-sensitive or require post-exposure chemical development, or both. This often makes them inconvenient for in-beam testing, especially for low-energy ions where a light-tight covering cannot be used. Recently, high- and low-sensitivity radiographic film has been developed (Gafchromic$^\\text{\\textregistered}$ EBT; International Specialty Products) which is relatively light-insensitive and does not require chemical development. This film is a direct image linear with dose over a wide range of exposures. We have specified and obtained a special uncoated version of this film suitable for beam-profile and ion-optical device imaging in low-energy nuclear accelerators. It also can be used to characterize radioactive source emission profiles. It can be exposed and viewed directly in situ which can greatly facilitate beam-profile measurements and optimization of ion-optical systems. Initial tests done in vacuum with an alpha source and a set of in-beam tests have been part of a project to develop an extended time-of-flight beam line at the UM-UND low-energy radioactive beam facility \\emph{TwinSol} operated at the University of Notre Dame FN tandem accelerator and will be reported.

WED-NP06-P3 #411 - Poster – Wednesday 5:30 PM - Rio Grande Room

Diffusion of Boron in MgF2

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The on-line isotope separation techniques (ISOL) for production of short-living radioactive atoms require the fast release of the nuclear reaction products from the GeV proton irradiated targets. First step in the complex transport chain (i.e., from the ion source to the irradiation/implantation chamber) the fast diffusion of the radioactive isotopes (RI) towards the target surface, is very important. For optimization of the ISOL systems is necessary to obtain reliable data about the diffusion of RI in the selected ISOL target materials. In this study, a monocrystal of fluoride MgF2 was examined as a possible ISOL target for production of RI boron. Currently, there is no RI beam of boron produce in the ISOL systems. Application of MgF2 seems to be, however, promising for boron release. In the study, the diffusion behavior of boron atoms (implanted into the MgF2 monocrystal) was analyzed (by Neutron Depth Profiling and Rutherford Backscattering techniques) in the broad range of temperatures (RT-700ºC,

isochronal annealing) and times (4-100 hours, isothermal annealing). The obtained data point out a one-directional (non-classical) diffusion of boron in MgF2 at elevated temperatures. This might be due to the radiation-induced defects created during the boron ion implantation. It is supposed that the defects serve as boron traps that may hinder the atoms diffusion into the bulk. The obtained experimental data suggest that MgF2 might be a suitable as a ISOL target for the effective radioactive boron beam production.

WED-NSF01-P1 #91 - Poster - Wednesday 5:30 PM – Rio Grande Room

Micropatterning of Poly(4-hydroxystyrene) by Ion Implantation

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Ion beam lithography is one of the possible candidates for next generation lithography. The main advantage of ion beam lithography is that the high energy ions have a long range and a low lateral spread making them ideal for exposing thick resistant materials to fabricate high aspect ratio structures. Thus, numerous activities on ion beam lithography have been carried out by using polymer resists like poly(methyl methacrylate) (PMMA). However, PMMA has a poor etch resistance due to its aliphatic structure. So new resist materials having a high etch resistance need to be developed for ion beam lithography.

PHS with proper protecting groups has been widely used as a matrix resin for a conventional deep UV lithography. It is well known that polystyrene-derivatives can be crosslinked by a high energy irradiation. So PHS could be a possible candidate for a negative type resist for ion beam lithography. To the best of our knowledge, poly(4-hydroxystyrene) (PHS) as a single component resist for ion beam lithography has not been explored yet.

In this study, we report on the possibility of PHS as a single component negative resist for ion beam lithography. PHS thin films were prepared by spin-coating of polymer solutions on a silicon wafer and baking. Ion irradiation was carried out with a 300-keV ion implanter. The irradiated films were baked and developed to generate polymer patterns. The irradiated films were characterized by using FT-IR, XPS, and SEM. Well-defined 50 micro-meter square patterns were obtained without using any additives.

WED-RE05-P1 #92 - Poster - Wednesday 5:30 PM – Rio Grande Room

Micropatterning of cells on a glass surface by using ion implantation

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Surface modification by ion impanation has attracted much attention because the projected range and ion fluence can be accurately selected to be suitable for various applications. Thus, this technique has been widely used for a surface modification of various organic and inorganic materials for an improvement of their surface properties such as their surface hardness, wear resistance, chemical erosion, biocompatibility, and so on. However, research on a cell patterning on a glass surface by ion implantation has not been studied intensively.

In this study, we report on a simple cell patterning method on a glass surface via ion implantation. A glass surface was irradiated through a metal mask with 150 keV Ar ions with or without oxygen gas. The changes in the surface properties were investigated by using a water contact angle measurement, and a cell adhesion test. The results showed that the cells were well adhered and proliferated on the irradiated region in the presence of oxygen gas.

WED-RE05-P2 #144 - Poster - Wednesday 5:30 PM – Rio Grande Room

Alpha Particle Radiolysis of Lithium Hydride

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LiH is a highly reactive solid that is used in nuclear weapons, where radiation environments are present that can disrupt the structure of a material. This disruption creates defects and can produce gases, most obviously H2 gas. We have performed

introductory experiments to determine the effects of long-term radiolysis on LiH. Our experiments focus on alpha particle radiolysis of LiH, as it is highly relevant for our application, relatively destructive, and less studied.

We have used an accelerator in the Ion Beam Materials Laboratory to produce alpha particle doses in LiH at desired energies that are equivalent to decades of exposure from an actinide source near the surface. Evolved gases were measured, particularly H2, and quantified. Our data allows prediction of concentrations that could be released over long periods of time in sealed containers. Finally, LiH was hydrolyzed in areas that have been irradiated and not irradiated; hydrolysis layers were analyzed using Rutherford Backscattering Spectroscopy (RBS) and compared.

WED-RE05-P3 #397 - Poster - Wednesday 5:30 PM – Rio Grande Room

Enhanced photoluminescence of Ar-ion implanted sapphire

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Single crystals of sapphire with the (10$\underline{1}$0) orientation were implanted at 623K with 110keV Ar-ions to a fluence of 9.5×10^{16} ions cm^{-2}.The ion-implanted samples were thermally annealed at different temperatures for 60 min in vacuum and air atmospheres, respectively. Photoluminescence spectrum of the as-implanted sample shows a new emission band at 506nm. The intensity of the emission band at 506nm increases after the annealing treatment at some temperatures. The PL peak intensity got maximum after the annealing at 1073K in both vacuum and air atmosphere. The annealing in air atmosphere at temperature between 873K to 1273K lead to higher intensity of the peak than the annealing in vacuum did. In all the samples the emission band almost disappeared after the annealing at 1373K in both vacuum and air atmosphere. The experimental results showed that the annealing temperature and the annealing atmosphere play important roles in the PL peak intensity at 506nm from sapphire implanted with Ar ions. The emission band at 506 nm after Ar-implantation and annealing is attributed to the production of interstitial Al atoms due to the ion bombardment and the formation of argon gas bubbles during annealing.

WED-RE05-P4 #416 - Poster - Wednesday 5:30 PM – Rio Grande Room

Low-energy Ar+ Ion Irradiation Effects in KY(WO4)2

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Monoclinic potassium yttrium double tungstate á-KY(WO4)2 (KYW), which exhibits strong anisotropy with scheelite-type crystal structure, has potential for several applications in optical and optoelectronics devices. KYW is considered as the most effective laser host material because of large absorption and emission cross sections of rare earth (RE) dopants. These binary tungstates exhibit large third order nonlinear optical susceptibilities and can be used for developing effective Raman lasers. Formation of KYW-based waveguide structures with low optical losses, however, is possible only under precise control of the surface structure and chemical state of the substrate, conditions of the interface formation between the substrate and epilayer, and lattice modification generated by the heavy doping of RE elements, and interaction with ions used for surface cleaning and etching. The present work was performed to understand the effect of 1.5 kV Ar+ ion-irradiation on the KYW (010) surfaces. The effect of Ar+ ion irradiation on the surface structure and chemical composition was investigated using reflection high-energy electron diffraction (RHEED) and x-ray photoelectron spectroscopy (XPS), respectively. The RHEED and XPS measurements as a function of 1.5 kV Ar+ ion-irradiation of the KYW(010) surfaces indicate the amorphization, partial loss of potassium atoms, and partial transformation of chemical valence state of tungsten from W6+ to lower valence state, W0 state predominantly, which induce electronic states at the top of valence band. The experimental results are compared with the calculations made for the effect of Ar+ ions in KYW crystal surfaces.

WED-RE05-P5 #548 - Poster - Wednesday 5:30 PM – Rio Grande Room

Correlations between phase stability and radiation tolerance in structurally related oxides

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Increasing efforts have been devoted in recent years to identifying radiation resistant ceramics that could endure hostile environments such as nuclear reactors or waste immobilization. Our recent studies in this area have identified trends in radiation damage behavior for families of structurally related oxide compounds. We have demonstrated through heavy ion irradiations (300 keV Kr+ ions) that improved amorphization resistance characteristics are to be found in oxide compounds that have a natural tendency in their temperature-composition phase diagrams to accommodate lattice disorder [1]. In this report, we reexamine three ZrO2-A2O3 mixtures (different cationic size A3+, A = Dy, Lu and Sc) with light ion irradiations (such as He+ ions). Light ions such as helium produce primarily simple interstitial-vacancy Frenkel pairs (mono point defects) while heavy

ions such as krypton can produce significantly higher densities of point defects and defect aggregates that may have different influences on damage evolution, defect accumulation, and ultimately amorphization. Order-to-disorder (O-D) structural transformations are characterized using grazing incidence X-ray diffraction (GIXRD) and cross-sectional transmission electron microscopy (TEM). Correlations between the radiation-induced O-D transformations and phase-stability characteristics for these compounds are discussed.

[1] K.E. Sickafus et al, Nature Materials, Vol 6 (2007) 217-223.

WED-RE06-P1 #624 - Poster - Wednesday 5:30 PM – Rio Grande Room

Results from Two Low Mass Cosmic Ray Experiments Flown on the HASP Platform

M. Tittsworth[1], R. S. Fontenot[1], W. Fountain[2], M. Christl[2], C. Thibodaux[1], B. M. Broussard[1], J. W. Deaton[1], W. A. Hollerman[1]
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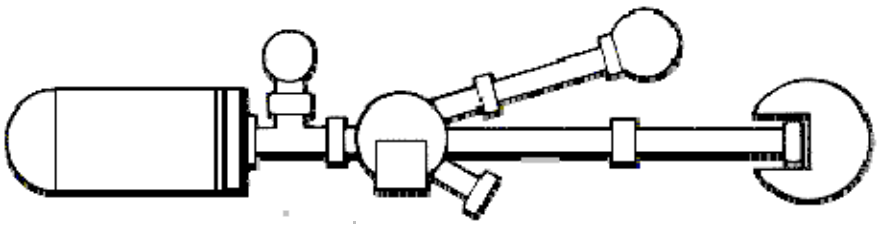
The High Altitude Student Payload (HASP) program is designed to carry twelve student experiments to an altitude of about 125,000 feet (~38 km) with flight durations of more than sixteen hours. Since 2003, physics students at the University of Louisiana at Lafayette (UL Lafayette) have participated in three balloon payload projects sponsored by the Louisiana Space Grant Consortium (LaSPACE). In 2006, students participated in the first HASP program to measure cosmic ray intensities using traditional film and absorbers. This 10 kg payload flew from Fort Sumner, New Mexico in early September 2006 and was a great success. In 2007, UL Lafayette physics students participated in the second HASP program and built a similar payload that measured the cosmic ray intensity and flux using the same traditional film. For the second HASP payload, the students added five layers of Optically Stimulated Luminescence (OSL) detectors in order to determine the cosmic ray dose. Results from both HASP payloads showed that the cosmic ray flux decreases as a function of payload depth. As the cosmic rays go through the stack, they deposit their energy in the payload material. Determining the cosmic ray flux is a tedious task. It involves digitizing the film and determining the real cosmic ray density. For the first HASP payload, students used a program known as GlobalLab to count particles. For the second payload, the students decided to use a combination of the GREYCStoration image regularization algorithm, an embossing filter, and a depth-merging filter to reconstruct the paths of the cosmic rays. This was done using the GNU Image Manipulation Program (GIMP) environment that is freely available worldwide. This presentation will discuss our participation in both HASP balloon projects with emphasis placed on the "hands-on" and step-by-step approach used to teach students practical space related skills.



THURSDAY

THU-ED01-1 #441 - Invited Talk - Thursday 8:30 AM - Bur Oak

USPAS and its role in educating the next generation of accelerator scientists and engineers

William A. Barletta
Department of Physics, Massachusetts Institute of Technology, 77 Massachusetts Ave, Cambridge MA 02139, United States

Accelerators are essential engines of discovery in fundamental physics, biology, and chemistry. Particle beam-based instruments in medicine, industry and national security constitute a multi-billion dollar per year industry. More than 55,000 peer-reviewed papers having accelerator as a keyword are available on the Web. Yet only a handful of universities offer any formal training in accelerator science. Several reasons can be cited: 1) The science and technology of particle beams and other non-neutral plasmas cuts across traditional academic disciplines. 2) Electrical engineering departments have evolved toward micro- and nano-technology and computing science. 3) Nuclear engineering departments have atrophied at many major universities. 4) With few exceptions, interest at individual universities is not extensive enough to support a strong faculty line. The United States Particle Accelerator School (USPAS) is National Graduate Educational Program that has developed a highly successful educational paradigm that, over the past twenty-years, has granted more university credit in accelerator / beam science and technology than any university in the world. Governed and supported by a consortium of nine DOE laboratories and two NSF university laboratories, USPAS offers a responsive and balanced curriculum of science, engineering, computational and hands-on courses. Sessions are held twice annually, hosted by major US research universities that approve course credit, certify the USPAS faculty, and grant course credit. The USPAS paradigm is readily extensible to other rapidly developing, cross-disciplinary research areas such as high energy density physics.

THU-ED01-2 #134 - Invited Talk - Thursday 8:30 AM - Bur Oak

Using accelerators for teaching electromagnetism to high-school students

Antonio Carlos Santos, Debora Sinflorio, Paulo Fonseca, Luis Felipe Coelho
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A programme was developed in 1999 by FAPERJ (a Brazilian State funding agency) for high-school students interested in natural sciences, with the aim of introducing them to the daily activities of scientists in universities and research institutes. The aim of this work is to describe physical experiments in which high school students may become involved. The objective of the experiments, which are suitable for senior high-school students, is to demonstrate the principles of electromagnetism. Some experiments, requiring the use of the 1.7 MV Pelletron accelerator, are described.

Work supported in part by FAPERJ and CNPq.

[1] D. A . Sinflorio, P.Fonseca, L. F. S. Coelho, and A C. F. Santos, Phys. Ed. 41, 539 (2006).

THU-ED01-3 #168 - Invited Talk - Thursday 8:30 AM - Bur Oak

Undergraduate Research Experiences in Positron Beams at St. Olaf

Jason John Engbrecht, Daniel E Endean, Barry N Costanzi, Kay M Pelletier, David J Green
Physics, St. Olaf College, 1520 St. Olaf Ave., Northfield MN 55057, United States

At St. Olaf College we have recently begun the construction of a slow positron beam for the eventual purpose of creating a beam of positronium atoms. This work is motivated by recent results which demonstrate that certain highly structured nanoporous material should produce positronium in a very directional manner. This talk will cover the fundamentals of how such a beam is constructed and operated. St. Olaf is an entirely undergraduate institution and thus undergraduates have participated in all aspects of the design and construction of this beam. Examples will be presented for the types of projects students have work on such as ion beam modeling, various machining projects, and pulsing electronics. The guiding principles used in generating these projects will also be discussed.

THU-ED01-4 #529 - Contributed Talk - Thursday 8:30 AM - Bur Oak

Undergraduate Teaching and Research at Union College using a Pelletron Particle Accelerator

Scott M LaBrake
Physics and Astronomy, Union College, 807 Union Street, Schenectady NY 12308, United States

The Union College Physics & Astronomy Department manages a 1.1-MV tandem Pelletron particle accelerator from the National Electrostatics Corporation that utilizes an external Alphatross ion source capable of accelerating a variety of ions, but primarily

protons and alpha particles for materials analysis studies using PIXE and RBS. The primary role of the Union College accelerator is as a multi-disciplinary teaching instrument. It serves as a foundation in many of the courses that we as a physics department offer, from our introductory to our most advanced courses for physics majors and engineers. Further it has the capability to serve and has served faculty and student majors from the life sciences, geological and atmospheric sciences, to the history department. The secondary role of this instrument is as a vehicle for undergraduate student research projects conducted by our junior and senior physics majors. Many of our majors over the last 15 years have utilized the Pelletron accelerator in materials analysis studies utilizing PIXE and RBS, but has seen some limited use in NRA studies of low energy ions in low Z materials. In this talk, I will give a brief history of the Pelletron accelerator used at Union College. An overview of the physics department courses that currently use the accelerator as part of their curricula will be presented as well as a discussion of the inter-disciplinary use of the accelerator. Lastly I will highlight the various research projects that have been done on our accelerator in the past few years as well as some future projects we are currently undertaking.

THU-ED01-5 #483 - Contributed Talk - Thursday 8:30 AM - Bur Oak

Teaching Ion Beam Analysis in the context of Solid Oxide Fuel Cell materials research*

R J Smith, H. Chen, W. Priyantha
Physics Department, Montana State University, EPS Bldg, Bozeman MT 59717, United States

The development of advanced ceramic materials for solid oxide fuel cell (SOFC) components offers a rich context for teaching a variety of ion beam analysis techniques using accelerators. The typical thickness (1-10 μm), composition (metal oxides), operating temperatures (~ 800 °C), and operating atmosphere (H_2, O_2, H_2O) for the SOFC anode, cathode, electrolyte, and seals present materials issues for investigation that are nicely suited to the probing depth, depth resolution, elemental specificity, relative yields and sensitivity of MeV ion beam analysis. Several examples of accelerator techniques used by students in our lab are discussed, including: RBS for studies of SOFC interconnect thermal stability, corrosion resistance, and vaporization rates for volatile surface species; non-Rutherford ion backscattering analysis to enhance sensitivity to light elements such as oxygen and nitrogen; NRA with deuterium beams to determine concentrations of light elements (C, N, O); NRA using the reaction $^{18}O(p,\alpha)^{15}N$ to measure oxygen transport in electrolytes and coated interconnects; and PIXE for elemental specificity in multi-component oxides where mass resolution with RBS is insufficient.

*Work supported through MSU-HiTEC funded by the United States Department of Energy (USDOE) under Award No. DE-AC06-76RL01830.

THU-ED01-6 #221 - Contributed Talk - Thursday 8:30 AM - Bur Oak

Undergraduate and graduate accelerator experiments at Yale

Stephen H Irons, Lawrence M Cerrito, Andreas M Heinz
Physics Department, Yale University, 217 Prospect Street, New Haven CT 06520, United States

In the Yale physics department we use a 1 MeV Van der Graaff accelerator to produce monoenergetic protons (300 - 1000 KeV) for use in undergraduate student experiments. In our undergraduate course, students perform two different labs. The first is the historic Rutherford scattering experiment. Students measure the angular distribution of scattered protons from a gold target as well as the angular dependence on the energy. The second is the nuclear interaction of p + Be9. Students collect data on a multichannel analyzer and record the number of peaks and their energies. Using the relativistic mass-energy equations students verify energy conservation and identify the resulting interaction products.

In our graduate lab course, students investigate the classic nuclear reaction: F19 (p,alpha)O16*(gamma)O16. By studying the angular correlations between the emitted alpha and gamma particles, information on the spin and parity assignments for the nuclear levels of Ne20 and O16 can be deduced. This experiment also provides students with a direct experience with alpha and gamma detectors, pulse processing, and coincidence techniques.
We will discuss the experimental procedure and analysis and present some typical student data.

THU-FIBP06-1 #433 - Invited Talk - Thursday 8:30 AM - Post Oak

Application of PIXE in Spintronics Material Research

Vaithiyalingam Shutthanandan
Environmental Molecular Sciences Laboratory, Pacific Northwest National Lab, P.O.Box:999, Richland WA 99352, USA

There is a growing interest in diluted magnetic semiconductors in the emerging field of spintronics. For example, the ability to efficiently inject spin-polarized carriers into nonmagnetic semiconductor heterostructures creates new and exciting possibilities for utilizing DMS materials in spin-based devices. It has been recently demonstrated that transition metal (TM) doped TiO2, GaN, ZnO and SnO2 show room-temperature ferromagnetism (RTFM). These materials exhibit Curie temperatures above room

temperatures. However, accurate knowledge of dopant concentration is necessary to quantify the magnetic moments of these materials. In general, Rutherford Backscattering spectrometry (RBS) is a powerful technique to quantify the magnetic transition metal dopants in these materials. However, the interference of RBS signals between the dopants and the substrate elements made analysis difficult. In addition, small quantity of dopants also complicated the RBS analysis. Hence, we employed proton induced x-ray emission (PIXE) to quantify the magnetic transition element dopants in several RTFM materials synthesized using different synthesis methods. In this talk, we will summarize extensive PIXE work that has been done in our laboratory in the past few years. In this work: (1) Co and Mn doped ZnO films grown by pulsed laser deposition (2) Co and Cr doped anatase TiO2 films grown by oxygen plasma assisted molecular beam epitaxy (3) Co and Ni doped rutile TiO2 single crystals synthesized by ion implantation, and (4) Co and Fe doped SnO2 and ZnO powders synthesized by wet chemical methods were characterized by both PIXE and RBS. These results will be discussed along with the results from magnetic measurements, Co K-edge x-ray absorption near-edge spectroscopy and extended x-ray absorption fine structure measurements.

THU-FIBP06-2 #50 - Invited Talk - Thursday 8:30 AM - Post Oak

Applications of High Energy PIXE using 18 MeV protons to the study of Cultural Heritage samples

Javier Garcia Lopez[1], Ines Ortega-Feliu[1], Roxana Bugoi[1,2], Yolanda Morilla[1]
[(1)]Centro Nacional de Aceleradores, University of Seville, Av. Thomas A. Edison 7, Sevilla 41092, Spain
[(2)]"Horia Hulubei´´ National Institute of Nuclear Physics and Engineering, PO BOX MG-6, Bucharest 077125, Romania

Early in the development of PIXE technique it was stated that High Energy PIXE (HEPIXE) using protons at high energy would present some advantages compared to the commonly used 1-3 MeV protons. One of the benefits of HEPIXE is the significant increase of the K- and L-lines X-ray production cross sections with respect to those of lower energy protons. This makes possible the identification of medium and heavy elements not only by their L-lines but also by their K-lines, which simplifies, in principle, the analysis.

In this work, several thick metallic certified reference materials (pure lead, bronze and 18 K gold) of potential interest for archeometrical applications were bombarded with 18 MeV protons using the cyclotron accelerator at Centro Nacional de Aceleradores, Seville, Spain. We will show that the nuclear reactions that take place in the target can modify considerably the PIXE spectra, not only by increasing the background by Compton scattering, or by introducing interference of low energy gamma-rays in the X-ray region, but also by the emission of the characteristic X-rays of element Z+1 during the internal conversion decays of the excited nuclei formed in (p, xn) processes. This effect is particularly pronounced for high-Z elements, for which the cross sections of (p, xn) nuclear reactions and PIXE K-line are comparable, and for which the phenomenon of internal conversion is relatively important.

The higher depth explored when using HEPIXE represents an asset for the analysis of thick targets, especially if the surface composition is different from that of the bulk material. As an example, we will present the analysis of two fibulae of the Later Bronze Age and of the First Iron Age presenting a well characterized corrosion layer at the surface; a comparison between the results obtained by 3 and 18 MeV protons PIXE will be made.

THU-FIBP06-3 #436 - Contributed Talk - Thursday 8:30 AM - Post Oak

Proton scanning microbeam analysis of gold flecks suspended in foam

Fern Elizabeth Gauntlett[1], Anthony Stuart Clough[1], Andrew Comley[2]
[(1)]Physics Department, University of Surrey, Stag Hill, Guildford Surrey GU2 7XH, United Kingdom
[(2)]AWE, Aldermaston Berkshire RG7 4PR, United Kingdom

Clumpiness of the interstellar medium may play an important role in the transfer of infrared continuum radiation in star-forming regions. Measurements of radiation transport through clumpy media (gold flecks suspended initially in foam) have recently been reported using the Omega laser facility and gold fleck bearing foam cylinders as targets. (1). Previously, IBA methods have been used to characterise molybdenum-doped foams (2).

Using a 4 MeV scanning proton microbeam we have investigated the use of RBS(with PIPS detectors) and PIXE (with CdTe detectors) to measure gold fleck mass and size (of order a few microns) in 1mm long by 1mm diameter foam cylinders. We use the K X-rays to determine the mass and L x-ray attenuation in the gold flecks to determine fleck size. We use a comparative technique, comparing measurements with those from a standard gold foil. Normalisation is via RBS per unit area from carbon included in each beam scan.

To obviate any experimental detection asymmetry we use pairs of RBS and CdTe detectors located at the same angles (up/down and left/right) with respect to the proton beam. Our proton induced K X-ray technique is the only one we know of capable of measuring masses for gold flecks of order 5 micron diameter. To compare with other techniques capable of inducing L x-rays we have also examined samples of finely ground (less than 1 micron) gold in identical foam cylinders. These were independently analysed for gold mass using XRF techniques.

We discuss the novel features of our measurements and present results for gold masses and gold fleck size. In validation, we compare the mass results for finely ground gold with those from XRF techniques.

[1] Rosen at al, Astrophysics and space science 307 (1-3) (Jan 2007), 213-217
[1] Antolak et al, Fusion engineering and Design 46(1999), 37-45

THU-FIBP06-4 #325 - Contributed Talk - Thursday 8:30 AM - Post Oak

Particle Induced X-ray Emission Spectroscopy (PIXE) and Cyclic Voltammetry (CV) Analysis of Selected Children's Toys for Lead

M. Abunaemeh, Hollis Lynn Bowman, C. Muntele, D. Ila
Physics - Center for Irradiation of Materials, Alabama A&M University, P.O. Box 1447, Normal AL 35762, United States

Heavy metals are pervasive in the environment. The most toxic are lead, cadmium, and mercury. These three heavy metals have no biological function and are toxic at all concentrations. Products state that they are lead safe, but that does not necessarily mean lead free. High-gloss oil-based exterior house paint is allowed 0.5% (5000 ppm) lead as polymerization catalysts. Current studies include the analysis of trace quantities of lead and other heavy metals in paint, soil and water specimens by Particle Induced X-Ray Emission Spectroscopy (PIXE) and Cyclic Voltammetry (CV). Children below the age of six years tend to place many foreign objects in their mouth such as paint chips, plastic and metal toys, crayons, chalk and clay. Lead poisoning in children manifests as behavioral problems, learning disabilities, and growth retardation. The toxicity of lead and other heavy metal ions is attributed to their ability to bind with protein molecules and prevent replication of DNA and ensuing cell division. The U.S. Consumer Product Safety Commission (CPSC) Office of Compliance mandates, in 16 C.F.R. 1303, the ban on paint or other similar surface coating material that contains more than 0.06% (600 ppm) lead. Crayons with an excess of 0.01% (w/w) (100 ppm) lead are considered a health hazard to children. PIXE is a highly sensitive and selective multielemental analytical technique. CV is a sensitive electrochemistry technique suitable for target compound analysis such as lead from digested samples. Our studies propose to utilize PIXE and CV to investigate their utility for the qualitative and quantitative analysis of lead and other heavy metals in selected children's toys.

THU-FIBP06-5 #597 - Contributed Talk - Thursday 8:30 AM - Post Oak

Comparative PIXE Analysis of Modern and Ancient Coins

Bobbak R Sistani, Claudiu Muntele, Daryush Ila, Robert Lee Zimmerman
Irridation of Materials Center, Alabama A&M University, 4900 Meridian Dr., Normal Alabama 35762, United States
Coins traditionally retained intrinsic and universal value independently of their origin. They accomplished that with their easily verifiable content of a pure and valuable metal, usually silver or gold. Paper money traditionally owed its value to an understanding that it could be exchanged on demand for a specific amount of metal. Currently, most coins in circulation have negligible intrinsic value, similar to paper money. We have used Proton Induced X-Ray Emission (PIXE) spectroscopy and Rutherford Backscattering Spectrometry (RBS) to analyse the composition of United States, and other government, issued coins before and after the transition away from the use of valuable metals. The techniques will be shown to be a quick and easy way to identify the alloys and quantify the metals used in modern coins to make them feel and look valuable.

THU-IBM03-1 #583 - Invited Talk - Thursday 8:30 AM - Pecos II

The use of accelerator and advanced-materials for nuclear energy

Liviu Popa-Simil[1], Barney L. Doyle[2]
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[(2)]Radiation Solid Interactions, Sandia National Laboratories, Albuquerque NM 87185, United States

Nuclear power is now a mature technology with more than 440 nuclear reactors in operation, and cumulating from thousands of man-years of nuclear research and experience, but any progress in the field of nuclear fuels is now very hard to achieve. We propose here that modern accelerator based knowledge and novel fuel materials based on nano-technologies can lead to novel concepts and new nuclear reactor fuel systems that if successful may take nuclear power closer to its technologic limits. The knowledge of the ion beam interaction with matter contributed to the development of a novel nuclear fuel material entitled "cer-liq-mesh", while in addition, an analysis of the fuel heating has led to the development of a new direct energy conversion nano-hetero structures. Ion beam will be used to test and simulate nuclear fuel behavior and understand effects as fuel damage, and fuel heating under thermal spike. Ion beam simulation in direct energy conversion nano-structure designs and tests will have capital importance in understanding the delta electron generation and harvesting in nano-layers and nano-clusters as well the associated thermo-electric effects. Moreover, usage of ion beam recoil analysis is used to measure and prove the nano-grains and nano-cluster special properties as shape-enhanced impurity diffusion and self-repairing in near magic cluster structures. The nano-grain liquid interface is studied by ion beam simulation to develop a new generation of nuclear fuels with enhanced breeding and transmutation properties, able to directly separate the transmutation products reducing the need for hard, hazardous chemical

processes. Simulations of the performance of these nano-system based nuclear fuel concepts will be discussed in this paper, as will plans for future experiments.

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

THU-IBM03-2 #592 - Invited Talk - Thursday 8:30 AM - Pecos II

SWIFT HEAVY ION BEAM MODIFIED BEHAVIOUR OF PURE AND DOPED TGS CRYSTALS

P.K. Bajpai
Department of Pure & Applied Physics, G.G. University, Bilaspur, C.G., India, Bilaspur Chhatisgarh 495 009, India

Swift heavy ions are used as an excellent tool to develop nanostructures on the material surfaces or in the region near to surface. The surface modifications are due to ion-beam interaction with surface particles and are governed by ion species, ion beam fluence and nuclear charges. Large number of material modifications is reported using swift heavy ions in semiconductors, superconductors, polymers, etc.

Ferroelectrics are unique materials in the sense that they possess switchable dipoles. Tri-glycine sulphate (TGS) is an excellent room temperature ferroelectric material suitable for pyroelectric detection of IR radiation. The dipoles in these materials are ordered in the long range and can be reoriented by applying external electric field. We have attempted SHI irradiation as a means of taking the system to non-equilibrium state by generating thermal flux. 100 MeV Oxygen ion beam is used to irradiate polar cleavage surfaces of the crystals doped with different concentrations of dopants.

It is observed that the field produced due to irradiation creates a bi-domain situation and orient domains of opposite polarity. Ferroelectric hysteresis, dielectric, optical and atomic force microscopic data have been analyzed Hysteresis loop parameters are used to calculate the internal field that matches well with the one estimated from the model. The dielectric response becomes diffuse and loss decreases with increasing ion fluence. The optical band gap also gets modified and band edge follows Urbach rule. Surface micro-relief's analyzed show pits and protrusions appearing on the irradiated surface and converts into regular hillocks of nano-dimensions. These structures can be controlled by varying fluence and doping level. The origin of micro-relief has been interpreted as due to domain orientation and piezoelectric compression and stretching leading to inhomogeneous force gradient at domain walls. The results will be presented in the talk.

THU-IBM03-3 #598 - Invited Talk - Thursday 8:30 AM - Pecos II

Formation of Periodic Nano-Structures using High-energy Ions

V. Shutthanandan, Y. Zhang, B. Arey, C. M.Wang, M. H. Engelhard, L. V. Saraf, S. A. Lee, J. Barton, J. S. Young, M Avila, S. Thevuthasan
Environmental Molecular Sciences Laboratory, Pacific Northwest National Laboratory, Richland WA 99352, United States

There has been considerable interest in ripple structures formed on cretin materials under ion bombardment since they provide easy templates for nano scale fabrication of textured materials. It is well known that these ripple structures are often formed during the low energy ion bombardment on cretin sample surfaces. However, recently, we have shown that similar periodic structures can be synthesized using high-energy ion bombardment. In this work, formation and nucleation of periodic nano-structures synthesized using gold ion implantation in SrTiO3 single crystals was investigated using Rutherford backscattering spectrometry (RBS) along with channeling, scanning electron microscopy (SEM), energy dispersive x-ray emission (EDX), high-resolution transmission electron microscopy (HRTEM) and x-ray photoelectron spectroscopy (XPS). Gold ions were implanted at off normal direction to the surface at room temperature. SEM micrographs obtained from the as implanted sample show that the surface of the implanted region underwent substantial rearrangement and formed "ridge" like periodic structures. These periodic structures are formed throughout the implanted region with the average height and wavelength in the order of 1 to 2 microns. Formation of these periodic structures was studied in detail as a function of ion spices, energies, doses, and implantation temperatures.

THU-IBM03-4 #524 - Invited Talk - Thursday 8:30 AM - Pecos II

Molecular Depth Profile of Sugar Films: A Comparison Study of C60 Ions and Traditional Cs+ and O2+ Ions

Zihua Zhu
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Time-of-flight secondary ion mass spectrometry (ToF-SIMS) is a powerful surface analysis technique because it supplies both molecular information and element information with a reasonable high spatial resolution (~100nm). Furthermore, 3-dimensinal

imaging is also feasible. Normally, dual beam analysis strategy is used , in which a second ion beam is applied for sputtering to realize layer-by-layer analysis. Traditionally, low energy Cs+ and O2+ ions are used. However, they are reactive species and organic molecules are easy to be extensively damaged during sputtering process so that only elemental information is collected. Recent years, a new sputtering species, C60 ions were introduced. They are relatively soft and they can sputter materials away with very limited damage so that molecular depth profiles can be realized.

3-dimensional imaging of cells and tissues by ToF-SIMS has been of great interest for more than ten years. However, cells and tissues contain a lot of water and they are not compatible with high vacuum environment at room temperature. Immobilizing cells in a sugar matrix has proven to be a good way to resolve this problem. The sugar matrix is stable in vacuum environment. Therefore, understanding the behavior of sugar molecules during ion sputtering is of great important. In this work, we did a comparison study of molecular depth prolife of sugar film on a silicon wafer with C60+, C60++, C60+++, Cs+ and O2+ species. C60n+ species show very exciting molecular depth profile behavior, but Cs+ and O2+ ions seems to damage most of sugar molecules in a short time.

THU-IBM03-5 #394 - Contributed Talk - Thursday 8:30 AM - Pecos II

X-ray standing wave study of swift heavy ion induced modification in Fe/Si films

Parasmani Rajput[1], Ajay Gupta[1], Vasant Sathe[1], D. K. Avasthi[2], Carlo Meneghini[3]
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[(2)]Inter University Accelerator Centre, Inter University Accelerator Centre, Aruna Asaf Ali Marg, University Campus, Khandwa Road, New Delhi New Delhi 110 067, India
[(3)]Department of Physics, University of Roma Tre, Roma, Italy

Swift heavy ions (SHI) irradiation is an excellent tool to achieve controlled modification in thin film and multilayers. In metallic systems, SHI are known to produce damage above certain threshold electron energy loss Se, which varies significantly from metal to metal. Since for Se value close to the threshold, the induced modifications are expected to be small, sensitive techniques are needed in order do elucidate the small changes occurring in the system. In the present work we use X-ray standing wave (XSW) technique [1] to study the changes occurring in a Si/Fe/Si tri-layer upon irradiation with 120 MeV Au ions. Multilayer with nominal structure: Substrate/Pt (70nm)/ Si (16nm)/ Fe (3 nm)/ Si (10nm), was deposited using ion beam sputtering technique. The bottom Pt layer is used for total external reflection of x-rays (below the critical angle for Pt). 3 nm Fe layer was intentionally kept asymmetrically inside the Si cavity, which was used as a local detector for X-ray field intensity. The concentration profile of Fe layer before and after irradiation to a fluence from 2× 1012 ions/cm2 to 2× 1013 ions/cm2 have been studied. The technique of XSW can measure intermixing as low as 0.1nm, permitting one to do quantitative measurements at very low fluences. It is found that the mixing of Fe at the two interfaces, namely Fe-on-Si and Si-on-Fe is asymmetric. The fluence dependence of mixing has been analysed in terms of the existing models for SHI effects in solids. We have conformed the Si is in amorphous state before and after irradiation using Raman spectroscopy.

[1] S. K. Ghose, B. N. Dev, and Ajay Gupta, Phys. Rev. B 64, 233403 (2001); Ajay Gupta, Parasmani Rajput, A. Saraiya, V. R. Reddy, M. Gupta , S. Bernstorff, H. Amenitsch, Phys. Rev. B 72, 075436 (2005).

THU-IBM03-6 #195 - Contributed Talk - Thursday 8:30 AM - Pecos II

Low energy Si_5^-cluster ion induced amorphization and a possible phase transition in Si

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The damage growth and surface modifications in Si(100), induced by 25 keV Si_5^- cluster ions, as a function of fluence, \\phi, has been studied using atomic force microscopy (AFM) and channeling Rutherford backscattering spectrometry (CRBS). From the surface peak intensity, as obtained from CRBS data, a non-linear growth in damage with ion fluence has been observed. The data when fitted to a saturation function as proposed by Dobeli et al [1], yield a threshold fluence for amorphization, \\phi_0, as 2.5e+13 ions-cm^{-2}, in agreement with the findings of Agarwal et al [2]. For \\phi < \\phi_0, AFM scans show a growth in surface roughness coupled with growth in subsurface damage. However, at a fluence of 1e+14 ions-cm^{-2}, much above the amorphization threshold, \\phi_0, a significant drop in surface roughness has been observed. The power spectral density (PSD) as derived from AFM data also shows a corresponding drop. This drop in PSD coupled with damage saturation and surface smoothing can be correlated with a possible transition to a stress relaxed amorphous phase as suggested elsewhere [3].

[1] M. Dobeli et al, Nucl. Instr. and Meth. B 94 (1994) 388.
[2] A. Agarwal et al, Appl. Phys. Lett. 70 (1997) 3332
[3] O.W. Holland et al, Appl. Phys. Lett. 55 (1989) 2503; G. Bai and M.A. Nicolet, J. Appl. Phys. 70 (1991) 649.

THU-MA08-1 #430 - Invited Talk - Thursday 8:30 AM - West Fork

The Future of Particle Therapy in Medicine: The Next Likely Steps

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[(5)]Research Center Hospital for Charged Particle Therapy, National Institute of Radiological Sciences, Chiba, Japan

As aggressive 3D-conformal treatment has become the clearly accepted goal of radiation oncology, charged-particle treatment with hadrons has concurrently and relentlessly ascended to the forefront. Protons and helium nuclei, with relatively low linear-energy-transfer (LET) properties, have consistently been demonstrated to be beneficial for aggressive (high-dose) local treatment of many types of tumors. However, some 15 to 20% of tumor types have proven resistant to even the most aggressive low-LET irradiation. For these relatively radio-resistant tumors, treatment with heavier hadrons (eg, carbon and neon nuclei) offers great potential benefit. These relatively high-LET particles have increased relative biological effectiveness (RBE), and irradiation with these heavier hadrons offers the unique combination of improved 3D-dose distribution and increased RBE. The future of particle therapy will be best realized by clinical trials in facilities that have ready access to a variety of these hadrons, that can be selected for treatment of a specific pathology, and which will permit direct randomized-trial comparison of the effectiveness of the various hadrons for different diseases. Such variable-hadron treatment should be deliverable via a wide range of beam-entry angles, typically requiring robotically-controlled isocentric patient-positioning tables, horizontal beam lines, and non-horizontal beam lines or gantries. Optimal results will require: (1) sophisticated target delineation that integrates CT, MRI and PET imaging; (2) reliable RBE modeling algorithms; (3) efficient beam-scanning technology; and (4) better understanding of dose-fractionation parameters.

THU-NBA04-1 #623 - Invited Talk - Thursday 8:30 AM - Brazos I

Photon Activation Analysis in Archaeology

Herbert D. G. Maschner[1], Buck Benson[1], Doug Wells[2], Jaromy Green[2], Zaijing Sun[2], Christian Segebade[3]
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Photon activation analysis (PAA) has a long history in materials analysis. The application of PAA to archaeology began in the 1970s and has continued sporadically over the last 30 years in a field dominated by neutron activation analysis and more recently, ICP-MS. With increasing need by museums, researchers, and Native American groups to conduct completely non-destructive analysis, and a growing need to conduct whole artifact analysis when other techniques, such as XRF, are only superficial, PAA is growing in importance. The Idaho Accelerator Center at Idaho State University has begun a series of experiments to begin the next generation in photon activation analysis for the isotopic and elemental analysis of archaeological materials and items of cultural heritage. Beginning with materials well characterized by other techniques, and testing our results against ICP and XRF datasets, we have shown that PAA is a valuable and completely nondestructive technique for whole artifact analysis that provides sensitivity in the range of 10ppb. We further demonstrate that PAA provides data and analytical capabilities not possible with other methods.

THU-NBA04-2 #591 - Invited Talk - Thursday 8:30 AM - Brazos I

Photon Activation Analysis - An Ananlytical Application of High Energy Electron Accelerators

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Photon activation analysis (PAA) was introduced about contemporarily with the other activation analysis methods (neutron, NAA, and charged particle activation, CPAA). Nonetheless, for different reasons, PAA has been applied less frequently than the other techniques men-tioned. The incident photon energy should exceed about 12 MeV (except in some special rare applications) so as to obtain appreciably high activity yields of the product nuclides. Thus, cyclic electron accelerators (LINACs or microtrons) are used for activation preferably. The predominant photonuclear reaction is of the (gamma,n)-type. Thus, normally neutron-deficient nuclides are produced. These usually emit gamma rays, annihilation quanta and characteristic X-ray fluorescence, all of whom can be used for analytical evaluation. The spectrometry equipment is the same as used for the other activation techniques (semiconductor detectors, sodium iodide crystals in coincidence geometry). Being uncharged, high energy photons have a large penetration power, thus do not suffer from strong matrix absorption. Although not having a detection power as large as in NAA (in the most cases), PAA offers several further convincing advantages, e.g. several elements not or hardly detectable by NAA can

be analysed: Titanium, nickel, thallium, lead, bismuth and, in particular, the light elements carbon, nitrogen, oxygen, fluorine, phosphorus. In the presentation several typical applications will be described.

THU-NBA04-3 #340 - Contributed Talk - Thursday 8:30 AM - Brazos I

A Comparison of Neutron-Based Non-Destructive Assessment Methods for Chemical Warfare Materiel and High Explosives

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Prompt Gamma Neutron Activation Analysis (PGNAA) systems employ neutrons as a probe to interrogate items, e.g. chemical warfare materiel-filled munitions. The choice of a neutron source in field-portable systems is determined by its ability to excite nuclei of interest, operational concerns such as radiological safety and ease-of-use, and cost. Idaho National Laboratory's PINS Chemical Assay System has traditionally used a Cf-252 isotopic neutron source, but recently a Deuterium-Tritium (DT) Electronic Neutron Generator (ENG) has been tested as an alternate neutron source. This paper presents the results of using both of these neutron sources to interrogate chemical warfare materiel (CWM) and high explosive (HE) filled munitions.

THU-NBA04-4 #307 - Contributed Talk - Thursday 8:30 AM - Brazos I

A Priori Method of Using Photon Activation Analysis to Determine Unknown Trace Element Concentrations in a NIST Standard

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Photon activation analysis detected elements in a NIST standard that did not have reported concentration values. A method is currently being developed to infer these concentrations by using scaling parameters from the appropriate known quantities within the NIST standard itself. These parameters include: neutron emission, threshold energy, brehmstraalung peak and endpoint energies, photo-nuclear cross sections for specific isotopes, brehmstraalung intensity and spectral distribution, target thickness, and photon flux. Photo-nuclear cross sections and energies from the unknown elements must also be known. With these quantities, the same integral was performed for both the known and unknown elements resulting in an inference of the concentration of the un-reported element based on the reported value. Since Rb was an element that was reported in the standard, and because its mass was similar to the masses of Ni, Y, and Zr, it was used as the standard of inference. This method was tested by choosing other known elements within the standard and inferring values based on the stated procedure. The reported values of Mn and Ca were was 403+/-15 and 7030+/-14.3 ppm and the inferred concentrations were 369+/- 23.1 and 6510+/-755 ppm. The reported concentrations (in ppm) of the four unknown elements were inferred to be: As = 2.94+/-0.628, Nb = 31.2+/-2.48, Y = 32.8+/-3.56, and Zr = 247+/-10.6. The possibilities and limitations of this method are discussed.

THU-NBA04-5 #155 - Contributed Talk - Thursday 8:30 AM - Brazos I

Measurement of activated Au foils by 2πβ+2πβ-γ coincidence counting and EGS5 Monte Carlo calculation

Yasushi Sato[1], Hideki Harano[1], Tetsuro Matsumoto[1], Kentaro Moriyama[1], Yasuhiro Unno[1], Takahiro Yamada[1,2], Akira Yunoki[1], Yoshio Hino[1], Katsuhisa Kudo[1]
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Neutron activation analysis using Au foil is common and important method for measurement of thermal neutron fluence. In this measurement, the 4πβ-γ coincidence counting is widely used for absolute activity measurement of gold foils, where the activity is obtainable from 4πβ counts, γ counts and their coincidence after corrections for the detection of conversion electrons and γ-rays by a β counter. However the correction is not simple due to self-absorption of internal conversion electrons and interactions of γ-rays with gold foils.

To determine these correction experimentally, Kawada et. al. [1] proposed 2πβ+2πβ-γ coincidence counting. In this method, a 4πβ counter is divided into two 2πβ counters independently operated. Several Au foils were measured experimentally. The correction factors and activities were derived from three sets of simultaneous coincidence counting; i.e., 2π (top) β-γ coincidence counting, 2π (bottom) β-γ coincidence counting and 4πβ-γ coincidence counting. In addition, the correction factor was also estimated by EGS5 Monte Carlo code. The results obtained with measurement and simulation were compared. These two results were in good agreement.

[1] Kawada, Y., Michikawa, T., and Yamashita, M., 1968, Experimental determination of a correction in the 4πβ-γ coincidence measurements on activated gold foils, Nucl. Instr. and Meth., 61, 117-118.

THU-NBA04-6 #292 - Contributed Talk - Thursday 8:30 AM - Brazos I

Accelerator-based neutron fluence standard at the National Metrology Institute of Japan

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We report the present status of the national standard on accelerator-based fast neutron fluences in Japan. The monoenergetic neutron fluence standards have been established at 144 keV, 565 keV, 2.5 MeV, 5.0 MeV, 8.0 MeV and 14.8 MeV. There are prepared to measure the detection efficiency and the energy response of neutron sensitive devices such as personal dosimeter and survey meter. The energies except 8.0 MeV are recommended for calibration purposes by the ISO standard for reference neutron radiations (ISO 8529).

A Van de Graaff accelerator is used to produce the 144 keV and 565 keV neutrons by the 7Li(p,n)7Be reaction, the 5.0 MeV neutrons by the D(d,n)3He reaction and the 8.0 MeV neutrons by the 9Be(a,n)12C reaction. A Cockcroft Walton accelerator is used to generate the 2.5 MeV neutrons by the D(d,n)3He reaction and the 14.8 MeV neutrons by the T(d,n)4He reaction. For all of the energies except 14.8 MeV, neutron fluences are determined with primary standard detectors based on recoil proton counting. Associated alpha particle counting determines the neutron fluence for 14.8 MeV.

We have been developing new monoenergetic neutron fluence standards of a few tens of keV and 19 MeV respectively produced by the 45Sc(p,n)45Ti and T(d,n)4He reactions using the Van de Graaff accelerator. There are several high-energy accelerator facilities capable of producing 20-100 MeV neutrons in Japan. We are examining their feasibility to the standard neutron field of the energy region.

THU-NHS07-1 #40 - Invited Talk - Thursday 8:30 AM - Brazos II

Laser-plasma accelerator based radiation sources

Carl B. Schroeder
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Plasma waves excited by high intensity, short pulse lasers are able to generate hundreds of GV/m accelerating fields, enabling extremely compact accelerators for applications such as radiation generation. High-quality GeV electron beams have been experimentally produced at LBNL in cm-scale plasmas using laser-driven plasma waves. I will discuss recent laser-plasma accelerator experimental results, and the possibility of using laser-plasma-accelerated electron beams to drive compact sources of radiation, including Thomson scattering sources. I will also discuss the potential of using the femtosecond laser-plasma-accelerated electron bunches to drive a high-gain free-electron laser, wherein coherent radiation is generated by passing the electron beam through a magnetic undulator.

THU-NHS07-2 #370 - Invited Talk - Thursday 8:30 AM - Brazos II

Intense broad-bandwidth THz radiation from laser-wakefield-accelerated electron bunches

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Through coherent emission, short electron bunches are able to produce intense radiation at frequencies of 1-10 terahertz (THz). Since intense sources in this frequency range are not easily realized, and only available recently, a range of novel THz applications has become accessible. Applications can vary from single-shot imaging over a large bandwidth to high-field condensed matter studies. Such applications will rely, among others, on 1) a compact size of the overall apparatus, 2) intrinsic synchronization with other pump/probe beams, 3) strong peak fields, and 4) a broad-bandwidth spectrum. We will demonstrate that THz pulses from the laser wakefield accelerator have these properties.

The laser wakefield accelerator is an accelerator based on the interaction of an ultra-intense near-infrared laser with a plasma. Over a length scale on the order of a millimeter, electrons from the plasma are bunched and accelerated to relativistic energies. By letting the electron bunch pass through a boundary of two media, intense coherent emission (transition radiation) at THz frequencies is realized providing that the electron bunches remain compact longitudinally (femtosecond duration) and transversely (tens of micron).

Although we will discuss the production of intense THz pulses from various laser wakefield accelerators (varying in laser energy, plasma length, etc), we will highlight experimental results from an accelerator based on a 10 terawatt laser, where the interaction length between the laser and plasma is on the order of several hundred micron. Nanocoulomb electron bunches with energies up to 10 MeV are produced. The intense THz pulses are created as the electrons pass through the plasma-vacuum interface (transition radiation). We show that such THz pulses are of single-cycle nature with peak fields of ~1 MV/cm (several

microjoule of pulse energy), while the spectrum is broad-bandwidth extending up to 7-8 THz. Planned upgrades to further enhance these parameters are also discussed.

THU-NHS07-3 #506 - Invited Talk - Thursday 8:30 AM - Brazos II

Optimized laser and accelerator systems for ultrabright gamma-ray generation

Christopher P. J. Barty
Photon Science and Applications Program, Lawrence Livermore National Laboratory, P.O. Box 808, L-470, Livermore CA 94551, United States

The combination of modern electron accelerator and short pulse laser technologies enables the generation of highly collimated beams of mono-energetic, tunable gamma-rays via Thomson or inverse Compton scattering. Optimized systems may have peak brightness at 1 MeV that is >15 orders of magnitude beyond present 3rd generation synchrotron sources. A survey of design considerations, machine specific technologies and operational characteristics of the 775 keV Thomson-Radiated Extreme X-ray (T-REX) source recently commissioned at the Lawrence Livermore National Laboratory will be presented. Applications of T-REX-like sources include isotope-specific material detection and imaging via excitation of nuclear resonance fluorescence, photo-fission and precision spectroscopy.

THU-NHS07-4 #636 - Contributed Talk - Thursday 8:30 AM - Brazos II

The Compact Light Source

Ronald D. Ruth, Jeffrey Rifkin, Rodrick Loewen
Lyncean Technologies, Inc., 370 Portage Ave., Palo Alto CA 94306, United States

Past research at Stanford Linear Accelerator Center introduced a new x-ray source concept, a miniature synchrotron light source [1]. This early research led later to the formation of Lyncean Technologies, Inc., which has recently developed the Compact Light Source (CLS) [2]. The CLS is a near-monochromatic, tunable, homelab-size x-ray source with up to three beamlines that can be used like the x-ray beamlines at the synchrotrons--but it is about 200 times smaller than a synchrotron light source. The compact size is achieved using a laser undulator and a miniature electron-beam storage ring, in other words--inverse Compton scattering from an electron beam in a miniature storage ring. The CLS is designed to produce a photon flux on sample that is comparable to highly-productive synchrotron beamlines. This presentation will first introduce the basic principles of the Compact Light Source and show how the quality and tunability of a synchrotron beam line can be brought to an x-ray scientist's local laboratory. The construction of the production-prototype CLS, funded by the NIGMS Protein Structure Initiative, is now complete, and the commissioning and testing phase of the CLS prototype is well advanced. The second CLS is under construction as part of the second round of the Protein Structure Initiative [3] The presentation will show details of the storage ring, laser system and x-ray optics and will conclude with the results of initial experiments using the prototype CLS.

[1] Z. Huang and R. D. Ruth, "Laser-Electron Storage Ring", Phys. Rev. Lett., 80:976-979, 1998.
[2] Supported by the National Institute of General Medical Sciences, NIH, R44 GM66511 and R44 GM074437.
[3] The Accelerated Technology Center for Gene to 3D Structure (ATCG3D) supported by PSI II, the National Institute of General Medical Sciences and the National Center for Research Resources, NIH, 5U54 GM074961.

THU-NHS07-5 #640 - Invited Talk - Thursday 8:30 AM - Brazos II

Compact High Field Cyclotrons and Synchrocyclotrons- Prospects and Applications

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Cyclotrons are now in their 8th decade of use, and superconducting cyclotrons are in their 3rd decade. Resistive magnet based cyclotrons operate at around 1-3 Tesla, and the superconducting cyclotrons operate at field levels of about 3-5T. Circular resonant particle accelerators in general have an inverse scaling of radius with increasing field for a given energy, and this translates into nearly an inverse volume scaling with increasing field in superconducting cyclotrons. One can exploit this compactness to make very powerful but small cyclotrons, as was done for heavy ion nuclear science, or exploit the low overall power levels (magnet, rf, cryogenics) of these compact cyclotrons to make a very efficient particle accelerator- for example ACCEL's PBRT cyclotrons. Recent advances in all aspects of superconducting cyclotrons (beam dynamics, engineering and supporting technologies) have made the step up to even higher field levels of 7-10 T rather straight forward, and this results in remarkable compactness and efficiency, that will, as a consequence, have significant impact in all applications in which cyclotrons are employed. High field weak focusing cyclotrons can be built that are better characterized as being portable 'devices' rather than as accelerator 'systems'. In this talk, high field cyclotrons and synchrocyclotrons will be introduced, their key features and critical issues will be discussed, and well advanced designs for radiotherapy, PET, SNMAV and other applications will be shown.

THU-NHS07-6 #350 - Contributed Talk - Thursday 8:30 AM - Brazos II

Intensity Modulated Advanced X-Ray Source (IMAXS) for Homeland Security Applications

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[(3)]Schonberg Research Corporation, P.O. Box S, Los Altos CA 94023, United States

X-ray cargo inspection systems for the detection and verification of threats and contraband must address competing performance requirements. High X-ray intensity is needed to penetrate dense cargo, while low intensity is desirable to minimize the radiation footprint, i.e. the size of the controlled area, required shielding and the dose to personnel. We report here on a collaborative effort between HESCO/PTSE Inc., Schonberg Research Corporation and Rapiscan Laboratories, Inc. to build an Intensity Modulated Advanced X-ray Source (IMAXS) that allows such cargo inspection systems to achieve up to 2 inches greater penetration capability, while on average producing the same or smaller radiation footprint as present fixed-intensity sources. Alternatively, the new design can be used to obtain the same penetration capability as with conventional sources, but reducing the radiation footprint by about a factor of three. The key idea is to anticipate the needed intensity for each x-ray pulse by evaluating signal strength in the cargo inspection system detector array for the previous pulse. IMAXS requirements therefore include a linac-based x-ray source capable of changing intensity from one pulse to the next by electronic signal, as well as electronics inside the cargo inspection system detector array determining the required source intensity for the next pulse. The project also aims to significantly reduce the overall size and weight of the IMAXS linear accelerator system and its shielding, as compared to comparable conventional sources. We discuss the progress of our R&D regarding both S-band (2998 MHz) and X-band (9303 MHz) linac designs for the IMAXS.

THU-NSF02-1 #581 - Invited Talk - Thursday 8:30 AM - Trinity Central

Self-Assembled Nanostructures: Buffer Layer Patterning and Confined States

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In the past decade, strain-induced self-assembled quantum dots (QDs) have enabled enormous advances in optoelectronics, including high performance infrared light-emitters and detectors. Further advances in thermoelectrics, photovoltaics, and quantum computing will require a narrowing of the density of states, ultra-high densities of QDs, and achievement of periodic charge distributions. Thus, an improved understanding and control of the electronic effects of QD composition, size, and shape is needed. Furthermore methods for fabrication of high density, nearly mono-dispersed, highly ordered QD arrays need to be developed. A number of reports have suggested that QDs often have non-uniform compositions across their width and height. However, the effect of composition gradients on the confined states in QDs remains unknown. In terms of QD array formation, various efforts have been made to achieve laterally ordered InAs/GaAs QDs. Yet, a significant remaining question concerns the effects of surface patterning on the lateral QD positioning. In this talk, I will discuss our investigations of the growth, nanometer-scale structure, and properties of both individual (uncoupled) and coupled InAs/GaAs QDs. First, I will discuss scanning tunneling spectroscopy studies of confined states in individual (uncoupled) QDs [1]. I will then present several surface patterning approaches to the lateral positioning of coupled InAs/GaAs QDs, including modified buffer layer growth [2] and pre-growth patterning via focused-ion beams and laser texturing.

[1] J.Q. Lu, H.T. Johnson, V.D. Dasika, and R.S. Goldman, Appl. Phys. Lett. 88, 053109 (2006).
[2] W. Ye, S. Hanson, X. Weng, and R.S. Goldman, J. Vac. Sci. Technol. B 23, 1736 (2005).

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THU-NSF02-2 #70 - Invited Talk - Thursday 8:30 AM - Trinity Central

Self-Organized Nanostructuring on Si and Ge Surfaces due to Low-Energy Ion Beam Erosion

Bashkim Ziberi, Frank Frost, Bernd Rauschenbach
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Low-energy ion beam erosion is a versatile tool for the erosion of surface materials. Under certain conditions, given by the self-organization processes, this erosion can lead to the formation of well ordered nanostructures on the surface. Usually this pattern formation process is considered to be a result of the interplay between curvature dependent sputtering that roughens the surface, and different surface relaxation mechanisms that act to smooth the surface.

In this talk, results about the evolution of the surface topography on Si and Ge surfaces during low-energy ion beam erosion with noble gas ions will be given. It will be shown that a multitude of topographies can evolve on the material surface, with mean size

below 100 nm. The formation, size and ordering of nanostructures depends on parameters like ion energy, ion incidence angle, ion fluence, secondary ion beam parameters of the ion source etc.

However, usually there is little control concerning the large scale ordering and positioning of nanostructures. Also, to explore the possibility for hierarchical nanostructuring, we used pre-patterned surfaces to study the self-organization processes, a fabrication principle also known as guided self-organization. The pre-patterned substrates are fabricated by various lithographic techniques in combination with etching techniques for structure transfer. Depending on the shape of the pre-patterned structure different results are obtained. Due to the spatial limitations and given by the lateral ordering of the pre-patterned templates the evolving topography shows not only an improved ordering and an exact positioning of nanostructures, but also the emergence of new patterns not observed on the flat surfaces, like perfectly ordered circular ripples. The formation of nanostructures depends on the local incidence angle, local orientation and curvature of the surface. At the end, potential applications of self-organized (hierarchical) nanostructuring in different fields of technology will be discussed.

THU-NSF02-3 #405 - Contributed Talk - Thursday 8:30 AM - Trinity Central

Ion Induced Pattern Formation on III/V Semiconductors by Low-Energy Ion Beam Erosion

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The surface topography evolution during low-energy ion beam erosion is a rather complex process. Under certain conditions, sputtering can roughen the surface resulting in a pronounced topography evolution, in some cases producing well ordered patterns. This pattern formation is attributed to a surface instability between curvature dependent sputtering that roughens the surface and smoothing by a different surface relaxation mechanism. Beside the ripple formation process which is well known, in recent years there have been reports of well ordered dot nanostructures observed on III/V semiconductors [1-3]. The dots were observed for ion beam erosion under normal ion incidence or oblique ion incidence with simultaneous sample rotation, with a mean periodicity < 100 nm, and are characterized by a relatively uniform size distribution and a high degree of spatial ordering showing a local hexagonal symmetry.

In this contribution, results for pattern formation due to Ar+ ion beam erosion of different III/V semiconductor surfaces (InP, GaSb, InAs) at oblique ion incidence with simultaneous sample rotation are summarized. The pattern formation on these surfaces with respect to different process parameters (ion energy, ion incidence angle, temperature during ion beam erosion, erosion time) are analyzed in detail. It is shown that depending on the ion incidence angle and temperature, these nanostructures show hexagonal or square lateral ordering with a (truncated) conical or sinusoidal shape. Furthermore, results on pattern formation on InAs surfaces by ion sputtering show structures like whiskers, or needle-like on the top with a cone-like base, depending on ion incidence angle.

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[2] F. Frost, A. Schindler, F. Bigl, Phys. Rev. Lett. 85 (2000) 4116.
[3] F. Frost, B. Ziberi, T. Höche, B. Rauschenbach, Nucl. Instr. and Meth. B, 216, (2004) 9.

THU-NSF02-4 #328 - Invited Talk - Thursday 8:30 AM - Trinity Central

Highly Charged Ion (HCI) Modified Surfaces - Scanning Probe and Transport Studies

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The neutralization energy carried by highly charged ions (HCIs) provides a fundamentally independent method for localizing energy on a target's surface, producing features and modifying surfaces with fluences and kinetic energies that are negligible for singly ionized atoms. Since each HCI can deposit an enormous amount of energy into a small volume of the surface, e.g., 44 times ionized xenon has 51 keV of neutralization energy, each individual HCI's interaction with the target produces a nanoscale feature. Scanning probe studies of HCI features have characterized some basic principles of this unique ion-surface interaction, but recent activity has focused on studying ensembles of HCI features in ultra-thin insulating films by fabricating devices in a perpendicular transport geometry. The ultra-thin insulating barriers only allow current to flow by tunneling, providing a very sensitive means of detecting changes in the barrier due to highly charged ions, and conversely, providing a means of finely tuning the transparency of the tunnel junctions over several orders of magnitude. Systematic variation of junction bias, temperature, magnetic field and other parameters provide insight into the properties and potential of these nano-features and this novel approach to device fabrication.

THU-NSF02-5 #104 - Invited Talk - Thursday 8:30 AM - Trinity Central

A Model System to Give Insights into the Behavior of a Second Phase under Irradiation

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Ion beam synthesis (IBS) has proved to be a suitable method for obtaining materials based on nanoparticles (NPs). However due to the uncontrolled nucleation and growth processes during the implantation and annealing steps the possible practical applications are reduced. In the present work, the challenge of rationalizing and improving the synthesis of NPs has been studied in detail. The final objective is to provide a guideline method to overcome the limitations in controlling the NP size and spatial distributions that are associated with the ion implantation technique.
To achieve this goal we first developed a protocol to fabricate a system with a superior control of the initial NP properties. Nearly monodisperse Au NPs were first chemically synthesized and then sandwiched at a controlled depth between two silica layers. Samples were then irradiated at room temperature with 4MeV Au ions under a constant ion flux of 1 $\mu A.cm^{-2}$ in the fluence range of $0\text{-}8x10^{16}cm^{-2}$. The evolution of NPs under irradiation was investigated by TEM and HRTEM analysis.

Using this model system we developed a procedure to characterize i) the kinetic growth of a second phase under irradiation, ii) the evolution of the metal solute concentration with the fluence and iii) the temporal window for the nucleation regime. Moreover, we estimate for the first time several thermodynamic parameters corresponding to these driven systems: the solubility and the diffusion coefficient of the gold in silica as well as the surface tension of the Au NPs under ion irradiation.

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THU-RE08-1 #514 - Invited Talk - Thursday 8:30 AM - Elm Fork

Experiment-with-Modeling Study of the Radiation Chemistry of Nuclear Waste Systems

Pavlina I. Pavlova[1,2], Eduardo A. Carrasco-Flores[2], M. S. Araos[2], Jay A. LaVerne[2,3], Simon M. Pimblott[1,2]
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Since the mid-1970's, there has been a catastrophic decline in the support for nuclear R&D in the United Kingdom, which has led to a skills gap in nuclear and radiation sciences. To address this problem, the Univ. of Manchester and the Nuclear Decommissioning Authority are building a coordinated program incorporating a fast electron and heavy ion accelerator facility for radiation science studies. The initial focus of this facility is on nuclear waste management, storage and disposition.
Poly (vinyl chloride), PVC, and other chlorinated hydrocarbon materials are commonly encountered in nuclear waste management scenarios. When exposed to ionizing radiation, chlorinated hydrocarbons give corrosive and potentially explosive degradation products, such as hydrogen chloride and molecular hydrogen, respectively.

An experiment-with-simulation approach is being used to examine the effects of Co-60 gamma, fast electron and He ion radiations on various chlorinated hydrocarbons in aqueous environments. The radiation-induced yields of the products hydrogen chloride and molecular hydrogen were measured for the different radiation qualities under aerated and deoxygenated conditions.

In direct contrast with gas phase studies, irradiation of chlorinated hydrocarbons in the presence of water primarily leads to the production of hydrogen chloride rather than hydrogen. The yield of the radiation products depend on the radiation quality, on radiation dose rate, and on the presence or absence of oxygen.

THU-RE08-2 #526 - Invited Talk - Thursday 8:30 AM - Elm Fork

Radiobiology at the NASA Space Radiation Laboratory

Mamta Naidu, Stefan Tafrov, Deborah Keszenman, Betsy Sutherland
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During space travel, each cellular nucleus in an astronaut will be exposed to about one proton per day, and to about one high energy, heavy charged particle every few months. Because little is known about the short term or long term risks of human exposure to these particles, investigators from all over the world are exposing a variety of biological systems to energetic charged particles from protons to gold at the NASA Space Radiation Laboratory (NSRL) at BNL.

Short-term risks are assessed at the cellular level by measuring radiation-induced mammalian cell death or growth alteration, and at the molecular level, by determining induction and repair of DNA damages, alterations of gene expression or of cellular levels of proteins. Biological damage to neighboring cells not directly hit by a particle-termed non-targeted or bystander effects-is also being investigated. A major long-term risk of radiation exposure is cancer induction. Approaches for evaluating cancer risk at the cellular level include evaluation of chromosome alterations, genomic instability, and at the individual cell level, transformation to altered growth.

In addition to beams of individual ions found in space, the NSRL also provides beams that simulate the complex space radiation environment. These include ultra-low rate proton beams for irradiating specimens with one proton per cell nucleus, as well as "mixed field" beams in which specimens are irradiated with specific doses and dose rates of one ion, then by a different ion. Most recently, investigators are determining the risks of solar particle events by exposing samples to proton beams of energies (e.g., 50-100 MeV) and at dose rates similar to those that occurred in specific solar particle events. This work should provide key data for assessing risk of long-term space travel, including trips to Mars and beyond.

THU-RE08-3 #575 - Invited Talk - Thursday 8:30 AM - Elm Fork

Ionization and fragmentation of biomolecules and biomolecular clusters

Thomas Schlathölter
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KeV proton and heavy ion interaction with DNA building blocks is of particular biological relevance in view of the increasing number of facilities employing MeV proton and heavy ion irradiation for tumor treatment. When the ions traverse tissue and are decelerated to sub-MeV energies, the so-called Bragg-peak is reached where the induced damage is highest due to maximum linear energy transfer and relative biological effectiveness. The volume selectivity given by the existence of a well-localized Bragg-peak region renders hadron therapy such a promising tool for cancer treatment. Biological consequences of irradiation with energetic protons and heavy ions from galactic cosmic rays and solar particle events are also a limiting factor for human space exploration.

Radiation damage in living cells always involves the condensed phase where the affected molecules are surrounded by a medium. Ion irradiation studies on nucleobases in the solid phase and on DNA deposited on substrates are however hampered by the great complexity of the systems under study.

We investigate the response of isolated DNA building blocks and their clusters upon keV singly and multiply charged ion impact using high-resolution coincidence time-of-flight mass spectrometry. Kinetic energies of nucleobase and amino-acid fragments exceeding several 10 eV are observed which have the potential to induce subsequent damage in a biological environment. Deoxyribose molecules from the DNA backbone are found to be most sensitive to keV ion impact.

To bridge the gap between the biologically relevant condensed phase regime and isolated molecules we also investigate finite systems that allow intermolecular interactions. Our recent studies on nucleobase clusters reveal that intermolecular hydrogen bonds strongly affect the fragmentation dynamics of the DNA building blocks under study.

Currently we are performing irradiation experiments on more complex biomolecular targets with the ultimate goal of producing model systems consisting of DNA oligomers surrounded by water molecules.

THU-RE08-4 #435 - Invited Talk - Thursday 8:30 AM - Elm Fork

Doubly-differential electron yields produced by fast protons and fluorine ions passing through molecular gases frozen on thin metal foils

Larry H Toburen[1], Robert A McLawhorn[1], Steve L McLawhorn[1], Michael Dingfelder[1], Kevin D Carnes[2], Patrick Richard[2], Jefferson L Shinpaugh[1]
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[(2)]Department of Physics, Kansas State University, Manhattan KS 66506, United States

The double-differential yields of electrons ejected from thin foils of molecular gases frozen on metal foils can provide detailed information on the transport properties of secondary electrons in condensed phase material. Models of charged-particle track structure in condensed phase material depend on theoretical elastic and inelastic scattering cross sections based on material parameters. Because of the uncertainties in theoretical methods used to describe "low-energy" electron scattering in the condensed phase and the infeasibility of direct measurements of cross sections in condensed phase, transport models are tested by comparison of calculated and measured spectra of electrons that have undergone transport and exited through the surface. Since energy and angular resolved electron yields provide the most stringent tests of theory and low-energy electron cross sections are most uncertain, we have applied time-of-flight methods to focus on the spectra of low-energy ejected electrons. Although residual electric and magnetic fields are observed to affect spectra for electron energies less than about one electron volt, these data provide detailed information on low-energy electron transport in the region where elastic and inelastic electron scattering

cross sections are most uncertain. Spectra for electron energies from 1 eV to several keV and emission angles from 15 to 155 degrees will be presented for electrons produced by transmission of 2- and 6-MeV protons and 19-MeV fluorine ions (1 MeV/u) in thin molecular targets of hydrocarbons and amorphous solid water frozen on copper foils.

This work is supported in part by the National Institutes of Health, National Cancer Institute Grant No. 2R01CA093351-04A1, and by the Chemical Sciences, Geosciences, and Biosciences Division, Office of Basic Energy Sciences, Office of Science, U.S. Department of Energy.

THU-RE08-5 #431 - Invited Talk - Thursday 8:30 AM - Elm Fork

Monte Carlo simulations of electron emission yields from biological materials and thin metal foils after proton impact

Anderson Travia, Michael Dingfelder
Department of Physics, East Carolina University, Howell Science Complex, Greenville NC 27858, United States

Electron emission spectra from thin metal foils (e.g., Al, Cu, Au and those covered by thin layers of frozen gases, like frozen water) provide valuable information on low-energy electron transport properties in condensed phase materials and can be used to validate or update Monte Carlo (MC) track-structure codes. These codes require reliable interaction cross sections of protons and electrons with the material under consideration as input data. We have recently simulated electron emission yields from liquid water (Dingfelder et al., Radiat, Phys. Chem. 2008, accepted). A comparison with preliminary experimental results showed a good agreement for electron emission energies of 100 eV and higher, but revealed large discrepancies at lower energies. In order to test the accuracy and applicability of our theoretical model assumptions used in the transport of charged particles in liquid water we have calculated total and energy differential inelastic cross sections for Al, Cu and Au using the same plane wave Born formalism. These calculations are based on optical oscillator strengths available in the literature and the δ-oscillator dispersion model from Ashley. Elastic electron scattering cross sections are taken from the general purpose MC code PENELOPE. We have implemented the transport models into the track-structure code PARTRAC. We will present simulated secondary electron emission spectra for Al, Cu and Au after fast proton impact and compare them to available experimental information.

This work is supported in part by the National Institutes of Health, National Cancer Institute Grant No. 2R01CA093351-04A1 and in part by the National Aeronautics and Space Administration Grant No. NNJ04HF39G.

THU-MR - VTS-1 #527 & #528 - Invited Talk - Thursday 9:30 AM - Pecos I

Commercialization of Medical Products using Accelerator Produced Isotopes: "From the laboratory to the marketplace"

A. Gaylord King
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The process of moving a potential pharmaceutical, radiolabeled with an accelerator produced isotope, from research to the market can be difficult and involves establishing rugged processes and seamless linking of different functions in the organization. For example in the production of the isotope, controls must be established on critical phases of the production process, such as accelerator beam characteristics, targets and radiochemistry.

The quality of the new radiopharmaceutical is directly dependent on the adequacy of the controls and the ruggedness of the manufacturing process. In addition, all aspects of the manufacturing process and the controls used must be documented in the organization's policies and procedure systems. Another critical factor in the process of moving the product to market is the commitment and skill of the personnel.

Transferring a product from the R&D to manufacturing requires discipline, pure determination and an excellent project manager. The key to a successful start-up is Project Management. The project manager must be able to identify the key elements of a project such as the critical path, time frames, schedule and staffing..

Radiochemicals are approached as drug ingredients and require raw material, process, testing and distribution controls. Radiopharmaceuticals that have been approved by the FDA to proceed to phase I clinical study (human studies) must have established manufacturing and release specifications have established stability profiles and must have undergone toxicology studies.

For Phase II clinical trials, FDA requirements for the product are more exacting and require that cGMP practices as they relate to adequacy of facilities, i.e., HVAC systems, utility systems, maintenance, equipment and QC capability.

For Phase III clinical trials FDA requirements are essentially those of the approved drug as described in the code of federal regulations 210 and 211.To receive approval to market a new drug FDA will conduct a pre-NDA approval inspection. The organization must successfully pass this inspection prior to FDA approving the organizations New Drug Application. At this phase all aspects of the drug manufacturing process must have gone through a validation that is described in a master validation plan.

THU-AP07-1 #425 - Invited Talk - Thursday 1:00 PM - Elm Fork

Electron Yields of Highly Insulating Materials Under Varying Electron Fluence

JR Dennison, Ryan Hoffmann
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Accumulated charge will directly affect both the flux and energy of incident charged particles and the number and energy of emitted electrons. This can lead to dramatic changes in the measured electron yields, particularly for high yield materials, materials that store charge well, or high incident fluence. This suggests the question: Is there an "intrinsic" yield for insulators, in the limit of no charge accumulation? To address this, accurate measurements of the absolute yields over incident energies from >30 eV to >20 keV have recently been made for high-yield, high-resistance insulators?including crystalline ceramic Al_2O_3 and polymeric polyimide (Kapton^{TM})?using novel high-accuracy, low-flux, pulsed techniques. Studies of charge accumulation and dissipation find significant changes in total yield curves and yield decay curves for fluences of <3 fC/mm^2 or doses equivalent to charge densities of <10^9 electrons/cm^3. We present a theory for the evolution of the electron yield as a function of incident charge based on the standard Chung-Everheart model for the emission spectra of secondary electrons and a general double dynamic layer model for the spatial distribution of accumulated charge. Our predictions are in good agreement with observed behavior of yield curves and yield decay curves. The model can be readily extrapolated to negligible incident flux to determine the "intrinsic" yield of a dielectric material. By contrast, electron yield measurements made with high flux beams?for example, from electron microscopes, Auger electron systems or accelerators?can under certain circumstances show substantially less charging effects than very low-flux measurements. We propose that the net charge accumulation in some highly insulating materials under high flux conditions can be less than low-flux conditions, since the dissipation of charge during yield measurements with high flux beams can be greatly enhanced by radiation induced conductivity (RIC) and persistent RIC effects

THU-AP07-2 #339 - Invited Talk - Thursday 1:00 PM - Elm Fork

Determination of the Secondary Emission Coefficient γ in Electron Capture Cross Section Measurements for Low-Energy, Multiply-Charged Ion Atom Collisions

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Physics and Astronomy, University of Toledo, 2801 West Bancroft Street, Toledo OH 43606, United States

Total cross section measurements of electron capture processes are important to the understanding of both laboratory and astrophysical plasmas. Experiments currently being conducted in conjunction with C.C. Havener and D.G. Seely at the Multicharged Ion Research Facility (MIRF) at Oak Ridge National Laboratory are aimed at the study of electron capture processes in low-energy, A^{q+} + H(D) collisions. For both the ion and neutrals, the beams are detected by Faraday cup detectors in which electrical currents are measured. For the neutral beam, secondary electron emission from a stainless steel plate provides the electrical current. The γ value is defined to be the number of secondary electrons emitted from the stainless steel surface upon the impact of an ion or atom. Determination of γ is necessary to accurately convert the measured electrical currents to the correct particle beam currents and thus, determine the absolute cross section values. In this talk, I shall discuss the method employed to determine γ and measurements of both the energy and mass dependences. I shall also attempt to compare the measurements at MIRF to measurements made at The University of Toledo Positive/Negative Ion Energy Loss Spectrometer.

THU-AP07-3 #103 - Contributed Talk - Thursday 1:00 PM - Elm Fork

ON THE ROLE OF NON-EQULIBRIUM ELECTRONS IN CHARGE STATE FORMATION OF SPUTTERED ATOMS

Alexander Zinovev, Igor Veryovkin, Michael Pellin
Materials Science Division, Argonne National Laboratory, 9700 South Cass Ave., Argonne IL 60439, United States

Charge state formation of sputtered atoms remains the topic of strong interest and ever-lasting discussion in the ion-surface interactions community. This topic is very important in a number of analytical ion beam applications, such as Secondary Ion Mass Spectrometry, and also in basic science of interactions of energetic particles with matter often called radiation effects. Non-adiabaticity of charge state formation in sputtering was assumed in many theoretical descriptions of this phenomenon. While the general approach of this kind might be justified, the non-adiabaticity of electron exchange processes between departing atoms and the surface remains questionable. This is because, for typical velocities of sputtered atoms, the rate of electron exchange is so high that the system atom-surface has sufficient time to adiabatically re-built itself into a new stable configuration. Alternatively, an idea of non-equilibrium electron distribution formation inside collision cascade region obtained significant theoretical attention. Indeed, lifetimes of electron excitations in this region were shown to be comparable with the time sputtered atoms remain within a critical distance when electron exchange with the surface is possible.

In this work we report results of our theoretical consideration of charge state formation of atoms sputtered from metal surface. We aimed to demonstrate that by taking into account non-equilibrium electron distribution in the collision cascade region, a correct relationship between ionization probability and normal velocity component of the departing ion could be obtained and

that both exponential and power dependencies for ionization probability thus could be derived. We show that dynamic characteristics of electrons, their effective temperature and kinetics of their relaxation mainly determine the charge state of the sputtered atoms and discuss the influence of material properties on this process and possible ways of experimental verification.

This work was supported under Contract No. DE-AC-02-06CH11357 between UChicago Argonne, LLC and the Department of Energy.

THU-AP07-4 #417 - Contributed Talk - Thursday 1:00 PM - Elm Fork

Doubly differential electron yields from thin metal foils induced by fast ion impact

Robert A McLawhorn[1], Steve L McLawhorn[1], Michael Dingfelder[1], Kevin D Carnes[2], Patrick Richard[2], Larry H Toburen[1], Jefferson L Shinpaugh[1]
[(1)]Department of Physics, East Carolina University, Greenville NC 27858, United States
[(2)]Department of Physics, Kansas State University, Manhattan KS 66506, United States

The doubly differential yields of electrons ejected from thin metal foils can provide detailed information on the transport properties of secondary electrons produced within condensed phase material by fast charged particles. Models of charged-particle track structure in condensed phase material depend on theoretical elastic and inelastic scattering cross sections based on material parameters. Because of the uncertainties in theoretical methods used to describe low-energy electron scattering in the condensed phase and the infeasibility of direct measurements of cross sections in condensed phase, transport models are tested by comparison of calculated and measured spectra of electrons that have undergone transport through the bulk and exited through the surface. Since energy and angular resolved electron yields provide the most stringent tests of theory, and low-energy electron cross sections are most uncertain, we have applied time-of-flight methods to focus on the measurement of spectra of low-energy ejected electrons. Although residual electric and magnetic fields are observed to affect spectra for electron energies less than about one electron volt, these data provide detailed information on low-energy electron transport in the region where elastic and inelastic electron scattering cross sections are most uncertain. Spectra for electron energies from 1 eV to several keV and emission angles from 15 to 155 degrees will be presented for electrons produced by transmission of 2- and 6-MeV protons and 19-MeV fluorine ions in thin (1 micrometer) copper and gold foils.

This work is supported in part by the National Institutes of Health, National Cancer Institute Grant No. 2R01CA093351-04A1, and by the Chemical Sciences, Geosciences, and Biosciences Division, Office of Basic Energy Sciences, Office of Science, U.S. Department of Energy.

THU-ED02-1 #277 - Invited Talk - Thursday 1:00 PM - Bur Oak

Accelerator-based experiments for introductory-level undergraduates

Justin M. Sanders
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Although accelerator based experiments for undergraduates are often considered only for junior or senior physics majors, introductory students can also benefit from them. Rutherford backscattering and a $^{12}C(p,p)^{12}C$ elastic scattering resonance can be presented in ways that are well-suited for students who have taken only an introductory physics course.

THU-ED02-2 #265 - Invited Talk - Thursday 1:00 PM - Bur Oak

Accelerator-Based Laboratory Activities at USNA

Jeffrey R Vanhoy, Daryl J Hartley, Francis D Correll, David M Moore, James R Huddle
Department of Physics, United States Naval Academy, 572C Holloway Road, Annapolis Maryland 21402, United States

The Naval Academy Tandem Accelerator Laboratory is dedicated to providing educational experiences for undergraduates. This facility is comprised of a CAMAC-based instrumentation lab and a National Electrostatics Pelletron 5SDH-1. The accelerator features a dual SNICS/ Alphatross injector and two beamlines. The microprobe beamline has an endstation for PIXE, PIGE, and RBS investigations. The other beamline contains a large scattering chamber appropriate for nuclear and accelerator-based atomic physics investigations using an array of surface barrier detectors or an electron spectrometer. Recent experiences with the facility will be discussed. Examples from the nuclear physics course, independent study projects, and community service projects will be presented.

THU-ED02-3 #359 - Invited Talk - Thursday 1:00 PM - Bur Oak

Teaching and Research with accelerators at Tarleton State University

Daniel Keith Marble
Math, Physics, and Engineering, Tarleton State University, Box T-470, Stephenville Texas 76402, United States

Tarleton State University students began perfoming both research and laboratory experiments using accelerators in 1998 through visitation programs at the University of North Texas, U.S. Army Research Laboratory, and the Naval Surface Warfare Center at Carderock. In 2003, Tarleton outfitted its new science building with a 1 MV pelletron that was donated by the California Institution of Technology. The accelerator has been upgraded and supports a wide range of classes for both the Physics program and the ABET accerdited Engineering Physics program as well as supplying undergraduate research opportunities on campus. A discussion of various laboratory activities and research projects performed by Tarleton students will be presented.

THU-ED02-4 #279 - Invited Talk - Thursday 1:00 PM - Bur Oak

MARIACHI, forefront science by scientists, teachers and students

Helio Takai
Physics Department, Brookhaven National Laboratory, Physics Department, Building 510A, Upton NY 11973, United States

The MARIACHI project is an innovative approach to implement and carry out a forefront scientific experiment. The project, carried out by a collaboration of scientists, high school science teachers and students, explores the use of forward scattering radar for the detection of ultra high energy cosmic rays. Cosmic rays were first discovered in 1927 and in the past decade particles with kinetic energy equivalent to a 100mph (160 km/h) fastball have been detected. The motivation for the use of radar is to develop new techniques to detect these rare occurring events with large statistics. The technique is based on the reflectivity of radio waves by the ionization produced by the cosmic ray showers. As a proof of concept the project is installing radar stations and conventional cosmic ray shower detectors in high schools across Long Island, NY. Different sites are connected to a central server using technology developed by the grid computing. The involvement of teachers and students has been one of the highlights of this project as they experience authentic science in real time. Their participation expands the reach of the project and a rich menu of scientific subjects was developed and is now being pursued. The list includes cosmic ray science, meteors, lightning and computer science. The close interaction between scientists and teachers has also led to a natural environment for the development of classroom experiments and science discussion. This presentation will discuss the educational and outreach aspects of the project. In particular we will discuss its impact in the classroom science teaching.

THU-ED02-5 #333 - Contributed Talk - Thursday 1:00 PM - Bur Oak

Enhancing the Undergraduate experience: Atomic and Nuclear Physics experiments at an Accelerator facility

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[(2)]Ion Beam Modification Analysis Laboratory, Department of Physics , University of North Texas, P.O. Box 311427, Denton TX 76203-1427, United States

Since 1994, undergraduate physics students have performed experiments in nuclear science at the Ion Beam Modification Analysis Laboratory (IBMAL) at the University of North Texas (UNT). In addition to the traditional offering of the experiments in Physics at the University of Central Arkansas (as part of their junior laboratory course) the students perform ion-atom collision experiments using ion beams from Van de Graaff and Tandem accelerators. In this paper we will discuss the experiments that were performed. Some of these were : 1) Measuring Rutherford scattering (e.g. proton on lead, silver and nickel) or non-Rutherford nature of scattering (proton on carbon) as a function of scattering angle, energy of the ion beam and atomic number 2) Verifying theoretical prediction of the kinematical scattering factor by measuring the scattered ion energy (e.g. 1.50 MeV proton on carbon, oxygen, fluorine, sodium, aluminum, chlorine, calcium, scandium, nickel, rhodium, silver, gold) 3) Particle Induced X-ray emission (PIXE) and/or Rutherford scattering to determine the elemental thickness and test the theoretical prediction for the x-ray production cross sections. 4) Determination of the mass absorption coefficient of lead using gamma ray spectroscopy 5) Nuclear reaction studies (proton on lithium fluoride) using sodium iodide detector 6) Applying X-ray fluorescence to determine elemental composition.

THU-ED02-6 #338 – Contributed Talk – Thursday 1:00 PM – Bur Oak

Construction and demonstration of a prototype low-cost, small-sized scanning transmission ion microscope of moderate resolution with educational and other potential applications

Arthur K Pallone
Engineering and Physics, Murray State University, Room 131 Blackburn Science Building, Murray KY 42071, United States
The applications for scanning transmission ion microscopy (STIM) span a broad range of fields in science, engineering, industry, history and the arts. The traditional STIM microscope is large and relatively expensive. A demonstration unit that is both compact and far less expensive will be developed. The unit will operate under less strict conditions than the traditional STIM microscope but will have acceptable spatial resolution for educational and other potential applications. A known alpha source replaces the traditional accelerator and is scanned over a sample that is affixed to the surface of a compensated solar cell detector. The energies of the alphas that pass through the sample to the detector are recorded for a known duration of time at each position and an image is reconstructed from the resulting data. Traditional nuclear electronics are replaced with a current-to-frequency converter to transform the detector output into a signal compatible with PC sound cards to reduce costs. Data are recorded, analyzed and displayed with free software. Future investigations on focusing the alphas will also be discussed.

THU-IBA04-1 #98 - Invited Talk - Thursday 1:00 PM - Pecos II

Ion beam analysis of H, D, T and ^{3}He in thin films

James A. Knapp[1], James C. Banks[1], William R. Wampler[1], James F. Browning[2]
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[(2)]Low-Q Scattering Group, Spallation Neutron Source, Oak Ridge National Laboratory, Oak Ridge Tennessee 37831, USA

Nondestructive analysis of tritiated films for both light element content and depth profile is a valuable tool for helping understand the processes of film hydriding and subsequent aging, during which tritium decays to ^{3}He. We are using ion beam techniques to perform such analyses on a range of samples, including rare earth tritide films fabricated for research purposes. Two systems are used, both with ion beams supplied by a tandem Van De Graaf/Pelletron accelerator. The first system uses 10 MeV $^4He^{++}$ ions to simultaneously measure heavy elements in the film with Rutherford Backscattering Spectrometry (RBS) and the hydrogen isotopes with Elastic Recoil Detection analysis (ERD), using a ΔE-E detector to obtain a separate high precision measurement for each isotope. A second system is used with a higher energy, heavier ion beam, 28 MeV Si^{+5}, to obtain ERD profiles of ^{3}He, O, C, and the hydrogen isotopes, with the added benefit of better depth resolution. This system uses two ΔE-E detectors at different scattering angles, one optimized for hydrogen and helium isotopes and the other for oxygen and carbon. By combining the use of these two IBA systems essentially all elements of interest can be repeatedly and nondestructively profiled as the sample ages. Examples will be presented of their use on thin films of erbium tritide.

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94Al85000.

THU-IBA04-2 #64 - Invited Talk - Thursday 1:00 PM - Pecos II

High-resolution depth profiling of absorbed hydrogen in palladium nanocrystals

Markus Wilde, Katsuyuki Fukutani
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We report the successful application of high-resolution $^1H(^{15}N,\alpha\gamma)^{12}C$ nuclear reaction analysis (NRA) [1,2] to study the low-pressure H absorption in nanometer sized Pd crystallites deposited on a thin Al_2O_3 film support in the ultra-high vacuum environment. These Pd clusters have clean, single-crystal like surfaces, and their morphology is thoroughly characterized [3]. By matching the enhanced NRA depth resolution at grazing ^{15}N ion incidence to the size of the Pd clusters (~6 nm wide, ~2 nm high), we are able to distinguish the H absorbed in the volume of the Pd particles from H adsorbed on their surfaces. This allows us to probe the H_2 pressure and temperature dependent hydrogen content inside the Pd clusters. We discuss our remarkable finding that the enthalpy of H solution in the small Pd crystallites is higher than in bulk Pd at H/Pd ratios below 0.2 [4].
Our results are of equally high importance for H-storage applications and industrial catalysis of olefin hydrogenation reactions over oxide-supported Pd particles, for which we recently proved the involvement of Pd cluster-absorbed hydrogen for the first time [5].

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THU-IBA04-3 #347 - Invited Talk - Thursday 1:00 PM - Pecos II

Simulating multiple scattering effects on coincidence spectra

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Coincidence is a sensitive method to depth profile light elements in relatively thick samples as it filters the contribution from the scattered beam without degrading the energy resolution. However, the occurrence of coincidence is strongly affected by multiple scattering, which makes the number of events dependent on depth in a way that is difficult to model analytically. Monte Carlo simulations of the ion transport should properly account for these effects. Here, the implementation of coincidence in Corteo is presented. Corteo is an open source program developed to carry out fast Monte Carlo simulations of ion beam analysis spectra. It relates on the binary collision and random phase approximations. The main calculation speed improvement comes from the method used to obtain the scattering angle components at each collision during the ions slowdown, which are extracted from a table rather than being computed using the MAGIC algorithm traditionally used in TRIM-related programs. Also, the tables of scattering angle components, stopping powers and energy straggling are indexed according to the binary representation of floating point numbers, which allows quick access to logarithmically distributed tables without computing logarithms. Ion slowdown is therefore computed without calling trigonometric, inverse, or transcendental functions, making possible the computation of 10^7 collisions/s on ordinary personal computers and the simulation of a complete coincidence spectrum within a few minutes. In the presentation, it will be shown that Corteo can reproduce to a good extent many features of experimental coincidence spectra, namely the decrease in the number of events as a function of depth. It will also be shown that energy difference discrimination cannot be simply interpreted an angular restriction on particle trajectories when trajectories are significantly affected by multiple scattering. A full geometrical description of the detectors is necessary in this case to properly reproduce the experimental spectrum.

THU-IBA04-4 #566 - Invited Talk - Thursday 1:00 PM - Pecos II

Looking for the Graal of a high temperature protonic conducting fuel cell: what can we learn from hydrogen ion beam analysis?

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Hydrogen appears to be the most promising energy vector to be used as feed for fuel cells. Thanks to their better reliability, most advanced fuel cell are based on solid electrolytes. Mature technologies are polymer electrolyte membrane fuel cells (PEMFC), based on protonic conducting electrolyte and solid oxide fuel cell (SOFC), based on oxide conducting electrolyte. Both combine specific advantages and drawbacks: PEMFC working temperatures are limited below 90°C and require use of catalysts. SOFC work above 800°C and suffer from enhanced material ageing. In spite of numerous efforts which tend either to find new polymers or new oxides, there is still a need for novel fuel cell technologies to fill the gap 400-600 °C which would combine the advantages of the two former systems.

A possible route is to develop new materials such as ceramics with protonic conduction (High Temperature Protonic Conductors, HTPC). Most mature HTPC are doped perovskites (ABO_3), e.g. $BaCeO_3$ or $SrCeO_3$-based perovskites doped with a rare earth, but their chemical stability are lower than predicted and not sufficient to fulfill technological requirements. In most cases, the reasons for these discrepancies lie in uncontrolled microstructures with inter- and intra-granular defects that act as barriers for hydrogen diffusion but are preferential paths for chemical degradation.

Microstructure induced limitations are usually evidenced via bulk impedance measurements. Improvement of microstructure design requires additional local measurements of hydrogen concentration. We report here use of ion beam microanalysis to the study of hydrogen transport within the microstructure of HTPC ceramics. According to the chosen technique, nuclear reaction, elastic recoil or forward scattering, the nuclear microprobe gives 2D-3D quantitative information on hydrogen distribution and diffusion within microstructure and enables to identify barriers and short-circuits. A special emphasis will be made on hydrogen microscopy with the use of Elastic Recoil Coincidence Spectroscopy (ERCS).

THU-IBA04-5 #47 - Invited Talk - Thursday 1:00 PM - Pecos II

Quantitative analysis of hydrogen using TOF ERDA spectroscopy

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Time-of-Flight Elastic Recoil Detection Analysis (TOF ERDA) is a well established and powerful ion beam analytical technique. It is used for simultaneous and quantitative analysis of elemental depth distributions of light and medium mass elements in both light and heavy matrices. Contrary to silicon particle detectors, the efficiency of the carbon-foil time detectors in TOF system depends on energy and electronic stopping power of analyzing recoil atoms in the C foil and it is often less than 100% for light elements. This is particularly critical for hydrogen where detection efficiency can be drastically reduced (~ 10%). Therefore, TOF ERDA spectrometers were so far not the best choice for depth profiling and quantification of H and their isotopes.

To improve the detection efficiency of TOF ERDA for H, the electron emission of C foils (~ 0.3 μg/cm2) has been enhanced by evaporating a thin LiF layer on the foil. That procedure improved significantly H detection efficiency, making TOF ERDA spectrometer more suitable for hydrogen analysis.

The capabilities of upgraded spectrometer were demonstrated on samples with well known as well as unknown concentration and depth distribution of H and D. Also, advantages and disadvantages of the TOF ERDA method over other methods for the quantitative analysis of hydrogen were discussed.

THU-IBA04-6 #199 - Contributed Talk - Thursday 1:00 PM - Pecos II

Transmission ERD Depth Profiling of Hydrogen in Alpha-Gamma Phase Titanium Hydride

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Transmission Elastic Recoil Detection (ERD) was used for profiling hydrogen in α-γ phase titanium hydride. Titanium foils 25μm thick were electrolytically loaded with hydrogen from aqueous HCl and NaCl to form a heterogeneous layer of α-γ phase titanium hydride on the surface. The foils were cyclically annealed between 250°C and 304°C and quenched at 304°C which resulted in homogenous titanium hydride across the thickness. The uniform hydrogen concentration was found to be empirically proportional to the natural log of the loading time during electrolysis. Hydrogen concentrations up to 41at% have been controlled using this technique. The effects of electrolyte concentration and electric cell current on the initial hydrogen profile are reported. Longer loading times to obtain concentrations greater than 41at% are also investigated.

THU-IBA04-7 #34 - Contributed Talk - Thursday 1:00 PM - Pecos II

Ion beam analysis of the thermal stability of hydrogenated diamond-like carbon thin films on Si substrate

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Thin, hydrogenated amorphous, diamond-like carbon films were deposited on silicon using unbalanced magnetron (UBM) sputtering of a graphite target under biased and grounded condition. Argon was used as sputtering gas. The effect of hydrogenation, and negative bias on the final concentration of trapped elements has been studied. Moreover, in-situ thermal stability of trapped hydrogen in the films have been studied using Rutherford backscattering spectroscopy (RBS), Nuclear Reaction analysis (NRA) and Elastic Recoil detection analysis (ERDA). Hydrogen content in the thin films was decreasing as the thin films were heated in vacuum.

THU-MR01-1 #83 - Invited Talk - Thursday 1:00 PM - West Fork

Intratumoral Administration of Particle Emitting Radionuclides

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Brachytherapy to treat tumors generally is done using a radioisotope encapsulated such that radioactive emissions need to traverse the capsule prior to reaching the target. For this reason most of the isotopes used are those that emit electromagnetic radiation. Even though the energy of the photons used are low, it gives rise to a larger treatment area than desired resulting in side effects. We have been exploring the potential of administering beta emitting isotopes directly into tumors using a miniature drill and pumps capable of delivering sub-microliter volumes.

Several forms of isotopes were administered to brain, prostate, bone, and soft tissue tumors using the tools mentioned above. Gamma images and dissection data were used to determine the amount of isotope remaining as a function of time.

We have found that the miniature drill and pump were easy to use and capable of delivering isotopes accurately even when it was necessary to penetrate bone such as a femur or scull. Highly stable complexes were found to be less retained at the site of injection than weaker chelates. This led to the conclusion that free metal was being retained. Animals injected with low pH formulations showed fast redistribution of the isotope outside the injection site. However, animals injected with high pH formulations were retained at the site of injection with little migration of the isotope for up to the time studied (7-10 days). Athymic mice with a HT-29 tumors injected with high pH formulations showed a reduction of tumor growth compared to controls.

These preliminary experiments show that rare earth radionuclides when administered in a high pH formulation are retained with minimum loss of isotope from the site of injection. The system developed warrants further investigation for the use in treating bone, prostate, brain and inoperable tumors.

THU-MR01-2 #442 - Invited Talk - Thursday 1:00 PM - West Fork

The U.S. Department of Energy Isotope Program: Isotope Production Using an Integrated Network of Accelerators

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Adequate supplies of radioisotopes are essential to maintain and improve the quality of life of modern human society. For over 50 years the U.S. DOE Isotope Program has been at the forefront of the development and production of stable and radioactive isotope products that are used worldwide. Hundreds of applications in medicine, industry, national security and research depend on isotopes as vital components with probably the most valuable applications occurring in nuclear medicine. The Isotope Program is serving over 150 customers worldwide in industry, hospitals, universities and U.S. National Laboratories. In this presentation I will give an overview of the U.S. DOE's Isotope Program and its role as a virtual center for isotope production and distribution by integrating domestic and foreign production capabilities.

At the core of the Isotope Program is a network of infrastructure and resources for isotope production and distribution. However, providing a reliable supply of radioactive isotopes is challenging because of the limited number of facilities available for production and processing. The program currently produces radioisotopes at three locations using reactors at Oak Ridge (HFIR) and Idaho (ATR) National Laboratories and accelerators at Brookhaven (BLIP) and Los Alamos (IPF) National Laboratories, each of which with associated hot cells for handling and processing radionuclides. The Program has been mitigating the risk of production interruptions by establishing backup supply agreements with other isotope suppliers, and by sustaining a network of production sites worldwide with integrated production schedules. As an example, to complement production of accelerator isotopes at BNL and LANL the Isotope Program has entered into cooperative agreements with the Institute for Nuclear Research (INR) in order to provide a reliable supply of short-lived accelerator-produced radioisotopes to the research community. The nature of the Isotope Program's accelerator network and the capabilities at the different production sites will be discussed.

THU-MR01-3 #38 - Invited Talk - Thursday 1:00 PM - West Fork

Activation and production of neutrons in beam line components by proton beams

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An unavoidable consequence of transporting energetic proton beams from accelerator to target is that while most protons lose energy by ionization in material that the beam passes through, some lose energy by initiating nuclear interactions thus producing

unwanted activation products and neutrons. Targets in a proton therapy beam line include the accelerator, beam line components, patient specific devices, patient implants and the patient. Elements often included are carbon, iron, nickel, copper, aluminum, silicon, tungsten, gold and compounds such as Lucite and brass. In our particular case at BPTC, where 70 -230 MeV beams are transported to the treatment rooms, on average one neutron is produced in each interaction and these neutrons also initiate nuclear interactions.. Thus, there are low level photon and neutron backgrounds associated with transporting a proton beam. These backgrounds are influenced by the choice of materials and their placement in the beam line. To assess the levels, the activation processes have to be understood, which in turn demand good measurements of the cross sections for all relevant proton- and neutron-induced reactions. Many of these cross sections have been measured relatively recently as part of systematic studies to measure those cross sections needed to interpret cosmic ray interactions in extraterrestrial materials and terrestrial samples. In most cases these measured cross sections for neutron-induced reactions are the first measurements to be made at energies above ~40 MeV or so. Using a proton therapy facility as an example, this talk will review the issues and the measurements made of the neutron background and the cross sections for relevant reactions.

THU-MR01-4 #245 - Contributed Talk - Thursday 1:00 PM - West Fork

The improvement of FDG synthesizer using MFC controller

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We have developed and evaluated the [^{18}F]FDG production module in parallel with the development of KIRAMS-13 cyclotron. The first module has been started a routine production of [^{18}F]FDG since 2005. Although our module has been worked well since then, it has two weak points. It was hard to install, access and maintain of the module due to its many IO ports in between a PC and the module. An additional problem stemmed from the instability of the production yields. The production yield are largely affected the pressure and the flow during the evaporation process although there are many other factors such as TBA concentration and the temperature, etc. The TCP/IP was introduced for covering the accessibility related problems and the MFC (Mass Flow Controller) was for the instability of the production yield. The synthesis program was also modified suitable for TCP/IP protocol. The average [^{18}F]FDG production yields was slightly improved and the standard deviation was decreased by 30% with our new module.

THU-NHS06-1 #175 - Invited Talk - Thursday 1:00 PM - Brazos II

Thermal neutron imaging in an active interrogation environment

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We have developed a thermal-neutron coded-aperture imager that reveals the locations from which thermal neutrons are being emitted. In principle, all neutron sources have a thermal neutron component, but efficient thermalization mostly occurs in hydrogenous materials. This imaging detector can be combined with an accelerator to form an active interrogation system in which fast neutrons are produced in a heavy metal target by means of excitation by high energy photons. The photo-induced neutrons can be either prompt or delayed, depending on whether neutron-emitting fission products are generated. Provided that there are hydrogenous materials close to the target, some of the photo-induced neutrons slow down and emerge from the surface at thermal energies. These neutrons can be used to create images that show the location and shape of the thermalizing materials. Analysis of the temporal response of the neutron flux provides information about delayed neutrons from induced fission if there are fissionable materials in the target. The combination of imaging and time-of-flight discrimination helps to improve the signal-to-background ratio.

It is also possible to interrogate the target with neutrons, for example using a D-T generator. In this case, an image can be obtained from hydrogenous material in a target without the presence of heavy metal. In addition, if fissionable material is present in the target, probing with fast neutrons can stimulate delayed neutrons from fission, and the imager can detect and locate the object of interest, using appropriate time gating. Operation of this sensitive detection equipment in the vicinity of an accelerator presents a number of challenges, because the accelerator emits electromagnetic interference as well as stray ionizing radiation, which can mask the signals of interest.

THU-NHS06-2 #85 - Invited Talk - Thursday 1:00 PM - Brazos II

Portable fast-neutron imaging using fast-timing, position-sensitive detectors

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For some time, the medical-imaging technique of positron emission tomography (PET) has used fast-timing, position-sensitive gamma-ray detectors in order to form images of the spatial distribution of positron emitters. In the present work, we report on the development of analogous fast-timing, position-sensitive neutron (and alpha-particle) detectors to enable fast-neutron transmission and induced-reaction imaging using D-T neutrons and the associated-particle method. Fast-neutron imaging normally requires a facility with an intense source and substantial shielding, but use of the associated-particle method allows transmission and induced-reaction imaging measurements to be performed with a modest source and no shielding. Historically, the associated-particle method has been used to image induced gamma rays from inelastic neutron scatter in order to detect the C, N, and O constituents of explosives or other contraband. The present work uses primarily the detection of neutrons, including transmitted, scattered, and induced neutrons, to form transmission images as well as material-specific images of fissionable and fusionable material. This presentation will discuss detector development, the variation of imaging performance with detector performance, and some experimental results.

THU-NHS06-3 #554 - Contributed Talk - Thursday 1:00 PM - Brazos II

Dose Studies for a Bremmstrhalung-based Photonuclear Interrogation System

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Active interrogation systems are being developed to support both national security and homeland security needs. These systems operate on the premise of using an active source to stimulate characteristic particle emissions in materials. These characteristic emissions can be measured to determine the presence of different materials. Several modalities for this approach have been suggested including using neutron or photon sources. One such modality utilizes an electron accelerator to produce bremsstrahlung photons. It is well known that if the bremsstrahlung are energetic enough, characteristic neutrons resulting from photofission will be stimulated and thus can be measured. The Idaho National Laboratory has been a leader in the development of active interrogation technology such as that described above. A concern in deploying this technology is the ability to characterize and understand the resulting doses from both photons and neutrons. Deployment of these devices will require the ability to control dose while simultaneously being able to stimulate suspect materials. This paper will describe a collaborative effort between the Georgia Institute of Technology and the Idaho National Laboratory to determine the doses associated with an active interrogation system under development for the Department of Defense. Work is underway to characterize both the photon and neutron dose in the on-axis primary beam, the off-axis secondary beam and the dose surrounding the interrogation source. A concern when attempting to determine the dose in this environment is the ability to understand the pulsed field effects on active detectors, to include the effects of charged particle equilibrium and the partial volume effect. This paper will address these concerns as well as describe experimental data and monte carlo models which have been developed to characterize the doses of interest.

THU-NHS06-4 #562 - Contributed Talk - Thursday 1:00 PM - Brazos II

Energy Deposition Measurements in an Organic Semiconductor Fast Neutron Detector

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Organic semiconductors have the potential to become an inexpensive and efficient alternative to scintillators for fast neutron detection. Currently, the polymer's poor charge collection efficiency has hindered its use as detectors. An important aspect to any particle detector is efficient energy deposition. The average linear rate of energy loss by a charged particle, also known as the linear energy transfer, in an organic semiconductor may not be fully detected by the saturation of charges created by the initial path of the detection particle. These space charge effects cause nonproportional carrier generation due to the Bragg curve, and may limit how much charge can be collected by the electrodes. Thus nonproportional effects may limit the amount of initial energy information that can be obtained from the incoming particle. In this experiment, ~10 micron thick film of a poly(p-

phenylene vinylene) derivative was fabricated by drop casting and bombarded by Am-241 alpha decay particles. The energy of the alphas was attenuated by layers of 0.5 micron Mylar placed between the alpha source and detector. Energy deposition sensitivity will be presented for different alpha particle energies.

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

THU-NHS06-5 #606 - Contributed Talk - Thursday 1:00 PM - Brazos II

Liquid Semiconductor Radiation Detector

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Liquid semiconductor materials, when coupled with the right type of dopants, can be used for both fast and thermal neutron detection. Unlike most existing detectors, liquid semiconductors require no external bias and can be operated at elevated temperature and in intense radiation environments. Uranium has been dissolved into a liquid semiconductor material (selenium) and it was found that excess uranium (2.7 atom % U) dissolved quickly and completely below 400°C. It was found that the resulting selenium/uranium liquid alloy behaves as a semiconductor in the molten state below ~650°C and the uranium did not settle out of solution during 10 hours of cooling to solidification, suggesting a system could be operated at much lower temperatures. Fission fragment energy spectra were collected using two selenium diodes operating at temperatures between 160°C and 180°C with no bias voltage on each diode. The energy scale calibration was based on fission fragment and alpha particle energies as detected by a standard silicon heavy-ion detector. These initial experiments marked the first ever detection of fission events in a liquid semiconductor material at elevated temperature. The fission fragment energy spectra were collected without any bias voltage (applied by using only Schottky barrier potential) and the results demonstrated long minority carrier lifetime.

THU-NP07-1 #605 - Invited Talk - Thursday 1:00 PM - Brazos I

Target designs to accommodate high primary beam intensities for future Radioactive Ion Beam facilities (HIE-ISOLDE, EURISOL)

thierry stora, luca bruno, richard catherall, pawel Kasprowicz, jacques lettry, sandrina fernandes, stefano marzari, etam noah, roman wilfinger, elian bouquerel, liviu penescu
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Second and next generation Radioactive Ion Beam facilities will significantly increase the available primary beam driver intensity for higher RIB intensities. Within EURISOL, both the 100kW direct targets and the 4MW Hg converter-fission target have to dissipate a generated heat load in the 10-30kW range. Such units can be designed using different numerical codes, provided relevant experimental input parameters are made available.

To go beyond today's operational standards, new materials must be developed which present both good thermal and isotope release properties, for an extended time at high temperature under high particle fluence. Illustration with recently developed submicron and nano-materials developed at ISOLDE and EURISOL will be given. In addition, development of a high power oxide target in the form of a composite niobium foil-nanograined alumina is under development for testing at high proton beam intensity at TRIUMF end of 2008. The EURISOL fission target design is also benefiting from the design of new actinide materials which preserve good release properties while being able to dissipate the 30kW heat generated by the fissions.

In a final part, considerations on the pulse nature of the beam available today at CERN for the ISOLDE facility will be put into perspective with respect to the ongoing upgrade of the proton accelerator chain, relevant for both the future HIE-ISOLDE and EURISOL European facilities.

[1] EURISOL High Power Targets, Y. Kadi, J. Lettry, M. Lindroos, D. Ridikas, T. Stora, L .Tecchio, to appear in Nuclear Physics News.

THU-NP07-2 #610 - Invited Talk - Thursday 1:00 PM - Brazos I

Production of High-Intensity Rare Isotope Beams at SPIRAL 2

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The SPIRAL 2 facility [1], an ambitious extension of the GANIL accelerator complex, has entered in its construction phase in 2005. In the frame of this project a new superconducting linear accelerator (LINAG) delivering high intensity, up to 40 MeV, proton and deuteron beams as well as a large variety of heavy-ion beams with mass over charge ratio equal to 3 and energy up to 14.5 MeV/nucl. will be constructed. Using a dedicated converter and the 5 mA deuteron beam, a neutron-induced fission rate is expected to approach 10^14 fissions/s for high-density UCx target. The energies of accelerated RIB will reach up to 7-8 MeV/nucl. for fission fragments and 20 MeV/nucl. for neutron-deficient nuclei.

In the present talk, recent developments dedicated to production, separation and acceleration of RIB exceeding by more than one order of magnitude the currently available beam intensities will be presented. In particular, design and tests of high-power deuteron-to-neutron converter, high-fission rate targets, several ion sources and proposed separation and acceleration schemes will be discussed. The manipulation of very high intensity (up to 10^11 pps) RIB implicates advanced solutions for the safety and radioprotection issues. A preliminary design of the RIB production area will be presented.

A versatility of the SPIRAL 2 driver accelerator and of the facility design will also allow using fusion-evaporation, deep-inelastic or direct reactions in order to produce very high intensity RIB and exotic targets via ISOL or in-flight techniques. A versatility of the SPIRAL 2 driver accelerator and of the facility design will also allow using fusion-evaporation, deep-inelastic or direct reactions in order to produce very high intensity RIB and exotic targets via ISOL or in-flight techniques. Highlights of new developments related to these techniques such us Super Separator Spectrometer (S3) and high-power fusion-evaporation target ion-source system will be presented.

[1] www.ganil.fr/research/developments/spiral2.

THU-NP07-3 #609 - Invited Talk - Thursday 1:00 PM - Brazos I

The ALTO facility for the production of rare nuclei

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The ALTO facility (Accélérateur Linéaire et Tandem d'Orsay) at Institut de Physique Nucléaire d'Orsay is under commissioning. The aim of this facility is to provide neutron rich isotope beams for both nuclear physics study (away from the valley of stability) and developments dedicated to next generation facilities such as SPIRAL2. The neutron rich isotopes are produced by photofission of 238U induced by the 50 MeV electrons from the linear accelerator. The isotopes coming out of the fission target effuse towards an ion source to form a beam that is analyzed through the on line separator PARRNe. Additional experimental beam lines are currently under construction. Experimental data will be presented and compared to simulations.

In the frame of the Spiral2 and the EURISOL-DS projects, a plasma ion source designed to produce radioactive beams under strong irradiation is being developed; a prototype of the IRENA (Ionization by Radial Electrons Neat Adaptation) ion source will be presented.

THU-NP07-4 #603 - Invited Talk - Thursday 1:00 PM - Brazos I

Rare Isotope Beam Manipulation - Stopping, Cooling, Breeding

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In order to fully utilize the benefit of the rare isotope beams, their properties need often to be changed and improved. Projectile fragmentation and in-flight separation, as for example performed at the NSCL at MSU, is fast and chemistry independent and provides nuclides far away from the valley of beta stability and for a very large range of elements. These benefits can be maximized if the rare isotopes are not only available at energies >80 MeV/u but also made available at rest or at moderate energies <15 MeV/u after re-acceleration. For this purpose, the fast beams need to be slowed down and thermalized, which can be achieved with gas stopping techniques. Beams from gas stopping, and also those from ISOL beam production, can be improved further by beam cooling and bunching. Low-emittance beams and short pulses are obtained, leading to high efficiencies for capturing rare isotope ions in traps and drastically increased sensitivity in laser spectroscopy experiments. Selective and efficient charge breeding of rare isotope beams with Electron Beam Ion Traps is a very promising approach for efficient and cost-effective re-acceleration, providing beams with energies up to several MeV/u. Work performed at the NSCL at MSU with respect to gas stopping, beam cooling, and charge breeding will be presented and its importance for next-generation rare isotope beam facilities will be discussed.

THU-NP07-5 #490 - Invited Talk - Thursday 1:00 PM - Brazos I

Possible upgrade of an existing tandem accelerator facility to an ISOL facility for neutron rich rare isotope beams

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Many existing accelerator facilities were upgraded to RIB facilities including tandems at ORNL and LNS,Catania. However, in both these tandems the injector is at the ground level. In this paper, we explore the idea of using He-jet method to transport RIBs vertically from the production target to the ion source room at the top and use the existing Tandem+SC-LINAC as post accelerator [1]. Neutron rich RIBs could be efficiently produced using photo-fission in Uranium. A target system for e-fission using He-multi-jet system had been tested at ORNL [2,3]. Ion source could be similar to Chalk River side-jet source [4]. Finally, housing an injector within the space constraints is also a tricky issue. Preliminary designs addressing these issues will be presented. Apart from extracting refractory neutron rich isotopes other isotopes also can also be extracted with competitive intensity. Moreover, with the on going positive ion injector program of this center [5] thick target ISOL option can be opted in future which may adequately justify investment in this scheme. JJD acknowledges HRIBF,ORNL for providing the opportunity to work on electro-fission R&D there.

[1] 15 UD Pelletron of the Nuclear Science Centre - status report: D kanjilal, GK Mehta, AP Patro: NIM A 268, 334 (1988).
[2] Neutron Rich Radioactive Ion Beam production with high power electron beams : JR Beene, TA Lewis, WT Diamond, JD Fox, JW Johnson, DW Stracener, M. Saltmarsh: LDRD project # 3211-2051.
[3] Investigations of Electron Beam Production of Neutron Rich Radioactive Ion Beams: JJ Das, JR Beene, WT Diamond, JD Fox, JW Johnson, DW Stracener, M. Saltmarsh. (APS April-2005 session B12.2).
[4] The Chalk River He-jet and skimmer system NIM 139(1976)335-342.
[5] Super Conducting Linac booster to NSC Pelletron :A Roy in Current Science 76, 149 (1999).

THU-NSF03-1 #272 - Invited Talk - Thursday 1:00 PM - Trinity Central

Ion Beam Fabrication of Nanopores in Polymer Membranes

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Porous membranes using synthetic polymers have been applied in several research methods and devices such as hydrophobic filters for removal of microorganisms and particles from air, chromatography and active biologic detectors. We report the fabrication of nanoporous membranes of PFA polymer with high selectivity and permeability by using ion beam bombardment. The development of an ion bombardment chamber that enables the controlled fabrication of nanometer-sized holes in solid-state thin film materials is described. The instrument employs a beam of MeV gold ions that impinges on a polymer membrane whose structure is to be modified. The instrument acts with a feedback control for the crafting of structures that defines a hole in the film through which a trapped gas is permitted to leak and be monitored by a Residual Gas Analyzer. The polymer thin film was fixed as a cover window between the vacuum and a He gas filled chamber and then exposed to a uniformly scanned gold MeV ion beam masked to define the exposed area. The gas leak rate through the fabricated pores is a real-time measure of the total area of the pores produced and is used as the feedback signal to trigger off the bombardment process when the desired nanopores size is obtained. The analytic methods used to study the mechanism of creation and to characterize the pores are Atomic Force Microscopy, Raman and Optical Absorption Spectroscopy and the Residual Gas Analyzer.

THU-NSF03-2 #392 - Invited Talk - Thursday 1:00 PM - Trinity Central

Solid-state Nanopore Fabrication by Noble Gas Ion Beams and Electron Beams

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By measuring the change in electrical resistance of a nanometer-sized pore in salt solution when a biomolecule is touring through, the electrical charge and size as well as its shape of the biomolecule can be sensed. A novel technique, feedback controlled ion beam sculpting, was invented by Golovchenko and co-workers at Harvard University. This technique is capable of fabricating solid-state nanopores with low energy (0.5 - 5.0 keV) noble gas ion beams. A similar solid-state nanopore fabrication method, using high-energy (200 - 300 keV) electron beams, was also discovered by Dekker and co-workers at the Delft University of Technology. The current progress of solid-state nanopore fabrication and its applications in single DNA and protein molecule sensing will be reviewed in this presentation.

THU-NSF03-3 #348 - Invited Talk - Thursday 1:00 PM - Trinity Central

Ion Beam Energy and Species Dependence on Solid-state Nanopore Fabrication

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Low energy noble gas ion beams impinging on a solid surface induce mass transport on the surface, and this phenomenon has been used to sculpt solid-state nanopores. Here we report how noble gas ion species (He, Ar, Xe) with energies (500eV, 1keV 3keV, 5keV) will affect the nanopore sculpting dynamics and nanopore properties (nanopore thickness, surface roughness). Computer simulations (SRIM and TRIM) and a surface adatom diffusion model are employed to model the nanopore sculpting dynamics. Our studies show that the thickness of nanopores fabricated does not depend on the penetration depth of the ions, however it depends more strongly on ion species.

THU-NSF03-4 #349 - Invited Talk - Thursday 1:00 PM - Trinity Central

Electrical Noise Characterization of Low Energy Ion Beam Fabricated Nanopores

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We employ nanopores fabricated with low energy noble gas ion beams in a silicon nitride membrane as the fundamental element of single biomolecule detection and characterization devices. The nanopore is used as the sole connection between two electrolytic solutions and allows an electrolytic current to flow through the nanopore under the influence of an applied electric field. As charged biomolecules are electrophoretically driven one at a time through the pore, the electrolytic current is modulated according to the charge, length, mass and cross sectional profile of each molecule. The effects of morphology, annealing, and surface treatments of the pore are systematically studied to determine their effect on the electrical noise characteristics of the electrolytic current passing through the pore. Atomic Force Microscopy (AFM) is used to measure the morphology of the region near the pore, while X-Ray Photoelectron Spectroscopy (XPS) and Rutherford Backscattering (RBS) are used to measure the change in the surface composition with annealing as well as initial depth profiles of embedded ions. We qualitatively discuss the underlying physical processes that contribute to the electrical noise characteristics of the electrolytic current and present our progress towards further reducing the noise in our measurements.

THU-NSF03-5 #26 - Contributed Talk - Thursday 1:00 PM - Trinity Central

Electrochemical Behaviour of Disposable Electrodes Prepared by Ion Beam Based Surface Modification for Biomolecular Recognition

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[(3)]*High Current Electroni, Institute, Tomsk, Russia*

Many important technological advances have been made in the development of technologies to monitor interactions and recognition events of biomolecules in solution and on solid substrates. The development of advanced biosensors could impact significantly the areas of genomics, proteomics, biomedical diagnostics and drug discovery. In the literature, there have recently appeared an impressive number of intensive designs for electrochemical monitoring of biomolecular recognition.

Herein, the influence of ion implanted disposable graphite electrodes on biomolecular recognition and their electrochemical behaviour was investigated.

THU-AP07-P1 #438 - Poster - Thursday 3:30 PM – Rio Grande Room

Radiation Induced Conductivity Measurements of Insulating Materials at Low Temperatures

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We report on measurements of Radiation Induced Conductivity (RIC) over a range of temperatures, ranging from ~110 K to ~350 K. RIC occurs when incident ionizing radiation deposits energy and excites electrons into the conduction band of

insulators. The measured steady-state RIC was found to agree well with the standard power law relation between conductivity and adsorbed dose rate. Both the proportionality constant and the power were found in general to exhibit a temperature dependence above temperatures around 250 K. We discuss the temperature dependence of both these two steady-state parameters and the time-dependant onset RIC and persistent RIC behaviors.

A change in conductivity was measured when a voltage was applied across the vacuum-baked thin film polymer samples in a parallel plate geometry. RIC was calculated as the difference in sample conductivity under no incident radiation and under an incident high energy electron flux. Minimum measurable current limits restricted measurements to resistivities of $<10^{18}$ to 10^{19} ohm-cm using <0.1 pA current resolution and an applied voltage of <6 kV. The apparatus was operated under high vacuum to prevent arcing and sample contamination. Measurements were conducted using a ~5 MeV pulsed electron beam from a LINAC accelerator at the Idaho Accelerator Center at low incident fluxes of 10^{-4}-10^{-1} Gy/sec.

Our initial work was motivated by interest in spacecraft charging that results from interactions of the materials with the space plasma environment. Charge-induced potentials can result in arcing, damaging electronics or the entire spacecraft. RIC enhancements to high-resistivity insulator materials are critical in determining the migration and dissipation of charge through the spacecraft under space conditions. Measurements were conducted on spacecraft materials including Kapton (HN and E), Teflon (PTFE, ePTFE, PFA, FEP), Tefzel, and Low Density Polyethylene.

THU-AP08-P1 #283 - Poster – Thursday 3:30 PM – Rio Grande Room

Nuclear properties and high-field electron dynamics explored by resonant recombination

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Dynamical and structural properties of heavy highly charged ions have been investigated by means of dielectronic recombination. Isotope shift measurements of low-lying dielectronic resonances, combined with our atomic structure calculations, allow one to extract information on the nuclear charge distribution of the isotopes involved. We analyze the dependence of electron interaction and QED contributions on the nuclear size and calculate mass shift terms to determine the change of nuclear radii corresponding to the isotope shift in Li-like Nd measured at the ESR storage ring of the GSI Darmstadt. This approach constitutes a new technique to determine nuclear radii. Furthermore, we study relativistic electron interaction and quantum electrodynamic effects in the strong binding fields of heavy nuclei in collaboration with experiments at the Heidelberg Electron Beam Ion Trap and the ESR. Our investigation confirms the role of relativistic corrections to the electron interaction in a dynamical setting.

THU-ED01-P1 #166 - Poster - Thursday 3:30 PM – Rio Grande Room

A radiation laboratory curriculum development at Western Kentucky University

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We present the latest developments for the radiation laboratory curriculum at the Department of Physics and Astronomy of Western Kentucky University. During the last decade, the Applied Physics Institute (API) at WKU accumulated various equipment for radiation experimentation. This includes various neutron sources (computer controlled d-t and d-d neutron generators, and isotopic 252Cf and PuBe sources), the set of gamma sources with various intensities, gamma detectors with various energy resolutions (NaI, BGO, GSO, LaBr and HPGe) and the 2.5-MeV Van de Graaff particle accelerator. XRF and XRD apparatuses are also available for students and members at the API. This equipment is currently used in numerous scientific and teaching activities. Members of the API also developed a set of laboratory activities for undergraduate students taking classes from the physics curriculum (Nuclear Physics, Atomic Physics, and Radiation Biophysics). Our proposal is to develop a set of radiation laboratories, which will strengthen the curriculum of physics, chemistry, geology, biology, and environmental science at WKU. The teaching and research activities are integrated into real-world projects and hands-on activities to engage students. The proposed experiments and their relevance to the modern status of physical science are discussed.

THU-ED01-P2 #229 - Poster - Thursday 3:30 PM – Rio Grande Room

UNIDIMENSIONAL KINEMATICS AS A TOOL FOR MOLECULAR STRUCTURE ELUCIDATION

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This work concerns to the application of simple kinematics concepts, accessible to undergraduate students, to illustrate some recent advances in the identification of biopolymer. Since late 80´s, soft ionization techniques have been used to produce molecular ions in the gas phase from the solid state. The analysis of such molecules can be done by the measurement of the time each molecule travels a determined length that is known as time-of-flight spectroscopy (TOF). A typical TOF experiment is done letting the molecules to be created in sample plate biased to a few kilovolts. In order to define an electric field, so that the ions can be accelerated, a fine electrically grounded mesh is positioned parallel to the sample plate a few mm away from it. After being accelerated, the molecules drift in a field free region before being counted by a detector. The acceleration of the molecular ions depends on their mass. Therefore, light ions will travel with greater velocities spending less time in the drift region. That means the time of flight, T, is mass dependent and can be used as a molecular weight, M, balance. It is straightforward to show that T=AM^1/2 using the kinematics of the problem. A collection of molecules of different masses, ionized simultaneously, produce a time of flight mass spectrum that can be measured with ease. This technique has been used to identify sequences of small biopolymers (polypeptides or DNA). In these cases, the sample is the result of an enzimatic reaction that leaves a mixture of polymers of different lengths. The method produces a mass spectrum where the mass difference between two adjacent peaks identifies the mass of the N-terminal aminoacids (for proteins) or the 3´-terminal (for DNA). In such way, the readout of the mass spectrum gives directly the sequence of the biopolymer.

THU-ED01-P3 #353 - Poster - Thursday 3:30 PM – Rio Grande Room

Rutherford backscattering measurements of attempts to remove oxide layers from silicon

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Well-known techniques for the removal of oxide layers from silicon involve significant instrumentation or the use of dangerous acids such as HF. These techniques are not usually available for undergraduates at the junior/senior level in the academic setting of a small college. There are published accounts of simple techniques for removing an oxide layer using a pencil eraser or scotch tape that can be done by undergraduates without supervision. As an end of the year project in the undergraduate advanced lab, students tried several removal techniques and used Rutherford backscattering with 1.25 MeV helium ions to study the effectiveness of these removal techniques. Very few of these produced a measurable change in the thickness of a 50 nm oxide layer on SOI material. Experiments were performed at the University of North Texas' accelerator lab.

THU-FIBP06-P1 #193 - Poster - Thursday 3:30 PM – Rio Grande Room

On the Stoichiometry Determination of TlBa2Ca2Cu3-xCoxO8.5 and TlxTi1-xBa2Ca2Cu3O8.5 Superconductor Materials Using the Thick Target PIXE Techniques with Al funny filter

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TlBa2Ca2Cu3Oa-ƒÔ (Tl-1223) superconductor phase is one of the most interesting phases in the thallium cuprites system since its superconducting transition temperature ¡§TC¡¨ is above 114K. One of the most effective ways to extend the variety of materials in a high temperature superconductor is to substitute some cations or anions with other elements of known systems. The doping in this phase may in some cases enhance the superconducting transition temperature and improve the physical properties of the pure samples.

TlBa2Ca2Cu3-xCoxO9-ƒÔ and TlxTi1-xBa2Ca2Cu3O8-ƒÔ superconducting samples with different doping levels 0<x<0.6 were grown by single-step of solid-state reaction using Tl2O3, BaO, CaO, CuO, TiO2 and Co2O3 oxides.

Usually a discrepancy can occur between the expected and the real stoichiometry of such materials. This can due to various and more or less uncontrolled experimental factors during the synthesis process. The determination of the real stoichiometry is an important key to understand the superconducting behavior of such materials.

The RBS technique has a limited mass resolution which can preclude the accurate determination of Ca-Ti and Cu-Co concentrations in such materials. By contrast, in this work we demonstrate the capability of the TT-PIXE Technique, using an appropriate ¡¥pine hole¡¦ aluminum filter and by using the matrix determination approach in the GUPIX code, to determine with high accuracy the stoichiometry of the superconducting studied materials. The complimentarily between the RBS and the TT-PIXE will be discussed.

THU-IBA04-P1 #367 - Poster - Thursday 3:30 PM – Rio Grande Room

A Compact Detection System for High Sensitivity Hydrogen Profiling of Materials by Nuclear reaction Analysis

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Hydrogen is a ubiquitous contaminant that is known to have dramatic effects on the electrical, chemical, and mechanical properties of many types of materials in even minute quantities. Thus, the detection of hydrogen in materials is of major importance. Nuclear Reaction Analysis (NRA) is a powerful technique for non-destructively profiling light impurities including hydrogen in materials. However, NRA has found only limited use in many applications because of its poor sensitivity due to cosmic ray background. Most attempts to eliminate this background to achieve ppm detection levels using higher energy nuclear reactions or tons of passive shielding are not compatible with commercial ion beam analysis space and equipment requirements. Zimmerman, et. al. 1 have previously reported upon a coincidence detector that meets IBA space requirements and reduces the cosmic ray background, but the detector suffers from lower detection efficiency and small sample size. We have replaced the BGO well detector in the Zimmerman coincidence detection scheme with a larger NaI well detector and used faster timing electronics to produce a detector that can handle larger samples with higher detection efficiency, and still y eliminate cosmic ray background.

[1] R.L. Zimmerman, et. al, AIP Conference Proceedings 392, pp. 685, 1997.

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THU-IBA04-P2 #381 - Poster - Thursday 3:30 PM – Rio Grande Room

Deuterium profiling for the detection of microscopic defects in semiconductors

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While techniques for physical detection of defects in semiconductors are well-developed in Si, they are lacking in other semiconductors, especially for groups III-V and II-VI compounds. A technique, developed by Amethyst Research, Inc., for defect detection in semiconductors at very low concentrations will be discussed. The method depends on the ability of hydrogen, i.e. deuterium, to bind with a wide range of morphological defects. The trapping of deuterium (D) in semiconductors generally occurs as a result of chemical binding to dangling bonds related to defects or adsorption in dilated regions associated with defects. Such D-tagging results in a rather faithful representation of the distribution of lattice disorder in semiconductors, which can be efficiently analyzed using the ion-induced nuclear reaction; 3He + D = á + p + 18.353 MeV. Thus, a demonstration of this technique will be presented that involves deuteration of ion-induced damage in implanted Si(100) followed by NRA analysis to measure the deuterium concentration. The damage measured by this technique was compared to that measured by ion channeling in both as-implanted and annealed samples.

THU-IBA04-P4 #546 - Poster - Thursday 3:30 PM – Rio Grande Room

Determine Concentration of Deuterium Atoms in Zinc Oxide Thin Films by Time-of-Flight Secondary Ion Mass Spectrometry

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Zinc Oxide (ZnO) is a wide-gap oxide semiconductor with very interesting electronic properties and has been extensively studied for many years. It has been found that dopant level concentrations of hydrogen in ZnO film can result in considerable change in the electronic behavior. Indeed, H is suspected of being an unintentional donor in ZnO due to its ubiquitous presence in synthesis environments. Dynamic secondary ion mass spectrometry (SIMS) is the best technique to determine low concentrations of hydrogen atoms in materials. However, the required instrumentation is somewhat limited, and is often unavailable in many universities and research laboratories. Time-of-flight SIMS (ToF-SIMS) is a more versatile instrument and it is more readily available in universities and research institutes. H detection in ZnO by SIMS is complicated the fact that hydrocarbon surface contamination can result in a background H SIMS signal that is difficult to distinguish from that of H dopants in the bulk of the

ZnO. In order to determine the effect of H doping on the electronic properties of ZnO without these ambiguities, we have grown ZnO epitaxial films by pulsed laser deposition in a background pressure of deuterium. We have used ToF-SIMS to quantify the D concentration in these films. We prepared a set of reference samples by implanting deuterium ions into ZnO single crystals for quantification. It has been found that the detect limitation of deuterium concentration in ZnO by our ToF-SIMS instrument is approximately 1-2?e1017 ions/cm3. In this presentation, we will discuss deuterium SIMS analysis in ZnO epitaxial films, and the relationship between concentration and electronic properties.

THU-IBA05-P1 #123 - Poster - Thursday 3:30 PM – Rio Grande Room

Vertical type high resolution RBS analysis system

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A compact vertical type high resolution RBS analysis system has been newly developed. Not only has this system achieved compactness thanks to a newly developed vertical type accelerator, but it also has various kinds of functions that a conventional high resolution RBS does not have, and is available for various kinds of analyses. In this presentation, firstly, the principles of high resolution RBS and the features of the vertical type high resolution RBS system such as a compact accelerator and a variable detection angle system are described. In addition, the latest examples of analysis such as a comparison to SIMS for gate stack film and an evaluation of crystallinity for implanted Si substrate are described.

THU-IBA06-P1 #154 - Poster - Thursday 3:30 PM – Rio Grande Room

Microstructural Characterization of III-V Semiconductors by Using Ion Bean Analysis

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Extensive efforts have been made in this study to characterize the composition, thickness, crystal quality and interfacial structures of III-V semiconductor thin films. By using channelling Rutherford backscattering spectrometry (RBS), we have measured the tetragonal strain in GaN epitaxial layers grown on either Si or sapphire substrates. We also measured the depth profiles of O and C light impurities in the films by using resonance non-Rutherford backscattering spectrometry (RN-RBS). No significant O peaks could be detected in our samples, indicating that the O concentration is lower than 1 %. Most C impurities were found near the surface. Resonance nuclear reaction analysis (R-NRA) was used to measure H distribution in the films. The R-NRS analysis is based on 1H(19F, 16O)αγ. Our results reveal that the near-surface H concentration is 3 % and it decreases at deeper depth and keeps at the level of 1% at the depth beyond 1000 Å. In this study, we further used proton induced X-ray emission (PIXE) to analyze Mn, Co, Ni and Fe implants for the purpose of materials modifications.

THU-IBA06-P2 #228 - Poster - Thursday 3:30 PM – Rio Grande Room

Stability of Strained SiGe under 2 MeV He Ion Irradiation

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We have studied the stability of strained SiGe under high energy He ion irradiation. Rutherford backscattering spectrometry analysis was performed on an (100) oriented molecular-beam-epitaxial grown Si/Si0.8Ge0.2/Si sample. The sample consists of a 50 nm thick Si top cap, a 60 nm thick buried Si0.8Ge0.2 layer, and a 200 nm Si buffer layer on the original (100) Si substrate. A 2 MeV 4He beam was used both as an irradiation beam and an analysis beam. Backscattering yields from the area around the <110> axis were continuously mapped with increasing ion fluences. Angular scan of Ge signals as a function of tilting angle around [110] axis is used to determine the strain. No considerable strain relaxation is found with ion fluence up to 3×1017 He ions cm-2. The study shows that, although strained structure is fragile under ion irradiation, 2 MeV He beams, which are frequently used to sample characterization, can still be called "nondestructive".

THU-IBA06-P3 #280 - Poster - Thursday 3:30 PM – Rio Grande Room

Accurate determination of the critical angle in ion channeling in Si

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Abstract: Ion channeling is an often used technique in the studies of crystalline materials with regard to issues hinging upon the location of specific atomic species within the crystal lattice. Results are deduced from the characteristics of an angular scan curve representing the yield of close collision events from the constant irradiation of the crystalline sample in a sequence of directions lying in a plane perpendicular to one particular crystal lattice direction. Such angular scans exhibit dips near major channels, and their angular widths are of concern. Accurate determination of these angular widths in the case of axial channeling comes up against two major uncertainties: (i) an uncertainty in the execution of the measurement as to whether the plane of the scan actually passes through the axial channel of interest as intended and (ii) an uncertainty in the interpretation of the outcome arising out of the absence of a preferred choice for the plane of the scan out of a continuum of possibilities in a wide range. Here, we shall illustrate these uncertainties in a representative case, the channeling of 2 MeV He+ ions in the <100> direction of Si, and discuss their ramifications in the results.

THU-IBA06-P4 #289 - Poster - Thursday 3:30 PM – Rio Grande Room

Ion Beam Study on The Evolution of Surface Morphology of InAs/GaAs1-xSbx/GaAs

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InAs-monolayers has been grown on the top of a GaAs1-xSbx buffer layer, we find an evolution of surface morphology with increasing thickness of the buffer layer. It can be classified into 4 stages: random distribution of InAs quantum dots, space-selective growth of InAs quantum dots on cross-hatching surface, purely cross-hatching surface, and random distribution of InAs quantum dots on cross-hatching surface. In this study, atomic force microscopy is used to examine the surface morphology, and Rutherford backscattering with channeling is performed to obtain the depth profile and crystal structure of the GaAs1-xSbx buffer layer. Various GaAs1-xSbx thicknesses are tested, which give different degrees of lattice relaxation. And it is found that the evolution of surface morphology which grown InAs monolayer for different GaAs1-xSbx thicknesses is related to the relaxation degree of the GaAs1-xSbx buffer layer.

THU-IBA06-P5 #330 - Poster - Thursday 3:30 PM – Rio Grande Room

Analysis of nanoparticles with elastic recoil detection

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Nanoparticles are currently an area of intense scientific interest due to their wide variety of potential applications in optical, electronic and biomedical fields. One important application of nanoparticles is their use as catalysts for carbon nanotube (CNT) growth. When very small diameter single-wall-CNTs are targeted, the catalyst particles must be only few nanometers in diameter. Detection and analysis of particles of this size is a very challenging task for most of the characterization methods in materials science.

In this work we show how catalyst nanoparticles for CNT growth can be characterized using Elastic Recoil Detection (ERD) analysis. With low-energy heavy ion ERD the presence of elements in the nanoparticles can be determined down to concentrations of 1e12 cm^{-2}. The shape of the nanoparticles can be distinguished from a continuous thin film by observing the sample from different angles. ERD measurements performed with incident angles between 5 and 20° relative to the sample surface show large differences in case of thin films but produce practically the same energy spectra in the case of spherical nanoparticles.

By comparing the measurements to the simulations calculated for different nanoparticle structures, conclusions can be made about particle size, size distribution, composition and, to some extent, even their shape. For these simulations we have further developed our Monte Carlo (MC) simulation code for ERD analysis to take into account random particle distribution on sample surfaces. The code was tested with comparisons to ERD spectra measured from known microfabricated structures.

We compare the results obtained for a variety of particle sizes and materials with measurements performed with scanning electron microscopy (SEM) and atomic force microscopy (AFM), and reasons for observed deviations are discussed.

THU-IBA06-P6 #352 - Poster - Thursday 3:30 PM – Rio Grande Room

Characterization of tungsten carbide electrical contacts for high-temperature electronics

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Silicon carbide based electronics components are sought after for applications in harsh environments (high temperature, corrosive atmosphere etc.). For such applications, electric connects made of tungsten carbide seems to be the best choice, for chemical and mechanical stability. In this work we are investigating the stoichiometry, microstructure, and electrical behavior of tungsten carbide thin films on silicon carbide substrates. We used Rutherford Backscattering spectrometry and X-ray photoelectron spectroscopy for measuring the stoichiometry and depth profile, scanning electron microscopy to monitor the surface morphology change, and electrical measurements for determining the WC-SiC contact behavior as a function of operating temperature, ranging from room temperature to 800 °C.

THU-IBA06-P7 #632 - Poster - Thursday 3:30 PM – Rio Grande Room

Ion Beam Analysis of Targets Used in Controlatron Neutron Generators

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Pulsed neutron generators are used in several elemental analysis applications using prompt inelastic scattering (n,n'γ) and radiative capture (n,γ) reaction techniques. These applications range from bulk materials analysis to the assay of transuranic materials in hazardous waste. Neutron generators can also be used for testing neutron detection systems. The required neutron flux used in these applications can range from ~10^6 to 10^{10} neutrons/pulse into 4π steradians. Therefore, these generators rely on the T(D,n)^{4}He inelastic reaction to create these high neutron outputs. Also, high quality targets and sources must be used to provide reasonable generator lifetimes.

Controlatron neutron generators are used in neutron detection systems at Sandia National Laboratories. To provide for increased tube lifetime for the moderate neutron flux output of these Controlatron generators, metal hydride (ZrT_2) target fabrication processes have been developed. Also, to provide for manufacturing quality control of these targets, ion beam analysis techniques are used to determine film composition. The target fabrication process and ion beam analysis techniques will be presented. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

THU-IBM03-P1 #185 - Poster - Thursday 3:30 PM – Rio Grande Room

SWIFT HEAVY ION BEAM INDUCED MODIFICATIONS IN $Ba_{0.75}Sr_{0.25}TiO_3$ CERAMICS

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Barium strontium titanate (BST) is a ferroelectric solid solution, which exhibits high dielectric constant, low loss tangent, high dielectric breakdown strength, good tenability, high pyroelectric coefficient and a Ba/Sr composition-dependent Curie temperature TC. Due to this, it has been identified as a promising material for ferroelectric dynamic random access memory (FE-DRAM), tunable phase shifters, high frequency capacitors, etc. The TC can be modified through the use of isovalent and aliovalent substitutions. Studies on the dielectric properties of $Ba_{0.75}$ $Sr_{0.25}$ TiO_3 (BST) solid solutions have shown that the compositions with $x \geq 0.2$ exhibited normal ferroelectric behavior while a Relaxor behavior is observed in the SrTiO3 rich region ($x < 0.2$). It is also not clear whether the transition diffusiveness is responsible for the discrepancies in Tc between the bulk and thin film samples. Swift heavy ion beams are mainly used to modify the surface and near surface properties of the materials and bulk modification are sporadic only. However, we have shown that dipolar ordering in polar ferroelectric surfaces could be tuned using appropriate swift heavy ion beam irradiation[1-2].

In the present paper, we discuss recent results on BST ceramics modified by 100 MeV oxygen ion beam. It is shown that dielectric losses are reduced considerably, micro structure of the material changes and ferroelectric properties improved due to ion beam modification. Detailed structural, micro structural, dielectric, ferroelectric and impedance properties are presented. Results are discussed in terms of A-site disorder induced effects in BST as reported recently by us. [3]

[1] P.K. Bajpai, Deepak Shah and Ravi Kumar, Nuclear Instruments and Methods in Physics Research B 244, 264 (2006).
[2] P.K. Bajpai and Ravi Kumar, Ind. J. Engg. Mat. Sc. (2008) In Press
[3] C.R.K. Mohan and P.K. Bajpai, Physica B doi:10.1016/jphyb.2007.10378 (2007)

THU-IBM03-P2 #215 - Poster - Thursday 3:30 PM – Rio Grande Room

Non rutherford elastic scattering to measure molecular energy loss of hydrogen in aluminium

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Experimental results of fast ion beam interacting with solids have revealed the presence of interference interference effects that occur when two or more particles travel in correlated motion throw a solid. These so called vicinage effects between molecular parteners may produce an enhancement or a diminution of the slowing down of the correlated particles when compared to that of an isolated projectile.

In the present contribution, the presence of vicinage effects is demonstrated for H2+ molecular ions slowing down in aluminium, using the 1.35 MeV resonance of 12C(p,p)12C elastic scattering. Aluminium thin films were obtained by evaporating aluminium on graphite substrate. The stopping power ratio deduced from the measured energy loss of H+ and H2+ ions showed an ehancement of about 40% in the energy loss of the H2+. A theoretical treatment, based on the LIndhard dielectric formalism generalized by N. Arista to molecular ions, were investigated to calculate the stopping power ratio for comparision. The G.M.R. and Latta & Scanlon models were incorporated for computation of the atomic and molecular electronic energy loss in solids, which takes into account the peripherical region of the electron density distribution. The results for the stopping power ratio are compared with the free-atom state.

THU-IBM03-P3 #635 - Poster - Thursday 3:30 PM – Rio Grande Room

OPTICAL PROPERTIES OF Ag NANOCLUSTERS FORMED BY IRRADIATION AND ANNEALING AT SiO2/SiO2+Ag THIN FILMS

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We have deposited 5 periodic SiO2/SiO2+Ag multi-nano-layered films on silica substrates using Ion Beam Assisted Deposition (IBAD). The co-deposited SiO2+Ag layers were 5-6 nm thick and SiO2 buffer layer were 3-4 nm, total thickness is between 40-50 nm. Different concentrations of Ag between 1-25 molecular percent with respect to silica were deposited to determine relevant rates for nanocluster formation and occurrence of interaction between nanoclusters. Using interferometer as well as in-situ thickness monitoring, we measured the thickness of the layers; using Rutherford Backscattering Spectrometry (RBS) measured the concentration of Ag in SiO2. The 5 MeV cross plane Si ion bombardments have been performed with varying fluence of 5x1014, 1x1015, 3x1015, 5x1015, 7x1015 and 1x1016 ions/cm2 to nucleate Ag nanoclusters along beam direction. Optical absorption spectra recorded to monitor the silver nanocluster formation in the thin films. Thermal annealing was applied to increase the size of nanoclusters. The suitability of formed crystal lattice has been criticized due thermoelectric applications.

THU-MR01-P1 #63 - Poster - Thursday 3:30 PM – Rio Grande Room

Converting an AEG Compact Cyclotron to H- acceleration and extraction

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Background: Trials are underway to evaluate agents labeled with the nuclide Ac-225 and its decay product, Bi-213, for targeted alpha-immuno-therapy [1]. Ac-225 can be produced using a cyclotron via the nuclear reaction Ra-226(p,2n)Ac-225. A vintage AEG Model E-33 cyclotron (22 MeV proton energy) with an internal target had been employed in a pilot production program at TUM. To enhance production capacity, the facility has recently been refurbished and upgraded, including a new external beam-line, automated target irradiation and transport systems, new laboratories, hot cells, etc. [2]

The Present Work: The AEG cyclotron has also been modernized -- modified to accelerate and extract H- ions. An augmented vacuum system with enhanced pumping capacity, including a pair of cryo-pumps, has been installed. We have designed, built,

and tested a new axial Penning-type ion source configured for the production of H- ions. While staying within the tight physical constraints of the original hot-filament H+ source, the design has continued to evolve through experiment and experience. Subtle, but significant improvements in materials and mechanical layout have helped solve a number of practical problems related to source stability, life-time, improved H- ion production, etc. We have designed and built a precision H- 'charge-exchange' beam-extraction system which is equipped with a vacuum-lock. The system incorporates a novel, low-profile 'chain-drive' foil-holder and foil-changer mechanism.

Results: The re-configured cyclotron system has now been in operation for more than 1 year. Three long-duration target irradiations have been conducted. The most recent bombardment ran 160 continuous hours at a beam current on target of ~80 micro-amperes for a total yield of ~70 mCi Ac-225.

[1]G. Sgouros, et al; JNM Vol. 40, No 11, 1935-1946.
[2]R. Henkelmann, et al; J. Labeled Compounds and RadioPharmaceuticals, Vol 50, Issue S1 p.S41-S45(abstract).

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THU-MR01-P2 #79 - Poster - Thursday 3:30 PM – Rio Grande Room

Measurements from a compact cost-effective beamline for the THC14 PET Cyclotron

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The THC14 PET Cyclotron produced by THALES specifies two compact cost-effective beamlines for high current PET radioisotope production. The design and development of the beamline system was reported previously in NIM B 261 (2007) pp 809-812. The present paper, described here, presents the successful installation, commissioning and testing of this compact beamline. A series of test and measurement data are presented starting from low current scintillator image data, medium to higher current beam diagnostic data (baffles, collimators, Faraday Cup) and finally single and simultaneous dual beamline runs on Faraday Cups or O-18 water targets licensed from TRIUMF for F-18 production. The beamline system has proven to be a flexible and valuable tool for optimizing high-current beam intensity distribution on target in a well-instrumented manner. This ability to tailor the beam characteristics for the target is particularly important as high power targets are developed which can handle very high beam currents.

THU-MR01-P3 #95 - Poster - Thursday 3:30 PM – Rio Grande Room

The properties of gas target with cooling fins at the cavity.

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In the case of a gas target, problem of density reduction caused by nuclear reaction is a more important factor for target design because it is one reason for a radioisotope production yield variation and low production yields. To solve this problem, we reported on a new gas target design with cooling fins. The cooling fins at the cavity improve a target cooling efficiency and suppress the density reduction because the cooling fin improve the heat exchange rate between the gas and target body. Using N_2/O_2 (0.5%) gas, we checked the fin target properties for C-11 production. The Proton beam from KIRAMS-13 was conducted in the static (non-circulating) mode.

At the results of this study, under the 20 minutes beam irradiation, the C-11 production yields were showed same yields of theoretical yield. Also, the target pressure was improved in comparison to a cylindrical gas target. In conclusion, this result shows that the proposed fin target is good for a high-current irradiation.

THU-MR01-P4 #227 - Poster - Thursday 3:30 PM – Rio Grande Room

Optimized [^{11}C]CO_2 production with the low energy cyclotron

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The low energy cyclotron is normally used for the production of the positron emitting nuclides such as F-18, C-11, N-13 and O-15. Many PET centers in Korea have a target system only for F-18 production and are in need of C-11 as well as N-13 and O-15. The C-11 is frequently used positron emitting nuclide in PET research and most PET centers having low energy cyclotron require the installation of C-11 production system. Here, the C-11 target system for low energy cyclotron has been developed and optimized.Two different targets has been designed (150 mm and 250 mm in length; 20 mm in diameter) and the shape of the target is cylindrical not conical. Two different concentrations of impurity oxygen (0.5% and 2.5% O_2) have been used to produce the [^{11}C]CO_2. Energy absorption was calculated by using the SRIM 2003 code. The irradiations were conducted at Chosun University cyclotron center. In case of the 0.5% O_2, 60±4.6 mCi/μAh of [^{11}C]CO_2 has been produced with 250 mm target and 90±4.2 mCi/μAh for 150 mm. In case of the 2.5% O_2, 85±6.1 mCi/μAh of [^{11}C]CO_2 has been produced with 250 mm target and 90±2.1 mCi/μAh for 150 mm. These results suggest that 150 mm target is more suitable for the production [^{11}C]CO_2 for both concentrations.The newly developed [^{11}C]CO_2 target for low energy cyclotron can effectively produce the [^{11}C]CO_2 and can be used for many cyclotron centers where need the C-11 target.

THU-MR01-P5 #247 - Poster - Thursday 3:30 PM – Rio Grande Room

Experimental test of the [18O] water target with double pleated-foil window

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This experimental test has conducted for certifying the performance of pleated foil target. The pleated-foil target had designed to overcome the deformation of the window foil under vapor pressure of [18O] water. We construct a new pleated-foil target which is more the versatile than our prototype. It has designed for 30 MeV proton beam energy. The double pleated foil windows reduce the 30 MeV proton beam to 11 MeV. The gap distance between the pleated foil windows is 7 mm and water flow through between these foils for cooling. This target can also change the pleated foil with plane foil. Thickness of 50 um and 75 um titanium foils were used for pleated and plane foils. With the same experimental conditions, we compare three kinds of results. Target yield, target pressure and, deformation of each foil. In case of foil deformation, we compare the qualitative results of deformation while the target yield and pressure have quantitative results.

THU-NHS03-P1 #209 - Poster - Thursday 3:30 PM – Rio Grande Room

Results of the Development of the Humanitarian Landmine Detection System by

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Research and development of the advanced anti-personnel landmine detection system using a compact discharge-type fusion neutron source called IECF (Inertial-Electrostatic Confinement fusion), and similar technique to BNCT (Boron Neutron Capture Therapy) was developed, originally for Afghanistan reconstruction program. Tests were conducted in excess of 200 for various combination of; wax-diluted explosives; (TNT 240 g, TNT 100 g, RDX 100 g, RDX 29 g), buried depths (5 cm, 10 cm, 15 cm), and soil moisture (2 wt%, 10 wt%, 18.5 wt%), respectively with the D-D neutron yield of ~1×10^7 n/s. Tests were performed 7 trials each under several mixed conditions for 20 minutes measurement. The measured neutron capture γ's are H-2.2MeV, N-5.3MeV, and N-10.8 MeV by the dual sensor consisting of BGO and NaI scintillators by making use of anti-coincidence method.

Judgments of the possible existence of landmines are made by using the statistical criteria. In the present test, we just arbitrarily set the criteria that the landmine would exist when δ/σ exceeds 0.67, i.e., probability in excess of 50 %.

231 tests were done, and the reliabilities of the landmine detection by measuring only 10.8 MeV γ-ray from nitrogen atoms are found to be 0.77 for less than 18.5 wt% soil moisture, and 0.83, for arid soil (less than 10 wt%), respectively. However, by the fusion detection of H-2.2 MeV, N-5.3 MeV, and N-10.8 MeV γ- rays, they are found to be 0.99 (=229/231) for soil moisture less than 18.5 wt%, and 1.00 (=231/231) for arid soil, respectively.

It is concluded that these results show the present detection system using the radiation method be basically quite effective to humanitarian landmine detection. Further improvements, particularly, judgment criteria, compactness and easy-handling of the detection device will be needed for the practical outdoor demining.

THU-NHS03-P2 #240 - Poster - Thursday 3:30 PM – Rio Grande Room

Neutron interrogation system for underwater threat detection and identification

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The technology to detect and identify waterborne or underwater threats approaching waterfront facilities such as ports, dams, locks, ports, refineries, LNG/LPG is vital for protection of these critical infrastructures. Modern geophysical surveying techniques can be used to effectively characterize sites potentially contaminated with munitions, mines, UXO on dry land. However, underwater environment may significantly impact the performance of established and emerging characterization technologies. Wartime and terrorist activities, training and munitions testing, dumping and accidents have already generated significant munitions contamination in the coastal and inland waters in the United States and abroad.

Currently various techniques, such as optical/visual methods1, use of sonar, magnetometers and standard land-mine detection devices, are used to locate concentrations of the underwater threats. Although these methods provide information about the existence of the anomaly (for instance, metal objects) in the sea bottom, they fail to identify the nature of the found objects. Field experience indicates that often in excess of 90% of objects excavated during the course of munitions clean-up are found to be non-hazardous items (false alarm). We are proposing a compact neutron interrogation system, which will be used to confirm possible threats by determining the chemical composition of the suspicious underwater object. The system consists of an electronic d-T 14-MeV neutron generator, a gamma detector to detect the gamma signal from the irradiated object and a data acquisition system. The detected signal then is analyzed to quantify the chemical elements of interest and to identify explosives or chemical warfare agents.

THU-NHS03-P3 #420 - Poster - Thursday 3:30 PM – Rio Grande Room

USE OF A NEUTRON REFLECTOR TO ENHANCE THE RAPID DETECTION OF EXPLOSIVE MATERIALS THROUGH NEUTRON INTERROGATION

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A scanning system has been designed with the capability of detecting explosive materials after an initial scan of 15 to 30 seconds. The scanner operates using the principle of neutron induced return gamma-ray spectrometry. This system utilizes high purity germanium (HPGe) detectors, a neutron generator based on deuterium-tritium (D-T) fusion and a unique neutron reflector design. The neutron reflector amplifies the flux and alters the energy spectrum of neutrons produced by the generator. A depleted uranium reflector is shown to perform 5.5 times better than no reflector, and is expected to perform 1.5 times better than a tungsten reflector. Due to the improvements, explosives detection for expected threat quantities is feasible.

THU-NHS03-P4 #549 - Poster - Thursday 3:30 PM – Rio Grande Room

Accelerator produced 14-Mev Interrogation for IED Detection

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Clear Path Technologies has developed an explosives detection instrument that has been deployed and used by law enforcement first responders. The system is dubbed SIEGMA. The SIEGMA system is based on a commercial off-the-shelf (COTS) neutron

generator and high-purity Germanium Gamma-ray detectors. Explosives based on Nitrogen as and Chlorine are sensed by stoiciometric analysis of the Gamma-ray signatures.

The physics of the process will be discussed briefly especially with respect to the difficulty of sensing the signal in the large amount of noise generated by the 14-MeV neutrons reacting with the surrounding material. The difficulties and solutions of detecting an unequivocal compendium of gamma-ray lines will be discussed. The choice of HPGe detectors as opposed to NaI will be explored in this context. The choice of HPGe over NaI is driven by the sacrifice of some detector efficiency in favor of high spectral resolution.

The operational characteristics will be discussed briefly. The system is comprised of two instrument cases. One of these houses the power unit; the other contains the sensing element. The total weight of both units is about 40 Kg. The system requires less than 10 minutes active interrogation time in close proximity to the explosives. Confidence level exceeding 97% can be achieved. The confidence level and quantity detectable is highly dependent on distance, and the amount of explosive material present in the target. Monte Carlo simulation results help explain these characteristics and will be presented.

Experience with first responders in the field will be discussed. The system is automatic in the sense that it completes all its analysis steps with the push of a single button. Our experience indicates that operators prefer to have some level of technical data in the field to back up the automatic conclusion.

THU-NHS05-P1 #100 - Poster - Thursday 3:30 PM – Rio Grande Room

Scalable Gamma Tube Interrogation Source

Michael J King[1,2], Nord Andresen[1], Arlyn J Antolak[2], Frederic Gicquel[1], Ka-Ngo Leung[1], Steve B Wilde[1], Jani Reijonen[1], Richard A Gough[1]
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A compact gamma generator has been developed for monochromatic photon interrogation applications. By leveraging recent innovations in rf-driven plasma neutron generators, the gamma generator has been designed as an axial-type tube source with a performance goal of producing 107 g/s from 10 mA of proton current via the 11B(p,g)12C reaction resonance at 163 kV. The key generator components are a radio-frequency (rf) driven ion source and matching network, a boron-containing gamma production target, and a high voltage power supply and feed-through system. Because the gamma tube operates at higher voltages than a comparable neutron generator, a compact commercially available acceleration column has also been incorporated into the design. The rf-driven ion source can provide 100 mA/cm2 H+ beam current with a high fraction of atomic species and can be pulsed up to frequencies of one kilohertz for pulsed photon source operation. A gamma intensity of 6x105 g/s has been measured from a lanthanum hexaboride target with 1.5 mA of beam current.

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THU-NHS05-P2 #271 - Poster - Thursday 3:30 PM – Rio Grande Room

Magnetic Field Effect on a PIG Type Ion Source for a Neutron Generator

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Magnetic field effect on a Penning or Phillips ionization gauge (PIG) type ion source has been investigated as a prototype ion source for a neutron generator. Performance of the PIG type ion source needs to be improved as a key part of the neutron generator which produces fast neutrons (14.1MeV) from deuterium and tritium (D-T) reaction with growing demand especially to detect explosives in airports or seaports. Magnitude and structure of the Magnetic field inside the plasma discharge chamber is one of the most important parameters. An electromagnet was utilized to optimize the strength of the magnetic flux density. Several sets of ring type permanent magnets were equipped, in turn, to modify magnitude and structure of magnetic field lines around the cathode region in a simple manner. Experimental results were evaluated in terms of voltage-current characteristics of the discharge and consequently extracted ion beam currents. Monoatomic fraction as well as beam current density will be presented with various magnetic field configuration for efficient neutron generation. This will be utilized for the design of an advanced PIG type ion source in a compact neutron generator.

THU-NHS05-P3 #331 - Poster - Thursday 3:30 PM – Rio Grande Room

Fast fall-time ion beam in neutron generators

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Ion beam with a fast fall time is useful in building neutron generators for the application of detecting hidden, gamma-shielded SNM using differential die-away (DDA) technique. In RF-driven ion sources, typically a fall time of less than 1 μs can not be achieved by just turning off the RF power to the ion source due to the slow decay of plasma density (partly determined by the fall time of the RF power in the circuit). In this paper, we discuss the method of using an array of mini-apertures (instead of one large aperture beam) such that gating the beamlets can be done with low voltage and a small gap. This geometry minimizes the problem of voltage breakdown as well as reducing the time of flight to produce fast gating. We have designed and fabricated an array of 16 apertures (4x4) for a beam extraction experiment. Our preliminary results showed that, using a gating voltage of 500 V and a gap distance of 1 mm, the fall time of extracted ion beam pulses is less than 1 μs at various beam energies ranging between 200 eV to 400 eV. In the experiment, the pressure was at 20 mTorr and the RF power was at 150 W. The average current density of the beam is approximately 3 mA/cm^2. Usually merging an array of beamlets suffers the loss of beam brightness, i.e., emittance growth, but that is less important issue for neutron source applications. More simulation and experimental results with higher beam current will be discussed.

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THU-NHS05-P4 #358 - Poster - Thursday 3:30 PM – Rio Grande Room

Carbon Nanotube Stripper Foils for Low-Voltage Tandem Accelerators

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Tandem accelerators utilize terminal stripper devices to remove electrons from the incoming negative ions and end up with an accelerated positive ion beam. Conventional gas stripper devices lead to elevated pressure in the accelerator tubes with beam quality degradation and possibly reduced transmission due to repeated charge exchange and straggling. These beam degrading effects become more important at lower energies (< 500 kV), an energy regime that allows building much more compact accelerator systems. The properties of carbon nanotube (CNT) foils have been shown to equal or surpass the electrical/thermal conductivity and mechanical strength of most other materials, particularly amorphous carbon. CNT films have been fabricated on highly transparent metal support frames with several cm2 of area and tested for their application as electron stripper foils in low voltage tandem accelerators. The results of performance tests at Tohoku University, Japan, to measure the robustness and charge exchange efficiency of CNT foils subjected to 180 keV negative ion (H-) beams are presented.
This work was supported by the US Department of Energy at Lawrence Berkeley National Laboratory under contract number DE-AC02-05CH11231. Sandia is a multi-program Laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

THU-NHS05-P5 #400 - Poster - Thursday 3:30 PM – Rio Grande Room

Coaxial Mono-Energetic Gamma Generator for Active Interrogation

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Compact mono-energetic photon sources are sought for active interrogation systems to detect shielded special nuclear materials in, for example, cargo containers, trucks and other vehicles. A prototype gamma interrogation source has been designed and built that utilizes the 11B(p,g)12C reaction to produce 12 MeV gamma-rays which are close in energy to the peak of the photofission cross section. In particular, the 11B(p,g)12C resonance at 163 kV allows the production of gammas at low proton acceleration voltages, thus keeping the design of a gamma generator comparatively small and simple. A coaxial design has been adopted with a toroidal-shaped plasma chamber surrounding a cylindrical gamma production target. The plasma discharge is driven by a 50 kW, 2 MHz rf-power supply that is coupled into the plasma by a circular rf-antenna consisting of a conductor inside a water-cooled quartz tube. About 100 proton beamlets are extracted through a slotted plasma electrode that is ~50% transparent towards the target at the center of the device. The plasma chamber is at ground potential and a negative 180 kV voltage is applied to the target for accelerating the beamlets toward the target. The target consists of LaB6 tiles that are brazed to a water-cooled cylindrical structure. The generator is designed to operate at 500 Hz with 20 micro-sec long pulses, and a 1% duty factor by

pulsing the ion source rf-power. A first-generation coaxial gamma source has been built for low duty factor experiments and testing. The design of the device and initial test results are presented.

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THU-NHS05-P6 #551 - Poster - Thursday 3:30 PM – Rio Grande Room

Evaporation of deuterated thin films as an ion source in deuterium-tritium neutron generators

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A key component of homeland and national security activities is the detection of special nuclear material, and in particular highly enriched uranium (HEU). As noted in a recent report published by the National Academy of Sciences, improved neutron generators are needed for HEU detection.

Proof-of-principle experiments have demonstrated an electrostatic field evaporation deuterium ion source for use in compact, high-output deuterium-tritium neutron generators. This source is based upon the ionization of deuterated metal films in high electric fields. The ion source produces principally atomic deuterium and titanium ions. Using an etched-wire tip we have demonstrated that more than 100 monolayers of deuterated titanium thin film can be removed and ionized in less than 20 ns. The measurements indicate that with the use of microfabricated tip arrays the ion source could provide sufficient atomic deuterium currents to produce 10^9 to 10^{10} n/cm^2 of tip array area.

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THU-NHS05-P7 #642 - Poster - Thursday 3:30 PM – Rio Grande Room

Thermal Testing of Potential Targets for Mono-Energetic Gamma Interrogation Sources

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Active interrogation can be used to detect the presence of special nuclear material (SNM) even if concealed by heavy shielding or cargo. Both gamma-rays and neutrons can penetrate thick shielding materials and induce unique fission signatures in SNM for detection. Recently, interrogation sources have been developed that use low-energy nuclear reactions to produce high-energy (MeV) gammas, i.e., via "nature's nuclear amplification." LiF is a candidate target material for these sources because the $^{19}F(p,\gamma)^{16}O$ nuclear reaction resonance at 340 keV produces 6-MeV gammas, while the $^{7}Li(p,\gamma)^{8}Be$ nuclear reaction resonance at 441 keV produces 15/18-MeV gammas. The gamma-ray energies from both these reactions are above threshold for producing photofission in SNM. We are evaluating the robustness of LiF targets by performing rapid thermal gradient tests that reach temperatures expected during the source operating conditions. The initial test sample is a 3000 angstrom thick LiF film on polished/etched Cu substrate. The sample was subjected to rapid heating to 1000°C in vacuum and held for 1 hour. Scanning electron microscopy (SEM) revealed that the LiF film remained intact, but had undergone some crystallization with sparse small voids (micron size) between grains. After 800°C rapid heating for 1 hour, SEM indicated the film was intact and some very thin crystalline edges appear to have formed. The results of these measurements indicate that LiF may be a suitable target material for nuclear reaction-based gamma interrogation sources. Thermal cycling followed by SEM and cross-sectional microscopies, are planned to gain a better understanding of LiF target robustness and lifetime.

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. Work at the University of North Texas is supported in part by the National Science Foundation and the Robert A. Welch Foundation.

THU-NHS07-P2 #379 - Poster - Thursday 3:30 PM – Rio Grande Room

Development of high gradient laser wakefield accelerators at LBNL

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Compact high energy linacs are important to many NHS and other applications, including monochromatic gamma sources. The LOASIS laboratory of LBNL is developing advanced particle accelerators based on laser driven plasma waves (wakefields), including recent demonstration of electron beams with low energy spread and divergence at energies of 1 MeV to 1 GeV. In such experiments an intense laser pulse drives a space charge wave in a plasma, producing acceleration gradients on the order of 100GeV/m. Electrons are trapped from the background plasma and accelerated by the space charge wave. Recent experiments demonstrated narrow energy spread beams, and new experiments observed energies of up to 1 GeV in 3 cm using a plasma channel at low density. This demonstrates the production of GeV beams from devices much smaller than conventional GeV linacs, and confirms the anticipated scaling of laser driven accelerators to GeV beam energies. Advanced diagnostics developed include single shot THz measurement of the fs-scale bunch length. Particle simulations are used to understand the trapping and acceleration mechanisms. Experiments and simulations are also in progress to control injection of particles into the wake and hence to improve beam quality and stability further. Using plasma density gradients to control injection, stable beams at 1 MeV over days of operation, and with an order of magnitude lower absolute momentum spread than previously observed, have been demonstrated. New experiments will post accelerate the beams from controlled injection experiments to increase beam quality and stability. Recent experimental and simulation results will be presented. Plans for extension of laser driven accelerators to 10 GeV energies using PetaWatt lasers, and for control of beam quality through controlled injection, will be discussed.

THU-NP07-P3 #378 - Poster - Thursday 3:30 PM – Rio Grande Room

Design study of a mini-cyclotron for the application of biomedical accelerator mass spectrometry

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A small cyclotron has been considered for the use of biomedical accelerator mass spectrometry (BAMS). Over a decade ago a few cyclotrons have been constructed and tested for AMS, but technical problems such as stability and transmission efficiency were some of difficulties confronted. The major reason of the demise of cyclotron afterwards was dominance of commercialized Tandem-based AMS facilities. Now the BAMS may ask for more compact system and perhaps the feasibility of using positive ions for tracing. We will present the design of a cyclotron to meet the requirements of BAMS by adopting compact magnet, flat-topping rf system to increase transmission efficiency, and so on.

THU-NP07-P4 #630 - Poster - Thursday 3:30 PM – Rio Grande Room

Actinide Targets for RIB Production at the HRIBF

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At the Holifield Radioactive Ion Beam Facility (HRIBF), neutron-rich radioactive ion beams (RIB) are produced via proton-induced fission of uranium contained in low-density uranium carbide (UC) targets. For the last few years, these RIB production targets have been made by depositing a thin layer of UC onto the fibers of a low-density, highly-porous carbon matrix. These targets have densities of about 1.2 g/cm3 and are quite robust, but they are expensive to produce and it is difficult to significantly increase the uranium density. Over the last couple of years we have studied the fabrication and operation of pressed-powder UC targets for the production of radioactive beams. These targets have the advantage of higher densities and the ratio of UC to graphite can be varied and optimized for the fast release of short-lived radioactive nuclei.

At ORNL, we have developed a technique to fabricate the uranium carbide powder. The starting materials are uranyl nitrate hexahydrate crystals and graphite powder with a grain size of about 1 micron. The uranyl nitrate is dissolved in an organic solvent, the graphite powder is added and this suspension is slowly heated to temperatures of about 2100 K to allow for conversion to uranium oxide and then to uranium carbide. The uranium carbide is then milled to a fine powder, mixed with a fine graphite powder and pressed with relatively low pressures into target samples. By varying the amount of graphite powder

used, samples can be produced with densities in the range of 2 - 6 g/cm3. The details of this fabrication process and operational experience gained during off-line and on-line experiments will be presented.

THU-NSF02-P1 #6 - Poster - Thursday 3:30 PM – Rio Grande Room

Study with Density Functional Method of Defect Vacancies and Dopants in Surface of MgO

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The effect of steps, corners, edges and terraces of nano clusters of MgO were investigated using the DFT B3LYP/6-31G* methodology in order to study the influence of defects and dopants on diverse physical-chemical parameters. We dope the cluster in 7 different positions with impurities (Li, Na, K, Si, Sc, Ti , V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga.) and calculate for each case using DFT B3LYP/6-31G* the charge distribution , total and formation energies as well as ionization potentials. In the pure cluster, the charge distribution or magnesium and oxygen increases with the increase of the coordination numbers. When we dope the cluster in different positions with impurities we observe a redistribution of charge in the neighborhood of the doping cation. The substituted alkaline and 3d-transition metals tend to donate charge to the neighboring atoms. We also made neutral and charged vacancies in all the oxygen positions and the charge distribution was investigated by three methods, Mulliken (CM), NBO (Natural Bond Orbital) and CHELPG. In general the three methods show similar tends. We also investigated the introduction of neutral and charged vacancies of magnesium in all the positions of the cluster as well as systems with both dopants and vacancies. For the neutral and charged vacancies there is redistribution of charges for the neighboring atoms. The calculated formation energies for the neutral and charged vacancies are in agreement with the work of other authors.

THU-NSF02-P2 #273 - Poster - Thursday 3:30 PM – Rio Grande Room

Small Angle X-ray Scattering Studies of Low-Energy Ion Induced Patterns Emerging on Si and Ge Surfaces

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Low-energy ion beam erosion of solid surfaces is a very effective alternative approach for the generation of self-organized nanostructures. Under certain conditions, sputtering can produce well-ordered patterns, like ripples or dots on Si and Ge surfaces [1,2].

In this contribution GISAXS (Grazing Incidence Small Angle X-ray Scattering) and GID (Grazing Incidence Diffraction) techniques are used to study the periodicity, ordering and lateral correlation of nanostructures formed by low-energy ion beam erosion on Si and Ge surfaces (E(ion) <= 2000 eV). While GISAXS gives information about the morphology of the nanostructures on the surface, GID enables us to study their crystalline interface. The beam spot (along the sample) for the experiments was a few millimeters in size. The measurements reveal: i) a high lateral ordering of nanostructures and the strong replication between the amorphous part of nanostructures and the crystalline interface, ii) The ripples are aligned perpendicular to the incoming ion beam, and the orientational ordering of ripples increases with increasing ion fluence, iii) the asymmetric shape of ripples, iv) an indirect confirmation that ripple formation is dictated by processes taking place on and near the surface region, independent of the crystallographic plane, v) the long range hexagonal ordering of dots covering the whole sample surface as observed with atomic force microscopy is verified. The short range ordering model (SRO) applied, gives a positional correlation up to 8 um for ripples.

[1] B. Ziberi, F. Frost, Th. Hoche, and B. Rauschenbach, Phys. Rev. B 72, 235310 (2005).
[2] B. Ziberi, F. Frost, and B. Rauschenbach, Appl. Phys. Lett. 88 (2006).

THU-NSF02-P3 #335 - Poster - Thursday 3:30 PM – Rio Grande Room

Transition Metal - Fullerene Hybridization and Modification

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In the present paper, hybrid films of the organic fullerenes and inorganic (metallic) transition metals have been synthesized and their specific structural forms inspected. Using the IBA analytical technique (mainly Rutherford Backscattering / Channeling),

and some other complementary methods (e.g., micro-Raman spectroscopy), nanostructures of the hybrid materials have been studied. It has been found that mixing of the organic-inorganic phases (proceeding at the atomic-molecular level) leads to (nano)structures that show a variety of structural arrangements. Their concrete compositions and forms depend strictly on the process of their synthesis, i.e., on the parameters of the deposition kinetics (deposition rates of fullerenes and metals, temperatures of the substrates during deposition, thickness of the deposited layers, etc.), and also on a type and (crystalline) quality of the selected substrates. When fullerenes and metals exhibit a mutual immiscibility, the final product (a hybrid film of two immiscible phases, forcibly co-existing together) is stressed and its integrity is unstable. Using energetic (laser and ion) beams and/or thermal processing, a phase separation can be triggered. The separation might be ?controlled' by energy of the beam (and its fluence), or temperature and time of the annealing. Moreover, it has also been proved that the phase separation can (under certain circumstances) lead to a spontaneous self-organization of the hybrid matter morphology.

THU-NSF03-P1 #564 - Poster - Thursday 3:30 PM – Rio Grande Room

Ion Beam Synthesis of PFA Porous Membranes with Enhanced Separation Capacity

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The development of porous membrane technologies based on highly efficient materials and effective processes is an important key for sustainable growth dependent on filtration processes such as water purification. While PFA properties of resistance to a broad range of pH chemical solvents and to biofouling degradation recommend the material as a suitable and desired membrane precursor, current processing technology for well shaped porous membranes is limited by its reliance on standard chemical and ion track etching techniques. We report in this work an ion beam method of fabricating porous membranes from PFA fluorpolymer films with pores being equally sized and spaced, therefore leading to enhanced separation capacity. Ion beam synthesis of PFA membranes is presented as an efficient method for pore drilling, due to equilibrium and non-equilibrium thermal effects and extreme charge up ablation, while preserving the material's attractive properties. The fabrication process and the characterization of the membranes by atomic force microscopy (AFM) and Raman spectroscopy are described.

THU-NSF04-P1 #22 - Poster - Thursday 3:30 PM – Rio Grande Room

Characterization of Cr and Cr+N Ion Implanted Ultra High Molecular Weight Polyethylene (UHMWPE)

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In this work, Ultra High Molecular Weight Poly Ethylene (UHMWPE) samples were implanted with Cr and Cr+N ions by using Metal-Vapour Vacuum Arc (MEVVA) ion implantation technique. Samples were implanted with a fluence of 10^{17} ion/cm^2 and extraction voltage of 30 kV. Results indicate that, both Cr and Cr+N ion implantation may be applied to UHMWPE surfaces. ATR+FTIR spectra indicate crosslink formation on the surface, increasing after both Cr and Cr+N implantation. TGA and DSC analyses of the implanted samples suggest that polymeric decomposition temperatures,T_m, ΔC_p and ΔH_m values were changed after Cr and Cr+N implantation. Possible reasons for the different thermal behaviours of Cr and Cr+N implanted samples are discussed.

THU-NSF04-P2 #23 - Poster - Thursday 3:30 PM – Rio Grande Room

Thermal Behaviour of W+C Ion Implanted Ultra High Molecular Weight Polyethylene (UHMWPE)

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In this work, Ultra High Molecular Weight Poly Ethylene (UHMWPE) samples were W+C ion implanted by using Metal-Vapour Vacuum Arc (MEVVA) ion implantation technique. Samples were implanted with a fluence of 10^{17} ion/cm^2 and extraction voltage of 30 kV. The mechanism underlying this modification was investigated using RBS and ATR-FTIR, and the thermal behavior of the materials was examined with DSC and TGA. Surface morphology of implanted and unimplanted samples was evaluated by AFM and SEM techniques. Results indicate that W+C ion implantation may successfully be applied to the

UHMWPE surfaces. It induces chemical modification of the surface and a crosslinking mechanism occurs. Due to this, thermal behaviors of implanted and unimplanted samples are different from each other. The mechanism behind this may be crosslink formation on the surface, which was observed with ATR-FTIR, and further effects are discussed.

THU-NSF04-P3 #24 - Poster - Thursday 3:30 PM – Rio Grande Room l

Ti and Ti-Al-N Ion Implanted Ultra High Molecular Weight Polyethylene (UHMWPE)

Ahmet Oztarhan[1], Emel Sokullu Urkac[1], Funda Tihminlioglu[2], Satilmis Budak[3], Bopha Chhay[3], Efim Oks[4], Alexey Nikolaev[4], Daryush Ila[3]
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In this work, Ultra High Molecular Weight Poly Ethylene (UHMWPE) samples were Ti and Ti-Al-N ion implanted by using Metal-Vapour Vacuum Arc (MEVVA) ion implantation technique. Samples were implanted with a fluence of 10^{17} ion/cm^2 and extraction voltage of 30 kV. The mechanism underlying this modification was investigated using RBS, ATR-FTIR, DSC and TGA. Results indicate that Ti and Ti-Al-N ion implantation may be applied on UHMWPE surfaces successfully. ATR+FTIR spectra indicate that C-H concentration on the surface decreased after Ti and Ti-Al-N implantation. Thermal characterization with TGA and DSC shows that polymeric decomposition temperature increased after ion implantation. It is also indicated that T_m , ΔC_p and ΔH_m values were changed.

THU-NSF04-P4 #32 - Poster - Thursday 3:30 PM – Rio Grande Room

Wet Chemical Etch Enhancement Due to Deep He Ion-Implantation in $LiNbO_3$

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Previously we have developed a technique to produce single-crystal oxide thin films, which have been shown to retain the bulk dielectric and optical properties of their parent materials. The technique, called crystal ion slicing (CIS), uses deep, high-dose ion implantation following by thermal treatment to effect exfoliation of a surface layer from a bulk crystal of complex oxides by either a selective wet-etching process or through purely thermal cleaving. Recently there has been a progress in using this method for fabricating high-quality fully single-crystal films of $LiNbO_3$. Here we will give a brief overview of recent results using this method, including a series of novel optical devices, and present an investigation, which uses a variety of advanced materials probes to understand the mechanism of enhanced wet etching following implantation.

A study of the effect of the thermal treatment of the 3.8 MeV implanted crystal, typically ~$5x10^{16}$ cm^{-2}, on the wet etching rate shows that there is a range of temperatures (175-275^{o}C), over which the process is enabled by the post implantation annealing; samples annealed at too low or too high a temperature do not undergo measurable etching. Structural changes, caused by heavy implantation of high-energy He^+ ions in $LiNbO_3$, promulgate the selective wet etching of the heavy implantation region. The etch enhancement can be seen to induce a thin crystal-domains structure in the heavy implantation region, resulting in a pattern of microfissures, imprinted inside the implantation zone and could be altered by thermal processing. RBS/channeling was used to show that the dechanneling rate has a maximum around the temperatures that give the highest etching rate. A uniform decrease of overall crystal strain with annealing temperature, measured using a ~10 keV, broad-area and microfocus X-ray beam, is attributed to the formation of crystal microfissures and to an out-diffusion of He.

THU-NSF04-P5 #275 - Poster - Thursday 3:30 PM – Rio Grande Room

Application of a High Power Ion Beam for Formation of Conductivity Nanoparticles on a Dielectric Surface

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We study the possibility of producing metal nanoparticles and their conglomerates by irradiating a system consisting of a thin metal film on a dielectric substrate with a high power ion beam of nanosecond duration. Al, Ag, Au and Ni thin films deposited on substrates made of glass-ceramic and silicate glass were used as objects in our study. The metals used in our study have very different thermodynamic characteristics and chemical properties (melting temperature, capability of forming an oxide, and adhesion to a substrate). The thickness of films obtained by thermal evaporation in a vacuum was varied from 5 to 200 nm. A "Temp" accelerator was used for irradiating the samples with a 300-keV proton-carbon beam (30% H^+ and 70% C^+); the average

current density was approximately 150 A/cm^2 , and the irradiation duration was 60 ns. The surface morphology of irradiated materials was studied by optical microscopy as well as a Solver Pro atomic-force microscope (AFM). By selecting the appropriate thickness of a metal film on a dielectric substrate, the current density of a high-power nanosecond pulsed ion beam, and the number of pulses acting on the film, it is possible to obtain nanodimensional metal particles on the substrate surface. The nanoparticle formation mechanism is discussed.

THU-NSF04-P6 #297 - Poster - Thursday 3:30 PM – Rio Grande Room

Carbon-Based Nanocrystal Formation using Low Energy Carbon Ion Implantation and Thermal Annealing in Silica

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Carbon-based nanocrystals, formed in silica by low-energy carbon implantation and subsequent thermal annealing, have been previously reported but ambiguities remain in the literature. In our study, silica samples were implanted with 2.0 x 10^{17} atoms/cm^2 C^- ions at energies of 8.5 keV, 40 keV and 70 keV. Samples were annealed for 15, 30, 60, 120, 240 minutes at 1100^{o}C in a forming gas (4%H_2+96%Ar). Rutherford backscattering (RBS), particle induced x-ray emission (PIXE), photoluminescence (PL), and transmission electron microscopy (TEM) were used to characterize the nanocrystals formed by these conditions. TEM results indicate that some of the nanocrystals were composed of the cubic form silicon carbide, β-SiC. The resulting photoluminescence analysis indicated that the size distribution of the nanocrystals could be tailored to yield a broad spectral output between 2.0-2.8 eV, by controlling the formation parameters. Also a few notable factors, such as liberation of oxygen in the silica during implantation and ambient oxygen in the annealing furnace, will be shown to play a critical role in the formation process. Additional passivation with 96%Ar+4%H_2 at a lower temperature (600^{o}C) had little effect. The results of this work will be presented and compared to previous studies.

THU-NSF04-P7 #523 - Poster - Thursday 3:30 PM – Rio Grande Room

Ion-cut Synthesis: Blister Formation and Layer Transfer

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In recent years, the ion-cut process has emerged as a useful technique for thin-film layer transfer. We are adapting this concept for simultaneous nanocomposite synthesis and layer transfer via "ion-cut synthesis." In this technique, ion implantation and annealing leads to nanocrystallization and bubble formation in the regions of highest vacancy and ion concentration, respectively, followed by exfoliation of nanocomposite layers leading to layer transfer. Previously, we reported the formation and blistering of GaN-rich nanostructures using high-dose (5x10^{17} cm^{-2}) 100 keV N^+ implantation into GaAs, followed by >800°C rapid thermal annealing.

We have explored the blister formation process using a variety of imaging and ion beam analysis techniques. SEM images of GaAs:N surfaces indicate both circular and elongated surface features, associated with blistering and surface buckling, respectively. Atomic force microscopy (AFM) of exfoliated surfaces show crater depths corresponding to the simulated depth of maximum N ion concentration, suggesting that layer transfer is induced by the coalescence of N bubbles. Nuclear reaction analysis (NRA) using $^{14}N(d,\alpha_1)^{12}C$, in conjunction with SIMNRA code, suggests that the maximum N concentration occurs at the observed bubble depth. Focused-ion beam (FIB) sectioning through the nanocomposite layer reveals surface buckling and possible plastic deformation, in contrast to traditional ion-cut which presumably involves only elastic deformation processes. Recently, using poly-methylsilsesquioxane (PMSSQ) spin-on glass as a bonding agent, we achieved transfer of GaAs:N to alumina substrates. We are currently endeavoring to optimize bonding parameters to maximize the interface toughness and the effectiveness of layer transfer. Future work includes Rutherford backscattering spectrometry (RBS) ion channelling (IC) and NRA of implanted + annealed structures to better elucidate the role of damage and N diffusion in nanostructure and bubble formation in the ion-cut synthesis process.

THU-RE08-P1 #73 - Poster - Thursday 3:30 PM – Rio Grande Room

Small-angle X-ray scattering / USAXS / diffraction from biological samples: Utilization of synchrotron X-rays

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Small-angle X-ray scattering / USAXS / diffraction from biological samples provide potential source of information in the field of biological sciences. These biological samples are prepared from soft tissues. We have chosen soft-bodied animals of various types with an external hard shell, for example, marine bivalves, and snail's with embedded biological soft tissue. As the name indicates, all the bivalves are characterized by a two-valve shell, which protects the soft tissue inside. The valves are joined by a hinge and are aquatic, with the majority of types living in shallow marine waters. It is interesting to the study the small-angle X-ray scattering / diffraction of these soft tissues with the use of synchrotron radiation. The external shell consists of many light atoms, which are of biological importance and the embedded soft tissue linked to the soft anatomy. The biological soft tissue is embedded in another object, and the microstructure is non-uniformly distributed. Under such identical conditions, small-angle X-ray scattering / diffraction of the embedded biological soft tissue and the external shell is necessary.

The SAXS / USXAS / diffraction pattern will explore some important information, for example, cellular functions, and therefore, have been the subject on both nutritional and toxicological studies. The necessity of information about the biological structures of these low absorbing materials is one of the most important goals in the field of structural biology. The understanding of these biological systems at the molecular level is very less and considerable amount of work is necessary in order to establish a more detailed molecular anatomy of these systems by imaging to know more about the embedded internal features.

THU-RE08-P2 #74 - Poster - Thursday 3:30 PM – Rio Grande Room

Cork embedded features with micro-CT using 20, 25 and 30 keV synchrotron X-rays: Identification of optimum energy.

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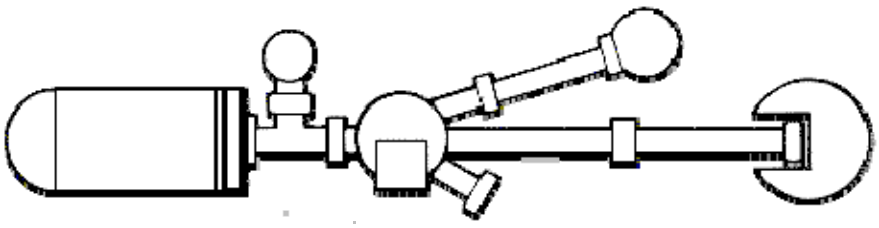
Cork, a unique biological material and is a highly valued non-timber forest product. It is used in a variety of products, from construction materials to gaskets, but it's most important use is as a stopper for premium wines. In terms of revenue, natural cork comprises one of the world most important non-timber forest products. The principle requirements for cork stoppers are the homogeneity of the cork and the lack of cavities and /or cracks. The quality control is performed in several steps. However, most of these controls are visual checks performed by experienced people and /or by electronic cameras. All these kinds of inspection allow analyzing only the external surface. Thus little known about the internal microstructure and cracks or holes inside the stopper will not be detected.

Images of the cork used for wine and other bottles are visualized with the use of micro-CT. (1) Micro-CT will provide potential source of information, for example, interior microstructure and sharp images with high contrast (2) Present experimental studies provide new and novel information to visualize the cracks, holes and porosity.

Recently, the proposer used the micro-tomographic technique in the field of biological imaging. The present proposal provides new and novel information and also for the comparison purposes using other imaging techniques.



FRIDAY

FRI-AP08-1 #602 - Invited Talk - Friday 8:30 AM - Elm Fork

Relativistic Collisions and Extremely Strong Fields

Reinhold Hans Schuch
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The talk will discuss the possibilities to investigate extreme fields by atomic collisions as envisaged by the Stored Particle Atomic Research Collaboration (SPARC). One class of experiments are planned at relativistic energies (SIS 100/300), another series of studies concern medium energy collisions in NESR. In peripheral collisions of high-Z systems at SIS300 with gamma=30, huge transient field pulses are generated that lead to large cross sections for production of free electron-positron pairs. The transverse electric component of the electromagnetic fields associated with the moving ion charge has strengths of 10^19 V/cm, that is far above the critical Schwinger field strength. Capture from pair production, the so-called vacuum capture process or ECPP, increases with beam energy and can bcome the dominant capture mechanism. Our efforts will adress new phenomena in pair production and capture process, particularly in the ?non-pertubative regime'. This regime is typically below 20 GeV/u and high nuclear charges, as well as at small impact parameters. There multiple pairs should become likely, whereby the unitarity rule could be violated. An additional process can occur where two electrons are captured quasi-resonant, one from a target, one by exciting the negative continuum by emitting a positron. That process can enhance the vacuum capture cross section additionally and is highly non-pertubative.

With the new FAIR machines, higher intensities of heaviest ions in highest charges are available and these are used in NESR for collision studies at moderate energies. At energies of ~MeV/u behave the strongest bound atomic energy levels during the collision quasimolecular and 1s is diving into the negative energy continuum. With the optimized features of NESR, internal or external targets, photon detectors, and COLTRIMS we plan to observe this effect by interference in molecular-orbital X rays and in charge transfer of target electrons.

* for the SPARC collaboration http://www.gsi.de/fair/experiments/sparc

FRI-AP08-2 #147 - Invited Talk - Friday 8:30 AM - Elm Fork

ELECTRON CAPTURE AND LOSS PROCESSES IN FORWARD ELECTRON EMISSION IN FAST ION-ATOM COLLISIONS

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Forward electron emission, i.e., cusp-electron production, has been investigated in 0.4-2 MeV/u O7+ and O8+ + He collisions. One and two-electron processes including electron capture to the continuum (ECC), electron loss to the continuum (ELC), and transfer ionization (TI) have been isolated by detecting cusp electrons in coincidence with the outgoing projectile charge state. These results are closely related to the recent observation of radiative-electron-capture-to-the-continuum (RECC) for 90 MeV/u U88+ ions colliding with N2, in which an incoming quasi-free electron is stopped in the field of the ion giving up its kinetic energy radiatively [1]. RECC, which competes with non-radiative ECC, can be considered as the short-wavelength limit of electron-nucleus bremsstrahlung [2]. In the present work, ECC for both O7+ and O8+ is the dominant process over the energy range investigated. Comparing data for bare and H-like projectiles permits examination of the role of the projectile electron in the ECC process, while the two-electron TI channel gives information on contributions of the e-e interaction. It is found that the TI yield compared to that for ECC cannot be explained in the framework of the independent particle model, a result also found for higher velocity Ne10+ + He, Ne, and Ar collisions [3]. This deviation is attributed to the e-e interaction, an effect that is apparently stronger for H-like projectiles than for bare projectiles. Further investigation is needed, however, to clarify the role of the e-e interaction in these processes. Additionally, it is noted that any radiative contributions to the cusp-electron yields, e.g. RECC, are presently unknown. Future studies will examine these radiative contributions.

[1] M. Nofal et al, Phys. Rev. Lett. 99, 163201 (2007).
[2] D.H. Jakubassa-Amundsen, Rad. Phys. and Chem. 75, 1319 (2006).
[3] J.A. Tanis et al, Phys. Rev. A 39, 1571 (1989).

FRI-AP08-3 #516 - Invited Talk - Friday 8:30 AM - Elm Fork

Challenges for Atomic Physics at the Future International Heavy Ions Facility FAIR

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The future international accelerator Facility for Antiproton and Ion Research (FAIR) has key features that offer a range of new and challenging opportunities for atomic physics and related fields. The proposed facility will provide the highest intensities for

relativistic beams of both stable and unstable heavy nuclei, in combination with the strongest possible electromagnetic fields, thus allowing to extend atomic spectroscopy virtually up to the limits of atomic matter. Due to a tremendous improvement concerning intensity and energy, new fields will be opened in addition by the strongly enhanced production yields for unstable nuclei. For the heavy ions, the program of the Stored Particle Atomic Research Collaboration can be associated mainly with three types of experimental studies: Energetic and relativistic heavy ions will be employed for a wide range of collision studies involving photons, electrons and atoms, and exploiting the large Doppler boost and the rapidly varying fields in those reactions. High-energy beams will be utilized for achieving high stages of ionization up to bare uranium nuclei. Experiments will focus on structure and collision studies for these ion species whereby special emphasis will be given to the test in critical and supercritical fields. Finally, fundamental atomic physics studies (e.g. test of the Standard Model) will be performed and in addition, by applying atomic physics methods, experiments for the determination nuclear quantities in a model-independent way.

FRI-AP08-4 #270 - Invited Talk - Friday 8:30 AM - Elm Fork

Direct laser acceleration of ions for application in cancer radiotherapy

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Linearly and radially polarized multi-terawatt and petawatt laser beams, focused to sub-wavelength waist radii, can directly accelerate protons and carbon nuclei, over micron-size distances, to the energies required for hadron cancer therapy. Radially polarized beams have generally a more favorable energy spread than those accelerated by linearly polarized lasers of the same intensity. We put forward direct laser acceleration of ions as an appealing alternative for utilization in cancer therapy, once the refocusing of ion beams accelerated by linearly polarized lasers is experimentally solved or radially polarized pulses of sufficient power can be produced. Using a table-top laser system to accelerate the ions may results in a cut on the cost and physical space required by the construction of a conventional accelerator. This scheme may also be a better candidate than the ion production and acceleration by a laser-solid-target method.

FRI-AP08-5 #537 - Invited Talk - Friday 8:30 AM - Elm Fork

Experimental developments for the Lamb shift investigation in heavy ions

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Aiming at an accurate determination of QED corrections in the critical field limit via an accurate determination of the ground state binding energy in a high-Z, H-like ions [1], novel high resolution spectrometer setups are presently commissioned for x-ray experiments at the Experimental Storage Ring (ESR) at GSI, Darmstadt. Up to now for the case of H-like uranium an accuracy of 1% could be reached in an experiment performed at the electron cooler [2] due to the deceleration capability of the ESR. A further improvement by almost one order of magnitude is envisaged by a transmission x-ray spectrometer set up in the Focusing Compensated Asymmetric Laue (FOCAL) geometry [3] as well as by the implementation of high-resolution micro-calorimeter devices [4,5].

Here we report on the latest commissioning experiment of a two arm transmission x-ray spectrometer along with high-performance position-sensitive microstrip Germanium detectors. Due to a photon efficiency of only 10^{-8} the position sensitivity as well as the energy and time resolution of segmented solid state Germanium detectors are absolutely essential for the experiment. A detector system with the desired properties has become available through a collaboration with the Forschungszentrum Julich [6]. In combination with the FOCAL-spectrometer this position-sensitive detector permits the simultaneous measurement of all energies in the regime of interest.

[1] S. Fritzsche, P. Indelicato, and Th. Stöhlker, J. Phys. B-At. Mol. Opt. Phys. **38**, S707 (2005)
[2] A. Gumberidze et al., Phys. Rev. Lett. **94**, 223001 (2005)
[3] H.F. Beyer et al., Spectrochimica Acta Part B **59**, 1535 (2004)
[4] P. Egelhof, Adv. in Solid State Phys. **39**, 61 (1999)
[5] E. Silver et al, NIM A **520**, 60 (2004)
[6] D. Protic et al, IEEE Trans. Nucl. Sci. **52**, 3194 (2005)

FRI-IBA05-1 #538 - Invited Talk - Friday 8:30 AM - Pecos II

Characterization and control of reactivity at Pt alloy surfaces

Bruce E. Koel
Chemistry, Lehigh University, 6 E. Packer Ave., Bethlehem PA 18015, United States

The addition of a second metal component to Pt-based catalysts often induces desirable properties, increasing selectivity or catalyst lifetime. Understanding the basic underpinnings of this alteration requires improvements in preparing and characterizing well-defined bimetallic surfaces. I will review our work seeking to find ordered alloy surfaces (intermetallic compounds) for several M-Pt(111) and Pt(100) (M=Ti, Fe, Cu, Zn, Ge, Ag, and Sn) systems and exploring chemisorption and catalysis on these surfaces, highlighting atomic level characterization of these surfaces by electron and ion-based structural probes and scanning tunnelling microscopy (STM). In particular, I will focus on results obtained using low-energy alkali ion scattering (ALISS). Such fundamental investigations enable the development of new concepts for understanding and tailoring properties of solid surfaces and hence improvements in heterogeneous catalysts and other advanced materials.

FRI-IBA05-2 #596 - Invited Talk - Friday 8:30 AM - Pecos II

Composition and Structure of high-k Materials on Silicon and New Channel Materials

Hang Dong Lee, Tian Feng, Lyudmila Goncharova, Eric Garfunkel, Torgny Gustafsson
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Advanced CMOS research has recently turned its attention to higher mobility substrate materials. We have examined a series of different III-V and Ge-based structures focusing on passivation, high-K growth, and gate metallization and thermal stability. By combining medium energy ion scattering (MEIS) and x-ray photoelectron (XPS) we have investigated the diffusion of various species, including sulfur, oxygen and nitrogen, as well as the semiconductor and metal components, in the stack and at the interfaces. MEIS is best thought of as a high resolution, low energy version of conventional Rutherford backscattering with a depth resolution of ~ 3 Å. As the ion-solid interaction law is known accurately in the ion energy range we use, detailed modeling of the spectra can be performed. XPS gives information about electronic states and complementary structural information.

We will report results on the interaction of high dielectric constant materials, such as hafnium and zirconium oxides, with new high mobility substrates, such as Ge, GaAs and InGaAs and compare this with their interaction with Si.

FRI-IBA05-3 #343 - Invited Talk - Friday 8:30 AM - Pecos II

Low-Energy Grazing Ion-Scattering from Alkali-Halide Surfaces: a Novel Approach to C-14 Detection

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Carbon-14 labeled compounds are widely used in the pharmaceutical industry, e.g., as tracers to determine the fate of these compounds *in vivo*. Conventional accelerator mass spectrometry (AMS) is currently the only approach that offers sufficiently high sensitivity to avoid radiological waste and contamination issues in such studies. At the ORNL Multicharged Ion Research Facility (MIRF) we are exploring a small size, low cost alternative [1] to AMS that utilizes keV-energy-range multicharged C beams from an ECR ion source grazingly incident on an alkali halide target, where efficient negative ion production [2] by multiple electron capture takes place with little energy loss. By using C ion charge states of +3 or higher, the molecular isobar interference at mass 14, e.g. $^{12}CH_2$ and ^{13}CH, is eliminated. The negatively charged ions in the beam scattered from the alkali halide surface are separated from other charge states by two large acceptance (~15 msr) stages of electrostatic analysis. The N-14 isobar intereference is thus removed, since N does not support a stable negative ion. The alkali halide targets are sufficiently large to fully intercept up to ~4 mm FWHM beams at incidence angles as low as 3°, permitting surface scattering by incident beams in the eμA range. Initial results for C-14 detection obtained using C-14 enriched CO_2 from ANSTO will be described. With its high sensitivity and high-current capability, the apparatus is also well suited for studying other low-intensity negative ion production phenomena in alkali-halide surface interactions, such as formation of D_2^- in dissociate-capture scattering of D_3^+ (see talk by D.G. Seely in Tuesday session AP02), and non-dissociative triple-electron-capture scattering of $^{12}CH_2^{+2}$ to form $^{12}CH_2^-$.

[1] U.S. patent 6,455,844 issued 9/24/2002.
[2] F.W. Meyer, Q. Yan, P. Zeijlmans van Emmichoven, I.G. Hughes, and G. Spierings, NIMB 125, 138 (1997).

FRI-IBA05-4 #354 - Invited Talk - Friday 8:30 AM - Pecos II

Sputter Depth Profiling of Solar Wind Implants by RIMS: Extending the Limits of Dynamic Range and Sensitivity

Igor V Veryovkin, C Emil Tripa, Alexander V Zinovev, Michael J Pellin
Materials Science Division, Argonne National Laboratory, 9700 S. Cass Ave., Bldg. 200, Argonne IL 60439, United States

NASA Genesis mission has delivered samples of solar wind (SW) for analysis of isotopic and elemental compositions using the most advanced analytical techniques available in laboratories on Earth. We conduct Resonance Ionization Mass Spectrometry (RIMS) analyses of these collectors using an instrument, SARISA, specifically developed and optimized for this kind of measurements. In the focus of our work on Genesis samples are various metallic elements with total fluencies such that their atomic concentrations range from above one part per million to below one part per trillion, and their depth of implantation is typically ~100 nm. To accurately and precisely determine SW fluencies by sputter depth profiling of such shallow implants, we have developed experimental procedures using custom-made standard reference materials. RIMS measurements of Mg and Ca in these implant standards allowed us to characterize efficiency and detection limits of SARISA: useful yield peaked at about 20% at mass resolution of ~2000, and detection limits corresponded to ~20 parts per trillion. Noise level in sputter depth profiles was defined by "wings" of primary ion beam profile sputtering walls of the crater and corresponded to remarkably low concentrations below 10^{12} atoms per cubic centimeter. Extremely wide dynamic range of 5 orders of magnitude above that noise level was demonstrated in depth profiles of the standards. In order to minimize influence of surface contamination, achieve lower detection limits and better understand effects of ion mixing, we conducted a series of experiments with back-side sputter depth profiling of the standards and the actual Genesis samples. We will discuss results obtained with the conventional front-side depth profiling and compare them to those for the back-side.

This work was supported under Contract No. DE-AC-02-06CH11357 between UChicago Argonne, LLC and the Department of Energy, and by NASA under Work Orders W-19,895 and W-10,091.

FRI-IBA05-5 #600 - Invited Talk - Friday 8:30 AM - Pecos II

Modeling Low Energy Ion Scattering with MARLOWE: Comparison of Theory with Experiment

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Hydrogen and Metallurgical Science Department, Sandia National Laboratories, P.O. Box 969, MS 9161, Livermore CA 94550, United States

Low energy ion scattering (LEIS) has been used extensively to study the composition and local atomic structure of surfaces. An important challenge associated with LEIS is extracting such information from experimental data. This study focuses on the use of LEIS to examine surface structure. In general, interatomic spacing has been measured using known dimensions of a shadow cone produced by a scattering center. A more precise approach would involve simulating ion scattering from an assumed surface configuration, and comparing these results with the experimental data. Here, we examine the use of reliability factors to compare modeling results (using the binary collision code MARLOWE) with experimental measurements. To demonstrate the comparison techniques, we consider the model system 2 keV He+ --> Mg(0001). Measurements taken with an angle resolved ion energy spectrometer (ARIES) are compared with simulations obtained with the binary collision code MARLOWE under the same conditions. The input surface structure for the MARLOWE simulations can be optimized to provide the best fit to the experimental data. Applications of this method to real space ion scattering maps are discussed.

Sandia is a multi-program Laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

FRI-IBA05-6 #2 - Invited Talk - Friday 8:30 AM - Pecos II

New measurements of carbon and oxygen concentrations in formvar and amniotic fluid by use of lithium forward elastic scattering

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A method based on forward elastic scattering of a light ion has been shown to be a useful tool for light element characterization (Z<11) in liquid samples. We have measured elastically scattered 13MeV ^{6}Li +^{12}C and 13MeV ^{6}Li +^{16}O cross sections at 17.5°, 25° and 28°. Using these cross sections, we have obtained carbon and oxygen concentrations a factor of 10 higher than values previously reported in formvar and amniotic fluid. When formvar is used as the backing of an evaporated organic liquid sample, its carbon and oxygen contents may not be negligible in comparison with the C and O concentrations present in the sample under

analysis, especially if the sample is diluted with distilled water which helps to improve the quality of the collected spectra. From the irradiation with a lithium beam of different formvar films at different locations per backing, a dispersion in the measured C and O concentration values per backing not greater than 7% has been found.

FRI-MR02-1 #579 - Invited Talk - Friday 8:30 AM - West Fork

Low Energy Cyclotron Irradiation as a Source for Radiochemical Actinium-225

A. Gaylord King[1], Josue Moreno, Ph.D.[5], R. Henkelmann, Ph.D.[6], Mark Harfensteller, Ph.D.[9], E. Heunges, Ph.D.[5], Matthias Mentler, Ph.D.[5], Ronald Finn, Ph.D.[8], David Schlyer, Ph.D.[3], Volker Bechtold, Ph.D.[2], David A. Scheinberg, MD, Ph.D[7], Michael R. McDevitt, Ph.D[7]

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An expanding field in antibody-based cancer therapy is the application of monoclonal antibodies (MoAB) to direct selective cytotoxic agents. Radio nuclides, toxins, vaccines, and prodrug converting enzymes have all been conjugated to various MoABs and are at various stages of development through clinical trials. Despite the novelty and some promising results reported in the scientific literature with the use of alpha emitting radionuclide for targeted radiotherapies, the necessary documentation in terms of clinical applications has not been reported. The delay may be attributable to several key factors: one is the availability of a supply of critical radionuclide required to undertake a multi-center clinical trial (1).

Review of relevant literature supports the paucity of experimental data related to alpha radiotherapies for increasing demands of large-scale clinical studies. However, potential irradiation of highly radioactive Ra-226 salt targets with a low energy cyclotron and the resultant chemical separation of the Ac-225 product with subsequent recovery of the initial target Ra-226 appear promising (2). The challenges for this undertaking were large, included technical, environmental and regulatory, but the results of several production irradiations indicate the feasibility and potential for the process that has been developed. The results support our supposition that cyclotron produced radiochemical Ac-225 is an alternate source of production.

In three consecutive runs more than 50 mCi of Ac-225 were produced. The radioisotopic purity was consistently higher than 99.5%. Chemical purity was comparable with Ac-225 obtained from a Th-229 cow. For these runs up to 100 mg of Ra-226 were purified and reused. It could be demonstrated that the recycling of radium was quantitative.

The entire Ac-225 production process is fully automated.

[1] Boll R, Malkemus D, Mirzadeh S. 2005. Appl. Radiation and Isotopes 62, 667-679.
[2] Apostolidis C, Molinet R, McGinley J, et al. 2005. Appl. Radiation and Isotopes 62, 383-87.

FRI-MR02-2 #238 - Invited Talk - Friday 8:30 AM - West Fork

Cyclotron Requirements for Multi-disciplinary Programs

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As time has passed, the various Cyclotron programs have changed over the years. In the "early" times of Cyclotron operations, the emphasis was on a more single sided approach such as Clinical or Research or Production. However, as time passed, the disciplines became more interconnected until today, it is unusual to have a Cyclotron and only have a single program unless it is pure production. More and more, especially in public areas such as Universities or Health Centers, you are seeing programs that do all three types of disciplines: Production; Clinical or Patient Diagnostics and/or Treatment; and Research, either in the development and manufacture of new Radio-Isotopes, new Diagnostic or Therapeutic Compound Development, or Clinical Research involving subject testing.

While all three of these disciplines have some common requirements, they also have some very different requirements that may be completely counterproductive to other requirements. For a program where all three disciplines are required to be successful, it is necessary come up with some sort of compromise that meets all the various requirements. During this talk, we will try to identify some of these different requirements for the various disciplines and how these could impact the other disciplines. We will also discuss ideas for some possible compromises that might reduce the conflict between the various disciplines.

FRI-MR02-3 #423 - Contributed Talk - Friday 8:30 AM - West Fork

Application of Proton LINAC for Medical Use for PBT, PET and BNCT

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AccSys Proton LINACs are currently used or under development for the injector of Proton Beam Therapy(PBT), Radioisotope production for Positron Emission Tomography(PET), and Boron Neutron Capture Therapy(BNCT). Since this is a medical use, very high reliability is required and has been achieved. For the PBT application, 6 systems have been shipped and under operation. For PET application, 5 systems have been shipped. For BNCT research application, one system has been shipped.

Proton LINAC has a capability to produce a large current. This is good for both BNCT and PET applications. Recently, AccSys has completed the design of 10.5MeV, 2.5mA LINAC. With this high current LINAC, large neutron flux for BNCT and large yield of RI for PET will be achieved.

FRI-MR02-4 #558 - Contributed Talk - Friday 8:30 AM - West Fork

Design of an automated system for synthesis of [18F] FDG for PET investigation at IFIN-HH Bucharest

Liviu Stefan Craciun, Catalina Cimpeanu, Olimpiu Constantinescu, Dorin Dudu, Nicolae Negoita, Petru Mihai Racolta, Ion Rusen
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An apparatus for automated synthesis of radiopharmaceuticals labelled with ^{18}F constructed at IFIN-HH for PET investigation is described. [^{18}F] fluoride was produced at the IFIN-HH cyclotron by irradiation of H_2O enriched 97 % in ^{18}O, with deuterons of 13 MeV or protons of 8 MeV. The irradiated H_2O was transferred (injected) into the radiochemistry full automated processing systems which ensure the separation of ^{18}F- from H_2O, the labelling with ^{18}F of a precursor compound by an acid or basic hydrolysis; then it is transformed in the radiopharmaceutical with ^{18}F and finally purified a selective absorbants. The system is easy to operate and contain a programmable logical controller which manages the entire operation program stored in its internal memory. The computer is used to assist the operator during the different steps of synthesis and to allow visualization of the process and printing the report. The device served for the production of [^{18}F] FDG at the IFIN-HH cyclotron, one of the most used radiopharmaceutical in PET investigations. The synthesis module has configurated so that it is enough flexible to accomplish and other nucleophile reactions of labelling with short lived radioisotopes.

FRI-NBA05-1 #30 - Invited Talk - Friday 8:30 AM - Brazos I

Active Inspection Techniques for the Quantification and Identification of Fissionable Materials

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Over the last seven years, there has been a substantial research and development effort into active inspection technologies that can nondestructively detect the clandestine shipment of fissionable materials. These active inspection techniques use a probing radiation source to stimulate fission reactions and then monitor for secondary emissions that are a signature of fissionable materials. In addition to detecting the clandestine shipment of fissionable materials, these techniques can be applied as advanced materials accounting and control techniques for nonproliferation. The authors investigated the emissions from photon induced fission reactions of aqueous solution containing ~1% by weight of U-238 or Th-232 for materials accounting and control. Using delayed neutron emission the minimal detectable limit was determined to ~9 mg and the statistical accuracy was ~0.3%. Furthermore two techniques for determining the isotopic ratios in bicomponent solutions were studied and will be discussed.

FRI-NBA05-2 #593 - Invited Talk - Friday 8:30 AM - Brazos I

Preliminary Assessment of Fissionable Material Detection From Standoff Distances

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Idaho National Laboratory and Idaho State University's Idaho Accelerator Center are currently developing an electron accelerator-based, active inspection technology to detect fissionable material from long standoff distances. This technology utilizes bremsstrahlung photons with endpoint energies up to 25 MeV to induce photofission reactions in a 238U target. Radiation emitted from the target following the photofission reactions is monitored with a combination of neutron and gamma-

ray detectors, located in various positions relative to both the inspection source and the target. Preliminary assessments of this technology demonstrate the ability to detect fissionable material at long standoff distances.

FRI-NBA05-3 #118 - Invited Talk - Friday 8:30 AM - Brazos I

Active Interrogation Using Electronic Neutron Generators for Nuclear Safeguards Applications

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Active interrogation, a measurement technique which uses a radiation source to probe materials and generate unique signatures useful for characterizing those materials, is a powerful tool for assaying special nuclear material. The most commonly used technique for performing active interrogation is to use an electronic neutron generator as the probe radiation source. Exploiting the unique operating characteristics of these devices, including their monoenergetic neutron emissions and their ability to operate in pulsed modes, presents a number of options for performing prompt and delayed signature analyses using both photon and neutron sensors. A review of literature in this area shows multiple applications of the active neutron interrogation technique for performing nuclear nonproliferation measurements. Examples in this area include measuring the plutonium content of spent fuel, assaying plutonium residue in spent fuel hull claddings, assaying plutonium in aqueous fuel reprocessing process streams, and assaying nuclear fuel reprocessing facility waste streams to detect and quantify fissile material. This paper discusses the historical use of this technique and examines its context within the scope and challenges of the Global Nuclear Energy Partnership.

FRI-NBA05-4 #60 - Invited Talk - Friday 8:30 AM - Brazos I

X-ray Fluorescence (XRF) Assay using Laser Compton Scattered (LCS) X-rays

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Laser Compton Scattered (LCS) x-rays are produced as a result of the interaction between accelerated electrons and a laser beam. The yield of LCS x-rays is dependent on the laser power, angle of collision between interacting particles, and the electron linear accelerator (linac) electron beam energy and current. One of our research goals at the Idaho Accelerator Center (IAC) focuses on applications such as detection and imaging of fissionable isotopes for nuclear non-proliferation, safeguards and homeland security. Monochromatic LCS x-rays offer much better signal-to-noise ratios for such applications and the energy of LCS x-rays are tunable, which enables element-specific analysis. A sharp 36.1 keV LCS peak was observed based on the electron beam tuned at 34 MeV that was brought in collision with 2.8 W ND:YAG laser operating at 532 nm wavelength. The linear accelerator (linac) was operating at 60 Hz with electrons bunched up to 50 ps. We exploited x-ray fluorescence (XRF) techniques to identify elemental $K\alpha_1$ and $K\beta_1$ lines in a high-purity germanium (HPGe) detector, with 0.5 mm thick Beryllium (Be) absorbing layer, emitted from Tin (Sn), Silver (Ag), and Cadmium (Cd) foils with thicknesses ranging from 25□500 μm, following absorption of 36.1 keV LCS x-rays. The use of LCS x-rays for hybrid K-edge densitometry future work will also be tested and extended to identify photo-fissile materials and make tomographic images.

Acknowledgements: This work was funded by the U.S Department of Energy (DOE) under contract# DE-FC07-06ID 14780.

FRI-NHS04-1 #521 - Invited Talk - Friday 8:30 AM - Brazos II

Challenges in Modeling and Decision Algorithms for NHS Applications

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The DHS Domestic Nuclear Detection Office (DNDO) has been given the mission to improve the Nation's capability to detect and report unauthorized attempts to import, possess, store, develop, or transport nuclear or radiological material for use against the Nation. Under the Transformational and Applied Research Directorate (TARD), an aggressive and expedited R&D program is underway to develop break-through technologies that will have a dramatic positive impact on capabilities to detect nuclear threats. Some break-through concepts are discussed in Session NHS02. A brief overview of challenges still remaining in physics modeling and decision algorithms for NHS applications will be discussed here.

FRI-NHS04-2 # - Invited Talk - Friday 8:30 AM - Brazos II

Development of technologies for standoff detection of nuclear materials by the Defense Threat Reduction Agency

James R. Lemley

FRI-NHS04-3 #374 - Invited Talk - Friday 8:30 AM - Brazos II

Physics Data and Modeling: How much can you really tell?

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Modeling, particularly Monte Carlo simulation, is playing a large role in the design and the predictive assessment of active interrogation devices for homeland security applications. The computational models are not only used to assess the performance of the instrument but also to predict the radiation doses in the vicinity of the instrument. These analyses may be performed using a pristine model of the environment surrounding the instrument that is not fully representative true field environments. For example, radiation environments which may mask the low-level signals obtained from the interrogation methods are often ignored. While the nuclear data for the typical energy ranges needed to model neutron-neutron interrogation systems is readily available, the cross sections may have a wide variation in uncertainty depending on the materials present and the presence of trace amounts of some elements in actual environments may yield vastly different signals in real situations. Bremsstrahlung-based interrogation systems which look for neutron signatures from photonuclear events, depend on nuclear data that are not as highly developed as photon and neutron interaction data. More exotic systems rely on data that may be even more variable. The complete simulation of detector response is a highly complex modeling exercise. The presentation will review the challenges and capabilities of simulating the response of active interrogation systems in light of the physics and models currently available and suggest avenues to improve existing capabilities.

FRI-NHS04-4 #296 - Invited Talk - Friday 8:30 AM - Brazos II

MCNPX Improvements for Threat Reduction Applications

Laurie S Waters[1], Gregg W McKinney[1], Joe W Durkee[1], Denise B Pelowitz[1], Russell C Johns[1], Jay S Elson[1], Toshihiko Kawano[2], Peter Moller[2], Shannon T Cowell[2]
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The DHS Domestic Nuclear Detection Office (DNDO) is now funding a multiyear program of improvements in the MCNPX Monte Carlo radiation transport code. Additional work is also underway for DTRA Active Interrogation programs.

Enhancements contained in the current MCNPX 2.6.0 RSICC release will be presented, including stopped muon physics, delayed neutron and photon generation, and automatic generation of source photons. Preliminary benchmarking comparisons with data taken with a PSI muon beam will be discussed. We will also describe current improvements now underway, including Nuclear Resonance Fluorescence, pulsed sources, and others. We will also describe very new work begun on a Threat-Reduction user interface, designed to simplify the setup of TR-related calculations, and introduce standards into geometry, sources and backgrounds.

FRI-NHS04-5 #543 - Contributed Talk - Friday 8:30 AM - Brazos II

High-energy laser-accelerated electron beams for long-range interrogation

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We are studying the use of 0.1 - 1.0 GeV laser-accelerated electron beams as active interrogation probes for long-standoff radiography or nuclear activation of concealed nuclear material. Interrogation beams in this energy range are largely unexplored, but provide significant advantages in terms of large penetration range through air and solids and in low beam divergence for both direct electron beams and secondary bremsstrahlung x-rays. We present laboratory measurements of radiography and activation,

performed at the Diocles laser facility at the University of Nebraska, as well as MCNP and GEANT Monte Carlo simulations used to aid experiment design and interpretation.

FRI-NHS04-6 #213 - Contributed Talk - Friday 8:30 AM - Brazos II

Evaluation of the Doppler-Broadening of Gamma-Ray Spectra from Neutron Inelastic Scattering on Light Nuclei

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Neutron-induced gamma-ray reactions are the primary means used in the nondestructive analysis of materials. Irradiated with neutrons, nuclei undergo through de-excitation process emitting gamma rays with specific energies. The intensities of the specific gamma rays in the collected gamma spectrum provide information about the number of atoms in the substance. This technique can be used in security applications to detect and identify explosives, medical studies to measure the fat content, and other areas where the information about the chemical composition of a substance is crucial.

The common technique to find the intensity of the gamma-ray is to fit gamma-ray line-shape with an analytical function, for example the Gaussian function. However, the Gaussian fitting may fail if the gamma ray peak is Doppler-broadened. This leads to the miscalculation of the area of the peak and, therefore, to misidentification of the material. Due to momentum considerations, Doppler-broadening occurs primarily with gamma-rays from neutron-induced inelastic scattering reactions with light nuclei. The recoiling nucleus of interest must have excited states whose lifetimes are much smaller than the time of flight in the material. We have been examining various light nuclei bombarded by 14 MeV neutrons to predict when the peak shape of a neutron-induced gamma ray emitted from these nuclei will be Doppler-broadened. The method to analyze Doppler-broadened peaks was proposed and tested for various cases.

FRI-NHS04-7 #184 - Contributed Talk - Friday 8:30 AM - Brazos II

Monte Carlo Analysis of Pulse Neutron Based Active Interrogation of Cargo

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The nondestructive technique to rapidly determine bulk elemental content of a cargo is based on the accelerator-based neutron interrogation. When the cargo is irradiated with pulse neutrons, the photons are emitted with characteristic energies as a result of neutron-induced nuclear reactions within the cargo materials. By counting the number of these specific gamma-rays, the cargo's isotopic content can be measured, and the possible hidden threat can be detected. To evaluate threat detection effectiveness of a neutron-based system, and to determine its optimal physical parameters, the detailed computer analysis of nuclear processes is required.

The MCNP5 code has been used to model radiation transport in a system consisting of the 14-MeV pulse neutron source, neutron and photon detectors, and cargo and its environment. Neutron and gamma coupled transport has been used. The 10-kHz frequency of neutron pulses with duty factor of 10% has been simulated using the time variable in the source definition card with the source probability distribution that corresponds to the square pulse. Energy spectra of neutrons and gamma-rays in the detectors and cargo cells have been calculated using the track length tally in two time bins, coincident with the neutron pulse and between the neutron pulses. The threat has been simulated as an explosive or hazardous chemical object hidden inside the cargo. The distances from the cargo to neutron source and detectors, the cargo's size and its material composition, and the threat's size have been varied to study minimum detectable amounts for various cargo scenarios including suitcases, pallets, and trucks. The time structure of neutron pulses has been varied to study the influence of low-Z materials on the photon spectra in the detector cells during the pulse and between the pulses. The results of calculations will be discussed.

FRI-NSF04-1 #146 - Invited Talk - Friday 8:30 AM - Trinity Central

Synthesis of Elongated and Oriented Gold Nanorods in SiO_2 by Ion Irradiation

Koichi Awazu[1,3], Xiaomin Wang[1], Makoto Fujimaki[1], Junji Tominaga[1], Tetsuro Komatsubara[2], Yuki Matsumoto[3], Jun Watanabe[3], Shin'ichi Warisawa[3], Sunao Ishihara[3]
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It has been reported that elongated Au nanoparticles oriented parallel to each other can be synthesized in SiO_2 by ion irradiation.[1] Our aim was to elucidate the mechanism for this elongation. We prepared Au nanoparticles of 30 to 80 nm

diameter embedded in an SiO_2 matrix. After irradiation by 110MeV Br^{10+} at a fluence of 10^{14} cm^{-2}, we found that elongation of Au nanoparticles with a small radius was larger than that of Au nanoparticles with a large radius. These experimental results are discussed in the framework of a thermal spike model of Au nanorods with a radius of 5 or 10 nm embedded in SiO_2. The lattice temperature [2] exceeds the melting temperatures of both SiO_2 and Au for 100 ns after one 110MeV Br^{10+} ion has passed through the middle of an Au nanorod of radius of 5 nm. In contrast, with the 10nm Au rod, neither the rod nor the SiO_2 is melted by 110MeV Br^{10+}. We conclude that dependence of the elongation of the Au nanoparticles on particle size can be explained in terms of the thermal spike model.

[1] S. Roorda et al., Adv. Master. 16 (2004) 235.
[2] M. Toulemonde et al, Nucl. Instru. and Meth. B166-167 (2000) 903.

FRI-NSF04-2 #498 - Invited Talk - Friday 8:30 AM - Trinity Central

Spatial Control of Nanoparticles by Patterned Ion Implantation

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Ion beam-based techniques offer various spatial control methods of nanostructures, either by masked implantation or by patterned interaction with ion implantation. The conventional masked implantation can be conducted with a stencil mask, which is typically prepared by lithography or FIB etching. A convenient method to prepare a mask is to employ naturally existent stencils, such as an anodic-oxidized porous alumina or a silica-bead membrane. Another method is to control perturbation fields interactive with implants. Patterning of metal nanoparticles embedded in insulators is one of the most attractive for plasmonic applications.

In this paper, we present attempts to control nanoparticles by laser co-irradiation or nano-indentation combined with ion implantation. For the atom-supply control, masked implantation has also been done with a lithography-mask and a porous alumina mask. Amorphous silica was irradiated with 60 keV Cu^-. Simultaneous laser (532 nm) irradiation under ion implantation tends to enhance surface plasmon resonance, i.e., nanoparticle precipitation/growth. Nano/micro-indentation in periodic arrays enhanced nanoparticle precipitation under Cu ion implantation. Advantage of the both perturbation methods is self-assembly of nanoparticles and they can be used for controlling nanoparticle assembly. However, the spatial resolution is limited to the perturbation size (~1 μm).

Masked implantation with either a lithographic mask or a porous-alumina membrane is a reliable method to reproduce the mask pattern into the substrate. Usage of a nano-sized mask may lead to the nano-patterning. However, the blurring of patterning becomes non-negligible due to peripheral effects, as the mask size decreases to a nano-size. The problems for patterning nanoparticles will be discussed.

FRI-NSF04-3 #399 - Invited Talk - Friday 8:30 AM - Trinity Central

Organized Nanostructures Induced by Very Low Energy Ion Beam

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Small metal and/or semiconductor nanodots embedded in a dielectric matrix, i.e. quantum dot composites (QDCs), have recently attracted much attention because of their potential applications in novel optical, photonic, and electronic devices. These applications include single electron devices, nonvolatile memory cells based on quantum dot charge storage in metal oxide semiconductor (MOS) structures, ultrafast nonlinear all optical switching networks, quantum dot based solar cells, and quantum computing.

Much fundamental scientific interest in the formation of QDCs and device fabrication from them has been stimulated by these prospects. For application purpose, the ideal QDCs should have nanodots that are homogeneous in composition and structure, distributed in ordered lateral and vertical configurations, and thermally stable. The fabrication technique of QDCs should be capable of producing arbitrary combinations of nanodots and hosts in order to tailor the material functions for specific applications. In this sense, extensive research on the control over the material structures such as nanodot morphology and their distribution in QDCs using a mature Si technology, ion implantation, is necessary.

Our recent study has demonstrated that ordered two-dimensional metal and semiconductor nanodots could be formed by implantation of very low energy ions into either bulk or thin film SiO2 matrixes. The nanodots have a uniform size distribution with small deviation, almost constant edge-to-edge spacing between neighboring nanodots in the lateral direction, and an

extremely confined narrow depth distribution. They can exhibit either non-crystalline or crystalline structure depending on the fabrication conditions. This kind of two-dimensional nanostructure would have potential application in nonvolatile memory cells using MOS structures with higher programming speed, lower power consumption, and longer retention time.

FRI-NSF04-4 #326 - Invited Talk - Friday 8:30 AM - Trinity Central

Self-Organized Layering in the Growth of Phase-Separated Films under Ion Bombardment

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We review our work of self-organized layering in ion beam assisted deposition of Au-silica and Au-Ni films. The self-organization process is attributed to the competition of bombardment-induced segregation and uphill diffusion within the advancing nanoscale subsurface zone in the film growth. We applied kinetic Monte Carlo simulations to show the effect of such a competition on the film structures. Our observations suggest that ion beams can be employed to control the film structures in the deposition of phase-separated systems.

FRI-NSF04-5 #27 - Invited Talk - Friday 8:30 AM - Trinity Central

Effect of Metal and Metal Gas Hybrid Ion Implantation on Properties of Various Materials and their Possible Applications in Industry

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[(4)]Lawrence Berkeley , National Laboratory, Berkeley CA, United States
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From as far back as its conceptual inception, we recognised the significance and great potential for industrial application of the MEVVA ion implantation facility, and the work that has been carried out on it has been overwhelmingly market-oriented research. The list of research work that has been carried out with this facility is large, and includes the following;

- Improvement of tribological characteristics and wear resistance of orthopedic implants, both of the polymer (UHMWPE) from which the acetabular cup is made, and the metal alloy articulating part which mates with the cup,

- Biological cell attachment and biocompatibility studies of titanium implanted with zirconium, for human body implant application,

- Antibacterial and cell attachment tests of ion implanted UHMWPE, textile fabrics and leathers (without changing their bulk properties, they can be made to gain an antibacterial, increased UV protection-factor of 30, increased resistance against wear, and hydrophobic properties),

- Surface properties of Glassy Polymeric Carbon nano-composites implanted with oxygen and nitrogen, including cell-attachment were also investigated.

The results related to the above work will be presented and discussed.

FRI-IBA06-1 #329 - Invited Talk - Friday 11:00 AM - Pecos II

The He solubility limit in buried Cu-Nb interfaces

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We apply nuclear reaction depth profiling and transmission electron microscopy to determine an upper bound on the solubility of implanted He^3 at buried interfaces in Cu-Nb multilayer nanocomposites. We find that the critical He concentration necessary

for precipitation of bubbles at Cu-Nb interfaces is in the range of several percent. By contrast, in bulk crystalline metals precipitation begins at concentrations on the part-per-trillion level. Atomistic Monte-Carlo simulations are used to demonstrate that this elevated interfacial He solubility arises from the structure of Cu-Nb interfaces, which contain a large number of high free-volume sites that can accommodate the implanted He. These findings pave the way for the design of nanocomposites that do not swell in nuclear reactor environments. We acknowledge the support of the LANL Directed Research and Development program, a LANL Director's fellowship, and the DOE Office of Basic Energy Sciences.

FRI-IBA06-2 #153 - Invited Talk - Friday 11:00 AM - Pecos II

Strain Depth Profiling of III-V Semiconductors by Using Channelling Rutherford Backscattering Spectrometry Analysis

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Control of strain and composition of III-V semiconductors is critical for their optoelectronic and microelectronic applications. In this study, we applied the technique of channelling Rutherford backscattering spectrometry (RBS) to measure strain in AlN, InN, AlGaN, InGaN, AlInN, AlInGaN, and InGaAs. For strained structures, tetragonal distortion along the growth direction result in a reduced angle between the sample normal and off-normal channelling axes. Thus, the shift of RBS angular scan dip can be used to determine tetragonal strain. By selecting the different energy window of the channelling RBS spectra, the elastic strain as a function of depth can be quantitatively determined. The study provides valuable information for device application of model III-V semiconductors.

FRI-IBA06-3 #380 - Contributed Talk - Friday 11:00 AM - Pecos II

Compositional and strain characterizations of Ion Beam synthesized GexSi1-x thin film

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Compressively strained Ge-rich GeSi thin film is a suitable candidate for high mobility microelectronic devices as well as for higher hole-mobility channels in silicon based heterostructure. Ge-rich thin film is synthesized by ion implantation and subsequent segregation by thermal oxidation where ‘snow-plowed' Ge has shown to form GeSi film which is expitaxially oriented on the underlying silicon substrate. The thickness and composition are controlled by Ge fluence and oxidation conditions. Below a critical thickness GexSi1-x adapts the substrate silicon lattice parameter pseudomorphically. Biaxial compressive stain of pseudomophic Si:Si1-xGex heterostructure exhibits higher carrier mobility. The downside is that the buildup of strain energy leads to the plastic deformation of the film above the critical thickness. Thin film composition and thickness are determining factors of strain in Si:Si1-xGex heterostructure. In the present study, ion beam synthesized Si:Si1-xGex heterostructure are characterized by high depth resolution grazing angle Rutherford backscattering and Raman spectrometry for thickness, composition and strain measurements. Standard Si (100) and Si (111) wafers were implanted with Ge-ions with the fluencies ranging from 5×1015 to 4×1016 atms/cm2 followed by thermal oxidation at different ambient with temperatures ranging from 900 to 1050 °C to attain different composition and thicknesses covering critical thickness region of pseudomorphic Si:Si1-xGex heterostructures. Ge-Ge, Si-Ge and Si-Si phonon wave number shifts are used for strain characterization. The relative influence of implantation ion fluences, oxidation condition and thin film thickness and compositions on the biaxial strain of the thin film will be reported and optimal parameters for pseudomorphic Si:Si1-xGex heterostructures will be discussed.

FRI-IBA06-4 #128 - Contributed Talk - Friday 11:00 AM - Pecos II

IBA with high resolution gas ionization detectors

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In recent years the energy resolution of gas ionization detectors has been dramatically improved for low energy ions. The most important enhancement has been obtained by the use of thin and homogeneous entrance windows and low noise electronics. The energy resolution of gas ionization detectors for ions in the low MeV region has now surpassed the resolution of silicon charged particle detectors for ions heavier than Li and is virtually equal even for helium. For protons of a few hundred keV an energy resolution of 10 keV is now reached. For He ions below 1 MeV the resolution is around 13 keV. For ions heavier than Cl of a few MeV, Si detectors are outperformed by gas filled devices by a factor of 3 or more.

Ionization chambers do not suffer from any radiation damage. They can be produced with large active areas and offer position sensitivity. If used with low velocity ions, the necessary length is only a few centimeters. Therefore, they have become now a

valuable alternative to silicon detectors. After being very successfully used for several years in low energy accelerator mass spectrometry, this technology is now ready to be applied in low energy IBA. Since all types of particles from protons to heavy ions can be detected with good energy resolution in a single, versatile detector these devices can not only be used for elastic recoil detection but also for backscattering spectrometry. An overview of the present status and potential of the technology will be given and recent results of detector performance for backscattering spectrometry with helium and heavy ions will be presented.

FRI-IBA06-5 #315 - Contributed Talk - Friday 11:00 AM - Pecos II

Compositional Analysis on SiO2/SixGex Multilayers byIon Beam Depth Profiling

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Depth profiling has been performed by using Rutherford backscattering spectrometry (RBS) on thermoelectric devices. The film consists of 50 alternating electron beam evaporated layers of SiO2/Si1 − xGex, each layer between 3-5 nm. The composition rate of films was determined by Rutherford backscattering (RBS) spectroscopy and thickness measurement was done by optical interferometer. The samples were bombarded by 5 MeV Si ions at the following dosages of 1x1013, 5x1013,1x1014, 5x1014,1x1015, 5x1015 ions/cm2 to induce the formation for nanocrystalline structures.

FRI-IBA06-6 #192 - Contributed Talk - Friday 11:00 AM - Pecos II

Atorvastatin? Quantification in Anti-Hyperlipidemic Commercial Solid Drugs using the PIGE Technique

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The quantification of the active ingredient (AI) in drugs is a crucial and important step in the drug quality control process. This is usually performed by using wet chemical techniques like LC-MS, UV spectrophotometry and other appropriate organic analytical methods. In the case of an active ingredient contains specific heteroatoms (F, S, Cl…), elemental IBA techniques can be explored for molecular quantification. IBA techniques permit the analysis of the sample under solid form, without any laborious sample preparations. This is an advantage when the number of sample is relatively large.

In this work, we demonstrate the ability of the Thick Target PIGE technique for rapid and accurate quantification of low concentration AtorvastatinTM in commercial anti-hyperlipidemic drugs. The analyzed drugs (Lipitor®, Liponorm® and Storvas®) have slight difference between their matrix and the pure AtorvastatinTM used as external standard. The experimental aspects related to the quantification validity are presented and discussed.

FRI-IBA06-7 #165 - Contributed Talk - Friday 11:00 AM - Pecos II

Characterisation of Gunshot Residue Particles using Simulatenous Treatment of PIXE and RBS Spectra

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The problem of identifying gunshot residues found on a suspect has challenged forensic scientists for many years [1]. Police authorities routinely use SEM/EDX to identify gunshot residue particles, and it has been suggested that the technique could be used to distinguish between residues from different ammunition powers [2]. However, it has proven difficult, if not impossible, to distinguish between some ammunition powders using this method [2], [3] and there is a particular problem with identifying residues from lead free ammunition powders. Microbeam PIXE/RBS is a more suitable technique to characterise such material because of the higher sensitivity to trace elements and the ability to gain an absolute determination of the concentrations of elements present, including their distribution with depth.

In this work, samples of gunshot residue were collected from the hands of different shooters who had fired guns containing different respective ammunition powders. Individual particles within the samples were analysed using a 2.5MeV H+ beam focussed to 4um.

The composition of each sample was determined by self consistent treatment of the RBS and PIXE spectra for each sample. This was done using the newly implemented PIXE module in the Datafurnace simulated annealing algorithm [4]. This allows accurate determination of the matrix composition (and its variation with depth) by RBS. Self consistent fitting of the PIXE spectra simultaneously with the RBS spectra allows the absorption of X rays in the sample to be accurately calculated. This allows the

composition of the residue particles to be determined unambiguously and with a higher sensitivity to trace elements than conventional methods.

[1] F S Romolo et al, Forensic Science International, 119, (2001) 195-211
[2] Z Brozek-Mucha et al, Forensic Science International (2001), p.39-41
[3] A Martiny et al, Forensic Science International (2007), doi 10.1016/j.foresnciint.2007.07.005
[4] C Pascual Izarra et al, NIMB, 261 (2007), 426-429

FRI-MR03-1 #252 - Invited Talk - Friday 11:00 AM - West Fork

Performance of a Lanthanum Bromide detector and a new conception collimator for Radiopharmaceuticals Molecular Imaging in Oncology

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Over the last years there has been a growing interest in the development of a new class scintillators like LaCl3:Ce and LaBr3:Ce, brighter than the sodium iodide, and featuring an extremely fast emission time, attractive as for SPET and PET applications in medicine. Either in pixilated or continuous configurations, these scintillators have shown a remarkable space resolution. Moreover, having a low melting point, they may in the long run become cost-effective and suitable for large detection areas.

Tests of new drugs in Oncology may consist in inoculating small animals with radio-labelled bio-molecules and imaging their distribution through a SPET (Single Photon Emission Tomography) that for such small subjects requires high resolution detectors and collimators. We propose here a detecting system consisting of a prototype collimator, a LaBr3(Ce) continuous crystal, and position sensitive photomultiplier tube Hamamatsu H8500. In particular, the collimator has been jointly developed with the company "Nuclear Fields", and features hexagonal parallel holes in lead, a large area, but quite small features (1.0 mm hole diameter, 18 mm length, 0.2 mm septa and 10x10 cm2 of useful detection area), in order to match the high spatial resolution of a LaBr3(Ce) continuous scintillation detector that we recently developed.

We have evaluated this system as for spatial resolution and sensitivity. We have also compared it to other three systems, similar as for crystal and photo-multiplier, but employing three traditional collimators, either pinhole or parallel. The test consisted in scanning the detector field of view at different source-to-collimator distance using a Co57 point source. We eventually show here how this prototype, allowing a very attractive trade-off between spatial resolution, sensitivity and detection area, outdoes other existing detectors and proves to be particularly suited for small animals SPET in radionuclide molecular imaging applications.

FRI-MR03-2 #535 - Invited Talk - Friday 11:00 AM - West Fork

Radiolabled polymeric nanoparticles for imaging Alzheimer's plaques in a mouse model of Alzheimer's' Disease (AD)

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Hallmark of Alzheimer’s disease (AD) is the presence of senile plagues and neurofibrillary tangles in the brain. Conventional methods of imaging such as CT, MRI are not very helpful in identification of the brain lesions in AD patients. Brain imaging to measure brain blood flow or 18FDG (fluorodeoxyglucose), positron emission tomography (PET) is being used in diagnosis of AD. However, they are not specific. It would be desirable to develop imaging technique to directly identify the presence and extent of plaques in AD patients.

The main component of plaques consists of deposits of aggregates of A-beta peptide; breakdown products of amyloid precursor protein (APP). A number of derivatives of Congo red and thioflavin (dyes that stain plaque) are being evaluated as imaging probes. Amongst these, Pittsburgh compound B (PIB) labeled with 11C has shown promise. The short half life of 11C (t1/2: 20 minutes) limits its application. We have shown that, clioquinol (CQ) (5-chloro-7-iodo-8 hydroxy quinoline) can be radioiodinated and has rapid brain uptake and fast clearance from the blood and brain in normal mice. In order to enhance its brain uptake and retard the fast brain clearance, we incorporated it into polycyanoacrylate nanoparticles. We studied its biodistribution in normal mice and experimental AD mice. AD lesions were created by administration of preformed aggregates of A-beta peptide (A?Ò-42) into hippocampus of mice using a stereotactic device. Biodistribution and ex-vivo autoradiography of the brains of mice injected with nanoparticles incorporated with radioiodinated (125I) CQ showed that: 1. nanopartilces enhanced (1.5-2 times) the brain

delivery of the 125I-CQ and 2. experimental animal brains had positive autoradiograms compared to the control animals and animals injected with the free drug. Our data indicate that butyl cyanoacrylate nanoparticles may be used as drug delivery vehicles with amyloid specific dyes for imaging AD.

FRI-MR03-3 #619 - Invited Talk - Friday 11:00 AM - West Fork

Comparison of X-ray and Proton Radiographs for Localization of Patients Treated for Prostate Cancer

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Because of its advantageous dosimetric characteristics, there is growing interest in using proton beams to treat a variety of adult and pediatric cancers. Currently, patient set-up is routinely verified through the use of onboard x-ray imaging systems. However, although rarely utilized in the clinic, radiographs acquired with proton beams - among other advantages - may provide a more detailed and convenient means for assessing patient position. The purpose of this study was to compare the image quality of proton radiography with x-ray radiography. Transmission radiographs were simulated using x-ray and proton beams using a Monte Carlo model of a passive scattering proton therapy beam line and voxelized model of a prostate patient. The proton radiographs provided adequate image quality while offering the advantage of directly verifying the position of the patient relative to the treatment portal. These results indicate that proton radiography can potentially improve verification of patient setup before the delivery of treatment fields.

FRI-MR03-4 #637 - Invited Talk - Friday 11:00 AM - West Fork

Labeling of peptides with In-111 for a steril non-pyrogenic inject able drug for terminal cancer patients.

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In Situ Radiotherapy with 111In-Pentetreotide: Initial Observations and Future Directions

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Purpose: Somatostatin and its analogues, such as octreotide and lanreotide, are used to treat neuroendocrine malignancies. Somatostatin analogues bind to somatostatin receptors (sst 1 -5), which are differentially expressed in a wide variety or neoplasms. Following ligand receptor binding, a fraction of these complexes internalize. Internalization of radiolabeled somatostatin analogues, especially those that emit Auger electrons, may allow treatment of somatostatin-receptor-positive tumors by delivering a radioactive isotope to the cancer cell in targeted fashion. 111In-pentetreotide, an sst-2-preferring somatostatin analogue, has been used for scintigraphic evaluation and management of neuroendocrine cancer patients. We hypothesized that binding and internalization of 111In-pentetreotide, an Auger electron emitter, may induce receptor-specific cyto-toxicity and could be a useful therapeutic agent in somatostatin - receptor - expressing malignancies.

Methods: To test this hypothesis, subjects who had failed conventional therapy and had somatostatin-receptor-positive malignancies, as determined by positive uptake on a 6.0 mCi 111In-pentetreotide scan, were treated with two monthly 180 mCi intravenous injections of 111In-pentetreotide. CT scans were obtained before therapy and within 30 days following the completion of the second 111In-pentetreotide dose. Toxicity was evaluated using standard criteria.

Results: Fourteen patients were studied from February 1997 to August 1997. Clinical benefit occurred in six of 10 gastroenteropancreatic tumor patients. Objective partial radiographic responses occurred in two of 14 patients, and significant tumor necrosis (defined by changes in Hounsfield units) developed in six of the 10 gastroenteropancreatic tumor patients. Possible treatment-related toxicity included two patients experiencing grade ¾ myelosuppression, and two patients had no measurable toxicity. The most common toxicity was grade ½ hemoglobin (N=6).

FRI-NBA06-1 #505 - Invited Talk - Friday 11:00 AM - Bur Oak

Fluorescent X-Ray Computed Tomography towards Molecular Imaging: Proof-of-Concept Experiment

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Fluorescent x-ray CT (FXCT), which combines x-ray fluorescence measurements and tomographic reconstruction algorithms, non-invasively allows investigating trace elements distribution inside a sample with high sensitivity at high spatial resolution. Use of synchrotron radiation (SR) empowers FXCT to obtain a resolution of um. FXCT has been an indispensable microscopically-analyzing tool in materials and biomedical sciences. Another potential of FXCT would be a molecular imaging with non-radioactive imaging-agent distribution such as iodine; in medicine and pharmacology, one desires to visualize the process of various diseases through in-vivo imaging ligands in a small animal for discovering drugs and elucidating patho-physiology. For this purpose, PET or SPECT for small animal have been developed in spite of their insufficient spatial resolution not higher than 1 mm. On the other hand, SR-FXCT will enable a sub-millimeter resolution. However, this approach is hampered by the long measurement time; the conventional FXCT is based on the first generation type of CT to acquire a set of projections by translation and rotation scans in pencil-beam geometry. Therefore, a conventional FXCT cannot be a substitutive tool because PET or SPECT can obtain 3-D images.

We propose the novel imaging geometry of fluorescent x-ray computed tomography using an array of detectors with an incident sheet-beam, which aims at a molecular imaging for small animals. In this research, we prove the concept and investigate the imaging properties such as spatial and contrast resolutions and quantitativeness by imaging an acrylic phantom and a normal mouse brain excised and fixed by formalin with the preliminary imaging system using a monochromatic synchrotron x ray. From the results, the spatial resolution and the minimum detectable limit of iodine concentration were about 0.35 mm and 5.0 ug/ml, respectively. Iodine content in the mouse brain was estimated to be about 20 ug/ml from the phantom experiments.

FRI-NBA06-2 #577 - Invited Talk - Friday 11:00 AM - Bur Oak

Synchrotron radiation based imaging methods for industrial applications at the German light source ANKA

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ANKA is a synchrotron facility at the Forschungszentrum Karlsruhe (Karlsruhe Research Center), operated by the Institute for Synchrotron Radiation (ISS) with user operation since 2003. ANKA is part of the national and European infrastructure offered to scientific and commercial users. Commercial users have full access to the ANKA facility on a contractual basis via ANKA's commercial services.

An imaging group within the ISS works on the development of instrumentation and methods as well as the application of imaging methods within inhouse research or projects with scientific and commercial users. Part of the activities of the group is also the management plus scientific participation in an European project for the development of novel X-rays detectors based on thin scintillating crystals. These novel detectors will be characterized and used at ANKA for topography and microtomography.

The white beam synchrotron topography as performed is based on recording a Laue-pattern of reflections where each reflection contains a topograph from the same investigated crystal position. The method is of high interest for the semiconductor industry as topographs deliver non-destructively information about e.g. dislocations and dopant inhomogeneities within a single-crystal. Mapping for example a selected topograph of a 300 mm Si-wafer allows to detect local defects which can lead to failures and losses in the production of semiconductor devices.

High resolution and phase contrast radiography is used to investigate micro-structured, multi-component material systems, e.g. to detect delaminations between substrates and glob tops encapsulating wire-bonded devices. Radiographs taken from different projection angles for computed micro-tomography allow to image objects in three dimensions with a spatial resolution down to the sub-micrometer range, e.g. bio-ceramics in regenerating bone. The application of 3D image analysis methods derived from stochastic geometry can be used for the determination of size distributions, orientations or spatial correlations within the tomographic, multi-constituent volume images.

FRI-NBA06-3 #72 - Contributed Talk - Friday 11:00 AM - Bur Oak

Utilization of advanced micro-CT to image rat lumber vertebra using 20, 25 and 30 keV synchrotron X-rays

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Micro-tomographic imaging with a spatial resolution on micrometer scale offers a potential tool for making certain types of measurements that were not feasible with other techniques or conventional methods. The synchrotron X-ray source gives substantial advantages because of its high brilliance and continuous X-ray spectrum. The superior properties of the synchrotron source have lead to micro-tomography instrumentation capable of superior spatial resolution and shorter data acquisition time. (1) The active use of micro-tomographic imaging is just beginning.(2) The present study is based on visualization of microstructure of rat's lumber vertebra using 20, 25 and 30 keV synchrotron X-rays for multi-model imaging with the data acquired at different energies and to estimate the Ca / P ratio. However, the visualization is purely at a fundamental level in order to know the radiation interactions and attenuation with in the embedded soft-tissue. (3) The image analysis will be extended to other 3D images to predict the suitability of this procedure for 3D analysis of bone microstructure at optimum energy, in order to know more about morphological changes.

(1) We acquired the images at different energies (2) State of decline of density and mineral content (3) Selection of optimum energy for routine clinical use based on the results (4) To know the porous and micro-architecture of the rat lumber vertebra (5) Calibration with hydroxyapatite using synchrotron X-rays (6) To develop an imaging technique to distinguish soft tissues in a matrix of hard tissues.

This approach is entirely new. As such there is no constructive research, utilizing the images for the estimation of the calcium content, with synchrotron X-rays. The results are based on the analysis of images and gray values obtained at different energies. We use this new method to measure the calcium content using high resolution synchrotron micro-CT.

FRI-NHS05-1 #382 - Invited Talk - Friday 11:00 AM - Brazos II

Studies of discharge characteristics in a cylindrical inertial electrostatic confinement fusion device as a neutron generator

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An inertial electrostatic confinement (IEC) fusion device is an alternative concept for neutron generation for its simple configuration and long lifetime. In IEC, the neutron production rate and its yield efficiency increase with the applied voltage. In our previous experiments, however, we have found that it is difficult to increase the applied voltage beyond certain point due to a unique characteristic of glow discharge. Therefore, to broaden operating regime, a new cylindrical IEC device has been developed and its performance is being investigated for various conditions such as gas pressures, electrode shape and sizes. Separately, the 2D particle-in-cell code has been developed and applied to explain the difference in operating regime of these two devices.

FRI-NHS05-2 #239 - Invited Talk - Friday 11:00 AM - Brazos II

Research and Development of Compact Neutron Sources based on Inertial Electrostatic Confinement Fusion

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An Inertial Electrostatic Confinement (IEC) fusion device consists basically of a spherical anode at grounded potential, and a highly transparent cathode grid at the center with a negative bias of ~100 kV. Deuterium ions are accelerated to the center as they gain energy from the applied electric fields and the spherical focusing of ions results in fusion reactions through beam-beam or beam-background gas collisions. The use of the highly transparent cathode grid minimizes the ion loss to the grid and allows the recirculation of energetic ions.

Unlike beam-target-based fusion neutron generators, the use of ?plasma target' allows an intense input power of the deuterium beam leading to a high neutron output, though the efficiency is low. The smallest IEC neutron source (a 20-cm sphere) has been developed at the Institute of Advanced Energy, Kyoto University, which produces D-D neutrons more than 10^7 per second in

steady-state without cooling of the inner cathode grid. Water-cooling of the chamber (outer anode) enables an input dc power of 6.4 kW (80 kV, 80 mA) for a stable continuous operation for more than 8 hours, and ~100 hours total so far without maintenance.

The fusion efficiency in the present IECs is supposed to be limited by the rapid loss of ion energy by charge exchange collisions with background neutrals. To date, several efforts are being made to reduce the operating gas pressure, while the scaling of neutron flux with the current remains linear, i.e. beam-background gas collision regime, where little enhancement is expected because of the reduced target density. A built-in ion source scheme by use of dc magnetron discharge is being studied intensively aiming at a drastically improved ratio of the current to the pressure to fulfill the nonlinear beam-beam collision regime.

FRI-NHS05-3 #366 - Invited Talk - Friday 11:00 AM - Brazos II

DEVELOPMENT OF AN ELECTROSTATIC FIELD DESORPTION ION SOURCE FOR ACTIVE NEUTRON INTERROGATION

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A collaborative design effort is underway for an electronic neutron tube based upon a unique ion source concept that uses high electrostatic fields (10-40 V/nm) to form pure atomic deuterium ions. Relying upon electrostatic field desorption of ions from a conductive surface, rather than ions produced from a deuterium plasma, this new concept has the potential to surpass current state of the art sealed neutron tube designs in many key performance areas including lifetime, reliability, efficiency, and neutron yield. The neutron generator yield in this design scales with the ion current which scales in proportion to the area of the conductive surface. The ion source is comprised of a microfabricated array of field tips based on the geometry of field emission arrays. Electrostatic modeling and simulations have aided the design of the arrays. Single etched wire tips have been used to test and calibrate ion current measurement techniques as well as to develop and test the performance of tip materials and tip surface cleaning procedures. Several iterations of tip arrays have been fabricated and tested. Ion current measurements were made and will be discussed.

FRI-NHS05-4 #39 - Contributed Talk - Friday 11:00 AM - Brazos II

Carbon Nanotube Based Deuterium Ion Source for Improved Neutron Generators

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We are developing a novel field ionization technology using carbon nanotubes (CNT) to produce the ion current in a neutron generator, enabling fast switching, high repetition rate and high yields. Carbon nanotubes possess two unique characteristics suited to this application: they have inherent hydrogen storage capacity and can be used as electron sources for e-beam applications including field emission and field ionization. The neutron generator will consist of three major components: an emission electrode made of carbon nanotubes, a smooth negatively biased target electrode, and a secondary electron suppression system. When a negative high voltage is applied on the target electrode, a high gradient electric field is formed at the tips of the nanotubes that can pull atomic deuterium (D+) ions from the anode surface (field ionization) while leaving the electrons behind. Beamlets of D+ ions from each nanotube will then be accelerated and impinge on the target with high energies, causing (d,n) reactions to occur and the production of neutrons. A large quantity of secondary electrons will also be generated when the D+ ions impinge on the target cathode surface, so a cross magnetic field will be used to suppress these secondary emission electrons on the target surface. We present preliminary results of a proof-of-concept demonstration of neutron generation from a small prototype device.

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FRI-NHS05-5 #120 - Contributed Talk - Friday 11:00 AM - Brazos II

Development and Testing of an Ultra Compact Piezotransformer Driven,Pulsed Neutron Source*

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We are presently developing an ultra compact D-D neutron source for various defense and homeland security applications. The device utilizes a high current, pulsed surface flashover ion source, a multilayer high gradient insulator, and a compact >1 MV, piezotransformer driven Cockroft-Walton power supply. Our development goal is to achieve greater than 10(sup)6 neutrons/s with the onset of directionality. Thus far we have shown >10(sup)6 neutrons/s at a 100 kV accelerating voltage for ~20 ns wide pulses and a 1 kHz PRF. We report on our work to increase the acceleration potential to >1 MV and increased repetition rate.

This work was supported by the Defense Advanced Research Projects under contract 1026419 with the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344.

FRI-NHS05-6 #68 - Contributed Talk - Friday 11:00 AM - Brazos II

Neutron generator for associated particle imaging

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We present work on a prototype compact neutron generator for associated particle imaging (API). API uses the alpha particle that is produced simultaneously with the neutron in a deuterium-tritium (2D(3T,n)4α) fusion event to track the position of the neutrons. This method determines the spatial position of each neutron interaction, and in order to have high spatial resolution, the neutrons should be generated from a nearly "point source". The neutron generator for API is designed to produce a focused ion beam with a beam spot diameter of 1-mm or less on the target. We use an axial type neutron generator with a predicted neutron yield of 10^8 n/s for a 50 μA D/T ion beam current accelerated to 80 kV. The device utilizes a RF planar spiral antenna at 13.56 MHz to create a highly efficient inductively-coupled plasma at the ion source. Experimental results showed that beams with an atomic ion fraction of over 80% can be obtained while consuming only 100 watts of RF power in the ion source. A single acceleration gap with a secondary electron suppression electrode is used in the tube. Experimental results from the ion source testing, high voltage testing, and ion optics and beam spot size measurements will be discussed.

FRI-NHS05-7 #99 - Contributed Talk - Friday 11:00 AM - Brazos II

Performance of a compact gamma tube

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High-energy monoenergetic gammas can efficiently induce detectable signals in fissile materials while minimizing absorbed radiation dose and background from surrounding materials. Performance tests were made on a first-generation axial-type gamma tube that utilizes the 11B(p,g)12C nuclear reaction resonance at 163 keV to produce monoenergetic12-MeV gamma-rays. The gamma tube employs a water-cooled cylindrical radio frequency (rf) induction ion source capable of producing a proton (H+) current density of up to 100 mA/cm2. The extracted protons are focused, accelerated, and bombard a lanthanum hexaboride target at energies up to 200 keV. Gamma intensity was measured as a function of proton energy, beam current and detector angle. The measured results were compared to yield calculations from MCNPX. Preliminary photofission measurements were made with depleted uranium (DU) and compared to MCNPX simulation results. Some applications and future improvements of the gamma tube will be discussed.

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FRI-NHS05-8 #88 - Contributed Talk - Friday 11:00 AM - Brazos II

A Tandem-Based Compact Dual-Energy Gamma Generator

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A mono-energetic dual-energy photon source is being developed that utilizes the nuclear reaction resonances of protons with boron at 163 keV and with fluorine at 340 keV to produce, respectively, 12-MeV and 6-MeV gammas. The photon source is based on a tandem accelerator configuration in which negative hydrogen ions (H^-) are accelerated to the centrally located high voltage terminal. An RF-driven H^- ion source is being tested to measure the ion beam current and the co-extracted electron current. These electrons must be trapped before they are accelerated to high voltage. The design of the electron trap and the low energy beam transport section is done by computer simulation using an ion optics code. The H^- ions at the high voltage terminal are converted to neutral (H^0) atoms as well as positively charged (H^+) ions with an electron stripper (either a gas cell or a thin foil). The positively charged ions, since they are created at the high potential, will be accelerated again towards the target at ground potential gaining twice the energy of the neutral beam. Thus, the tandem method reduces the high voltage power supply requirement as well as the overall size of the system. Here, we describe the mechanical design of the tandem-based gamma tube and preliminary results from the ion source testing.

Work performed under the auspices of the US Department of Energy, NNSA Office of Nonproliferation Research and Engineering (NA-22) by Lawrence Berkeley National Laboratory under Contract DE-AC02-05CH11231. Sandia is a multi-program Laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

FRI-NP08-1 #545 - Invited Talk - Friday 11:00 AM - Brazos I

Use of Resistive Plate Chambers in the Upgrade of the PHENIX Forward Spectrometers

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Resistive Plate Chambers (RPCs) are being used for a number of applications outside of the fields of nuclear and particle physics. These include large arrays for neutrino detection and various imaging applications. A brief summary of RPC applications will be given, but the talk will focus on the specific application of a muon trigger upgrade for the PHENIX experiment at the Relativistic Heavy Ion Collider (RHIC). A large portion of the RHIC scientific program is devoted to a study of the origin of the proton spin. A part of this program is to determine the contribution to the proton spin of the up and down quarks and anti quarks. The PHENIX experiment will study these contributions using the forward muon spectrometers to observe muons from the decay of W bosons produced in the collision of 100 and 250 GeV polarized protons. Due to the high muon backgrounds the forward spectrometer triggers will be upgraded using a series of RPCs with bakelite gaps to track charged particles and provide prompt signals for the trigger. The layout for the upgraded spectrometers will be given along with a discussion of the background rejection expected. A series of RPC prototypes have been built and testing procedures will be discussed. Test results on timing, efficiency and spatial resolution will be shown.

FRI-NP08-2 #641 - Invited Talk - Friday 11:00 AM - Brazos I

STAR Vertex Detector Upgrade - HFT Pixel Development

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The STAR Heavy Flavor Tracker upgrade group is working to extend the capabilities of the STAR detector in the heavy flavor domain by providing a tracking system that will allow for very high resolution vertex measurements. This upgrade is designed to allow for the direct topological reconstruction of D and B mesons through the identification of decay vertices displaced from the primary interaction vertex by 100 - 150 microns.

The HFT upgrade, scheduled to be deployed in 2011, consists of two new concentrically arranged detector systems. The inner-most and highest precision system of the HFT tracker will consist of a PIXEL detector with a sub 40 micron DCA pointing resolution. The PIXEL detector will be composed of two layers of Monolithic Active Pixel Sensors (MAPS) that integrate the detector and front-end electronics layers in one silicon die and are fabricated using standard CMOS processes. Each sensor is an array of pixels with 18.4 um pitch giving the Pixel Detector system a total pixel count of approximately 400 M. Achieving the

required pointing resolution constrains the detector to a design limit of < 0.5% radiation length per layer in the sensitive region. Sensors thinned to 50 microns, air cooling, a 500 micron thick Be beam pipe, and aluminum rather than copper conductor readout cables become necessary. The expected final system design is an array of 40 sensor ladders with ten 2 cm x 2 cm sensors per ladder and 10 parallel independent readout systems. The Pixel detector coverage is +/- 1 in eta with the first active sensor layer at a radius of 2.5 cm from the beam axis. We will present the detector design, sensor and readout development and current prototyping results.

FRI-NP08-3 #46 - Invited Talk - Friday 11:00 AM - Brazos I

Updates to the Forward Array Using Silicon Technology (FAUST)

B C Stein[1], S N Soisson[1], L May[1], R Q Dienhoffer[2], M Jandel[3], G A Souliotis[1], D V Shetty[1], A L Keksis[3], S W Wuenschel[1], Z Kohley[1], S J Yennello[1]
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FAUST is a forward array of 68 Si-CsI telescopes which has been in use since 1996. Current advances in technology have allowed for dramatic improvements to the performance of such arrays. To bring this system up to date, new preamplifiers from Zepto Systems have replaced the original Si and CsI preamps. A new calibration software package has also been developed utilizing a novel linearization algorithm. The combination of these two upgrades have led to isotopic identification for elements above the previous Z=8 limit. In addition, FAUST has also been modified to accommodate a new Dual Axis-Dual Lateral position sensitive silicon detector recently developed. This will greatly increase the angular resolution of the existing array. Descriptions and results of each of these upgrades will be presented.

FRI-NP08-4 #639 - Invited Talk - Friday 11:00 AM - Brazos I

The Large Area Time-of-Flight (TOF) Upgrade for the STAR Detector

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The STAR experiment at RHIC concentrates on the tracking of charged hadrons via ionization in gas- and silicon-based detectors, and the detection of electrons and photons via calorimetry, in a wide and azimuthally complete acceptance that's unique at RHIC. STAR's ability to directly identify the tracked charged hadrons is however limited to low momenta. Approximately half of the charged particles in the event at higher momenta cannot be directly identified, which hampers the physics reach of STAR in a number of key areas. To address this blind spot, STAR is presently constructing a large-area (~50 m^2) Time-Of-Flight (TOF) system. This system is based on Multi-gap Resistive Plate Chambers (MRPCs). Prototype TOF systems based on this technology were operated in STAR during RHIC Runs 3 through 6, and the first five final-system trays were operated in the recent Run 8. A new start detector for this system has also been constructed and operated in STAR. The performance of these detectors in STAR, and an update on the status of the construction of the full system, will be discussed.

FRI-NP08-5 #503 - Invited Talk - Friday 11:00 AM - Brazos I

The PHENIX Hadron Blind Detector

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Colorless probes, such as charged leptons, have proven to be useful tools for investigating the dense partonic matter created in RHIC collisions. However, dielectron measurements are limited by the combinatorial background from randomly matched positrons and electrons that do not originate from the same pair. The Hadron Blind Detector will substantially upgrade the ability of PHENIX to reject dielectron pairs produced from the photon conversions and pion Dalitz decays which dominate the low-mass region of the spectrum.

The HBD is a windowless, unfocused Cherenkov detector that utilizes CF4 as both radiator and detector working gas. Triple GEM stacks, which have the upper surface of the top GEM coated with a CsI photocathode, allow detection of Cherenkov photons into the deep UV. The transparency of CF4, high quantum efficiency of CsI in the UV, and absence of a window between the gas radiator and the GEMs allow a large photoelectron yield, while minimizing the hadron signal. Results from the HBD during RHIC's Run 7 and subsequent tests will be discussed.

FRI-NSF05-1 #467 - Invited Talk - Friday 11:00 AM - Trinity Central

Three-Dimensional Nanostructure Fabrication by Focused-Ion-Beam Chemical-Vapor-Deposition

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Focused-ion-beam chemical-vapor-deposition (FIB-CVD) has big advantages and potential in the fabrication of 3D nano-structures. The key issue in making such 3D-work is the short penetration depth of the ions in the target material. This short penetration depth reduces the dispersion area of the secondary electrons, and thus the deposition area is tightly limited to within about several tens nanometers.

Three-D nanostructure fabrication has been demonstrated by 30 keV Ga^+ FIB-CVD using a phenanthrene ($C_{14}H_{10}$) source as a precursor[1]. The characterization of deposited film on a silicon substrate was performed by a transmission microscope and Raman spectrometry. This result indicates that the deposited film is a diamondlike amorphous carbon (DLC) which has attractive interest because of its hardness, chemical inertness and optical transparency. A large Young's modulus that exceeds 600 GPa seems to present great possibilities for various applications [2]. Nanoelectrostatic actuator, and nano-space-wiring with 100 nm dimension were fabricated and evaluated as parts of a nanomechanical system [3]. Furthermore, nanoinjector and nanomanipulator were fabricated as a novel nano-tool for manipulation and analysis of subcellular organelles [4]. These results demonstrate that FIB-CVD is one of the key technologies to make 3D nanostructure devices in the field of electronics, mechanics, optics and biology.

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[2] J. Fujita et al, J. Vac. Sci. Technol. B 19, 2834 (2001).
[3] T. Morita et al, J. Vac. Sci. Technol. B21, 2737 (2003).
[4] R. Kometani et al., J. Vac. Sci. Technol., B23, 298 (2005).

FRI-NSF05-2 #309 - Invited Talk - Friday 11:00 AM - Trinity Central

Metal Nanorod Fabrication

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Gold nanoparticles embedded in silica can be deformed by irradiation with energetic (several MeV) heavy ions. The deformation has been observed in colloidal core-shell particles as well as in thin films, and results in polarization-dependent changes in the surface plasmon resonance optical absorption band. The mechanism by which the deformation occurs has not been fully identified, but appears to be related to the "hammering" deformation known to occur in amorphous silica subjected to heavy ion irradiation. I will discuss this and other possible deformation mechanisms and present experimental data concerning the link between hammering and nanoparticle deformation.

FRI-NSF05-3 #278 - Invited Talk - Friday 11:00 AM - Trinity Central

Nano-Fabrication and Characterization of Individual One-Dimensional Nanostructure Devices

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One dimensional nanostructure materials such as nanotubes and nanowires, which have novel size-dependent electrical and optical properties, are well recognized as building blocks of nanoelectronics. To understand the intrinsic properties of one dimensional nanostructure materials, the fabrication of single nanotube or nanowire devices for electrical characterization is critical. The Focused Ion Beam (FIB) based nanofabrication method combined with conventional electron beam lithography was used to fabricate prototype electrical test structures with various single one dimensional materials and to measure their electrical properties in-situ. This combined method allows the rapid fabrication of prototype nano-devices with a freedom in structural geometry. In this research, we have fabricated single stand-alone devices with various kinds of nanotubes and nanowires including TiO_2 nanotubes, carbon nanotubes, and Si nanowires, for the characterization of their intrinsic electrical properties and potential sensor applications. Three dimensional electrical test structures were also fabricated using a nanomanipulator and their properties were measured in-situ. To the best of our knowledge, this is among the first attempts of electrical characterization of single stand-alone nanostructure devices. The results are presented and discussed.

FRI-NSF05-4 #447 - Invited Talk - Friday 11:00 AM - Trinity Central

Ion-Beam Assisted Fabrication of GaN Nanorods and Applications

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GaN is a direct band gap semiconductor. Its ternary compound with In or with Al could cover a very broad band region, with potential applications in field emission sources, laser sources, light emitting diodes, and high efficiency solar cells. We have studied GaN nanorod formation during MBE growth of GaN film on Si[111] substrates, and nanorod fabrication assisted by ion implantation on Si before the MBE growth. In this talk, we will give a overview on GaN nanorod growth studies, ion beam assisted growth, nanorod characterization, and potential applications of GaN nanorods for field emission and LEDs.

FRI-NSF05-5 #233 - Contributed Talk - Friday 11:00 AM - Trinity Central

Patterned Exfoliation of GaAs Based on Masked Helium Implantation and Subsequent Rapid Thermal Annealing

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A momentary avalanche type exfoliation had been found in GaAs wafers implanted with 100 keV helium ions with fluence higher than 2 x 10^{16} He^{+}/cm^{2} at room temperature and subsequently annealed in the temperature range of 200 ~ 300 C. Based on this preliminary study on the surface morphological change, patterned exfoliation of single crystal GaAs has been tried with high energy (200 ~ 500 keV) He implantation with fluence of (3 ~ 4) x 10^{16} He^{+}/cm^{2} at room temperature through mesh (40 um opening), stainless steel wire (50 um in diameter) or hole masks, followed by rapid thermal annealing at 250 ~ 500 C. The influences of ion energy and fluence, mask pattern and its orientation with respect to the GaAs lattice, and subsequent annealing conditions (temperature and ramp rate) on the patterned exfoliation were studied by Nomarski optical microscopy and field emission secondary electron microscopy. Our results suggest that the microscopic patterning of single crystal GaAs can be realized by selective area exfoliation based on masked helium implantation and subsequent rapid thermal annealing. In grid patterning, the sharpness of the exfoliated border line markedly increases with decreasing exfoliation depth. The exfoliation process is more complete when the ramp rate of the annealing temperature becomes higher and when the mask with straight sharp edges was well aligned with the lattice of the GaAs crystal.

FRI-IBA07-1 #504 - Contributed Talk - Friday 2:00 PM - Pecos II

The ion beam induced luminescence of Mn-doped GaAs thin-film using helium-beam annealing

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The ion beam induced luminescence of Mn-doped GaAs thin-film is analyzed to investigate the re-crystalization of thin film using helium-beam annealing. The modification of electronic band structure is closely related to the formation of Mn cluster in GaAs thin-film. High-sensitivity, high-resolution luminescence spectrum will be further studied to check the scale of re-crystalization and the substitution percentage of of Mn-doping.

FRI-IBA07-2 #419 - Contributed Talk - Friday 2:00 PM - Pecos II

Optimization of Ion-Luminescent Properties of GaN and InGaN/GaN Quantum Well Structures for Application in Ion-Photon Emission Microscopy

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The development of a new microscopy technique, namely ion-photon emission microscopy (IPEM), is crucial for analyzing failure and pinpointing radiation sensitive elements in today's complex integrated circuits. In order for this technique to be useful, a thin (<5 um) self-supporting luminescent layer, demonstrating sufficient quantum efficiency when excited by ions, as well as

rapid decay, must be developed. As a result of their potential for producing high light intensity with short lifetimes, n-type GaN as well as InGaN/GaN multiple quantum well structures grown by Metal-Organic Chemical Vapor Deposition (MOCVD) on sapphire substrates are being studied as possible candidates. These materials have demonstrated two significant ion-luminescence peaks, namely the blue near-band edge emission and the yellow band. These characteristic emissions exhibit very fast (nanoseconds) and very slow (hundreds of microseconds) lifetimes, respectively. Another obstacle entails the removal of this layer from the sapphire substrate, to create a free-standing film, while maintaining a high-quality material. Results from progress on this issue, as well as lifetime measurements, ionoluminescence intensity, and the application of these films in table-top and accelerator-based emission microscopy will be presented.

Sandia is a multi-program Laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

FRI-IBA07-3 #511 - Contributed Talk - Friday 2:00 PM - Pecos II

De-stabilization study by Ionoluminescence of t'-phase zirconia co-doped with Gd and Eu

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[(3)]Radiocarbon Dating and Cosmogenic Isotopes Laboratory, Kimmel Center for Archaeological Sciences, Weizmann Institute of Science, Rehovot 76100, Israel

Novel materials are being developed for thermal insulation of gas turbine engines for power generation, to increase the current operation temperatures. One approach is the implementation of a co-doped tetragonal phase zirconia stabilized with yttria (t'-YSZ) and rare earth oxide additions. This zirconia-based ceramic works as the outer most layer of a thermal barrier coating (TBC) that reduces the operating temperature on the surface of the metallic alloy of the engine. The primary motivation for adding rare earths is to further reduce the thermal conductivity of the coating while preserving the high durability associated to currently used t'-YSZ compositions. Furthermore, research is underway to create thin luminescent sensing layers within the coating at strategic depths to monitor the "health" of the coating using laser-based techniques. A fundamental requirement of any sensor used for this application is that it should be thermodynamically stable within the temperature range of operation (typically from room temperature to ~1200ºC).

The aim of this work is to compare the de-stabilization kinetics of selected single and co-doped t' phase YSZ compositions primarily by X-ray diffraction and Ionoluminescence. The idea is to determine the effects of combining a rare earth dopant (Gd) and a luminescent sensor (Eu) on the phase stability of t' phase YSZ through changes in ionoluminescence. Zirconia-based pellets were prepared by chemical routes for this study; the phase composition was monitored upon isothermal heat treatments at 1350ºC with increasing treatment time. Particle induced X-ray emmission (PIXE) and photoluminescence were also used as complementary techniques to identify possible effects on composition and re-arrangement of dopants before and during phase de-stabilization.

FRI-IBA07-4 #130 - Contributed Talk - Friday 2:00 PM - Pecos II

New High Resolution RBS System

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We summarize the design and performance of the new NEC high resolution, Ångstrom level RBS system, now operational in Japan, including results for 20Å HfO_2 on Si. The detector consists of a solid angle defining aperture and a 305 mm radius, single focusing 90° magnet with a 100mm x 15mm position sensitive, micro channel plate system. Scattered ion energy resolution is about 1 keV, compared to about 15 keV for standard solid state detectors. Mounted on tracks, the detector is easy to move between the 90° and 135° ports on the NEC Model RC43 analysis end station, which has multi-axis sample positioning. Adjustable over a ±5° range of scattering angles at either port, the detector can be accurately positioned for small angle grazing measurements. A terminal ripple reduction system in the Pelletron® accelerator reduces spread in the 400 keV incident beam energy to about 40 eV. Computer controls allow unattended data acquisition with multiple detector signal gating. Off-line analysis provides energy calibration, peak fitting, depth profiles, and reports.

FRI-IBA07-5 #129 - Contributed Talk - Friday 2:00 PM - Pecos II

Annular gas ionization detector for backscattering spectrometry

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A versatile gas ionization detector has been built that is suited to be used for standard 2 MeV He RBS as well as for backscattering spectrometry with any heavier projectile. Thanks to recently developed technology the energy resolution of the device virtually matches the one of silicon charged particle detectors. Below 1 MeV the resolution is close to 13 keV for He.

The new detector has cylindrical shape. It is of annular design and can be placed in-line with the incident beam which passes through its center. This allows scattering angles close to 180° while maintaining reasonable solid angles. It can be integrated into the beam line of already existing analysis chambers. The device is equipped with a circular array of 50 nm thick silicon nitride entrance windows. The length of the chamber and the maximum possible gas pressure allow the detection of particles in a wide energy range. The electrode design is optimized for low capacitance, enabling the best possible performance with low noise electronics. For all ions heavier than Li the energy resolution is considerably better than that of a silicon detector. The device does not suffer from any radiation damage.

Examples for standard 2 MeV He RBS and heavy ion backscattering (HIBS) are shown and compared to results obtained with conventional detectors.

FRI-IBA07-6 #224 - Contributed Talk - Friday 2:00 PM - Pecos II

Studies on Ion Beam Induced Damage in Si during Channeling Rutherford Backscattering Spectrometry Analysis

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Although radiation damage is usually minimized in channelling Rutherford backscattering spectrometry (RBS) analysis, its destructive effects can be an issue under certain analysis conditions. To model the phenomena, we have studied the disorders in Si caused by a He analyzing beam. The model has considered the transition from single scattering to multiple scattering in dechannelling phenomena and also the interstitial-vacancy recombination under room temperature analysis. The model has assumed that displacements are caused only by the dechannelled component of an incident ion beam. As a result of Chi-square curve fitting of RBS spectra which were obtained as a function of charge collection during channelling RBS, we are able to extract dechannelling cross section and defect recombination efficiency (the factor to adjust the prediction from classical binary collision simulation). Based on these results, we provide an energy vs. charge window for RBS user to minimize RBS induced radiation damage.

FRI-NHS03-1 #11 - Invited Talk - Friday 2:00 PM - Brazos II

Detection of illicit drug samples with the EURITRACK system

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The EURopean Illicit TRAfficking Countermeasures Kit (EURITRACK) inspection system has been developed within the 6th EU Framework Program to complement X-ray scanners in the detection of explosives and other illicit materials hidden in cargo containers. Gamma rays are produced inside the cargo materials by 14-MeV tagged neutron beams, which yield information about the chemical composition of the transported goods. In the beginning of year 2007, the EURITRACK system has been implemented in the Seaport of Rijeka, Croatia, primarily to carry out a demonstration with real containers, but also a series of detection tests. This article reports tests performed with real samples of illicit drugs hidden in a metallic cargo with an average density of 0.2 g/cm3. Heroin and cocaine have been distinguished from benign substances from their chemical composition. Marijuana, which chemical composition is similar to benign materials, cannot be distinguished from common organic materials. However, the detection of an unexpected organic substance inside the metallic cargo indicates that a suspect object has been hidden in the container.

FRI-NHS03-2 #12 - Invited Talk - Friday 2:00 PM - Brazos II

Tagged neutrons system based on portable neutron generator for explosives detection in cargo containers

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Prototype of measuring inspection system created in VNIIA and intended for active interrogation of cargo containers to detect high explosives (HE) is presented. The system is based on 14 MeV "tagged" neutron method in combination with nanosecond neutron analysis, as well as detection of characteristic secondary gamma radiation from reaction of inelastic neutron scattering on objects under inspection.

The system includes:

- VNIIA portable neutron generator ING-27 with built-in segmented 9-pixel semiconductor alpha-particles detector (30mm x 30mm),

- 12 scintillation gamma-rays detectors based on bismuth germanate crystal (BGO) with size of 63mm(in diameter) x 63mm,

- gamma detector shielding from primary neutron flux (borated polyethylene + iron),

- electronics for data acquisition and processing system.

Experimental results on detection of 50 kg of HE simulator - melamine (C3H6N6) are presented for different container matrixes (wood, iron) with average density of 0.4 g/cm3 and for different distances of HE simulator from container front wall.

With increase of distance from container wall to melamine the signal-to-background ratio decreases. This is conditioned both by measurement geometry and attenuation of probe neutron beam and produced inelastic gamma-quanta by container matrix.

This work was supported by LLNL (USA)

FRI-NHS03-3 #8 - Invited Talk - Friday 2:00 PM - Brazos II

Material recognition using neutron/gamma interrogation with time tagged fission sources

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Material recognition by measuring simultaneously transmission of neutron and gamma ray from a spontaneous fission source has been studied and the average atomic number resolving power determined. In addition, the possibility of deriving direct signatures able to identify light elements (C,N,O) using the measured transmission versus neutron time of flight is demonstrated. This allows one to determine the relevant elemental ratios (C/O and C/N) that are normally used to identify threat organic materials as explosives and drugs. On the heavy element side, it is proposed that the discrimination between different materials might also by optimized by implementing the measurement of the average absorption coefficient for gamma rays as a function of the energy. This can be measured exploiting the wide energy range of the fission gamma rays. Possible applications of this technique are discussed.

FRI-NHS03-4 #159 - Invited Talk - Friday 2:00 PM - Brazos II

Detection of explosives in the objects on the sea bottom

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Several tests were done with the neutron generator incorporated inside the small submarine equipped also with a few other sensors like video camera and magnetometer. Following the detection of an anomaly on the sea bottom, neutron sensor is requested to check for the presence of the explosive. In the experiment several scenarios were tested: TNT explosive was measured behind the iron shield and behind the sea sediments collected from the sea bottom. Comparison was made with the similar measurements with the TNT explosive replaced by the stones. By measuring the C/O ratio TNT explosive was successfully identified. All the measurements were done first in the air, after that repeated in the freshwater and in the sea water.

FRI-NHS03-5 #473 - Contributed Talk - Friday 2:00 PM - Brazos II

SIMULATION STUDIES FOR THE OPTIMIZATION OF TAGGED NEUTRON BASED EXPLOSIVE DETECTION SYSTEM

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Though x-rays or gamma ray based radiography has been used for a number of years for non intrusive inspection of cargo containers, the fact remains that such techniques are chemically blind as they can identify only shapes and sizes but not the chemical composition of objects being interrogated. Neutron, in particular, fast neutrons based technique remain virtually the only method which has the potential for the identification of materials such as explosive, narcotics and special nuclear materials (SNM) hidden inside large cargo. One such technique namely tagged neutron technique is under active development in some countries for such element specific detection. This technique also has the potential to map spatial distribution of specific element within inspected object which also increases signal to noise ratio considerably.

However there are a number of factor which affect the signal to noise ratio in tagged neutron detection system which will ultimately decide its technical and commercial acceptability. Some major issues which need to be investigated is its performance in a variety of conditions such as change in surrounding material, background noise, optimum number and type of detector, location of detector etc. Since investigation of all possible variations cannot be experimentally carried out due to expensive instrumentation and limited life of neutron tube, simulation has become an essential tool for development of such a technique and indeed for any such neutron based technique.

In order to design such a system for our applications on explosive detection in cargo and large vehicle, we have carried out extensive monte-carlo simulation studies in order to understand the potential and limitations of tagged neutron technique and to design an optimum generator, detector combination. We will present some interesting results of such simulations and some possible optimum design for specific applications.

FRI-NHS03-6 #563 - Contributed Talk - Friday 2:00 PM - Brazos II

Nuclear Solutions for Development: Combined Devices for Explosives Detection & Humanitarian Demining

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Landmines and explosives kill or injure thousands of people a year. With increases in cross-border movement and trade, their detection and removal pose formidable challenges to national and international security. Counting the value of lives lost, property damage, and lost production of goods and services, economic losses resulting from landmine accidents and explosions worldwide are almost immeasurable, with three out of every four casualties being civilian. Security studies say that only a combination of methods for inspection and verification can ensure the safety of goods and personnel. Nuclear technology offers a key option - particularly in verification and confirmation of the presence of explosives. The International Atomic Energy Agency (IAEA) works with experts in Member States to combine nuclear and non-nuclear techniques to achieve greater reliability for detecting explosives. This presentation gives an overview and describes the major activities at Agency's departments. The main topics are a focus on nuclear, essentially neutron based, techniques for the detection of landmines, illicit materials, and explosives. Based on lessons learned from previous results on landmine detections, new activities towards explosives detections have been initiated and elaborated at Technical Meetings. Promising nuclear technology based techniques and preliminary results are described including their limitations. Present and future activities are shown in view of promoting and coordinating actions in interested Member States.

FRI-NHS03-7 #164 - Invited Talk - Friday 2:00 PM - Brazos II

Matrix characterization in threat material detection processes

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Matrix characterization in the threat material detection is of utmost importance, it generates the background against which the threat material signal has to be identified. Threat materials (explosive, chemical warfare,...) are usually contained within small volume inside variable matrices.

We have studied the influence of matrix materials on the capability of neutron systems to identify hidden threats. Three specific scenarios are considered in some details:

Case 1: Explosive in the sea containers.
Case 2: Explosives in the soil - landmines.
Case 3: Explosives and chemical warfare on the sea bottom.

Effects of container cargo material on tagged neutron system are seen in both increase of gamma background and decrease of neutron beam intensity.

Detection of landmines is more complex because of variable soil properties. We have studied in detail space and time variations of soil elemental compositions and in particular hydrogen content (humidity).

Of special interest are ammunitions and chemical warfare on the sea bottom, damping sites and leftovers from previous conflicts (WW-I, WW-II and local). In this case sea sediment is background source and its role is similar to the role of the soil in the landmine detection. In addition to geochemical cycling of chemical elements in semi-enclosed sea, like Adriatic Sea, one has to consider also anthropogenic influence, especially when studying small scale variations in concentration levels.

Some preliminary experimental results obtained with tagged neutron sensor inside an underwater vehicle are presented as well as data on sediment characterization by X-Ray Fluorescence.

FRI-NP09-1 #601 - Invited Talk - Friday 2:00 PM - Brazos I

Laser ionization at the IGISOL facility

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The ion guide technique developed in Jyvaskyla, Finland, provides a novel approach to the production of low-energy radioactive ion beams by stopping energetic ions produced by fusion-evaporation or light-ion induced fission reactions in noble gases. A variant of this method is based on the selective laser ionization of short-lived radioactive species after they have been thermalized in gas as neutral atoms. The laser ion source, coupled to the IGISOL, utilizes a versatile twin laser system incorporating both dye and titanium sapphire lasers with frequency doubling, tripling and quadrupling capabilities, affording a broad spectroscopic coverage and spectral resolution of the deep ultraviolet to the infrared spectrum. Two distinct configurations are being pursued: laser ionization in the gas cell; laser ionization in a sextupole ion beam guide.

In the first approach, the laser ion source has been successfully used as a selective probe to highlight the important roles played by gas phase chemistry [1] and primary beam-related effects [2] on the survival of ions during evacuation from the gas cell. The second approach is a variant of the so-called LIST method, originally proposed to improve the quality of the ion beam from a hot cavity ion source. In the JYFL LIST method the reaction products are neutralized in the gas cell, extracted and finally re-ionized selectively within an rf sextupole device. The non-neutral fraction is repelled at the entrance to the sextupole, providing the highest selectivity as any ion transported to the acceleration stage of the mass separator is guaranteed to be resonantly produced.

In this contribution I will summarize the status of the laser ion source and provide a future outlook.

[1] T. Kessler, I.D. Moore et al., Nucl. Instru. and Meth. B 266 (2008) 681.
[2] I.D. Moore, EMIS2007 Proceedings, accepted for publication in Nucl. Instru. and Meth. B (2008).

FRI-NP09-2 #608 - Invited Talk - Friday 2:00 PM - Brazos I

SOLID-STATE LASER, RESONANT IONIZATION LASER ION SOURCE (RILIS) AT RADIOACTIVE ION BEAM FACILITIES

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Isotope Separator On-Line (ISOL) facilities are producing isotopes of virtually any element by proton induced spallation and fragmentation of target materials. Especially the short-lived, exotic isotopes are of scientific interest. In order to deliver the required isotopes, efficient ion sources have to be coupled to the production targets. Laser ion sources are particularly interesting, as they allow for element selective ionization, which potentially leads to isobar contamination free beams. From a practical point of view it is the simplest, most cost effective source to operate inside the high radiation environment of the target ion source region of an ISOL facility, as most critical components are situated outside the radiation area, and hence do not inflate the nuclear waste inventory of the facility. These considerations led to the TRIUMF on-line LIS, based on all solid-state lasers. The TRIUMF RILIS capitalized on recent advances in laser technology. This required the development of new laser excitation schemes, as the wavelength tuning range of the Titanium Sapphire lasers used (680 nm - 990 nm) and their harmonics differ from that of dye

lasers. The target-ion source conditions call for resonance ionization in a hot cavity. For high efficiency a pulsed, high repetition rate (e.g. 10 kHz) laser system is required.

Mainz University, JYFL, ORNL and TRIUMF have outlined 25 laser excitation schemes, additional 22 elements have been fully characterized on stable isotopes for RILIS and isotopically pure beams of radioactive isotopes of 5 elements (Al, Ga, Ag, Mg, Be) have been delivered experiments at TRIUMF.

The experience gained since project start in late 2002 will be presented. It reflects the move towards laser excitation schemes of increasing complexity on one side as well as towards increasing operational robustness. The principles, challenges and current developments for on-line laser ion sources will be discussed.

FRI-NP09-3 #475 - Invited Talk - Friday 2:00 PM - Brazos I

Efficient Isobar Suppression by Photodetachment in a RF Quadrupole Ion Cooler

Yuan Liu[1], Charles C. Havener[1], Thomas L. Lewis[2], Alfredo Galindo-Uribarri[1,2], James R. Beene[1]
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The purity of radioactive ion beams (RIBs) is crucial to experimental research in nuclear structure and nuclear astrophysics at the Holifield Radioactive Ion Beam Facility (HRIBF). The RIBs produced using the Isotope Separator On-Line (ISOL) technique are often mixtures of the radioactive isotope of interest and isobaric contaminants that complicate and sometimes compromise the experiments. As the HRIBF tandem post-accelerator requires negatively charged ions as input, a highly efficient method for selectively suppressing contaminants in negative RIBs by photodetachment has been developed (Liu et al., APL 87, 113504 (2005)). In this method, a laser beam having the appropriate photon energy is used to selectively neutralize the contaminant if the electron affinity of the contaminant is lower than the electron affinity of the desired radioactive ions. The photodetachment efficiency can be dramatically increased when the laser-ion interaction is made inside a RF quadrupole ion beam cooler where the ion residence time can be a few milliseconds. In off-line experiments with ion beams of stable isotopes, more than 99.9% suppression of Co^-, S^-, and O^-, ions by photodetachment has been demonstrated. These ions would be the contaminants of desired beams of Ni^-, Cl^- and F^-, respectively. Under similar conditions only 20% reduction in Ni^- and no reduction in Cl^- and F^- ions were observed. These off-line results demonstrate the potential of this technique for on-line purification of a number of interesting radioactive beams and possible applications in Accelerator Mass Spectrometry.

FRI-NP09-4 #540 - Invited Talk - Friday 2:00 PM - Brazos I

Isobar Selection at eV Energies

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The use of anions in Accelerator Mass Spectrometry (AMS) originates from the necessity to use negatively charged particles for injection into a tandem accelerator. But, in several classical cases (e.g. ^{14}C), they also play an essential role in the separation of the analyte ion from a more abundant atomic isobar (^{14}N does not form anions). In the general case, however, other more complicated and expensive methods are required to remove atomic isobars. This presentation describes the use of a radiofrequency quadrupole (RFQ) reaction cell to accomplish this purpose.
The negative ions used in AMS are in general, however, more fragile than positive ions and manipulation in an RFQ reaction cell is consequently much more difficult. Fortunately the Cl anion has the largest binding energy of the negative atomic ions and it was known in 1972 that ^{36}Cl and ^{36}S could also be separated in NO_2 at eV ion energies. It should be noted that the eV deep potential well in an RFQ combined with a small electric field gradient along the RFQ can be used to suppress the effects of multiple scattering that are a problem for isobar separation at keV energies. The ions in an RFQ at eV energy are also cooled by their collisions and can be transported with reduced energy spread. A reaction cell assembly has been designed and constructed that incorporates the suppression of ^{36}S for ^{36}Cl analysis. Results of the initial tests of this equipment will be presented.

FRI-NP09-5 #536 - Invited Talk - Friday 2:00 PM - Brazos I

Radioactive Ion Beam Purification by Selective Adsorption

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In the past decades many techniques have been developed to reduce isobaric contaminations in ISOL beams, e.g. laser ion sources and molecular side bands. Another promising method to achieve improved selectivity is employing surface effects in the transfer line between target container and ion source. Since adsorption behavior is dependent on the interaction of the atoms' outer electrons with the surface, it can change drastically within an isobaric chain. Thus an adsorption material with suitable atomic structure and polarity can lead to a high chemical selectivity. Interactions may include physical and chemical adsorption as well as diffusion into the crystal structure.

The principle of selective adsorption has already been employed successfully in the past [1]: Quartz transfer lines were applied on-line at ISOLDE and have been shown to reduce Rb contaminations by 4 orders of magnitude [2].

Since quartz is the only compound that has been tested yet we plan to conduct a broad on-line study of the adsorption behavior of various elements on a range of materials. Ceramic compounds which can endure high temperatures and introduce a variety of different structures and polarities seem promising, though the high-temperature adsorption properties of these materials are not fully understood.

For testing at the on-line separator, UNISOR / OLTF, at the Holifield Radioactive Ion Beam Facility, ORNL, a special target-ion source unit with a variable-temperature transfer line has been constructed in collaboration with the ISOLDE technical group. Based on the design of the ISOLDE prototype unit it was modified to match the unique capabilities of UNISOR / OLTF. Results of first tests will also be presented.

Work supported in part by the U.S. Department of Energy

[1] Rudstam et al, Radiochim. Acta 20, 85 (1973).
[2] Bouquerel et al, Europ. Phys. J. - Spec. Top. 150, 277 (2006).

FRI-NSF06-1 #131 - Invited Talk - Friday 2:00 PM - Trinity Central

Surface Treatment of Polymers by Ion Beam Irradiation to Control the Human Osteoblast Adhesion

Geoffroy Guibert[1], Thibaud Rossel[2], Gilles Weder[2], Serguei Mikhailov[1], Cathy Meunier[3], Bruno Betschart[2]
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Introduction

In the biomaterial field, the surface treatments are developed to create some mimetic polymer with high performances, preserving the bulk properties and creating some specific interaction between the designed surfaces and the cells. Polymer materials are irradiated with a 900 keV Helium beam to modify their topographical and chemical properties. Ion beam is produced by a Van de Graaf accelerator. 10'000 human osteoblasts (hFOB 1.19) are seeded on ethanol-sterilized samples in complete growth media at 37°C for 96 hours. Observation and counting are performed with an Olympus ® microscope.

Results

For the PTFE, PS and PEEK polymers, the cells naturally don't adhere on the surface. It is possible to modify and control the cell adhesion on theses polymers after an ion irradiation. For the other polymers such as PET and PMMA polymers, the cells could adhere on the surface without any treatment. The irradiation modifies the cell density. For PMMA, the dose and the current density both directly influence the control of the cell adhesion.

Conclusion

By selecting the dose and the current density, the control of the cell adhesion is possible. These parameters depend on the material. The chemical and topographical modifications are created on the surface without affecting the bulk properties. The field of polymer application is vast. The surface treatment must be adapted according the application where the control of cell is required: Biosensors, tissue engineering, tissue regeneration, neural probes, drug delivery, bio-actuators etc.

This research was supported by Haute Ecole Arc and MaCHop network in Collaboration with CSEM and Neuchatel University.

FRI-NSF06-2 #219 - Invited Talk - Friday 2:00 PM - Trinity Central

Bio Applications of Accelerators to Control Cell Attachment

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Ion accelerators may be used to enhance biocompatibility of both metallic and polymeric surfaces. Biocompatibility of those materials is determined primarily according to their susceptibility to cell attachment. Surface geometry, porosity, wettability, charge and the nature of the extracellular matrix are the most important points to be considered. Polymeric carbons (PC) are produced by carbonization of the organic polymeric systems. One kind of those PCs is glassy polymeric carbon (GPC) which is used in clinics for dental implants, orthopaedic biomaterials and artificial heart valves. GPC surfaces can be modified by the deposition of silver ions. The objective of this contribution is to talk about the cell-surface interactions for biocompatibility studies. In this context, the subject will be discussed together with the results of some experimental studies.

FRI-NSF06-3 #25 - Contributed Talk - Friday 2:00 PM - Trinity Central

Cell Attachment Studies and Antibacterial Properties of Ag and Ag+N Ion Implanted UHMWPE Samples

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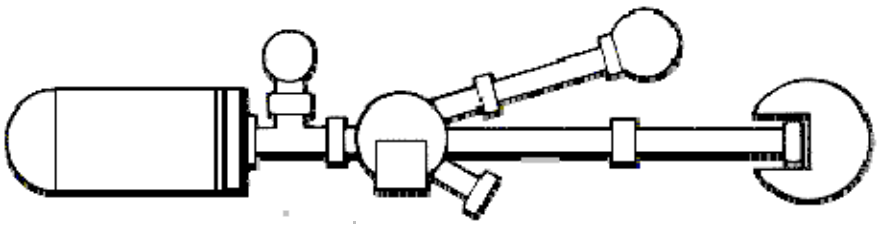
Implanted biomedical prosthetic devices are intended to perform safely, reliably and effectively in the human body thus the materials used for orthopaedic devices should have good biocompatibility. UHMWPE has been commonly used for total hip joint replacement because of its very good properties.

In this work, Ultra High Molecular Weight Poly Ethylene (UHMWPE) samples were Ag and Ag+N ion implanted by using Metal-Vapour Vacuum Arc (MEVVA) ion implantation technique. Samples were implanted with a fluence of 10^{17} ion/cm^2 and extraction voltage of 30 kV.

Rutherford Backscattering Spectrometry (RBS) was used for surface studies. RBS showed the presence of Ag and N on the surface. Antibacterial tests were made with Staphylococcus Epidermis organisms, and in vitro biocompatibility tests have been carried out with model cell lines (L929 mouse fibroblasts) to demonstrate that Ag and Ag+N ion implantation can favorably influence the surface of UHMWPE for biomedical application. Scanning electron microscopy (SEM) was used to demonstrate the cell attachment on the surface.



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