Tuesday, June 3
Plan of the Day

SORMA West 2008 moves from International House to an adjacent part of the campus: Stanley Hall and Bechtel Engineering Center, Sibley Auditorium. Contributed orals in parallel sessions will be given in the morning.

Early in the noon hour, after a brief break (not long enough to return to the Doubletree or explore the campus), buses will load for the San Francisco and Muir Woods tours. Box lunches will be provided. The buses will return to the Doubletree.

Those who did not sign up for a tour are free for the afternoon and may wish to stop by the information desk for maps, restaurant guides, etc.

8:00am-12:00pm	Information Desk	Sibley Auditorium Foyer
9:00am-10:15am	Parallel Sessions	Stanley Hall and Bechtel/Sibley Aud.
10:15am-10:45am	Break	
10:45am-12:00	Parallel Sessions	Stanley Hall and Bechtel/Sibley Aud.
Noon- Afternoon	Lunch (Boxed) SF Tour/ Muir Woods Tour	

New Scintillators

Tuesday AM I: Stanley 105

Chair: Chuck Melcher, Univ. of Tennessee

Tuesday AM I: Stanley 105-1

Crystal Growth and Scintillation Properties of Strontium Iodide Scintillators

Edgar Van Loef, Radiation Monitoring Devices, Inc. (RMD)
Cody M. Wilson; Nerine J. Cherepy, Giulia Hull, Stephen A. Payne (LLNL); Woon-Seng Choong, William W. Moses (LBNL); Kanai S. Shah (RMD)

Security applications and nuclear non-proliferation depend on the rapid identification of highly enriched uranium, weapons grade plutonium, radioactive sources and other special nuclear materials. Efficient detection of their gamma-ray signature is the most common method for identification and requires a scintillator that has a high light yield, good energy resolution, fast scintillation decay and high effective atomic number. Currently, LaBr3:Ce and CeBr3 [1-3] provide the best combination of these properties. However, both are moisture sensitive and are prone to cracking during crystal growth [4]. Recently, the alkaline-earth iodides doped with divalent europium, i.e. SrI2:Eu and BaI2:Eu, have been rediscovered as inorganic scintillators that may rival LaBr3:Ce and CeBr3. Initially discovered by Hofstadter in 1968 [5], our recent research indicates that these materials exhibit high light yields and shows good energy resolution [6]. In this paper we report on the crystal growth and scintillation properties of strontium iodide scintillators doped with Eu2+ and Ce3+. Single crystals were grown from anhydrous alkaline- and rare-earth halides by the vertical Bridgman technique in evacuated silica ampoules. Growth rates were of the order of 5 - 30 mm/day. Radioluminescence spectra of SrI2:Eu2+ and SrI2:Ce3+ exhibit a broad band due to Eu2+ and Ce3+ emission, respectively. The maximum in the luminescence spectrum of SrI2:Eu2+ is found at 435 nm. The spectrum of SrI2:Ce3+ exhibits a doublet peaking at 404 and 440 nm attributed to Ce3+ luminescence, while additional impurity - or defected - related emissions are present at 524 and 601 nm. The strontium iodide scintillators show very high light yields of up to 100,000 photons/MeV, have energy resolutions of less than 4% at 662 keV (FWHM) and exhibit excellent light yield proportionality with a standard deviation of less than 5% between 6 and 460 keV, measured as a function of electron energy.

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[3] K. S. Shah, J. Glodo, W. M. Higgins, E. V. D. van Loef, W. W. Moses, S. E. Derenzo and M. J. Weber, IEEE NSS Conf. Rec., 4278 (2004).
[4] W.M. Higgins, A. Churilov, E. van Loef, J. Glodo, M. Squillante and K. Shah, J. Crystal Growth, In Press, Accepted Manuscript.
[5] R. Hofstadter, "Europium-activated Strontium Iodide Scintillators," US Patent 3,373,279 (1968).
[6] N. J. Cherepy, G. Hull, A. D. Drobshoff, S. A. Payne, E. van Loef, C. M. Wilson, K. S. Shah, U. N. Roy, A. Burger, L. A. Boatner, W.-S. Choong and W. W. Moses, Appl. Phys. Lett, To be published.

Tuesday AM I: Stanley 105-2

Scintillators with Potential to Supersede LaBr3

Nerine Cherepy, Lawrence Livermore National Laboratory
Stephen Payne, Giulia Hull, Joshua Kuntz, Jeffery Roberts, Stephen Asztalos, Douglas Manatt, Alexander Drobshoff, Robert Sanner, Thomas Tillotson, Scott Fisher (LLNL); Edgar van Loef, Cody Wilson, Kanai Shah (RMD); Utpal Roy, Rastgo Hawrami, Arnold Burger (Fisk Univ.); Lynn Boatner (ORNL), Woon-Seng Choong, William Moses (LBNL)

Use of gamma ray spectroscopy for isotope identification requires adequate energy resolution, and is also enhanced by the high effective atomic number of the detector material. The inorganic scintillator currently providing the highest energy resolution is LaBr3(Ce), ~2.6% at 662 keV,1-3 but it is highly hygroscopic, possesses intrinsic radioactivity due to the presence of primordial 138La, and its crystal growth is still challenging. We have identified new materials offering higher effective Z than LaBr3(Ce), light yields adequate to achieve energy resolution in the 2-3% range, and no intrinsic radioactivity. Methodology for selecting promising candidates, as well as progress in growth and performance of new iodide crystals and oxide ceramics will be discussed. Our search has been guided by potential for high resolution, prospects for good light yield proportionality, stopping power, crystal growth/phase transitions, deliquescence, optical properties, photodetector spectral response and noise, and other considerations. We selected the alkaline earth halide family for study, since CaI2, while difficult to grow due to its hexagonal structure, exhibits an excellent light yield (~100,000 Ph/MeV). We have found both BaI2 and SrI2 to be readily growable. The first SrI2(Eu) crystal we tested provided energy resolution of 3.7%, which we expect can be improved based on its light yield (>85,000 Ph/MeV) and its excellent light yield proportionality (Fig. 1, 2).4 For selection of oxide ceramics candidates, cubic structures that accommodate Ce3+ were identified. We found that Gadolinium and Terbium-based garnets are amenable to ceramics processing, exhibit very high light yields and (Fig. 3) adequate proportionality, but have defect populations that lead to afterglow which must be suppressed. Ultimately, the energy resolution from scintillator detectors will reach achievable limits with the use of scintillators exhibiting the most proportional and highest light yields, and when light collection and detection are optimized. To this end, we have identified several technological advances to maximize optical transfer and uniformity that, combined with the promising new scintillator materials we are developing, could lead to a 2% resolution scintillator detector.

Tuesday AM I: Stanley 105-3

Novel Mixed Elpasolite Halide Scintillators for Gamma Radiation Detection

Steven Duclos, GE Global Research
Samual Camardello, Holly Comanzo, Adrian Ivan, Alok Srivastava (GE Global Research)

In this paper we report on novel mixed elpasolite compositions with general formula A2BLnX6:Ce, and describe the influence on the Ce3+ scintillating efficiency and phase formation with increasing concentration of I- substitution on the anionic sub-lattice. The results show that the scintillating efficiency of the Ce3+ ion in iodine-substituted

materials exceeds that of the pure chloro and bromo-elpasolites. These compositions are currently being optimized and several specimens have already been grown as single crystals. We will report on the optical properties of the obtained compounds, in particular the Ce3+ emission under UV excitation, the light yield under X-ray excitation, and the light yield and spectral resolution under gamma radiation. Due to their performance under high-energy radiation, its high effective Z, the lack of natural radioactive elements in their composition, and reduced thermal anisotropy upon cooling, these compositions may become an important class of materials for radioisotope identification, in particular when integrated into HPRDS and ASPs.

This work was supported by the Domestic Nuclear Detection Office at the Department of Homeland Security.

Scintillation Properties of Undoped and Cerium Doped LiGdCl4 and NaGdCl4

Yetta Porter-Chapman, Lawrence Berkeley National Laboratory(LBNL)
LaToria Wiggins, Floyd James (North Carolina A&T State University); Edith Bourret-Courchesne, Marvin Weber, Stephen Derenzo (LBNL)

We report the scintillation properties of two compounds: LiGdCl4 and NaGdCl4. Powder samples of the undoped and cerium-doped (0.0 - 20.0 molar %) phases exhibit significant scintillation under x-rays. Previous studies of ternary lanthanide halide scintillators of general formulas A3LnX6 and A2LnX5 have revealed significant light outputs originating from their undoped STE and lanthanide doped luminescence.[1-6] LiGdCl4 and NaGdCl4 scintillators have higher densities than their ternary counterparts in the A3LnX6 and A2LnX5 families[1-2] and are less hygroscopic than GdCl3. Powder samples of these materials were synthesized by solid state methods from a 1:1 molar ratio of lithium or sodium chloride and gadolinium chloride. The physical, optical, and scintillation properties of these materials were analyzed by powder x-ray diffraction, photoluminescence, pulsed x-ray, and x-ray excited luminescence measurements. Increases in light yields and decreases in light decays are observed as the concentration of cerium increases. In particular, LiGdCl4 : 0.5 % Ce3+ exhibits a high light yield resulting from a combination of Gd3+ and Ce3+ luminescence. The highest light yields and shortest decay times occurred at 20 % cerium doping for both compounds. At larger concentrations neither compound formed, indicating a breakdown of the lattice with the addition of large amounts of cerium cations. At 20.0% cerium, LiGdCl4 and NaGdCl4 display scintillation light 3.5 times and 2.1 times the light yield of YAP : Ce3+ standard phosphor powder, respectively. Both emit at approximately 350 and 370 nm and display multi-exponential decays with major components at 29 ns (LiGdCl4) and 40 ns (NaGdCl4).

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[3] H. J. Seifert, J. Sandrock, and G. Thiel, "Ternary chlorides in the systems ACl/GdCl3 (A = Na - Cs)," Z. Anorg. Allg. Chem., vol. 598/599, 1991, pp. 307-318.

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Acknowledgements: This work was supported by the U.S. Department of Homeland Security and carried out at the Lawrence Berkeley National Laboratory under U.S. Department of Energy Contract No. AC02-05CH11231 and by a grant from the Department of Energy, National Nuclear Security Administration NA-22 (Non-proliferation) program.
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Tuesday AM I: Stanley 105-5

High Light Yield Scintillator: YI3:Ce

Jarek Glodo, Radiation Monitoring Devices Inc. (RMD)
E. V. D. van Loef, K. S. Shah (RMD)

YI3 doped Ce is a new addition to family of high light yield rare-earth iodide scintillators that are being actively explored at RMD. This family includes LuI3, GdI3 and recently examined solid solutions of these compositions. It has been showed that these materials not only exhibit high light yield [1], but they are also capable of achieving high energy resolution (3.3% FWHM at 662 keV [2]). Investigated YI3 crystals were grown at RMD using the Bridgman method. A typical boule size was 6 mm diameter and a ~2-3 cm long. The grown crystals have a greenish color. Similar to other iodides in the family YI3 has a layered structure. We grew and tested crystals with Ce3+ concentration varying from 0.5% to 5%. The emission spectra, energy spectra, non-proportionality and decay times were collected. Typical emission spectrum of YI3:Ce spans a broad band from 450 to 700 nm peaking at 530 nm, and unlike the emission of LuI3:Ce, its spectral distribution is practically independent of the Ce concentration. The scintillation under gamma excitation is fast and decays with the time constant between 30 and 45 ns (major component), depending on the Ce concentration. The rise time changes with the concentration, as well. It is the slowest for the 0.5% sample, and becomes faster as the Ce concentration increases. The light yield of all investigated crystals reaches 100,000 photons/MeV, with the exception of the 0.5% sample.

Silicon Detectors

Tuesday AM I: Bechtel

Chair: Gianluigi de Geronimo, BNL

Tuesday AM I: Bechtel-1

Characteristics of 3D Micro-Structured Semiconductor High Efficiency Neutron Detectors

Steven L. Bellinger, Kansas State University
Douglas S. McGregor, Walter J. McNeil, Eric L. Patterson, Troy C. Unruh (Kansas State University)

Silicon diodes with large aspect ratio perforated micro-structures have been filled with 6LiF and show a dramatic increase in neutron detection efficiency beyond that of conventional thin-film devices. This work employs the same technology, but with increased structure depths to achieve unmatched solid state neutron detection efficiency. The highest efficiency devices thus far have delivered over 30% thermal neutron detection efficiency at an operating bias of 3 volts. Sinusoidal trench and straight trench perforated devices of 200 microns in depth have been fabricated and filled with 6LiF neutron absorber material. Neutron response for the sinusoidal and strait trench devices have been theoretically modeled and experimentally found. This work is part of on-going research to develop a solid state semiconductor neutron detector with high detection efficiency and a uniform angular response.

Tuesday AM I: Bechtel-2

Monolithic Pixel Sensors in 0.15micron Silicon-On-Insulator Technology

Professor Marco Battaglia, UC Berkeley and LBNL
Devis Contarato (LBNL, presenting), Dario Bisello (INFN Padova, Italy), Peter Denes (LBNL), Piero Giubilato (LBNL and INFN Padova, Italy), Lindsay Glesener (UC Berkeley and LBNL), Chinh Vu (LBNL)

A monolithic pixel sensor has been design and fabricated in a novel deep-submicron fully-depleted Silicon-On-Insulator (SOI) CMOS technology. A thin layer of silicon electronics is isolated from a high-resistivity silicon substrate. The latter can be contacted from the electronics layer by means of vias through the buried oxide, so that pixel implants can be created and, above all, the substrate can be depleted as in standard reversely-biased silicon detectors. Hence, this technology is of great interest for its potential to implement complex architectures, featuring high speed and low power dissipation designs, combined with a high-resistivity, depleted substrate ensuring large signals and fast charge collection. The first prototype chip features pixels of 10 micrometer pitch arrayed in two analog sections (with 1.0 V and 1.8 V operating voltages) and one digital section with a comparator and a latch integrated in each pixel. The prototype response has been extensively tested with infrared lasers and with the 1.35 GeV electron beam extracted from the injection booster at the LBNL Advanced Light Source (ALS). A significant effect of back-gating of the CMOS electronics has been observed. This is due to the electric field present in the high resistivity substrate, and limits the maximum depletion voltage that can be applied to the sensor substrate. Despite that, a signal to noise ratio of 15 and good detection efficiency were found with the analog sections of the chip for depletion voltages up to 15 V. The digital section of the chip also proved to be functional and higher substrate biases, up to 30 V, could be used. The circuitry in the digital pixels is indeed active only when the pixels are triggered, and is thus less sensitive to back-gating. Irradiation tests with low energy protons and neutrons have been performed at the LBNL 88-inch Cyclotron facility. The test of single transistor structures revealed an increased effect of back-gating as a function of the delivered proton dose, hinting at the build-up of charge trapped in the buried oxide. Moderate doses of low energy neutrons showed no significant degradation of the chip performance. These results are very encouraging for the further development of monolithic pixel sensors in SOI technology. A second prototype has been submitted in a similar fabrication process at the beginning of 2008. The potential applications for this technology range from fast and high resolution silicon detectors for high-energy physics applications to imaging in electron microscopy and synchrotron radiation applications.

Tuesday AM I: Bechtel-3

Development of a 4-Element Large Area Silicon Drift Detector Array for Synchrotron Applications

Liangyuan (Larry) Feng, SII NanoTechnology USA Inc.

V. D. Saveliev, C. R. Tull, S. Barkan, M. Takahashi (SII NanoTechnology USA Inc); J. S. Iwanczyk (Photon Imaging, Inc.), M. Rivers (Center for Advanced Radiation Sources, University of Chicago, Argonne, IL 9); G. Srajer, A. Miceli, K. Attenkofer, J. Maser (Advanced Photon Source, Argonne National Laboratory)

We will introduce a novel, 4-element Silicon Drift Detector (SDD) array for use in synchrotron applications in place of traditional liquid nitrogen cooled multi-element germanium detectors. The SDD element is fabricated on ~0.35 mm thick, high resistivity n-type silicon with an active area of ~45 mm2, featuring extremely low capacitance (~0.06pF) and thus excellent energy resolution (optimum Mn K-alpha FWHM < 130 eV) and up to ~500 kcps output rate at 0.25 microsecond peaking time. The 4-element SDD array offers a total of ~180 mm2 active area with a maximum output rate up to 1.5 - 2 mcps. Vacuum-sealed by a 12.5 micron beryllium window, the four SDD elements are in a square-arrangement around the center and are cooled using separate Peltier coolers with the heat removed through an innovative heat pipe heat transfer system. The SDD array spectrometer utilizes the X-ray Instrumentation Associates (XIA) 4-channel digital pulse processor, DXP-xMAP, in conjunction with the National Instruments PXI/CompactPCI module, offering 4 MB on-board high speed memory and ~100 MB/sec data transfer speed.

Tuesday AM I: Bechtel-4

Characterization and Calibration of PILATUS II Detectors

Philipp Kraft, Paul Scherrer Institut (PSI), Switzerland

Anna Bergamaschi (PSI); Christian Broennimann (Dectris Ltd. and PSI); Roberto Dinapoli (PSI); Eric Eikenberry (Dectris Ltd., Switzerland); Beat Henrich, Ian Johnson, Aldo Mozzonica, Bernd Schmitt (PSI)

PILATUS is a silicon hybrid pixel detector system for detecting X-rays in single photon counting mode with a dynamic range of 10^6 per pixel. The PILATUS detectors are modular with 16 radiation tolerant PILATUS II chips bump-bonded to one single Si-Sensor. The active area of a module is 84 x 34 mm^2 comprising 94'965 pixels with a pitch of 172 mu^2. We achieve bump-bonding yields of 100 %. The maximum frame rate of the modules is 200 Hz. The modules were calibrated and characterized with monochromatic X-r ays. An algorithm to adjust pixel thresholds individually based on X-ray flat-field images was developed improving the threshold dispersion of a module to 47 eV. By the means of trim files and a threshold-energy calibration any required threshold can be set above the noise between 2.14 keV and 22 keV. The dead time of the pixel was determined allowing for online rate correction and the maximum detectable incident rate was found to be 8 x 10^6 photon/s/pixel. Based on the Pilatus modules, different detector geometries have been realized, ranging from 6 megapixels (Pilatus 6M), 2 megapixels (Pilatus 2M) to 0.5 (Pilatus 500K) and 0.1 megapixels (Pilatus 100K). The PILATUS modules are applicable for various applications such as X-ray diffraction, small angle X-ray scattering (SAXS) and X-ray imaging techniques.

Tuesday AM I: Bechtel-5

Charge Collection Efficiency Measurements of Heavily Irradiated Segmented P-Type Silicon Detectors for Use at the Super-LHC

Anthony Affolder, University of Liverpool

Gianluigi Casse, Prof. Phil Allport (Oliver Lodge Laboratory, Department of Physics, University of Liverpool)

The planned luminosity upgrade of the Large Hadron Collider at CERN (Super-LHC) will provide a challenging environment for the tracking and vertexing detector systems. With a proposed nearly 10-fold luminosity increase to 10^35 square centimetres per second, the innermost devices will have to be able to withstand a charged hadron dose on order of 1x10^16 1 MeV neutron equivalent particles per square centimetre over the anticipated 5 year lifespan of the experiments. Planar, segmented silicon detectors with n-strip readout are one of the many radiation tolerant technologies under consideration for use for the Super-LHC tracking detectors in either pixel or strip geometries. This presentation details measurements made with n-strip planar devices that have been irradiated to doses as high as 1x10^16 neq cm-2 with reactor neutrons and fast protons. The doses under study cover the expected range of final fluences for the different tracking systems of the ATLAS and CMS experiments at the Super-LHC. The measurements have been carried out using analogue, high-speed (40MHz) electronics and a Strontium electron source. The effects of the initial substrate resisitivity and of the choice substrate type (float zone or magnetic Czochralski) on the collected charge have been measured. These measurements are intended as a reference of the expected collected charge by segmented devices at these extreme doses and as an input to the design of the readout electronics necessary for the various pixel and micro-strip tracking subsystems planned to be used at the Super-LHC.

Gas-Based, Light, and Radio Detectors

Tuesday AM I: 106 Stanley

Chair: David Nygren, LBNL

Tuesday AM I: 106 Stanley-1

Study Of Electroluminescence Light In Low Pressure CS2-Ne And CS2-CF4 Gaseous Mixtures

Kirill Pushkin, Occidental College

The Directional Recoil Identification From Tracks (DRIFT) detector has been proposed to search for Dark Matter in Galaxy. The DRIFT detector is based on low pressure (40 torr) electronegative gas - carbon disulphide (CS2) to drift negative ions instead of electrons to drastically reduce lateral and longitudinal diffusion of the charged tracks what makes this detector unique. One of the current crucial problems of the detector is a natural radioactive background due to 222Ra progeny plating out on the central cathode wires of the DRIFT detector. This alpha decay occasionally producing alphas which deposit their energy in the wire and producing Pb (214Pb, 210Pb, 206Pb) recoils in the gas which mimic the WIMP recoils DRIFT seeks to detect. We show that Pb recoils exiting the central cathode wires can be made to scintillate, providing us with a veto for such events, by adding Ne or CF4 to the CS2 gas.

Tuesday AM I: 106 Stanley-2

Recent Developments Of Micromegas Detectors For Neutron Physics

Samuel Andriamonje, CEA-Saclay DSM/IRFU/SPHN

After a short description of the Micromegas principle, a new concept of neutron detectors based on this technique is presented. It is illustrated by an overall picture of the possible use of these detectors in different domain such as: nuclear physics, inertial fusion and industrial application. A particular description will be devoted to the compact detector named "Piccolo- Micromegas". This detector, able to measure neutron flux in a broad range of energy of neutron, is developed for the measurements of neutrons flux in-core of the future generations of the nuclear reactors.

Tuesday AM I: 106 Stanley-3

Techniques for Radio Detection of Ultra-High Energy Cosmic Rays

Hartmut Gemmeke, Forschungszentrum Karlsruhe

Radio signals emitted from electromagnetic showers in air can be used as an additional new technique for the detection of ultra high energetic cosmic rays or neutrinos at energies above 10**18 eV. The LOPES experiment in Karlsruhe demonstrated that the radio flashes emitted from cosmic showers in the atmosphere can be understood in terms of the coherent radio emission of the geo-synchrotron effect seen in the frequency range of 30 to 80 MHz. More than 90% of the created particles in a high energetic shower are electrons and positrons. These particles are mostly absorbed in the atmosphere but create by their interaction with the geomagnetic field of the earth synchrotron radiation narrowly focussed into the direction of the shower. The atmosphere is transparent to the radio emission, which can be observed at the ground level as bolometric sum of all emissions of the individual particles. In addition, due to the ultra-relativistic shower front with a thickness of one to several meters the radio emission of the shower is coherent. The results from the LOPES collaboration show that it is possible to determine the direction and energy of the incoming cosmic particle, and the composition of ultra high-energy cosmic rays may be also analyzed by the lateral distribution of the emission, which is related to the longitudinal shower development. In addition to the KASCADE-Grande experiment in Karlsruhe the environment of the southern site of the Pierre Auger Observatory is now used to test this new technique up to the highest energies. Cosmic rays with energies above 10**18 eV are rare and need a large antenna array for sufficient detection efficiency. To guarantee the application of an antenna array as instrument for the detection of air showers cost effective new antennas, and on line self-trigger systems have to be developed. In a larger field of detection an overall radio quiet region can't be guaranteed. Therefore trigger with effective suppression of radio interferences and transients had to be developed. A FPGA based self-trigger was designed with the help of external triggered data. As antenna a logarithmic periodic dipole antenna is under use and a simple cross-polarized short-loaded Beverage-antenna is now proposed. This type of antenna has the right direction sensitivity, has real impedance, and is very cost effective as it is necessary for a larger array. The frequency-dependency of the antenna gain fits perfectly to the atmospheric and galactic noise level. The overall electronics including trigger has a power budget as low as 5W. The applied techniques and experiments will be described. Furthermore the amplification effect of thunderstorms on radio signals from cosmic showers was also measured but gives at periods of non-thunderstorm conditions -- including cloudy sky -- no measurable distortion of the radio signal. That is an essential requirement for the application of radio detection of Ultra High Energy Cosmic Rays.

Tuesday AM I: 106 Stanley-4

Detection of Special Nuclear Material with a Water Cerenkov based Detector

Steven Dazeley, Lawrence Livermore National Laboratory (LLNL)
Robert Svobda, Adam Bernstein, Nathaniel Bowden (LLNL)

Special Nuclear Material (SNM) emits both neutrons and high energy gamma-rays either spontaneously or via induced fission. The detection of these signatures within a cargo container has recently become a high priority area of study, however, most cargo radiation detectors being developed rely primarily on the gamma-ray component to detect SNM. High energy gammas (>3MeV) and neutrons are particularly penetrating and may represent the best chance to detect such particles in a shielded cargo scenario. It may indeed be possible to detect SNM within sophisticated shielding with a detector that efficiently covers an extremely large solid angle. The LLNL advanced detector group is designing and building a water Cerenkov based gamma and neutron detector for the purpose of developing an efficient and cost effective way to deploy a large solid angle "car wash" style detector. We have built and deployed a small prototype water Cerenkov detector and tested it with a 252Cf fission source. We will explain the reasons for using water Cerenkov rather than scintillator and present some preliminary results from our prototype detector that indicate that we have detected neutrons.
This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Tuesday AM I: 106 Stanley-5

Neutron Gas Detectors for Instrumentation on New Spallation Sources

Bruno Guerard, Institut Laue-Langevin
JF. Clergeau, JC. Buffet, S. Cuccaro, F. Horst, G. Manzin, F. Millier, J. Pentenero, M. Platz, P. Van Esch, G. Viande (Institut Laue-Langevin, Grenoble, FR)

Several of the neutron gas detectors recently introduced at the Institut Laue-Langevin or in development are strong candidates for the spallation sources SNS and J-PARC. In particular for SXD (Single Crystal Diffractometry): 1/ The curved two-dimensional MWPC in operation on the D19 instrument is operational since 2006; its main feature is an unequalled angular range of 120 x 29 degrees; 2/ The MILAND (MIllimetre resolution Large Area Neutron Detector) aims to deliver a detector with a sensitive area of 32 cm x 32 cm, and a pixel size of 1 mm x 1 mm; it is based on an MWPC using a sealed double pressure vessel filled at 15 bars and includes 640 individual readout channels, 3/ A new detector concept known as the Multi-blade is currently being studied with a view to designing a cylindrical gas detector. In order to suppress the parallax effect inherent in gas converters and to optimise detection efficiency, it uses solid converters mounted with a small angle to the incident neutrons, 4/ Other detectors currently in development will push forward the limit of counting rate, in particular the "Hexagonal MWPC" which includes an additional readout electrode to solve simultaneous events, and the MSGC with parallel charge division readout. For time-of-flight spectrometry, requiring very large area detectors, the Multitube technique allows good quality mass production at a reasonable cost. For example, the IN5 instrument includes 12 identical detection modules mounted in a very large vacuum chamber, covering a sensitive area of 30 m2 in total. Each module is made up of 32 stainless steel tubes 3 m long, welded side by side on a common gas vessel. The design and manufacture of these detectors, as well as the experimental results, will be presented.

Ceramic Scintillators

Tuesday AM II: Stanley 105

Chair: Steve Payne, LLNL

Tuesday AM II: Stanley 105-1

Sintered Sodium Iodide: High Throughput NaI:TI Process

Kevin P McEvoy, GE Global Research
Steven J Duclos, Carl J Vess, Alok M Srivastava, Hrishikesh Keshavan, Venkat S Venkataramani, Adrian Ivan

NaI (Tl) scintillators demonstrate good energy resolution at ambient temperatures enabling spectroscopic radiation detection of radionuclides. Currently this material is ubiquitous for healthcare and security applications involving single crystal material. However large single crystal applications are limited due to several constraints. It is prohibitive to fabricate high quality large volume single crystals, due to the labor, time and equipment costs. Increases in crystal size result in challenges with TI uniformity and optical quality. Sintered polycrystalline NaI (Tl) material may solve problems associated with traditional processes. The benefits would be reducing manufacturing cost and improved activator homogeneity, without compromising on the scintillation properties. The ability to utilize a sintering process to obtain polycrystalline alkyl halides has been explored. We will discuss the recent results from experiments on processing of polycrystalline sintered NaI (TI).

Tuesday AM II: Stanley 105-2

GE Healthcare's New Computed Tomography Scintillator -- Gemstone

James Vartuli, GE Global Research
Robert J. Lyons, Carl J. Vess, Kevin P. McEvoy, Randy S. Hagerdon, Steven J. Duclos (General Electric Global Research); Mohandas Nayak (General Electric John F. Welch Technology Center, Bangalore, India); Haochuan Jiang (General Electric Healthcare)

GE Healthcare announced its latest Computed Tomography (CT) concept at the 2007 Radiological Society of North American (RSNA) in late November. Called HDCT (High-Definition CT), this new technology has potential for a step-function improvement in image quality while reducing patient dose. One of the key technologies is a new scintillator called "Gemstone." Reformulated from the garnet gemstone structure, this transparent ceramic was invented and developed to meet the stringent demands of artifact-free imaging. The garnet ceramic platform enables precise composition control (at the tens of ppms levels) and greater homogeneity than single crystals. We will discuss the processing steps required to achieve superior performance across all necessary properties: primary speed, afterglow, radiation stability, chemical stability, mechanical strength.

Tuesday AM II: Stanley 105-3

Development of ZnO-based Polycrystalline Ceramic Scintillators for Use as Alpha-Particle Detectors

John S. Neal, Oak Ridge National Laboratory (ORNL)
David M. Devito (ORNL); Mei Hong (University of California, Davis); Banu Kesanli, Joanne O. Ramey, Beth L. Armstrong (ORNL); Xiaocheng Yang, Nancy C. Giles (West Virginia University); Jane Y. Howe, Dariusz J. Wisniewski, Monika Wisniewska (ORNL); Zuhair A. Munir (University of California, Davis); Lynn A. Boatner (ORNL)

ZnO-based scintillators are particularly well-suited for use as the associated particle detector in a deuterium-tritium (D-T) neutron generator. Application requirements include the exclusion of organic materials, outstanding timing resolution, and high radiation resistance. ZnO, ZnO:Ga, ZnO:In, ZnO:In,Li, and ZnO:Er,Li have demonstrated fast (sub-nanosecond) decay times with relatively low light yields. ZnO:Ga has been used in a powder form as the associated particle detector for a D-T neutron generator. Unfortunately, detectors using powders are difficult to assemble and the light yield from powders is less than satisfactory. Single crystal ZnO of sufficient size has only recently become available, and the scintillation properties of these specimens are, as yet, unknown. New applications for D-T neutron generators require better timing resolution and higher count rates than are currently available with associated particle detectors using YAP:Ce as the scintillator. Recent work suggests that ZnO-based scintillators can provide alpha-particle-excited light yields comparable to YAP:Ce scintillators. ZnO-based polycrystalline ceramic scintillators offer the advantages of high light yield, ease of fabrication, low cost, and robust mechanical properties. Precursor powders used in these studies include ZnO and ZnO:Ga powders synthesized using solution phase, urea precipitation, and combustion synthesis techniques as well as ZnO powder from a commercial vendor. Precursor powders have been sintered using uniaxial hot pressing and spark plasma sintering techniques. The best results to date, in terms of dense, stable bodies that scintillate, have come from those sintered bodies using the commercial ZnO precursor powders. X-ray-excited scintillation and photoluminescence measurements have confirmed that the emissions from these sintered bodies consist primarily of slow, visible emissions rather than the desired, sub-nanosecond near-band-edge emissions. Subsequent hydrogen treatments of the ceramic bodies have, as yet, not improved the scintillation characteristics of the ceramic bodies.

Research carried out in the Center for Radiation Detection Materials and Systems at ORNL is supported by the NNSA Office of Nonproliferation Research and Engineering (NA-22), USDOE and by the U. S. Department of Homeland Security, Domestic Nuclear Detection Office.

Tuesday AM II: Stanley 105-4

Transparent Lu2SiO5:Ce Optical Ceramic Scintillator

Yimin Wang, Radiation Monitoring Devices, Inc. (RMD)
Edgar Van Loef (RMD);Bill Rhodes (ALEM Associates), Jarek Glodo (RMD); Charles Brecher, Alex Lempicki (ALEM Associates); John Certorino, William M. Higgins , Kanai S. Shah (RMD)

Lutetium oxyorthosilicate (Lu2SiO5: Ce3+) (LSO) is a well known scintillator that is used in gamma-ray spectroscopy and medical imaging applications such as Positron Emission Tomography (PET) because of its high light output, high gamma ray stopping power and fast response. However, high melting point and modest yield of LSO single crystals elevate the cost of producing high quality single crystals. Alternatively, the relative low processing temperature for polycrystalline ceramic offers the possibility of obtaining inexpensive LSO for PET. However, unlike cubic isotropic ceramic peers such as Y2O3 and rare-earth garnets, the monoclinic-structured LSO ceramic is anisotropic with different refractive indices along different crystallographic planes, which makes obtaining transparent polycrystalline LSO ceramics challenging. In this study, optically transparent LSO ceramic was prepared by a nano-technology approach. XRD examination confirms the presence of single-phase LSO. The density of the ceramic was found to increase with sintering temperature due to the elimination of pores. Further SEM examination confirms the decrease of the porosity with increasing temperature. Finally, to further densify the LSO ceramic and eliminate the porosity, the sintered LSO ceramic was hot isostatic pressed (HIPed). Transparent polycrystalline LSO ceramics are obtained after the final HIPping. XRD examination confirms single LSO phase. Optical characterization and scintillation properties of LSO:Ce ceramic are examined in this study and the results are compared to those of LSO and BGO single crystals. Light output under gamma-ray excitation is investigated by using different excitation sources (137Cs, 22Na, 241Am and 122Co). A light output as high as 30,100 ph/MeV was obtained using a 22Na excitation source. LSO ceramic shows an energy resolution of 15% (FWHM) at 662 keV (137Cs source). LSO ceramic shows a fast scintillation decay of 40 ns due to the 5d to 4f transition of Ce3+. In summary, phase pure transparent LSO ceramic was obtained with its scintillation properties rivaling those of single crystalline LSO, which makes LSO ceramic a promising candidate for gamma-ray spectroscopy as well as medical imaging applications such as PET .

Tuesday AM II: Stanley 105-5

Fabrication of ZnSe:Te by Hot Pressing Techniques

Steven Cool, Radiation Monitoring Devices, Inc. (RMD)
Vivek Nagarkar, presenting
Stuart Miller (RMD); Charles Brecher, Helmut Lingertat (ALEM Associates), Vinod Sarin (Boston University), Vivek Nagarkar (RMD)

We have recently fabricated tellurium-doped zinc selenide (ZnSe:Te) in a robust optical ceramic form, in the first synthesis of this remarkable material from a precursor powder, using powder consolidation techniques. We utilized two techniques in particular -- hot isostatic pressing and hot pressing --in order to achieve the desired physical and chemical properties, and we are continuing our efforts to refine processing methodologies and parameters to improve this material's physical characteristics and performance. ZnSe:Te promises major advances in radiation imaging and spectroscopy applications with its potential of well over 100,000 photons/MeV brightness, fast emission (~3 usec and ~40 usec), negligible afterglow (<0.05% at 6 ms), high density (>5.2 gm/cc), light emission in the visible range (610-650 nm), and extraordinary radiation hardness (10^6 Gy). This paper will describe our fabrication methods and report our preliminary performance characterization results.

This project was partially funded by Department of Defense/DTRA Grant No. HDTRA 1-07-P-0242. We thank Bruker AXS and Bodycote Hot Isostatic Pressing for their technical assistance and support in this effort.

CdZnTe/CdTe Detectors and Imagers

Tuesday AM II: Bechtel

Chair: Ralph James, BNL

Tuesday AM II: Bechtel-1

Characterization of 10 mm Thick Pixellated Redlen CdZnTe Detectors

Feng Zhang, University of Michigan
Zhong He, Willy Kaye, Yuefeng Zhu, Steve Anderson (University of Michigan)

Ten 20*20*10 mm^3 pixellated CdZnTe detectors fabricated by Redlen Technologies Inc. were characterized using the VAS_UM/TAT ASIC readout system. Three of them have 11 by 11 pixel anodes with a common anode-grid surrounding pixel electrodes, and the other seven have 11 by 11 simple pixels without the grid. All detectors have identical pixel pitch of 1.72 mm. Each detector was connected to a VAS_UM2.3/TAT4 ASIC. Signals of the 121 pixels and the cathode are read out by the ASIC for each triggered event. The cathode break-down bias voltage was determined by observing the break-down pulses in the pre-amplifier signal of the cathode, and was found to be in the range from -1000V to -3000V. It was discovered that the surface resistance between some pixels and the anode grid are low, causing high-noise pixels and excessive grid-pixel leakage current. The single-pixel events energy resolution of these detectors ranges from ~1.0% to ~1.5% FWHM at 662 keV. After being annealed at 90 degrees C for 8 hours, most detectors showed improvements of lower electronic noise, higher cathode break-down voltage and better energy resolution (~0.9% to 1.3% FWHM at 662 keV). The performance of these detectors are presented and discussed in this paper.

Tuesday AM II: Bechtel-2

Investigation of Internal Electric Field Distribution in CdZnTe Detectors By Using X-Ray Mapping Technique

Aleksey Bolotnikov, Brookhaven National Laboratory (BNL)
G. S. Camarda, Y. Cui, A. Hossain, G. Yang, R. B. James

Ideal operation of many CdZnTe devices relies on a uniform distribution of the internal electric field. A uniform E field is especially critical in the case of thick long-drift-length detectors such as large-volume CPG and 3-D multi-pixel devices. Using a high-spatial resolution X-ray mapping technique, we investigated the distribution of the electric field in the real devices. Our measurements demonstrate that the electric field lines have a tendency to bend away from the side surfaces (i.e., a focusing effect). However, in most cases the field line distribution is found to be perturbed by the presence of extended defects and residual strains existing inside the crystals. Data clearly demonstrating the non-uniformity of the internal E field will be presented.

Tuesday AM II: Bechtel-3

The Experimental Results of a Gamma-Ray Imaging with a Si/CdTe Semiconductor Compton Camera

Shin'ichiro Takeda, ISAS/JAXA
Hiroyuki Aono, Shin-nosuke Ishikawa, Hirokazu Odaka, Shin Watanabe, Motohide Kokubun, Tadayuki Takahashi (ISAS/JAXA); Sho Okuyama, Kazuhiro Nakazawa (Univ. of Tokyo); Hiro Tajima (SLAC)

A gamma-ray imaging detector is required in various fields such as high-energy astrophysics, medical imaging and nondestructive inspection. We have proposed a concept of the Si/CdTe semiconductor Compton camera, which consists of many layers of thin Si and CdTe detectors. The Si/CdTe Compton camera features high energy resolution and high angular resolution. Recently, we developed a new Compton camera system for a balloon borne astrophysical experiment. It consists of a 4-layers stack of double-sided silicon strip detector (DSSD) modules (SPIE newsroom 2008. in press) and 32 CdTe pad detectors symmetrically surrounding the DSSD stack. The Compton reconstruction was successfully performed and the gamma-ray images were obtained from 662 keV down to 59.5 keV. The Angular Resolution Measure (ARM) is 3.5 degree (FWHM) and 2.5 degree (FWHM) at 356 keV and 511 keV, respectively. In order to evaluate the causes of the ARM distribution, we performed Monte Carlo simulations based on the Geant 4 simulation toolkit. In the simulation, we assumed the effects of the position and energy resolutions of the detectors, and the Doppler broadening effect. The experimental energy dependance of ARM distribution was well reproduced by the simulation. According to the simulation, the Doppler broadening which determines the theoretical limit of Compton imaging is the dominant cause of the ARM distribution below 350 keV gamma-rays. Thus, our Compton camera achieved the theoretical limit in the energy band. In the higher energy band, the effect of the position resolution is larger than that of the Doppler broadening. The Si/CdTe Compton camera which has such good angular resolution is also attractive for medical imaging and/or nondestructive inspection. An internal structure of about one mm can be resolved when the distance between the camera and a target becomes closer than a few mm. We developed another prototype which enable us to approach the target down to 20 mm. In this presentation, we will show the experimental results of this prototype and also discuss Compton reconstruction methods.

Tuesday AM II: Bechtel-4

High Energy Resolution Gamma-Ray Imagers Using CdTe Diode Devices

Shin Watanabe, ISAS/JAXA
Shin-nosuke Ishikawa, Hiroyuki Aono, Shin'ichiro Takeda, Hirokazu Odaka, Motohide Kokubun, Tadayuki Takahashi (ISAS/JAXA); Kazuhiro Nakazawa (University of Tokyo)

We have developed new CdTe diode imaging spectrometers using aluminum (Al) or nickel (Ni) electrodes as anodes. Conventional In/CdTe/Pt diode detectors have good spectral performance due to their extremely low leakage current under high bias voltage (> 1 kV for ~ 1 mm thick). However, since it is difficult to divide an In anode into pads, pixels or strips, only cathode segmented detectors are available. Ideally, electrons, which

have a larger mobility and a longer lifetime than holes in CdTe, have to be collected for high energy resolution, therefore, the anode side should be divided. Recently, as an electrode material, Al and Ni have been found to be good alternatives to In. In addition to low leakage current and high energy resolution comparable to those of In/CdTe/Pt detectors, Al/CdTe/Pt and Ni/CdTe/Pt detectors have an advantage that anodes can be divided. Firstly, we constructed the Al-pad/CdTe/Pt and Ni-pad/CdTe/Pt detectors, which have a pad pitch of 1.4 mm and 8x8=64 pads on the anode side. The full-width-half-maximum (FWHM) energy resolution of 1.1 and 1.8 keV at 59.5 and 122 keV, respectively, were successfully obtained, when the Al-pad/CdTe/Pt detector with a thickness of 0.75 mm was subjected to a bias voltage of 400 V and was operated at -20 degree C. The spectral performance obtained with the Al-pad/CdTe/Pt exceeded that obtained with the conventional In/CdTe/Pt-pad detector, under the same operating conditions. By dividing both anode and cathode into strips, the double sided CdTe strip detector is available. It provides a large area and a high position resolution with a relatively small number of readout channels. We developed the first prototype of the double sided CdTe strip detector by applying Al and Pt to anodes and cathodes, respectively. The prototype has 64 strips on each side. The strip pitch is 0.4 mm and the thickness of the detector is 0.5 mm. We successfully operated at -20 degree C and obtained gamma-ray images with a position resolution of 0.4 mm.

Tuesday AM II: Bechtel-5

Assessment of the Radiation Tolerance of CdZnTe and HgI2 to Solar Proton Events

Alan Owens, Advanced Studies and Technology Preparation Division, ESA/ESTEC)
V. Gostilo (Bruker Baltic Scientific Instruments), V. Ivanov (RITEC), R.W. Ostendorf (Kernfysisch Versneller Instituut, University of Groningen), F. Quarati (Advanced Studies and Technology Preparation Division, ESA/ESTEC) L. van den Burg (Constellation Technology)

Radiation effects caused by solar proton events will be a common problem for many types of sensors on missions to the inner solar system because of the long cruise phases coupled with the inverse square scaling of Solar particle events. In support of the BepiColombo and Solar Orbiter missions we have undertaken a comprehensive series of tests to assess the effects on a wide range of sensors. In this paper, we report on a comparative study of the radiation tolerance of two commonly used compound semiconductors -- cadmium zinc telluride and mercuric iodide, both of which have been proposed to form the detection planes of hard X-ray imaging systems intended for inner solar system missions. Single crystals of CdZnTe and HgI2 of dimension 10x10x2 mm^3 were fabricated into planar detectors. In total, four detectors were produced for each compound. Each set of detectors were then exposed to simulated solar proton events over the energy range 60 MeV to 200 MeV having a spectral shape approximating that of the August 1972 solar particle event but with four different fluences. One pair of detectors (a CdZnTe and HgI2) was exposed to an integral fluence of 10^8 protons cm^-2, a second to 10^9 protons cm^-2, a third to 10^10 protons cm^-2 and the fourth to 10^11 protons cm^^-2. The latter corresponds to an absorbed dose in silicon of 100 krad or in SI units 1 kGy. The tests were carried out at the Kernfysisch Versneller Instituut in Groningen, The Netherlands. A 190 MeV proton beam was extracted from the AGOR super-conducting cyclotron [1] and transported to the irradiation hall whereupon it was expanded and spatially linearized using a dual scatterfoil method. The incident spectrum at the detector was then shaped using a computer controlled energy degrader system. The detectors were characterized both before and after the irradiations in terms of energy resolution and background count rate. The energy resolutions were determined using 241Am, 57Co and 137Cs radiation sources. Typical pre-irradiation FWHM energy resolutions of 3 keV and 4 keV were recorded at 60 keV for the CdZnTe and HgI2 detectors, respectively

Cryogenic Detectors and Techniques

Tuesday AM II: 106 Stanley

Chair: Michael Rabin, LANL

Tuesday AM II: 106 Stanley-1

Liquid Xenon Time Projection Chamber for LUX

Adam Bradley, Case Western Reserve University

[Adam Bernstein, LLNL, will present a substitute talk regarding LUX]

LUX is a new dark matter search experiment to be carried out in the renewed underground laboratory at the Homestake (SD) old gold mine. The detector's large size supports effective internal shielding from natural radioactivity of the surrounding materials and environment. The LUX detector consists of a cylindrical vessel containing 350 kg of liquid xenon (LXe) cooled down using a novel cryogenic system. We tested a small-scale four PMT prototype utilizing over 200 gm of active xenon, installed in the full-sized cryostat. We report the efficiency of a unique internal heat exchanger and liquid level stabilizer system, with standard gas phase purification with a heated getter, which allows for very high flow purification without requiring large cooling power. A stable LXe surface is required for good energy resolution. Such a system is required for multi-ton scale up.

Tuesday AM II: 106 Stanley-2

Ultra-High Resolution Alpha Particle Spectroscopy Using Superconducting Microcalorimeter Detectors

Robert Horansky, National Institute of Standards and Technology (NIST)
J.N. Ullom, J.A. Beall, G.C. Hilton, K.D. Irwin (NIST); D.E. Dry, M.W. Rabin, E. Hastings, S.P. Lamont, C.R. Rudy (Los Alamos National Laboratory)

Alpha spectroscopy is the preferred technique for analyzing trace samples of radioactive material because the alpha particle flux from many materials of interest is significantly higher than the gamma-ray flux. Traditionally, alpha spectroscopy is performed with silicon detectors whose resolution is limited to 8 keV FWHM or higher for 5 MeV alpha particles. Here, we describe the design and operation of a superconducting microcalorimeter alpha detector with energy resolution of 1.4 keV FWHM at 5 MeV. We demonstrate the ability of the microcalorimeter to clearly resolve the alpha particles Pu-239 and Pu-240 at 5.157 and 5.168 MeV, respectively, in a mixed isotope Pu sample. The Pu-239/Pu-240 ratio differentiates reactor-grade Pu from weapons-grade and is a vital identifier for safeguards and materials accounting applications. Hence, our detector may eliminate the need for costly and time-consuming mass spectrometry analysis of trace Pu samples. We also demonstrate the first direct observation of the 4.885 MeV alpha decay of Po-209 to the ground state of Pb-205 which has traditionally been obscured by a much stronger alpha line 2 keV away. The unprecedented resolution of microcalorimeters may allow elements in mixed actinide samples to be individually identified and would eliminate the need for time-consuming chemical separation of these elements prior to alpha counting. Measurements of mixed actinide samples are currently under way and will be presented. Finally, the 1.4 keV resolution observed for alpha particles is far worse than the 0.12 keV resolution predicted from thermal fluctuations and measurement of lower energy gamma-rays. The cause of the resolution degradation may be ion damage in the detector. We will present modeling of ion damage statistics and compare to experiments that are now possible due to the fine resolution achieved with the microcalorimeter. The alpha particle microcalorimeter may provide a new tool for studying ion damage and lattice displacement energies in bulk materials. We also discuss the limits these phenomena impose on detector resolution and possible routes to improvement.

Tuesday AM II: 106 Stanley-3

Large-area microcalorimeter detectors for ultra-high-resolution x- and gamma-ray spectroscopy

Minesh Bacrania, Los Alamos National Laboratory
D.E. Dry, E.P. Hastings, A.S. Hoover, P.J. Karpius, C.R. Rudy (LANL); L.R. Vale (NIST, Boulder, CO); S.P. Lamont, J.H. Rim, M.W. Rabin , D.T. Vo (LANL); J.A. Beall, W.B. Doriese, G.C. Hilton, R.D. Horansky, K.D. Irwin, J.N. Ullom (NIST); C.A. Kilbourne, J.M. King, F.S. Porter (NASA Goddard Space Flight Center)

We will present a summary of our experience developing and operating the next generation of microcalorimeter spectrometer for x- and gamma-ray measurements. This spectrometer consists of an array of up to 256 ultra-sensitive cryogenic transition-edge sensors, coupled to multiplexed SQUID circuitry for readout. The entire system is located inside a mechanically-cooled cryostat, and is operated at approximately 100 mK. Our measurements to date have demonstrated unprecedented spectral resolution. Our best single-pixel resolution has been 22 eV (FWHM) at 103 keV, a factor of ~20 times better than typical high-purity germanium (HPGe) performance. We have also achieved 45-eV (FWHM) resolution with an 11-pixel array. This instrument will be valuable for nuclear materials analysis and forensics. Specifically, our current system is extremely suitable for the determination of Pu isotopic compositions, through the analysis of the 100-keV region of the gamma-ray energy spectrum. For example, we are able to separate the 98.78-keV and 98.95-keV gamma rays emitted by 239Pu and 241Am, respectively. Such performance is vital to understanding the fabrication history and intended purpose of nuclear material. We are in the process of upgrading our detector with a new 64-pixel TES array, as a step towards populating the microcalorimeter detector at full capacity with 256 pixels. A fully-populated detector will achieve efficiency comparable to a small planar HPGe detector. Along with presenting the details of our x- and gamma-ray measurements with this array, we will discuss new developments in microcalorimeter signal analysis, long-term detector system performance, and future prospects.

Tuesday AM II: 106 Stanley-4

Superconducting High- Resolution High-Speed Tunnel Junction Spectrometers for Soft X-Ray Spectroscopy

Stephan Friedrich, Lawrence Livermore National Laboratory
Simon J. George, Stephen P. Cramer (LBNL); Ludwig Fritzsch, Ronny Stolz, Viatcheslav Zakosarenko (Institute for Physical High Technology Jena); Owen B. Drury (LLNL)

Superconducting tunnel junctions (STJs) are being developed as X-ray detectors because they combine the high energy resolution of cryogenic detector technologies with the high count rate capabilities of athermal devices. We are developing STJ spectrometers for chemical analysis of dilute samples by high-resolution soft X-ray spectroscopy at the synchrotron. The instruments use 36 pixels of 200 x 200 micron Nb-Al-AlOx-Al-Nb STJs with 165 nm thick top Nb absorber films. They are operated in an adiabatic demagnetization refrigerator at the end of a cold finger at a temeprature below 0.5K within 1 cm of a room temperature sample. We have recently upgraded the cryostat to a liquid-cryogen-free refrigerator that attains the required operating temperature at the push of a button. The STJ X-ray detectors have achieved an energy resolution of ~10 - 20 eV FWHM for X-ray energies below 1 keV, and can be operated at a total count rate of ~10^6 counts/s. For increased sensitivity and operation at higher energies, we are currently developing larger STJ arrays with higher quantum efficiency. Initial results show extremely low leakage currents in the subgap region and correspondingly low electronic noise. We will discuss the performance of the instrument in fluorescence-detected X-ray absorption spectroscopy, and the most recent results on detector upgrades. We will also present speciation measurements on dopants in novel scintillator materials to illustrate the potential for STJ spectrometers at the synchrotron.

Tuesday AM II: 106 Stanley-5

Fabrication of Large Uniform Arrays of Superconducting Ultra-high Resolution Gamma Detectors

Stephan Friedrich, Lawrence Livermore National Laboratory
Presenter: Miguel Velazquez
R. Soufli, O. B. Drury, J. C. Robinson, J. G. Dreyer, S. L. Baker (LLNL)

Ultra-high energy resolution Gamma-ray detectors based on superconducting transition edge sensors (TESs) can improve the accuracy of non-destructive isotope analysis in fundamental science and nuclear non-proliferation applications. We are developing molybdenum-copper multilayer TESs that have achieved an energy resolution of ~50 - 90 eV FWHM at 100 keV and can be operated at count rates about 100 counts/s per pixel. To address concerns about the uniformity of the detector response over cm2-sized arrays, we have developed a velocity modulation algorithm during the Mo/Cu multilayer sputtering process where the 4-inch-diameter substrate is passing at a variable velocity under the sputtering target during deposition. This produces multilayers with extremely high homogeneity and lateral thickness uniformity < 0.6 % peak-to-valley across 90 mm diameter. The Mo/Cu ratio sets the transition temperature and the Mo/Cu thickness is adjusted for a resistivity matched to the readout electronics. We will present results on 112-pixel array fabrication on 4-inch substrates and discuss scaling to larger array sizes.

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