

Innovations in Materials Research

Newsletter of the OSU Institute for Materials Research

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Faculty Spotlight: Arthur Epstein, Physics

In this issue's Faculty Spotlight we honor Dr. Arthur Epstein, Distinguished University Professor of Physics, who retired from Ohio State this summer. Our community has been most fortunate in that it includes a number of truly distinguished researchers and leaders, and several who, like Dr. Epstein, have retired from their positions at Ohio State during the existence of IMR. This issue's spotlight shines upon Dr. Epstein for two reasons: first, to recognize his superlative research career, his many contributions and their impact on materials science; and second, his visionary leadership over 14 years in creating and directing the OSU Center for Materials Research (CMR), which existed from 1989-2003. The CMR was an organization that led to a new culture of interdisciplinary collaboration in our community, the initiation of what are now internationally leading research areas that benefit many of us today.

Dr. Epstein pursued a 14-year career in industry research as a Member of Technical Staff at the MITRE Corporation and as a Principal Scientist at the Xerox Webster Research Center before joining Ohio State's faculty in 1985. During his tenure at The Ohio State University, Dr. Epstein was named Distinguished University Professor in addition to being a Professor of Physics and Professor of Chemistry and he was the first faculty member to hold tenured appointments in those two departments. Epstein also helped found several companies based on his group's research, including Eonyx Corp and Traycer, and has served as a consultant for a number of large companies such as DuPont, Xerox, Honda, and Mitsubishi.



IMR Director Steve Ringel congratulates Art Epstein at his retirement reception.

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IMR Announces Two New Associate Directors



This Fall, IMR announced the appointment of two new Associate Directors, Professors David McComb and Fengyuan Yang. They join Dr. Bob Davis, Director

of Nanotech West Lab, who continues to serve as an IMR Associate Director.

in electron microscopy and the application of such methods to biological and structural materials. His research concentrates on the development and application of nanoanalytical electron microscopy techniques for the study of chemistry, structure and bonding at the interfaces of atoms. His work also includes the synthesis of novel, multifunctional three-dimensionally ordered solids.

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Dr. McComb is a Professor of Materials Science and Engineering, the Ohio Research Scholar in Nanoscale Materials Characterization and the Director of the new Center for Electron Microscopy and Analysis (CEMAS). McComb is a world leader



Director's Note



Dear Colleagues,

Welcome to the Autumn 2013 edition of *Innovations in Materials Research!* It's already been a busy beginning to the current academic year, with a continuous stream of great advances in a wide swathe of materials research and many other activities that you can read about in this issue.

The OSU materials community has welcomed a large cadre of new faculty members, (including the completion of IMR's Ohio Research Scholars Program cluster in Technology-Enabling and Emergent Materials (TEEM) with the arrival of Prof. Rafael Brüscheiler to the departments of Chemistry and Biochemistry. We also opened a new world-class experimental core facility, the Center for Electron Microscopy and Analysis (CEMAS), directed by Prof. David McComb, and we have added new members to the IMR leadership team. I am thrilled to announce the appointments of Professor David McComb of the Department of Materials Science and Engineering and Professor Fengyuan Yang of the Department of Physics as IMR Associate Directors. Fengyuan and Dave follow the large footprints left by Professors Malcolm Chisholm (Chemistry) and Michael Mills (Materials Science and Engineering), who have completed their tenures as IMR Associate Directors. We thank Mike and Malcolm for the substantial contributions and service and we look forward to working with both Malcolm and Mike as vital faculty members of the IMR community. At the same time, we heartily welcome Dave and Fengyuan to our leadership team and I look forward to working with them toward the continued advancement of the materials research enterprise at Ohio State.

I also want to acknowledge Professor Arthur J. Epstein – the person, the mentor, the innovative researcher and the leader, who recently announced his retirement from OSU. Many of you know Art due to his prolific research career in electronic and magnetic polymers and

his visionary leadership as the Director of the Center for Materials Research (CMR) at OSU. To a large extent, the CMR launched the interdisciplinary community that we now enjoy today. While time moves quickly, we should not forget the importance of those formative days of our community when true multidisciplinary teams and core user facilities that are now so much part of the fabric of our community were only goals of the future. I am happy to note that Art is remaining at OSU as Professor Emeritus in the Department of Physics, where he continues to vigorously focus on forward-looking, interdisciplinary research. Art and his research are the focus of our faculty spotlight in this issue.

Inside, you can also read about several important activities across the community that have occurred in the past few months, including the award of a new MURI (Multidisciplinary University Research Initiative) to a team lead by Profs. Joseph Heremans and Roberto Myers, numerous highlights from the Center for Emergent Materials (CEM), and the establishment of the State-funded Ohio Sensor and Semiconductor Innovation Platform (OSSIP) at Nanotech West led by IMR Associate Director Bob Davis, which will bring in key industry partnerships in the area of semiconductor optoelectronic sensors.

Finally, please mark your calendars for the 2014 OSU Materials Week conference to be held May 6-9, 2014! A great lineup of topics and speakers are now forming. Check the IMR website, imr.osu.edu, for updated information.

Warm Regards,

Steven A. Ringel, Ph.D.

Neal A. Smith Chair Professor

Director, The Ohio State University Institute for Materials Research

Campus Celebrates CEMAS Grand Opening

On September 18 and 19, 2013, the campus formally welcomed the newest materials research lab facility, the Center for Electron Microscopy and Analysis (CEMAS). Located on Kinnear Road, CEMAS boasts the highest concentration of high-end microscopes in North America and the center is expected to be ranked among the top ten electron microscopy facilities worldwide, thus elevating the capabilities and status of The Ohio State University's materials community globally.



Considerable construction and preparation was needed to turn a cement warehouse into a world-class microscopy facility.

This new hub for business and academia materials characterization is home to \$28 million of equipment, including 10 FEI electron microscopes, two X-ray diffractometer systems, facilities for nanoindentation, and an extensive array of sample preparation facilities. CEMAS is directed by Dr. David McComb, Professor of Materials Science and Engineering and Ohio Research Scholar in Nanoscale Materials Characterization, who has worked tirelessly for two years to bring the facility to fruition. It is anticipated that researchers from life sciences,

physical sciences and engineering will use CEMAS for a wide range of experimentation with full technical support. The facility will be available to materials researchers from all disciplines, and the microscopy available at CEMAS could help develop novel solutions in medicine, healthcare, environment, energy and technology.

As part of the grand opening festivities, CEMAS hosted plenary addresses from world leaders in microscopy followed by a day of related seminars from researchers from academia, national labs and a

graduate student poster session. A ribbon cutting ceremony included remarks by several OSU leaders and Dr. Don Kania, President and CEO of FEI, an event sponsor and manufacturer of CEMAS microscopes.



Left: One of several electron microscopes available for use now at CEMAS.

Right: CEMAS Director David McComb is joined by OSU and FEI leaders at the facility's ribbon cutting ceremony.

IMR is proud to be a partner with CEMAS, providing funds to support the facility through the Ohio Research Scholars Program award in Technology-Enabling and Emergent Materials, an Ohio Third Frontier award which allowed OSU to recruit Dr. McComb in October 2011 and contribute to the acquisition of the world class instrumentation available today at CEMAS. Attendees of 2013 OSU Materials Week were able to tour CEMAS labs during a conference reception held in the CEMAS facility.

For more information on CEMAS and the facility's staff and instrumentation, visit cemas.osu.edu.

Spin Caloritronics V Workshop Hosted by OSU



and Computer Engineering and Joseph P. Heremans, Professor of Mechanical and Aerospace Engineering and Ohio Eminent Scholar in Nanotechnology. This is the first time that the Spin Caloritronics

The Ohio State University hosted the fifth annual Spin Caloritronics Workshop (SpinCat V) on May 12-15, 2013. This workshop was co-chaired by Roberto Myers, Associate Professor of Materials Science and Engineering and Electrical

workshop has been held in the United States, with previous workshops held alternatively at the Lorentz Center in Leiden and Tohoku University in Sendai.

The workshop was dedicated to reports of new results and general exchange of thoughts concerning the role of the thermal excitations in driving spin fluxes in spin-polarized materials. Spin Caloritronics is a totally new technology that promises to result in all solid-state heat to electricity conversion technologies. Like thermoelectrics, it could be used to convert the world's waste heat into useful energy with possible transformational implications for solving the world's energy crisis.



The research topic has brought the fields of spin-physics, magnetism, and thermoelectrics together due to recent breakthrough experiments revealing new means for coupling the properties of spin, magnetism, and heat in solids. The meeting united 30 invited speakers from over 10 countries, each at the top of one of the main fields (spin physics, magnetism, the thermal sciences and thermoelectricity) and the workshop was attended by 62 participants who represented 35

Universities and Research Centers. SpinCat V provided an opportunity for OSU's graduate students to learn from the experts and observe how they interact with others in different fields is unique and students and postdocs presented posters throughout the workshop.

IMR was a contributing sponsor of the SpinCat V meeting, and IMR administrative staff planned and coordinated the event. Myers and Heremans' work in the area of spin has previously been seeded by an internally-funded two-year Proto-IRG (Interdisciplinary Research Grant) award, which also contributed to the recent Department of Defense Multidisciplinary Research Initiative (MURI) award described on page 12 of this issue.

Faculty Spotlight: Arthur Epstein, Physics

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Dr. Epstein co-discovered the first magnet based on organic materials in 1985, and is recognized as the world's leading expert in how polymers conduct electricity. In 2002, he was named a Fellow of the American Academy for the Advancement of Sciences, one of the greatest honors bestowed upon a scientist for meritorious efforts to advance science or its applications, in recognition of his "leadership in the fundamental and applied interdisciplinary science of conducting, semiconducting and magnetic polymers, particularly for the co-discovery and studies of organic-based magnets."

On the occasion of Dr. Epstein's retirement, colleagues spoke fondly of his work and his leadership. Professor of Chemistry Terry Gustafson said, "Art Epstein has been and continues to be a pioneer in organic materials, particularly organic conductors and organic spintronics. His leadership in the OSU materials community has been essential in raising the visibility of OSU's materials community to the international community." "Art has had a major impact at Ohio State – as a physicist, an educator, and as CMR Director," adds Len Brillson, Professor of Electrical and Computer Engineering and a Center for Materials Research Scholar recruited to OSU by Epstein in 1996. "It's fair to say that Art put Ohio State on the international map of organic electronics, creating a state-of-the-art laboratory, generating hundreds of publications in some of the world's top journals, and receiving tens of thousands of citations to those

papers. His many discoveries generated patents that have been eagerly taken up by industry. In addition, he has been a respected teacher, often undertaking the prodigious task of introducing freshman physics to our undergrads. He has trained dozens of students, who have gone on to become professors, or staff members in technology companies, as well as some very successful businessmen. We will miss him, his leadership and his scientific presence very much."

Art Epstein - by the numbers

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|--------|---|
| 56 | doctoral students advised by him to completion (8 Masters students also advised and 26 undergraduate students mentored) |
| 50 | patents (40 of these patents are issued, while 10 are pending) |
| 703 | articles published (368 in refereed journals) |
| 439 | invited presentations (plus 198 seminars and colloquia and a contributor to an additional 560 talks) |
| 30,059 | citations of his work in scientific publications |

Photovoltaics Pioneer Martin Green Leads Inaugural IMR Distinguished Lecture



For many years, IMR has run its IMR Colloquia Series as a cross-college, high level forum to host presentations and visits by select renowned materials research leaders. This year, IMR changed the name of the Colloquia Series to the IMR Distinguished Lecture Series, to more accurately reflect the prestige of the guests and their talks. IMR will host one Distinguished Lecturer

each semester, and hosted the first IMR Distinguished Lecture on October 7, with an outstanding presentation by Professor Martin Green of the University of New South Wales.

Professor Green is the Scientia Professor at the University of New South Wales, Sydney and Director of the Australian Centre

for Advanced Photovoltaics. Green is the author of the popular textbook, *Solar Cells: Operating Principles, Technology and System Applications* and he has received a number of awards in recognition of his role as a photovoltaics pioneer, most recently being named a Member of the Order of Australia.

In his Distinguished Lecture, titled *Silicon Photovoltaics: Power Source for the Future?*, Green discussed the photovoltaic (PV) industry and its challenge to compete in the energy market. He suggested that to be truly competitive, PV manufacturers need to reach the desired cost of less than 50 cents per watt by doubling the efficiency of PV panels to reach approximately 50% efficiency without increasing manufacturing costs. Green discussed how combining other elements with silicon, such as perovskites, may be the key to reach this increase in solar cell efficiency.

Welcome, New IMR Members!

This semester we welcome eight new members to the OSU Institute for Materials Research. Below is a brief description of the areas of focus of their research.



Rafael Brüschweiler is an Ohio Research Scholar with joint appointments in the Department of Chemistry and Biochemistry and at the College of Medicine. He received his M.S. and PhD from Eidgenössische Technische Hochschule Zürich in 1986 and 1991, respectively. His research focuses on the development and application of nuclear magnetic resonance (NMR) for studying the structure, dynamics, and functions of proteins and small molecules, covariance NMR and quantitative and automated analysis of metabolomics mixtures. Prior to joining Ohio State, Dr. Brüschweiler was the George Mathew Edgar Professor at Florida State University and the Associate Director for Biophysics at the National High Magnetic Field Laboratory in Tallahassee, Florida.



Maryam Ghazisaeidi is an Assistant Professor in the Materials Science and Engineering Department researching computational Materials Science at the atomic scale with an emphasis on understanding the structure and chemistry of defects in structural materials to predict novel behavior. Dr. Ghazisaeidi received her B.S. and M.S. degrees from Sharif University of Technology in Tehran, Iran, and her Ph.D. from the University of Illinois at Urbana-Champaign. She also was a postdoctoral researcher at the Brown/GM collaborative Lab for Computational Materials Research at Brown University, studying Mg deformation mechanisms.



Liang Guo is an Assistant Professor of Electrical and Computer Engineering. He earned his B.E. in Biomedical Engineering from Tsinghua University in Beijing, China in 2004 and his PhD from the Georgia Institute of Technology in 2011. After completing his PhD, Dr. Guo worked as a postdoctoral researcher at the Massachusetts Institute of Technology. His research areas include neural interfacing technology, neural prosthetics, biotronic engineering and biological cyber-physical systems (bioCPS), i.e. biological circuits engineering as applied to neuroscience and neural prosthetics.



Alan Luo is a Professor of Materials Science and Engineering and of Integrated Systems Engineering. Dr. Luo studies lightweight materials and manufacturing for automotive application with a focus on computational alloy design, manufacturing process development for structural design, and industrial applications. He also is an Adjunct Professor in the Department of Materials Science and Engineering at the University of Wisconsin-Madison and Shanghai Jiao Tong University in Shanghai, China. Dr. Luo has 12 patents and more than 150 technical publications as well as being the recipient of numerous awards.



Roland Kawakami received his PhD from the University of California, Berkeley in 1999. Prior to receiving his PhD, Dr. Kawakami received his M.S. from the University of California, Berkeley in 1997 in addition to both a B.A. in Physics and a B.S. in Electrical Engineering from the University of Pennsylvania in 1992.

The primary goals of his research is to better understand electron spin and magnetism in nanostructures and to develop new types of hybrid structures made from a variety of materials including magnetic semiconductors and metals, epitaxial oxides, nanotubes, and molecular crystals. Dr. Kawakami was most recently an Assistant Professor of Physics at University of California, Riverside.



Stephen Niezgoda is an Assistant Professor in the Department of Materials Science and Engineering and the Department of Mechanical and Aerospace Engineering. His research foci include crystal plasticity and other micromechanics modeling, stochastic approaches to multi-scale modeling,

computational material design tools, and materials data sciences. Dr. Niezgoda was a post-doctoral researcher with the Materials in Dynamic and Radiation Extremes group within the Materials Science and Technology Division at Los Alamos National Laboratory in New Mexico. Before his engineering studies, Dr. Niezgoda worked as an industrial mechanic and machinist and an FAA certified aircraft mechanic. He received his PhD from Drexel University in Philadelphia, Pennsylvania in 2010.



Soheil Soghrati is an Assistant Professor of Mechanical and Aerospace Engineering and the director of the Automated Computational Mechanics Laboratory (ACML). His research interests include computational mechanics with a focus on advanced FEM and meshless methods for the treatment of problems with

complex geometries. Dr. Soghrati earned both his B.S. and M.S. in Structural Engineering from Isfahan University of Technology in Isfahan, Iran and a certification of Advanced Structural Engineering and Computer-aided Engineering from Bauhaus University in Weimer, Germany.



Wei Zhang is an Associate Professor in the Department of Materials Science and Engineering, Welding Engineering Program. Previously, Dr. Zhang was a Senior Researcher at the Oak Ridge National Laboratory in Tennessee from 2008-2012 and an Engineer Team Leader at the Edison Welding Institute

from 2004-2008. His research focuses on multi-physics modeling of welding and materials processing, materials processing, material constitutive behavior under extreme conditions, and neutron and synchrotron X-ray diffraction. Dr. Zhang earned his B.S. and M.S. degrees from Huazhong University of Science and Technology in Wuhan, China and his PhD from Pennsylvania State University in 2004.

Center for Emergent Materials Update

The following update was provided by the Center for Emergent Materials (CEM), a National Science Foundation Materials Research Science and Engineering Center (MRSEC) at The Ohio State University. The MRSEC program funds teams of researchers from several different disciplines who work collaboratively on materials research in order to address fundamental problems in science and engineering. By working in teams, called Interdisciplinary Research Groups (IRG), the researchers at CEM tackle scientific problems that are too large and complex for a scientist working alone to solve. There are two IRGs at the Center for Emergent Materials focused on researching the quantum mechanical phenomenon called “spin” in order to understand and engineer functional nanostructures. For more information about CEM, visit their website: <http://cem.osu.edu/>.

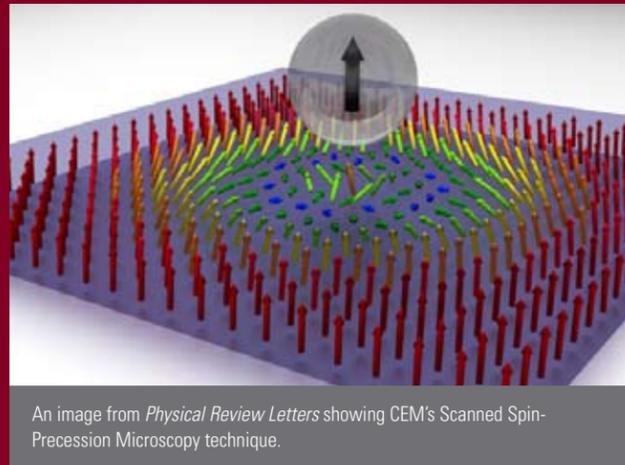
CEM Research Featured in Three High-Impact Publications

Researchers from the Center for Emergent Materials (CEM) recently published three high-impact publications in scientific journals. Summaries of each are provided below:

Alone, neither lanthanum aluminate nor strontium titanate exhibit any particularly notable properties. But when they are layered together, they become not only conductive, but also magnetic. In the current online edition of *Nature Physics*, researchers Sumilan Banerjee, Onur Erten and Professor Mohit Randeria report the first-ever theoretical explanation to be offered for this phenomenon since it was discovered in 2004.

A recently published article in *Applied Physics Letters* titled, “Buffer-layer enhanced structural and electronic quality in ferrimagnetic $\text{Sr}_2\text{CrReO}_6$ epitaxial films,” describes how the structural and electronic qualities in $\text{Sr}_2\text{CrReO}_6$ epitaxial films were enhanced through the minimization of defect states, particularly at the substrate – film interface. Minimization of the defect states was achieved through epitaxial growth of the $\text{Sr}_2\text{CrReO}_6$ double perovskite on an insulating and non-magnetic double perovskite buffer layer, $\text{Sr}_2\text{CrReO}_6$. Crystalline quality and Cr/Re ordering in this material are crucial for intrinsic behavior such as semiconductivity at room temperature. The team comprised OSU students and postdoctoral researchers Jeremy Lucy, Adam Hauser, Hailong Wang, Jennifer Soliz, Manisha Dixit, Robert Williams, Alexanne Holcombe, and OSU professors Patricia Morris, Hamish Fraser, David McComb, Patrick Woodward and Fengyuan Yang

A new technique for imaging spin properties at the nanoscale, Scanned Spin-Precession Microscopy, works by incorporating a scannable micromagnetic tip in conjunction with any of a variety of established spin detection tools—electrical or optical, and improves upon their limited or non-existent imaging capabilities. The magnetic field gradient from the probe directly selects spins from



An image from *Physical Review Letters* showing CEM's Scanned Spin-Precession Microscopy technique.

certain regions of the sample for study. The technique can achieve high resolution, beyond the optical diffraction limit, governed by the field gradient strength in a manner analogous to MRI. This new tool should help in further understanding the microscopic details relevant to spin and its transport and will be an asset to researchers in spintronics, especially in the study of technologically important materials such as silicon and graphene that have been challenging to investigate with current tools. The new technique, pioneered by a collaborative team of experimentalists and theorists from OSU and Texas A&M, is to be highlighted as an Editor's Suggestion in *Physical Review Letters*. The CEM team involved includes Professors Fengyuan Yang, Patrick Woodward, David McComb, Hamish Fraser, and Patricia Morris, as well as student and staff researchers Jeremy Lucy, Adam Hauser, Hailong Wang, Jennifer Soliz, Manisha Dixit, and Robert Williams.

Recent CEM-Sponsored Events

The CEM sponsored a two-day Labview Short Course with Dr. Jan Jacob this July. A total of 38 students attended this scientific software training, from the departments of Physics, Chemistry, Biochemistry, Mechanical Engineering, Chemical Engineering, Biomolecular Engineering, and Electrical Engineering, representing the breadth of materials research at OSU.

In spring 2013, the CEM sponsored two trips to Research and Development labs at both Ford and General Motors headquarters thanks to the connections of Professor Joseph Heremans, Mechanical and Aerospace Engineering. Nine students were able to attend a trip to Ford, and three students traveled to GM, where they learned practical applications to their materials-related coursework and research.

In October, Emily Lakdwalla from the Planetary Society presented a talk called “Speak Your Science,” in which she outlined many effective and debilitating characteristics of speakers and their

presentation methods. The talk drew a large and diverse audience with attendance from departments across the university.

Education and Human Resource Development Activities

The Center for Emergent Materials participates in many education and outreach activities throughout the year through focused, coordinated, and sustained activities that engage groups extending from elementary school students through faculty ranks. The goal of these programs is to increase the quantity and quality of scientists and engineers well-prepared to contribute to and lead research, development, and commercialization in materials-related fields.

The CEM organized a **MRSEC Symposium at the 2013 Society for the Advancement of Chicanos and Native Americans in Science**, SACNAS, National Conference. Professor Ezekiel Johnston-Halperin, Physics, chaired the session with Prof. Rolando Valdes-Aguilar, Physics, as co-chair. Speakers included Dr. Nick Carroll, Harvard University; Dr. Gabriel Lopez, Duke University; and Dr. Bill Brittain, Texas State University.

With support from a national award from the American Institute of Physics and the CEM, the OSU Physics Department established a **Bridge Program** for transitioning into Physics graduate school, debuting in Fall 2013 with four graduate fellows. The program's goal is to enhance the diversity of qualified applicants to physics Ph.D. programs at OSU and other universities. CEM is committed to the success of this program and several faculty and staff serve as program coordinators and mentors to the students.



Center for Emergent Materials hosted eight Research Experience for Undergraduates (REU) students (seen here with CEM Program Manager Michelle McCombs and Professor Tom Lemberger) this summer to engage in fundamental and applied materials science.

CEM hosted eight undergraduate researchers from across the country this summer for a 10 week **Research Experiences for Undergraduates (REU)** program. The research focused on fundamental and applied

science of exotic and novel materials and next-generation electronics that move toward a new generation of low-power-dissipation high-density electronics. Students participated in professional development activities focusing on preparing for graduate school and research related careers. The summer culminated with a joint poster session with NSEC students where everyone shared their summer work with the materials community at OSU.

Twenty-seven teachers from Columbus City Schools, Springfield City Schools, and suburban and rural schools in the Columbus area participated in a week-long professional development camp to learn to incorporate materials science into their high school physical science classes. This camp is part of an **Ohio Department of Education Math Science Partnership program** that supports teachers for an authentic 120-hour, year-long materials science-based professional development program. Teachers in this program take an online course taught by Professor Glenn Daehn, Materials Science and Engineering, during the Fall semester and meet four times per year at COSI for day long professional development workshops. School-based coaching is also provided so that teachers have in-context assistance and consultation about scientific content and classroom implementation of materials science topics.

CEM supports the **Scientific Thinkers Program**, which takes place at Innis Elementary School and brings active scientists into the 1st through 5th grade classrooms. The Scientific Thinkers motto is “Meet a scientist, Be a scientist, Think like a scientist.” Through a joint partnership between the elementary school and the university, and the leadership of Professor Nandini Trivedi, Physics, the mission is to motivate the next generation of scientific thinkers from parts of our society that are often marginalized. The volunteers in this program are graduate and undergraduate STEM students from across campus and they thrive upon seeing the kids get excited about science. They visit the classroom once every two weeks to engage the students in hands-on science experiments.

IMR Hosts 5th Annual OSU Materials Week

Since 2008, the OSU Institute for Materials Research has hosted Materials Week, an annual conference that showcases materials-allied research at The Ohio State University and beyond. This annual event brings together hundreds of researchers from OSU, other universities, national and government labs, and private industry at plenary sessions, technical talks, and poster sessions covering the full spectrum of materials-allied research.

The IMR hosted the fifth annual OSU Materials Week May 7-10, 2013. Traditionally held in Fall to kick off the beginning of the academic year, this year's Materials Week was moved to early May to accommodate OSU's new academic calendar which incorporates semesters and a short May session. The 2013 OSU Materials Week conference hosted approximately 400 attendees, including significant nonlocal participation from academia and

industry with 27 universities, governments labs and industry collaborators represented.

This year's conference began with a microscopy-focused afternoon featuring the inaugural IMR Keynote Address, "Atoms Under the Microscope" by Dr. Stephen Pennycook of Oak Ridge National Laboratory, followed by a reception with preview tours of the Center for Electron Microscopy and Analysis (CEMAS), the newest materials research facility on campus. The event included Cross-Cutting Sessions on materials microscopy and integrated computational materials

engineering (ICME) and six Focus Sessions covering the broad range of materials research, from nanofluidics to two-dimensional materials. Two student poster session/evening receptions had 100 student posters presented to show off the best of the dynamic materials research taking place daily on OSU's campus.

2014 OSU Materials Week is scheduled to take place **May 6-9, 2014**. More details will be available in the near future on IMR's website (imr.osu.edu) and through our member listserv.



2013 OSU Materials Week Student Poster Awards

Congratulations to these nine OSU students who earned Best Poster awards for their research posters and presentations at the 2013 OSU Materials Week conference.

Karen Bellman, Measurement of Electromagnetic Properties of Tissue; Advisor: Shaurya Prakash, Mechanical and Aerospace Engineering; Co-authors: Emily Sequin, Joseph West, Vish Subramaniam and Shaurya Prakash

Jeremy Cardellino, Direct Measurement of Spin Diffusion in Diamond Nanowire; Advisor: P. Chris Hammel, Physics; Co-authors: Nicolas Scozzaro, Michael Herman, K.C. Fong, Denis Pelekhov and P. Chris Hammel

Alexanne Holcombe, PLD Film Growth Optimization Using Double Perovskite Buffer Materials; Advisor: Patricia Morris, Materials Science and Engineering; Co-authors: Patricia Morris, T. Meyer, and P.M. Woodward

Carol Lee, Fatigue Properties of Electrospun Tri-Layered Vascular Graft Scaffolds; Advisors: John Lannutti and Heather Powell, Materials Science and Engineering; Co-Authors: B.N. Blackstone, M.T. Nelson, J. J. Lannutti and H.M. Powell

Jeremy Lucy, Buffer-Layer Enhanced Structural and Electronic Quality in Ferrimagnetic $\text{Sr}_2\text{CrReO}_6$ Epitaxial Films; Advisor: Fengyuan Yang, Physics; Co-Authors: A.J. Hauser, J.R. Soliz, M. Dixit,

R.E.A. Williams, A. Holcomb, P. Morris, H.L. Fraser, D.W. McComb, P.M. Woodward, F.Y. Yang

Derek Miller, Nanoscale Modifications of TiO_2 Aerogel and Xerogel Structures to Improve Photocatalytic and Sensing Performance; Advisor: Patricia Morris, Materials Science and Engineering; Co-Authors: Patricia Morris and Sheikh Akbar

Michele Nielson, Doping I-V-VI₂ Compounds for Thermoelectric Applications; Advisor: Joseph Heremans, Mechanical and Aerospace Engineering; Co-Author: Joseph Heremans

Prateik Singh, Phase Inversion-Assisted Synthesis of Electrospun Nanoporous Poly-ε-caprolactone (PCL) Fibers for Protein Impregnation; Advisor: W. S. Winston Ho, Chemical and Biomolecular Engineering; Co-Authors: Hrishikesh Munj, David Tomasko, John Lannutti and W.S. Winston Ho

Zihao Yang, Ferromagnetism and Magneto-Transport in Gd-Doped AlN-GaN Two-Dimensional Electron Gases; Advisor: Roberto Myers, Electrical and Computer Engineering; Co-Authors: T.F. Kent, H. Jin, J. Yang and R.C. Myers

IMR Announces Two New Associate Directors

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Fengyuan Yang is an Associate Professor of Physics and was recently named the Director of the NanoSystems Laboratory (NSL). He is an active member of the Center for Emergent Materials and serves on its Executive Committee, and his research focuses on magnetism and spin in 2D and 1D heterostructures. His research group works on the fabrication of a variety of complex oxide epitaxial films and multilayers, spin dynamics and spin transport in single-crystal semiconductor nanowires using prototype nanowire devices and dielectric matching, and the fabrication of a large variety of metallic materials in thin films and patterned structures for superconducting and magnetic studies.

McComb and Yang are replacing two long-standing IMR Associate Directors, Malcolm Chisholm (Chemistry) and Michael Mills (Materials Science and Engineering). Chisholm and Mills served as IMR Associate Directors since IMR was founded in 2006, stepping up to the challenge of helping create a new multidisciplinary institute for the OSU materials community. They both contributed significantly to the establishment of IMR's policies and procedures and the continued evolution of many of IMR's programs, such as our highly successful internal seed grant programs. They also participated in key faculty recruitment and core facility management and helped develop OSU Materials Week into the successful technical conference it is today.

IMR's three Associate Directors represent much of the core OSU materials community, with one Associate Director with a home department in the College of Engineering (McComb), one Associate Director with a home department in the Division of Natural and Mathematical Sciences of the College of Arts and Sciences (Yang), and a third Associate Director who represents leadership from OSU's materials-allied research facilities on our west campus research park, emphasizing core facilities and industry interactions (Davis). IMR Associate Directors play an integral role in the leadership of IMR, assisting with the planning of the IMR's activities and directions, and serving as a formal liaison between his/her college or unit constituency and the IMR. More specifically, IMR Associate Directors help to plan and participate in major IMR events and coordinate and review IMR Members of Technical Staff. They meet with the IMR Director to consult with and provide advice regarding strategic decisions that include research priorities, facility planning, modifying and proposing new plans, and related issues. They create and recommend review processes regarding allocation decisions to the Director for funding of programs and support of technical staff through its Research Enhancement Program.

Please join us in welcoming Dave McComb and Fengyuan Yang in their new roles as IMR Associate Directors, and please feel free to reach out to them and Bob Davis with any suggestions, ideas, and feedback regarding any IMR activities that continue to grow and enhance the quality, impact and visibility of OSU's materials research enterprise.

IMR Member News



Bharat Bhushan, Ohio Eminent Scholar and Howard D. Winbiger Professor of Mechanical and Aerospace Engineering, began a year-long role as a Policy Fellow at the US Congress in September 2013 and recently accepted an assignment to serve on the House Committee on Science, Space & Technology, Subcommittee on Research and Technology. His duties while on research leave from Ohio State will include working on science policy and arranging important hearings for the subcommittee while bringing an engineer's perspective to the nation's public policy arena.



Stuart L. Cooper, department Chair of Chemical and Biomolecular Engineering, was named the 2013 recipient of the Chemistry of Thermoplastic Elastomers Award by the American Chemical Society Rubber Division. This award honors significant contributions in the advancement of the chemistry of

thermoplastic elastomers, particularly innovations that have yielded significant new commercial or patentable materials or patentable innovations in process chemistry for the production of new thermoplastic elastomers. Dr. Cooper's award was in recognition of his outstanding research on the chemistry and microphase morphology of polyurethane multiblock polymers, as well as for his contributions in evaluating these polyurethanes as biomaterials.



Liang-Shih (L.S.) Fan, Distinguished University Professor and C. John Easton Professor of Engineering Department of Chemical and Biomolecular Engineering, received the 2013 American Institute of Chemical Engineers (AIChE) R. H. Wilhem Award in Chemical Reaction Engineering. The Wilhelm Award is

given annually to an individual who has advanced the frontiers of chemical reaction engineering through originality, creativity, and novelty of concept or application. Fan received the award for his sustained and lasting contributions to multiphase reaction engineering and for his pioneering work on ground-breaking clean energy technologies.



Samir Ghadiali, Associate Professor of Biomedical Engineering, has been awarded a National Institute of Health (NIH) P50 grant for his research entitled "Patient-Specific Modeling of Eustachian Tube Function and Middle Ear Pressure Regulation." This five-year award is part of a Clinical Research Center Grant to the

University of Pittsburgh. Ghadiali is the sole PI on the subproject awarded to OSU and his portion totals \$1.2M and provides support of post-doc and graduate student collaborators.



Keith Gooch, Associate Professor of Biomedical Engineering, has received a three-year National Science Foundation (NSF) award in the amount of \$280K, for his study of "Complex Emergent Behaviors Arising from Simple Mechanically-Mediated Cell-Matrix Interactions." If successful, these studies would add significantly to the field's understanding of cell-matrix interactions, including the basic underlying biomechanical rules that work together to give rise to the observed biological behaviors.



Richard Hart, Professor and Department Chair, Biomedical Engineering, was elected president of the Biomedical Engineering Society (BMES). Dr. Hart is a BMES Fellow and most recently served as the Society's secretary. Hart will assume his new role at the 2014 BMES Annual meeting in San Antonio next October.



John Volakis, Chope Chair Professor of Electrical and Computer Engineering and Director of the ElectroScience Laboratory, received the 2013 IEEE Rudolf Henning Distinguished Mentoring Award in recognition of his mentoring of students and young engineers to achieve successful careers in the areas of RF/microwave and wireless engineering. The award was presented at the 2013 Wireless and Microwave Technology Conference in April 2013, and recognizes an individual who has performed exemplary service encouraging students and/or mentoring young engineers to advance their careers in the areas of RF/microwave and/or wireless engineering.



Jessica Winter, Associate Professor, Chemical and Biomolecular Engineering and Biomedical Engineering, was awarded a four-year, \$1.2M grant from the National Science

Foundation, "Continuous, Large-Scale Nanocomposite Production via Micellular Electrospray." Winter is the principal investigator for the project, which focuses on scalable nanomanufacturing. Working with her are three co-PIs: Barbara Wyslouzil (Chemical and Biomolecular Engineering and Chemistry), Lisa Hall (Chemical and Biomolecular Engineering), and Carol Lynn Alpert (Museum of Science Boston). The grant provides funding to establish new methods and equipment to produce nanocomposites for biomedical applications at increased volume for direct translation to industry. This new synthesis method will combine electrospray, a top-down, continuous spraying process, with self-assembly, a bottom-up process that occurs spontaneously.

Materials Facilities Updates

In each issue of our newsletter, IMR provides updates on our three core materials research facilities, the NanoSystems Laboratory (NSL), Center for Chemical and Biophysical Dynamics (CCBD), and Nanotech West Laboratory. More information on these facilities and over a dozen other open user materials research facilities on OSU's Columbus campus, visit our website at: imr.osu.edu/research/facilities.

Nanotech West Laboratory – nanotech.osu.edu

IMR and Nanotech West Awarded \$2.54 Million to Form Ohio Sensor and Semiconductor Innovation Platform (OSSIP)

In June 2013, the state of Ohio's Innovation Platform Program awarded The Ohio State University Institute for Materials Research (IMR) funding to establish the Ohio Sensor and Semiconductor Innovation Platform (OSSIP) Program. The primary site for the Innovation Platform is OSU's Nanotech West Lab, and OSSIP leadership includes Principal Investigator Dr. Robert J. Davis, IMR Associate Director and Director of Nanotech West Lab, and co-investigators Dr. Steven A. Ringel, IMR Director and Neal Smith Chair Professor of Electrical Engineering, and Dr. John Carlin, Associate Director of Nanotech West Lab.

The \$2.54 million, three-year award will partner OSU with Ohio industry to bring new high-tech products to commercialization and to create high-tech jobs in the state. The initial two industry partners in the program are L-3/Cincinnati Electronics of Mason, Ohio and SRICO of Columbus, Ohio. The partnership with L-3/CE will build on their broad product offering of InSb-based infrared (IR) focal plane arrays and associated IR cameras, primarily for military and Department of Homeland Defense applications. The work with SRICO will involve their numerous products in niobate-based electro-optic modulators (EOMs) and in EO sensors applications. OSSIP will help both companies bring new products to commercialization in the three-year initial timeframe, with a primary goal of high-tech job creation in Ohio. In many ways, OSSIP will be an expansion of the Ohio Third Frontier Wright Center for Photovoltaics Innovation and Commercialization (PVIC), as the primary goal of PVIC is also job creation in Ohio, specifically in the photovoltaics technology arena.

The overall OSU materials research community was instrumental in winning this award. Many (if not most) of the technology challenges to current and future OSSIP companies are materials-related, and the current, broad materials-related activities at Nanotech West were vital in winning the award. The near-term impact to Nanotech West operations will be the hiring of 2 to 3 micro- / nanofabrication OSSIP engineers whose primary responsibility will be to serve the needs of L-3/CE and SRICO and

also to the needs of Ohio companies who work in this technology sector. The capabilities of these engineers will also be available to the OSU research community.

NanoSystems Laboratory (NSL) – ensl.osu.edu

New Tabletop Maskless Aligner System μ PG501 at OSU NanoSystems Laboratory



The Heidelberg Instruments Tabletop Maskless Aligner System μ PG501 now installed in the NSL clean room in the basement of the Physics Research Building.

NanoSystems Laboratory (NSL) recently added a new instrument, a Tabletop Maskless Aligner System μ PG501, to the existing instrument lineup in the NSL clean room in the basement of the Physics Research Building (PRB). The purchase of the

instrument was funded by OSU ENCOMM TIE (Targeted Initiative in Excellence) funds. This new instrument, in addition to NSL's Kurt J. Lesker sputtering/e-beam evaporation system also installed in the clean room, allows users to complete the process chain of photolithographic patterning and material deposition without leaving the clean room. The aligner is fabricated by Heidelberg Instruments Mikrotechnik GmbH in Heidelberg, Germany, and it enables photolithography for prototyping without a need for a contact mask. Instead, the desired pattern is computer generated and subsequently projected on a photo resist coated surface using an optical projection system. The smallest achievable feature size of the instrument is 1 μ m. It uses substrates up to 6" x 6" with an address grid of 50 nm x 50 nm. The aligner is very easy to use since it is equipped with an auto focus system and a high resolution camera system for metrology and multilayer alignment. The photo resist is exposed with a high power 390 nm LED with Microchem Shipley 1805 Photoresist used in a standard process. The instrument can be used for both custom photolithographic patterning and for contact mask fabrication for subsequent use in a conventional contact mask aligner. The instrument has become very popular with NSL users.

Please contact NSL Lab Coordinator Bob Wells (wells@physics.osu.edu) to schedule training or for other questions.

Ohio State Receives \$6.25 Million to Lead Spin and Thermal Effect Research

A research team led by Roberto Myers, Associate Professor of Materials Science and Engineering and Electrical and Computer Engineering, was recently awarded a five-year \$6.25 million grant through the U.S. Department of Defense Multidisciplinary Research Initiative (MURI) program to explore materials with spin mediated thermal properties. The research initiative, funded through the Army Research

Office, aims to develop new materials and devices for thermal management and waste heat recovery based on an effect – known as spin – that converts heat into a quantum mechanical phenomenon. The team's initial results show that thermal effects due to magnetism and spin properties of materials might open new pathways for thermally based technologies, such as thermal switches, tunable thermal conductivity, and thermo-electric power generation or refrigeration. This work was seeded by a two-year Proto-IRG (Interdisciplinary Research Grant) funded by the OSU Materials Research Seed Grant Program through the Center for Emergent Materials (CEM), the Center for the Exploration of Novel Complex Materials (ENCOMM), and IMR.

Myers leads the interdisciplinary, inter-university team, which includes Ohio State's Joseph Heremans, Professor of Mechanical and Aerospace Engineering and Ohio Eminent Scholar in Nanotechnology; David Cahill of University of Illinois at Champaign Urbana; David Awschalom from the University of Chicago; Li Shi from the University of Texas at Austin; and Yaroslav Tserkovnyak from the University of California, Los Angeles. These experts have extensive knowledge and experience from the world of thermoelectrics and thermal transport in solids, as well as from the fields of magnetism and spin-transport to identify structure properties and relationships for materials exhibiting spin-mediated properties.

Related topics were covered by Myers, Heremans, and their colleagues at a focused technical session at 2013 OSU Materials Week and the three-day Spin Caloritronics V conference, both coordinated by IMR on OSU's Columbus campus in May 2013.

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