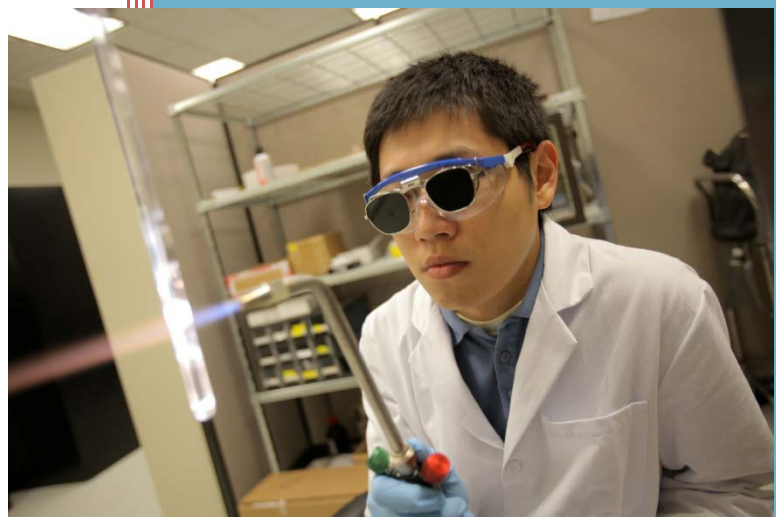


2010

SMRC Annual Report



Scintillation Materials Research Center
University of Tennessee

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SMRC Annual Report

January 1, 2010 through December 31, 2010

Mission Statement

Our mission is to discover and develop new scintillation materials which will provide the foundation for the next generation of gamma-ray, x-ray, and neutron detectors. New radiation detectors will have a major impact on future medical imaging systems, homeland security inspection and monitoring systems, neutron experiments, and remote exploration for new energy resources.



The Science and Engineering Research Facility (SERF)

About the SMRC

The Scintillation Materials Research Center (SMRC) is a unique multidisciplinary research facility that was originally formed via collaboration between the University of Tennessee and CTI Molecular Imaging, Inc. (CTI) which is now merged with Siemens Medical Solutions Molecular Imaging (SMSMI). We are located in the University's Science and Engineering Research Facility, and are part of the College of Engineering.

CTI was founded in 1983 by four alumni of the College of Engineering. After winning Time Magazine's "Medical Invention of the Year" award in 2000 and introducing their proprietary LSO

scintillator technology to medical imaging, CTI embarked in 2003 on a number of joint research projects with faculty in the college to expand research in scintillation materials. CTI and Siemens Medical Solutions merged in 2005, forming SMSMI.

The SMRC combines the academic resources of the university with the scintillator research legacy of CTI to develop innovative materials for state-of-the-art radiation sensors and imaging systems. The center's research activities include the synthesis and characterization of new material compositions, fundamental investigation of scintillation mechanisms, development of novel crystal growth techniques, applications of nano-technology to ceramic scintillator fabrication, modification of existing optical materials for scintillator applications, mathematical modeling of materials and synthesis processes, optimization of existing scintillator crystals for specific applications, and advances in scintillating fiber technology.

The center draws upon the extensive high-technology resources of the Knoxville/Oak Ridge area and offers unique training and educational opportunities for students as well as providing a mechanism for collaborative research with industrial partners and academic research groups.



The University of Tennessee

Contact information

Mailing address:

Scintillation Materials Research Center
The University of Tennessee
124 Perkins Hall
Knoxville, TN 37996-2000

Physical addresses:

SMRC Office: 301 SERF
Bridgman Lab: 303 SERF
Characterization Lab: 302 SERF
Czocharlski lab: 306 SERF

Telephone numbers:

Chuck Melcher: 974-0254
Merry Spurrier Koschan: 974-0267
Mariya Zhuravleva: 974-8440
Fax: 974-4998

E-mail:

SMRC@utk.edu
cmelcher@utk.edu
mkoschan@utk.edu
mariya@utk.edu

Website:

<http://www.engr.utk.edu/smrc>



SMRC Steering Committee:



Wayne Davis, Dean, College of Engineering



George Pharr,
Department Head,
Materials Science and
Engineering



David Townsend, Director,
Molecular Imaging and
Translational Research
Program, Grad. School of
Medicine

Carl McHargue, Director,
Center for Materials
Processing



Claudia Rawn, Assistant
Professor, Materials Science
and Engineering

Brief overview of 2010 accomplishments

Research areas

Our research projects have centered on the discovery and synthesis of new materials, the development of new instrumentation and synthesis techniques, and the fundamental understanding of physical phenomena in scintillation materials.

Funded research

During the past year the successful **UT-Siemens Medical Solutions** collaboration was extended, with a new 5-year contract effective October 31, 2010. This project will continue to fund ongoing work on the development of new scintillator materials for medical imaging applications. In conjunction with this work, a large number of prospective materials have been synthesized and characterized over the past year; four patent applications were filed, and an additional invention disclosure has been submitted. A new **NA-22** project, “Enhancing Energy Migration and Proportionality in Scintillation Materials” was funded for three years, beginning in June 2010. In addition, we started a new effort, along with Dr. Philip Rack, to provide thin film scintillators for research at **Y-12**. Over the past year we continued partnering with faculty and students in Nuclear Engineering, Civil Engineering, and the Chemistry Department on the **NSF-DNDO** funded project, “Transformational Scintillation Materials for Neutron and Gamma Detectors and Educational Integration,” aimed at developing novel radiation detectors for nuclear threat detection, as well as offering unique educational opportunities for students in this field. The SMRC also partnered with **RMD** on a small project, providing crystals to be used in a detector characterization and optimization study.

Collaborations

The SMRC collaborated extensively over the last year with groups both inside and outside the University. In addition to our external collaborations

with Siemens and ORNL, our University collaborators included faculty and students from Chemistry, Civil and Environmental Engineering, Nuclear Engineering, and Materials Science and Engineering.

Intellectual property

We filed four invention disclosures in 2010, three of which reached provisional application status during the calendar year.

Publications

SMRC students and staff authored or co-authored seven papers for peer-reviewed journals which were published or accepted for publication in 2010.

Conferences

SMRC students and staff gave one refresher course and 17 presentations, either oral or poster, during the past year, including at the 16th International Conference on Crystal Growth and Epitaxy in Beijing, China, the 2010 IEEE Nuclear Science Symposium – Medical Imaging Conference (NSS-MIC) in Knoxville, TN, the NNSA NA-22 Office of Nonproliferation and Verification Research and Development, University Information Technical Interchange (UITI) Review Meeting, in Knoxville, TN, the DOE Radiochemistry and Radionuclide Imaging Instrumentation Program Contractor-Grantee Workshop in Rockville, MD and the Thin Film and Small Scale Mechanical Behavior Gordon Conference, 2010 held in Waterville, ME.

Degrees awarded

Two SMRC students graduated during 2010, one with a Masters Degree and one with a PhD, both in Materials Science and Engineering.

SMRC Outreach Activities

The SMRC has engaged in significant outreach activities over the past year. We frequently give laboratory tours to a wide variety of groups, ranging from prospective students to business leaders. The Knoxville, TN location of the 2010 IEEE-NSS

conference gave several outreach and service opportunities, from hosting tours to serving on the Conference Committee to assisting session chairs.

Research capabilities and expertise

The SMRC has broad capabilities and expertise in both material synthesis and material characterization. Three well equipped laboratories provide the opportunity to both synthesize and characterize new materials in house, thus facilitating prompt feedback and shortening the development cycle.

Materials synthesis equipment

- Cyberstar Oxypuller 05-03 Czochralski Growth Station
- Mellen Furnace with Vertical Gradient freeze and Bridgman capabilities
- Mbraun UNILab Glovebox
- Lindberg clamshell furnace
- Lindberg box and tube high temperature (up to 1700°C) annealing furnaces
- Quincy Lab Model 20GC laboratory oven
- Dycor Dymaxion residual gas analyzer
- Sartorius balances and density determination kit
- Leica 6SD microscope with dual light source

Additional capabilities available via cooperation with the Materials Science and Engineering Department:

- RF magnetron sputtering system for combinatorial synthesis of thin films
- Philips X'Pert X-ray diffraction (XRD)
- Hitachi 4300 scanning electron microscope

Materials characterization equipment

- Horiba Jobin-Yvon Fluorolog 3 lifetime spectrometer
- Varian Cary 5000 UV-VIS-IR spectrophotometer

- Hitachi F4500 fluorescence spectrophotometer
- Relative and absolute light yield measurement systems
- Gamma ray coincidence setup
- Decay time measurement system
- Thermoluminescence system
- Radioluminescence measurement capability
- Buehler IsoMet 4000 diamond saw for sample preparation

Major instruments

The Cyberstar Oxypuller 05-03 is a research-grade Czochralski crystal growth system primarily used in the SMRC to grow single-crystal inorganic scintillators in the ~30mm diameter size range. This system is fully computerized with an automatic diameter control system. The atmosphere inside the growth chamber is continuously monitored via the Dycor Dymaxion residual gas analyzer; multiple gases can be mixed in order to optimize growth conditions.

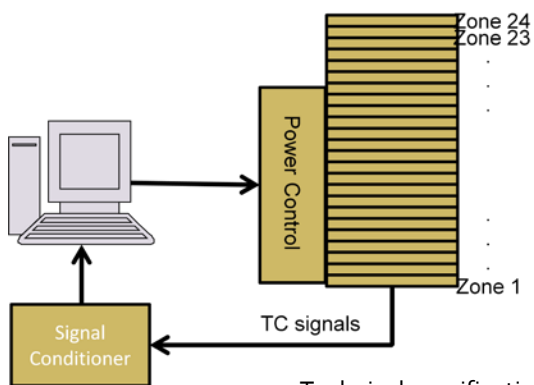


Technical specifications:

- Maximum temperature of ~2100°C with an iridium crucible and zirconia insulation
- A removable bellows, permitting use as either an open or closed growth chamber
- A dedicated cooling water system with high precision (within 0.1°F) temperature control
- High stability, compact 30 kW Huttinger MF (10 kHz range) power supply with closed loop control

Mellen Vertical Gradient Furnace

The Mellen crystal growth station in the SMRC laboratory (on indefinite loan from Siemens) can be used as both a classical bridgman growth station and as a vertical gradient freeze growth station. The latter differs from normal gradient freeze techniques in that there are no moving parts; rather than moving an ampoule through the thermal gradient, the thermal gradient is electronically moved through the ampoule by controlling the temperature of 24 independent thermal zones. Control parameters are modifiable in real time using the Mellen ADAPT software package.



Technical specifications:

- Heated length of furnace: 24"
- 24 independently controlled 1" temperature zones
- Thermocouple port in each control zone, oriented perpendicular to the furnace bore
- Maximum temperature 1300°C
- Nominal bore ID 2.25"
- Voltage: 110V per zone

Mbraun UNILab Glovebox System

The SMRC laboratories are equipped with a glovebox system, also on indefinite loan from Siemens, for handling hygroscopic or atmosphere-sensitive materials. This capability greatly expands the range of materials that we are able to handle.



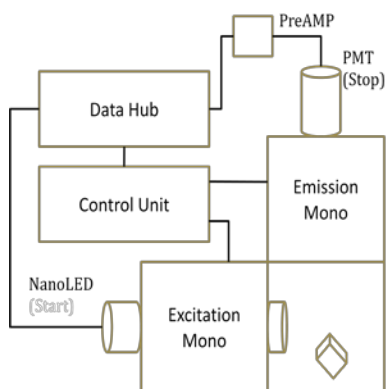
Technical specifications

- Dimensions: 1200 x 920 x 780 mm³
- Inner volume: ~0.8m³
- Box material: US 304 Stainless steel
- Attainable purity: H₂O < 1 ppm, O₂ < 1 ppm
- Leak rate: < 10⁻⁵ mbar l/s
- Optional components installed:
Mini-antechamber,
H₂O analyzer, O₂ analyzer



Horiba Jobin-Yvon Fluorolog 3 lifetime spectrometer

This modular system with interchangeable pulsed UV Nano LED light sources and time-correlated single photon counting analysis is a key instrument in the study of photoluminescence kinetics. The one ns excitation sources can be selected to match the excitation bands of the scintillators of interest; the system can operate at temperatures from 9K to 700K.



Specifications:

Dual lamp housing: 450W Xenon source and UV xenon flash tube.
 Double excitation spectrometer with 1200 g/mm gratings blazed at 330 nm
 Double emission spectrometer with 1200 g/mm gratings blazed at 500 nm

Varian Cary 5000 UV-VIS-IR spectrophotometer



The electronic energy levels of luminescence centers are readily determined via optical spectroscopy. In addition, optically active defects such as F-centers can be characterized. This instrument employs Schwarzschild coupling optics to ensure the maximum level of light throughput, and out-of-plane double Littrow monochromators to minimize photometric noise and stray light. An optical isolation system incorporates a floating aluminium casting that isolates the optics from external disturbances. The monochromators and sample compartments have separate nitrogen purging capabilities, allowing the sample compartment to be purged at a higher rate than the instrument. The optics are silica overcoated, so that they can be cleaned without damage to the reflective surface.

Specifications:

Wavelength: 175 -3300 nm
 Gratings: 1200 lines/mm
 Wavelength accuracy (UV-Vis): +/-0.1 nm
 Photometric accuracy (UV-Vis): 0.0003 abs

Hitachi F4500 fluorescence spectrophotometer



Emission and excitation transitions of luminescence centers are investigated by means of steady-state fluorescence spectroscopy. We often implement a helium cryostat and temperature controller with this instrument to achieve a wide range of sample temperatures. Spectra can be corrected for instrument sensitivity as a function of wavelength.



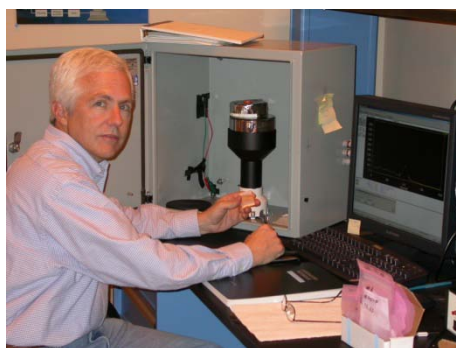
Specifications:

- Wavelength: 200 – 900 nm
- Gratings: 600 lines/mm
- Wavelength accuracy: 1.0 nm
- Sample temperature: ~40 – 600K

Scintillation light yield measurements

The SMRC laboratories are well equipped for both relative and absolute light yield measurements.

Relative light yield measurements are done in comparison with a known reference scintillator, typically BGO, and can be carried out at a variety of excitation energies. The test set is first calibrated with a reference crystal of known light yield, using a Hamamatsu R877 photomultiplier tube, and the sample spectrum is then compared to that of the reference.



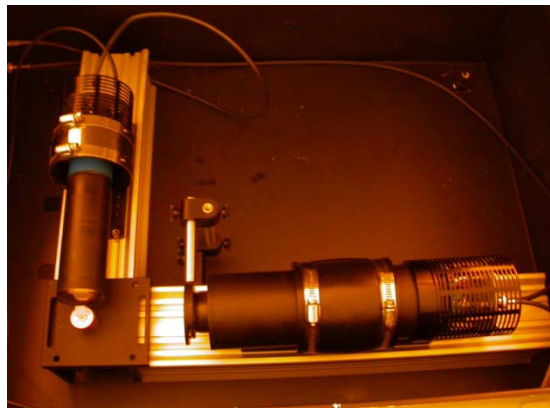
Absolute light output is measured with a Hamamatsu R2059 photomultiplier; again, a number of sources of differing energies are available. In order to increase



the light collection efficiency the crystal may be coupled with optical grease, and tightly covered with a Tetratex TX3104 PTFE membrane. The pulse height of a single photoelectron is measured and

compared to that of the sample in order to obtain the photoelectron yield per unit gamma ray energy. Assuming full light collection, the emission spectrum of the scintillator and the quantum efficiency curve of the photomultiplier are then used to calculate the number of photons per unit gamma ray energy.

Decay time measurement system



Scintillation kinetics are investigated with a system that employs the time-correlated single photon counting principle. A fast timing photomultiplier tube is used to start the time measurement when a gamma ray is absorbed by the sample, and a similar one is used to record correlated single photon stop counts as a function of time. An adjustable aperture ensures that only single photon events are analyzed. The time distribution of single photons illustrates the rise and decay of the scintillation light pulse.



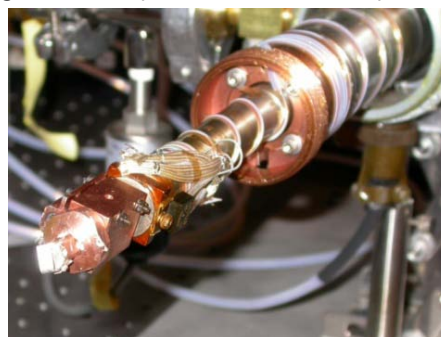
Scintillation processes on time scales of nanoseconds to microseconds and longer can be investigated in this way.

Thermoluminescence and Radioluminescence systems

Thermoluminescence is a useful tool for studying the energy transfer or, specifically, the role of charge carriers in the scintillation process, which can be carried out on crystals with a variety of compositions. It is generally accepted that deep traps, revealed by high-temperature thermoluminescence (measured at temperatures higher than 300K), can reduce the scintillation light yield and that shallow traps are usually responsible for slow components in scintillation decays.



The SMRC thermoluminescence system includes an ARS compressor and cryostat designed for measurements in a 9K-800K temperature range, a LakeShore controller for precision temperature control, a 200-900 nm Ocean optics HR2000 high-resolution CCD spectrometer, and a 35 keV X-ray generator capable of continuous operation.



The same system can be configured for radioluminescence measurements, which can be done in the same temperature regime.

Dycor Dymaxion Mass Spectrometer

A Dycor quadrupole mass spectrometer system is used for real-time monitoring of crystal growth station atmospheres and volatile melt components, enabling the crystal grower to optimize the atmosphere provided for each crystal composition as well as detection of undesired atmosphere leaks or melt decomposition.



Technical specifications:

- Mass range: 1-100 AMU
- Enclosed ion source
- Capillary inlet manifold
- Compound turbomolecular pump, dry pump, and pump controller
- Minimum Detectable Partial Pressure 5×10^{-12} Torr.



Personnel

The Scintillation Materials Research Center has joined with departments within the COE to obtain grants that help to support UT faculty and staff and their research activities. These grants fully supported three staff members in 2010, and offered partial financial support to three others, as well as supporting the laboratory activities of three additional professors. Six graduate students were funded through the SMRC; six undergraduate students have been employed by the center at different times over the past year on a part-time basis to assist with sample prep, measurements, and other laboratory operations.

Faculty and Staff

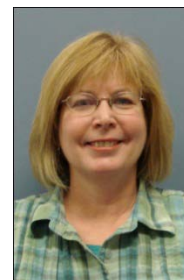
The full-time center staff:



Dr. Chuck Melcher –
Director of the SMRC, Research
Professor in Materials Science and
Engineering

<http://www.engr.utk.edu/mse/faculty/melcher/default.html>

Merry Spurrier Koschan –
Research Associate III, SMRC



Dr. Mariya Zhuravleva – Post-
doctoral Research Associate

Partially supported staff:



Frank Holiway - Materials Science and Engineering Accounting Specialist



Dr. Bin Hu – Associate Professor in Materials Science and Engineering

<http://www.engr.utk.edu/mse/faculty/hu/default.html>



Dr. Philip Rack – Associate Professor in Materials Science and Engineering

<http://www.engr.utk.edu/mse/faculty/prack/default.html>

Adjunct faculty:

Dr. Lars Eriksson – Scientific Advisor, Siemens Medical Solutions; Adjunct Professor, Materials Science and Engineering



Dr. Piotr Szupryczynski – Research Scientist, Siemens Medical Solutions; Adjunct Assistant Research Professor, Materials Science and Engineering

Additional personnel:



Dr. George Pharr – Professor and Head, Materials Science and Engineering

<http://www.engr.utk.edu/mse/faculty/pharr/default.html>

Students:

Graduate students (advisor):

- Paul Cutler (Melcher)
- Kurt Johanns (Pharr)
- Jonathan Peak (Rack)
- Harold Rothfuss (Melcher)
- Hua Wei (Melcher)
- Kan Yang (Melcher)

Undergraduate students (Department)

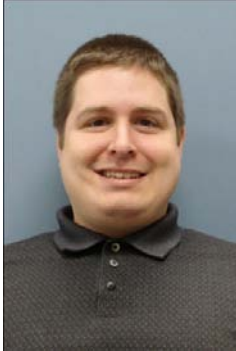
- Bonnie Blalock (MSE)
- John Bohling (MSE)
- Brandon Goodwin (MSE)
- Lucas Hofmeister (MABE)
- Breana Harwell (MSE)
- Brett Lewis (MSE)



Undergraduate student John Bohling operating our Buehler Isomet 4000 saw.

Graduate students

Paul Cutler



Graduate Student in Materials Science and Engineering*

Advisor – Professor Chuck Melcher

*Also supported by the Center for Materials Processing

Research interests:

Synthesis/Processing of ceramic scintillators and nonproportionality in single crystal inorganic scintillators.

Thesis:

“Synthesis and Scintillation of Single Crystal and Polycrystalline Rare-Earth-Activated Lutetium Aluminum Garnet”, accepted as partial fulfillment of the requirements for the degree of Master of Science with a major in Materials Science and Engineering in August, 2010.

Current position:

Upon graduation, Paul Cutler accepted a Post-Master’s position as a Scientific Associate at the Spallation Neutron Source/Oak Ridge National Laboratory. He is currently working on the Cold Neutron Chopper Spectrometer: <http://neutrons.ornl.gov/instruments/SNS/CNCS/>

Kurt Johanns



Graduate Student in Materials Science and Engineering

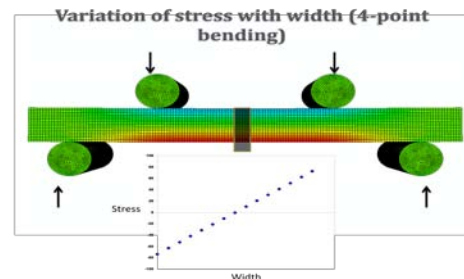
Advisor – Professor George Pharr

Research interests:

- Modeling crack initiation and propagation in brittle materials during indentation.
- Experimentally measuring the mechanical properties of single crystal scintillation materials with unique methods.
- Improving material properties for enhanced component lifetime and reliability.

Recent poster presentations:

K. E. Johanns, G. M. Pharr, J. H. Lee, and Y. F. Gao, “FE Analysis of Median Cracking During Wedge Indentation”, at the Thin Film and Small Scale Mechanical Behavior Gordon Conference, 2010.



Jonathan Peak



Graduate Student in Materials Science and Engineering
Advisor – Professor Philip Rack

Research interests:

Thin Film Combinatorial Synthesis of Scintillation Materials

Dissertation:

“Thin Film Combinatorial Synthesis of Advanced Scintillation Materials”, December, 2010.

Recent publication:

Jonathan D. Peak, Charles L. Melcher, Philip D. Rack, Combinatorial thin film sputtering investigation of cerium concentration in Lu₂SiO₅ scintillators, J. Luminescence 130(8) 1366-1370 (2010).

Recent presentations:

Poster presentation: J. D. Peak, C. L. Melcher, P. D. Rack, “Thin Film Combinatorial Exploration of Scintillation Materials” at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN October 30 – November 6, 2010.

Harold Rothfuss



Graduate Student in Materials Science and Engineering/Siemens employee
Advisor – Professor Chuck Melcher

Research interests:

Scintillation materials/Simulations of radiation transport in scintillators including the use of codoping to improve fundamental scintillation properties.

Recent publications:

Accepted for publication: L. Eriksson, C. L. Melcher, M. Zhuravleva, M. Eriksson, H. Rothfuss, M. Conti, “Phoswich solutions for the PET DOI problem”, Nucl. Instrum. Methods A, 2010, doi:10.1016/j.nima.2010.11.049

Recent presentations:

Coauthor of several presentations at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN October 30-November 6, 2010

Hua Wei



Graduate Student in Materials Science and Engineering

Advisor – Professor Chuck Melcher

Hua Wei is a new graduate student who joined the SMRC in August of this year. She comes to us from the Harbin Institute of Technology in Harbin, China where she was a student in their Honors School with an undergraduate major in Composite Materials and Engineering.

Her undergraduate research projects included “Synthesis of responsive hydrogel poly (N-isopropylacrylamide)”, “Study and evaluation of silica aerogel/sodium silicate composite”, and “Fabrication and characterization of ITO based thin films”.

Kan Yang



Graduate Student in Materials Science and Engineering

Advisor – Professor Chuck Melcher

Research interests:

Research interests include the discovery and bulk single crystal growth of novel gamma/neutron detection scintillators via Vertical Gradient Freeze and Bridgman technique, investigations on the effect of ionic co-doping on the basic scintillation mechanisms of LSO:Ce, and designing and building a new modified vacuum Bridgman crystal growth furnace

Recent degree:

Master of Science in Materials Science and Engineering, August 2009.

Thesis: Charge Traps and Luminescence Centers in Ca co-doped LSO:Ce Single Crystals

Recent oral presentations:

“Crystal Growth and Scintillation Properties of $\text{CsSr}_{1-x}\text{Eu}_x\text{I}_3$ High Light Yield Scintillators”, at the 16th International Conference on Crystal Growth and Epitaxy in Beijing, China, August 2010.

“Growth and Scintillation Properties of $\text{AGd}_2\text{Cl}_7:\text{Ce}^{3+}$ (A=K, Cs) New Scintillators for Gamma/Neutron Detection” at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN 10/30 – 11/6, 2010.

“Optical and Scintillation Properties of Single Crystal $\text{CsSr}_{1-x}\text{Eu}_x\text{I}_3$ ” at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN 10/30 – 11/6, 2010.

Recent poster presentations:

“Crystal growth and scintillation properties of Cs_3EuI_5 crystals”, at the 16th International Conference on Crystal Growth and Epitaxy in Beijing, China, 8/ 2010.

“Temperature Response and Thermoluminescence of $\text{SrI}_2:\text{Eu}^{2+}$ Single Crystals” at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN 10/30 – 11/6, 2010

Undergraduates

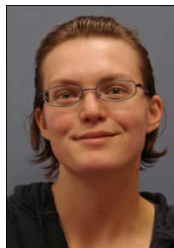
John
Bohling



Breana
Harwell



Bonnie
Blalock



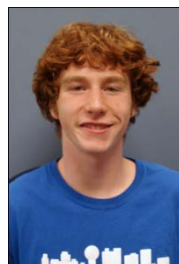
Lucas
Hofmeister



Brandon
Goodwin



Brett
Lewis



Student and Staff Awards and Honors

John Boling, MSE Senior, received the University of Tennessee Citation for Extraordinary Academic Achievement in April 2010.

John Boling and Brandon Goodwin, both MSE Seniors, jointly shared the E. Eugene Stansbury Award for Outstanding Senior in April 2010.

Where are our former graduate students today?

To date, two of the SMRC graduate students have completed their degree requirements and entered the workforce.

Paul Cutler accepted a post-Master's position as a Scientific Associate at the Spallation Neutron

Source/Oak Ridge National Laboratory. He is currently working on the Cold Neutron Chopper Spectrometer:

<http://neutrons.ornl.gov/instruments/SNS/CNCS/>

Jonathan Peak accepted a position as a Research Fellow at Shasta Crystals in the Redding, CA area.

Service activities

Editorial

During the past year, Dr. Melcher served as Associate Editor of IEEE Transactions on Nuclear Science, Associate Editor of the Proceedings of SCINT 2009, and as Chair of the IEEE Radiation Instrumentation Technical Committee.

Conferences

Dr. Melcher served on the organizing committees for the Scint 2011 conference to be held in Giessen, Germany and the IEEE Nuclear Science Symposium and Medical Imaging Conference, held in Knoxville in 2010.

Dr. Melcher and Dr. Eriksson served as Reviewers for the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference.

Review panel activities

In 2010 Dr. Melcher served on a review panel for the Department of Energy.

Committees

During the past year, Dr. Melcher served as Chair of the Radiation Instrumentation Technical Committee in the IEEE Nuclear and Plasma Sciences Society, as a member of the Awards Committee of the IEEE Nuclear and Plasma Sciences Society, member of the IEEE AdCom Constitution and By-laws Committee, and member of the 2010 IEEE NSS-MIC Organizing Committee (Scholarship Chair).

In addition, he served as a member of the Translational Research Committee at UTK, and as a

member of the Materials Science and Engineering External Affairs Committee

Merry Spurrier Koschan served on the Executive Committee of the Oak Ridge Chapter of ASM, International as Yearbook Chair.

Intellectual Property

Intellectual property developments during the last year include three provisional patent applications filed.

Theses

Two theses were completed in 2010. Paul Cutler presented his Master's thesis, "Synthesis and Scintillation of Single Crystal and Polycrystalline Rare-Earth-Activated Lutetium Aluminum Garnet" in August.

Jonathan Peak presented his Doctoral dissertation, "Thin Film Combinatorial Synthesis of Advanced Scintillation Materials", in December.

Publications

1. A. Rakov, U. S. Salikhbaev, A. K. Islamov, R. H. Bartram, C. L. Melcher, Restored thermoluminescence in oxide crystals, *J. Luminescence* 130, 2004-2012 (2010).
2. M. Moszynski, T. Szczesniak, M. Kapusta, M. Szawlowski, J. Iwanowska, IEEE, M. Gierlik, A. Syntfeld-Kazuch, L. Swiderski, Member, C.L. Melcher, L. Eriksson, J. Glodo, Characterization of Scintillators by Modern Photomultipliers - a New Source of Errors, *IEEE Trans. Nuc. Sci.* 57(5) 2886-2896 (2010).
3. Jonathan D. Peak, Charles L. Melcher, Philip D. Rack, Combinatorial thin film sputtering investigation of cerium concentration in Lu_2SiO_5 scintillators, *J. Luminescence* 130(8) 1366-1370 (2010).

4. W. W. Moses, M. Janecek, M.A. Spurrier, P. Szupryczynski, W.-S. Choong, C.L. Melcher, and M. Andreaco, Optimization of LSO for Time-of-Flight PET, *IEEE Trans. Nuc. Sci.* 57(3) 1570-1576 (2010).
5. M. Zhuravleva, K. Yang, P. Szupryczynski, A. Yoshikawa, C.L. Melcher, Crystal growth and evaluation of LuAG:Ce:Tb scintillator, *J. Crystal Growth*, 312, 1244-1248 (2010).
6. T. Szczesniak, M. Moszynski, A. Syntfeld-Kazuch, L. Swiderski, M.A. Spurrier Koschan, and C.L. Melcher, Timing Resolution and Decay Time of LSO Crystals Co-doped with Calcium, *IEEE Trans. Nuc. Sci.* 57(3) 1329-1334 (2010).

A seventh paper was accepted for publication:

7. L. Eriksson, C. L. Melcher, M. Zhuravleva, M. Eriksson, H. Rothfuss, M. Conti, "Phoswich solutions for the PET DOI problem", *Nucl. Instrum. Methods A*, 2010, doi:10.1016/j.nima.2010.11.049

Presentations

Refresher course

Dr. Melcher gave a refresher course on "New Trends in Scintillators" at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference in Knoxville, TN

Oral Presentations

1. C. Melcher, M. Zhuravleva, "Wavelength shifting phoswich detectors for superior depth-of-interaction resolution", Wavelength shifting phoswich detectors for superior depth-of-interaction resolution", at the DOE Radiochemistry and Radionuclide Imaging Instrumentation Program Contractor-Grantee Workshop, Jan 5-6, 2010, Rockville MD

2. M. Zhuravleva, K. Yang, C. Melcher, "Crystal Growth and Scintillation Properties of Cs₃CeCl₆ and CsCe₂Cl₇", at the 16th International Conference on Crystal Growth and Epitaxy in Beijing, China, August 2010.
3. Kan Yang, Mariya Zhuravleva, Harold Rothfuss, Charles L. Melcher, "Crystal Growth and Scintillation Properties of CsSr_{1-x}Eu_xI₃ High Light Yield Scintillators", at the 16th International Conference on Crystal Growth and Epitaxy in Beijing, China, August 2010.
4. M. Zhuravleva, K. Yang, H. Rothfuss, C. Melcher "Crystal Growth and Scintillation Characterization of Cs₃CeX₆ and CsCe₂X₇ (X = Cl, Br)" at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN October 30 – November 6, 2010.
5. K. Yang, M. Zhuravleva, H. Rothfuss, C. Melcher Crystal "Growth and Scintillation Properties of AGd₂Cl₇:Ce₃₊(A=K, Cs) New Scintillators for Gamma/Neutron Detection" at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN October 30 – November 6, 2010.
6. K. Yang, M. Zhuravleva, H. Rothfuss, C. L. Melcher "Optical and Scintillation Properties of Single Crystal CsSr_{1-x}Eu_xI₃" at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN October 30 – November 6, 2010.
2. M. Koschan, B. Goodwin, B. Blalock, C. Ahn, A. Green, M. Zhuravleva, D. Fielden, C. L. Melcher, "Lithium yttrium borate crystals for radiation detection", at the 16th International Conference on Crystal Growth and Epitaxy in Beijing, China, August 2010.
3. Kan Yang, Mariya Zhuravleva, Bonnie Blalock, Charles L. Melcher, "Crystal growth and scintillation properties of Cs₃EuI₅ crystals", at the 16th International Conference on Crystal Growth and Epitaxy in Beijing, China, August 2010.
4. M. Zhuravleva, K. Yang, B. Blalock, A. Green, C. L. Melcher, "Crystal growth and scintillation properties of Ce³⁺-doped KGd₂Cl₇", at the 16th International Conference on Crystal Growth and Epitaxy in Beijing, China, August 2010.
5. L. A. Eriksson, M. Conti, C. L. Melcher, H. Rothfuss, M. L. Eriksson, M. Zhuravleva, "LuYAP/LSO Phoswich Detectors for High Resolution Positron Emission Tomography", at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN October 30 – November 6, 2010.
6. J. D. Peak, C. L. Melcher, P. D. Rack, "Thin Film Combinatorial Exploration of Scintillation Materials" at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN October 30 – November 6, 2010.
7. K. Yang, M. Zhuravleva, P. Szupryczynski, C. L. Melcher, "Temperature Response and Thermoluminescence of SrI₂:Eu²⁺ Single Crystals" at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN October 30 – November 6, 2010
8. S. St. James, M. Spurrier Koschan, C. L. Melcher, S. R. Cherry "Characterizing the Performance of a 220 Micron Depth-of-Interaction LSO PET Detector", at the 2010 IEEE Nuclear Science

Poster Presentations

1. M. Zhuravleva, L. Eriksson, M. Koschan, R. Graziozo, H. Rothfuss, F. Bauer, C. L. Melcher, "Wavelength Shifting Phoswich Detectors for Superior Depth-of-Interaction Resolution", at the DOE Radiochemistry and Radionuclide Imaging Instrumentation Program Contractor-Grantee Workshop, Jan 5-6, 2010, Rockville MD

Symposium and Medical Imaging Conference, Knoxville, TN October 30 – November 6, 2010.

9. S. St. James, P. A. Cutler, C. L. Melcher, S. R. Cherry, "Pushing the Spatial Resolution Limits in Positron Emission Tomography: the Effect of Inter-Crystal Scatter and Event Mispositioning with Sub-mm Crystals" at the 2010 IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville, TN October 30 – November 6, 2010.
10. K. E. Johanns, G. M. Pharr, J. H. Lee, and Y. F. Gao, "FE Analysis of Median Cracking During Wedge Indentation", at the Thin Film and Small Scale Mechanical Behavior Gordon Conference, 2010.
11. C. Melcher, "Enhancing Energy Migration and Proportionality in Scintillation Materials" the NNSA NA-22 Office of Nonproliferation and Verification Research and Development, University Information Technical Interchange (UITI) Review Meeting held in Knoxville, TN December 7-9, 2010

Review meetings and reports

1. Siemens: In the interest of maintaining a close and effective working relationship, we held regularly scheduled review meetings with Siemens personnel at which the activities, results and accomplishments are presented and Siemens and UTK staff and students have an opportunity to discuss future plans and priorities.
2. NNSA: The SMRC staff participated in the NNSA NA-22 Office of Nonproliferation and Verification Research and Development, University Information Technical Interchange (UITI) Review Meeting held in Knoxville, TN December 7-9, 2010.

3. DOE: SMRC staff participated in a DOE Radiochemistry and Radionuclide Imaging Instrumentation Program Contractor-Grantee Workshop held in Rockville, MD in 2010.

SMRC social activities

The SMRC held several social activities during the past year; photos from a few of these are shown below:

Group cookout

In July we had a group cookout at Look Rock, near Townsend, TN:

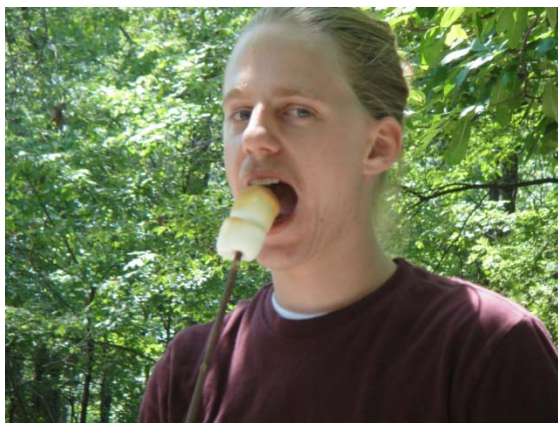
<http://www.nature.nps.gov/air/webcams/parks/grsmcam/grsmcam.cfm>





September cookout and boating party

On Labor Day, the SMRC held a cookout (with this group, food is a common theme!), followed by boating and water skiing:



Imoni party

In November we had an Imoni party: <http://en.wikipedia.org/wiki/Imoni>. The Imoni was prepared by a group of visiting colleagues from Tohoku University in Sendai, Japan, who were in Knoxville for the IEEE NSS-MIC conference. The imoni soup required extensive preparation, but it was very delicious!



Holiday potluck lunch

In December of every year, the SMRC has a potluck lunch; here are a few pictures from 2010:

