Innovations in Materials Research

Newsletter of the OSU Institute for Materials Research

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OSU and IIT-Bombay Formalize Research and Education Partnership

This January, an OSU delegation including OSU President Michael Drake and IMR Executive Director Steve Ringel traveled to India to formalize a partnership between Ohio State and the Indian Institute of Technology – Bombay (IIT-B). This strategic partnership builds on the two universities' complementary strengths and assets, beginning with first wave focus areas of advanced materials and manufacturing, solar energy, semiconductor devices and bioengineering, and a commitment to fold in data analytics over time. IIT-B is amongst the very top tier of all Indian universities and is a global leader in its own right. Prof. Ringel has been working to create the partnership for the better part of a year and this signing follows a visit by the IIT-B Director this past fall which was hosted by IMR.

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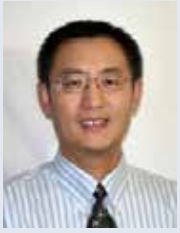
IIT-Bombay Director Devang Khakhar and OSU President Michael Drake (center) sign the memorandum of understanding between their universities as their colleagues look on

Faculty Spotlight: Lei R. Cao, Nuclear Engineering



Lei Cao joined The Ohio State University as an Assistant Professor of Nuclear Engineering within the department of Mechanical and Aerospace Engineering in January 2010. He received his Bachelor degree in Experimental Nuclear Physics from Lanzhou University, a Masters degree in Particle Physics from China Institute of Atomic Energy, and a Ph.D. in Nuclear and Radiation Engineering from the University of Texas at Austin. Before coming to OSU, he was a Postdoctoral Research Associate at the National Institute of Standards and Technology. Dr. Cao conducts research at the intersection of nuclear, materials science, and physics. The focus of his research group is on the applied nuclear physics and radiation science in addressing the challenging national needs for counter nuclear terrorism, improvements in the safe production of nuclear energy, and characterization of materials' properties with nuclear methods.

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The Ohio State University

IMR
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Director's Note

Dear Colleagues,

This is certainly one of the most fulfilling Directors' Notes that I have had the pleasure to provide in our semi-annual Innovations in Materials newsletter, as it has been a banner year for Ohio State's materials enterprise. First off, our NSF-funded Materials Research Science and Engineering Center (MRSEC) – the Center for Emergent Materials (CEM), not only successfully renewed its center grant from the NSF, a major feat in its own right given the extraordinary national competition for the MRSEC award, but CEM was also able to expand from 2 to 3 Interdisciplinary Research Groups (IRGs) and almost doubled its base funding from NSF for the next six years (page 10). In the midst of challenging federal budget issues supporting university research, this is an undeniable testament to the quality, impact, depth and scope of CEM. I would like to congratulate Chris Hammel, CEM's Director, and all of the CEM-affiliated faculty, staff, postdocs and students for a job well done!

In parallel, the IMR-led Discovery Themes Initiative project has changed its name to the "Materials and Manufacturing for Sustainability (M&MS)" initiative to more appropriately brand and capture the essence of this large effort, and initial activities to start up the M&MS are well underway. One of these important activities, separate from the faculty hiring campaign associated with all Discovery Themes projects happening concurrently throughout campus, is the creation of a global conduit for M&MS faculty to conduct international collaborations in relevant areas. To that end we have developed and signed a special agreement with the Indian Institute of Technology – Bombay (IIT-B), one of India's leading institutions of higher education and technology-oriented research, which will create opportunities for such interactions, starting with a workshop being hosted by IMR at Ohio State on June 22-23, 2015 (page 1). The formal agreement was signed by OSU's President Drake and IIT-B leadership at a special event in January.

And while discussing M&MS, we have re-organized this year's OSU Materials Week conference to reflect the thrust areas of M&MS, including a special keynote by Dr. Nathan Lewis, a world-leading sustainability expert, and several plenary sessions that focus on materials and sustainability in the industrial world. This is sure to be a great conference and I hope all of you can attend. 2015 OSU Materials Week will be held May 12-15 at the Blackwell Inn on Ohio State's Columbus campus. See imr.osu.edu for more details.

And finally, I am happy to take a few lines here to preview one of the most innovative and impactful accomplishments that has been achieved in the past few months with the opening of multiple remote access nodes that will allow users from around the state of Ohio to utilize the world-class microscopy capabilities housed within the Center for Electron Microscopy and Analysis (CEMAS), right from their own organizations (page 3). This amazing capability will enable a new paradigm of electron microscopy education, as well as make CEMAS perhaps the most user-friendly facility of its kind in the nation. This program was partly developed via IMR's Ohio Research Scholars Program award from the Ohio Third Frontier and I'd like to provide a note of "kudos" to Dave McComb, the CEMAS Director, for his leadership in making this happen.

Inside this issue you will read about all of the above, some significant advances in our core facilities, numerous faculty accomplishments, and the exciting research being led by Lei Cao and his team in the area of nuclear-based methods to characterize materials and energy storage devices.

With warm regards,

Steven A. Ringel, Ph.D.
Neal A. Smith Chair Professor
Executive Director, The Ohio State University Institute for Materials Research

CEMAS Partners with Wright-Patterson Air Force Base to Expand Electron Microscopy Collaboratory

The Center for Electron Microscopy and Analysis, OSU's materials characterization research facility, continues to grow its collaboratory for materials characterization through remote access.

CEMAS has partnered with sites around Ohio to establish a direct access connection between researchers at remote locations and characterization instruments and researchers at CEMAS. Because of the issues that arise from the complexity of new equipment available to researchers, the operation of these instruments has become more demanding and image analysis has become more complex. Therefore, these partnerships allow access to experts, both in instrument operation and interpretation of data.

CEMAS instruments are equipped with remote operation capabilities and through a direct connection onto the 100 Gb/s Ohio OARnet network, provide a unique opportunity for remote teaching and research to partners across the State of Ohio. The unique digital environment and electron microscopy collaboratory enables investigators to interact with and operate electron and ion microscopes in a live, seamless manner – as if one was sitting in front of the instrument. CEMAS also provides high quality audio and visual streaming between the two sites once both locations are suitably equipped. CEMAS is pioneering the use of this technology for research and training of the next generation of electron microscopy specialists, providing an environment to facilitate world-class collaborative research, and maximizing productivity while minimizing economic and environmental impact of remote research collaborations.

CEMAS research scientist Frank Scheltens remotely operates an electron microscope from the Air Force Research Lab at Wright Patterson Air Force Base

Through funding from the Ohio Third Frontier's Ohio Research Scholars Program, an EM Collaboratory system was recently installed at the University of Dayton, while a second system has been built for OSU's Wooster campus, allowing remote access from those sites to CEMAS' world-class electron microscopes. This March, the Air Force Research Laboratory at Wright-Patterson Air Force Base installed a new Talos electron microscope, as well as an EM Collaboratory system connecting AFRL to CEMAS's instruments to further expand its electron microscopy capabilities.

This article and photos originally appeared in the Dayton Daily News in the March 6, 2015 article "Wright-Patt, OSU partner on $2.5M microscope project," and are reprinted here with permission.

Air Force Research Laboratory scientists will be able to more quickly analyze materials needed in weapon systems with nearly $2.5 million spent on electron microscopes that can peer deep into materials. AFRL's Materials and Manufacturing Directorate has simultaneously launched its first "remote collaboratory" in a partnership with The Ohio State University. Researchers can access over the Internet additional high-powered microscope technology at the Center for Electron Microscopy and Analysis on OSU's campus in Columbus.

"Partnerships are essential today," said Rudy Buchheit, an OSU associate dean of academic affairs and administration. "Our budgets aren't getting bigger, our problems aren't getting easier."

A new $1.9 million AFRL electron microscope, dubbed FEI Talos, and another called FEI Titan that had a $500,000 upgrade, will help scientists analyze how materials perform on aircraft, said Thomas A. Lockhart, director of the Materials and Manufacturing Directorate. The technology, for example, can explore the cause of cracks or corrosion in materials. "In the past, it's taken a significant amount of time to do that assessment," Lockhart said. "With this new machine, what we could do in days now will take hours and minutes." The high-resolution technology can peer into strings of atoms and show two-dimensional and three-dimensional images, said Krishnamurthy Mahalingam, an AFRL research scientist. "We can look at how different elements in the material change," he said.

OSU researchers will work with AFRL's workforce to solve technical problems, officials said. "No one center can be state of the art in everything," said Matthew O'Malley, program manager of AFRL's Materials Characterization Facility, where the work is performed.

Ohio State has had a decades-old partnership with Wright-Patterson researchers in areas such as material durability, corrosion protection and human performance, Buchheit said. "Our business is training our future colleagues so in order to make sure that we're preparing people to participate and have impact in the workforce we have to be relevant and having a partner like AFRL brings us real problems that helps us evolve in that way," he said.

Nationwide, AFRL has 10 directorates, four of them at Wright-Patterson. The Materials and Manufacturing Directorate at Wright-Patt has about 900 employees and a $200 million annual budget, Lockhart said.

OSU and IIT-Bombay Formalize Research and Education Partnership (continued from page 1)

This visit coincided with OSU's first Health Sciences Innovation Conference in Mumbai, India on January 15 – 18, 2015. The focus of the conference was India's rapidly growing biotech and health sciences industry with the goal of developing strategic partnerships between Ohio State faculty and other Indian academic institutions. The All India Institute for Medical Sciences (AIIMS), the country's top public health care and research institution, partnered with Ohio State in hosting this conference. President Drake spent several hours with the OSU and IIT-B leaders, and the formal signing ceremony concluded a day of initial workshops, one led by OSU's Prof. Vishnu Sundaresan, Assistant Professor of Mechanical and Aerospace Engineering, in the area of bioengineering, and one led by Prof. Ringel covering the areas of semiconductor research and solar energy research. A number of IIT-B faculty members also presented their own work at these parallel workshops.

President Drake expressed his great enthusiasm and support of this important partnership as did IIT-B Director Dr. Devang Khakhar, who mentioned it several times during his public addresses to Indian government and business leaders at the Health Sciences Innovation Conference. Many of India's high ranking officials attended the conference as well, including J.P. Nadda, the Minister of Public Health, Mahesh Misra, director of the AIIMS, India's minister of health, the mayor of Mumbai and the highest-ranking U.S. government official in Mumbai, Consulate-General Thomas Vajda. The keynote address was delivered by Nobel Laureate Professor Luc Montagnier, one of the individuals credited with discovering the HIV virus.

The next joint activity between OSU and IIT-Bombay is a workshop to be held at Ohio State on June 22-23, 2015, which will include lab tours and a set of presentations from both OSU and IIT-Bombay faculty with the expectation that fruitful collaborations can be identified. Both partners fully anticipate that the MOU will enable easy student exchange, faculty exchange in the form of short term sabbaticals, and lay the groundwork for very close cooperation for years to come.

Representatives from Ohio State and IIT-Bombay after the historic MOU signing

While the MOU with IIT-Bombay was a major goal Ringel's trip, an equally critical goal was to meet and firm up relationships with multiple Indian technology corporations to forge linkages between IMR, the IMR-led discovery theme in Materials and Manufacturing for Sustainability, and Indian companies deeply involved with technologies that impact clean energy, reduced energy consumption, manufacturing and transportation.

Faculty Spotlight: Lei R. Cao, Nuclear Engineering (continued from page 1)

Cao and his research group have built a neutron beam facility at the OSU Research Reactor (OSURR), which delivers a pencil-sized neutron beam to a working bench where various instrumentation can be set up for neutron sensor evaluation and multidisciplinary investigations of advanced materials (see picture). A facility of this kind is rare in the nation. One of significant successful applications is the development

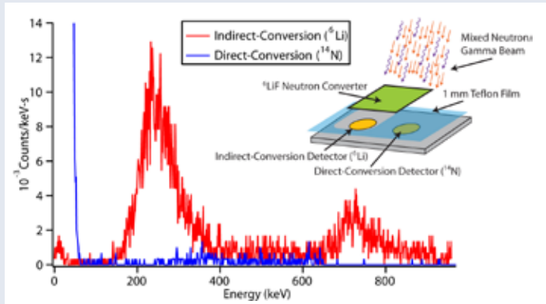

Figure 1: Neutron detection spectra with schematic from Prof. Cao's research

of a neutron technology for imaging the flow of Li-ions in the batteries. An *in situ* measurement of an electrochemical cell was demonstrated by Cao (collaborated with Marcello Canova and Anne Co) to investigate lithium transport phenomena in normal, working batteries during charging and discharging. This work is published in the journal *Angewandte Chemie International Edition (IF: 11.336)* and is recognized as a Very Important Paper (VIP) by the publisher.

In additional to this research, Dr. Cao has received grants from Department of Defense, Department of Energy, and Nuclear Regulatory Commission in support of his research to develop wide band gap semiconductor sensors for neutron detection in harsh environments. His group is the first to develop a gallium nitride sensor for high flux neutron detection, which was accomplished by pairing one device with a thin (0.5 mm) ^{6}LiF screen (σ_0=940 b), while a second detector was left bare to detect neutrons via proton emission from the ^{14}N(n,p)^{14}C reaction (σ_0=1.8 b). Both detectors were placed in the thermal neutron beam at the OSURR, generating the spectra in **Figure 1**. Charged particles emitted from neutron capture in ^{6}Li were clearly resolvable in the two spectral peaks (red), demonstrating the device's ability to detect thermal neutrons indirectly. Direct neutron conversion was also verified in the second detector through strong agreement between the experimental detection efficiency and the theoretical detection efficiency of a Geant4 model. This work is also supported by an IMR Facility Grant.

One of the instruments used by the Cao group for neutron sensor evaluation and multidisciplinary investigations of advanced materials

Another aspect of Dr. Cao's research involves exploring new materials for radiation detection. A recent achievement is a collaborative effort with Prof. Jinsong Huang at University of Nebraska with the development of an organic-inorganic perovskite for gamma-ray response. Their first finding was reported in *Science* on February 27, 2015 (DOI: 10.1126/science.aaa5760).

For more information on Lei Cao's research, visit his group's website at http://mae.osu.edu/labs/nars/

IMR Executive Director Honored with 2015 University Distinguished Scholar Award

On February 6th, IMR Executive Director Steve Ringel was surprised at an Electrical and Computer Engineering department meeting with the awarding of a 2015 University Distinguished Scholar Award. Ohio State President Dr. Michael Drake presented Ringel with the award in front of ECE faculty and staff, members of Ringel's research group, and IMR members and administrators. Ringel was nominated for this award by a committee of his peers, in recognition of his scholarly activities and international impact in electronic materials research focused toward the areas of advanced photovoltaics and wide bandgap semiconductor devices. President Drake, College of Engineering Dean David Williams, Senior Vice President for Research Carol Whitacre, and Senior Associate Vice President for Research Jan Weisenberger, all spoke about Ringel's far-reaching accomplishments in research, as well as his central role in propelling Ohio State to excellence in materials-allied research in part due to his leadership of the OSU Institute for Materials Research (IMR) and, most recently, as the Principal Investigator of the Materials and Manufacturing for Sustainability Discovery Theme Initiative.

IMR Executive Director Steve Ringel (center) honored by OSU President Michael Drake, Vice President for Research Carol Whitacre, Electrical and Computer Engineering department chair Joel Johnson, Senior Associate VP for Research Jan Weisenberger, and College of Engineering Dean David Williams

The Distinguished Scholar Award, established in 1978, recognizes exceptional scholarly accomplishments by senior professors who have compiled a substantial body of research. The award is supported by the Office of Research. Recipients are nominated by their departments and chosen by a committee of senior faculty, including several past recipients of the award. Distinguished Scholars receive a $3,000 honorarium and a research grant of $20,000 to be used over the next three years. Please join us in congratulating Steve on this well-deserved honor!

Materials Facilities Updates

In each issue of our newsletter, IMR provides relevant updates from our core materials research facilities - the NanoSystems Laboratory (NSL), Nanotech West Laboratory, the Center for Electron Microscopy and Analysis (CEMAS), and our newest addition, the Semiconductor Epitaxy and Analysis Laboratory (SEAL). 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

New Homebrew Interlock Box Simplifies Tool Use Tracking and Billing

Like most labs, the OSU Nanotech West Lab (managed by IMR) struggles with accounting and paperwork associated with the numerous tools and instruments for which it charges user fees. Historically, all of these tools used paper log sheets where users signed in and tracked their time, which were later entered manually into databases by administrative staff to be used for reporting and accounting functions.

After researching commercially-available options that did not fit the facility's needs or budget, Nanotech West Lab staff members Stacy Coil and Derek Ditmer devised their own system. They created an inexpensive way to switch on/off an instrument with a key-fob-based interlock with the same key fob that users already use to access the doors of the lab. Coil and Ditmer used an inexpensive Raspberry Pi (a single-board computer which runs a stripped-down version of the operating system Linux), added an SD memory card as a hard drive, a USB key fob reader, and a USB-based switchable terminal block and wrote code that, during key swaps, a) checks if a user is trained on the particular tool; b) records the time "in"; and c) records their time "out" during a final key swipe. The device stores the data in the primary NTW database over the local internet, and other software can then turn those records into an accounting record.

Nanotech West staff members Derek Ditmer (left) and Stacy Coil with their new tool interlock box. A USB line leads to the front of a spin coater in the photolithography bay and makes the tool available by enabling the vacuum hold-down for the spin chuck.

As of this writing, the interlock box parts currently cost a total of $150 per point, but Derek and Stacy believe that they can lower the price significantly. A box will interlock a tool by turning on and off some significant feature such as a computer monitor, a keyboard, a vacuum switch, or something else. In March, the interlock debuted on tool COT03, a spin-coater in the photolithography area, and other IMR-affiliated laboratories have already asked for assistance in duplicating this system.

NanoSystems Laboratory (NSL) – ensl.osu.edu

The OSU NanoSystems Laboratory (NSL) is excited to welcome a new staff member, NSL Lab Coordinator Billy Kelley. Kelley served in the United States Marine Corps for 5 years as a communication electronics technician. During that time, he was deployed overseas for 3 years in Japan and Iraq in support of Operation Iraqi Freedom, where he maintained and repaired mission critical communication equipment as the on-site technician for intelligence and reconnaissance teams.

Upon finishing his tour of duty, Mr. Kelley enrolled in college to study electrical engineering, later switching his major to physics and transferring to The Ohio State University. While an OSU student, he also worked at night for the University of Dayton Research Institute (UDRI) as a research technician in support of an Ohio Research Scholars Program, where he gained experience in process and chemical engineering by operating and maintaining a fuel upgrading rig designed to turn biomass into jet fuel. Mr. Kelley also worked as a student research associate in OSU's Physics department machine shop where he assisted the instrument makers with many of the setups that are used in physics lab demonstrations, and in the electronics shop, where he assisted in various projects including equipment repair and assembly. Upon graduating from OSU, he was employed at the Wright-Patterson Air Force Base as an RF/microwave engineer. Please join us in welcoming Mr. Kelley to the NSL team.

Center for Electron Microscopy and Analysis (CEMAS) – cemas.osu.edu

FEI Vitrobot Mark IV now available at CEMAS

The Center for Electron Microscopy and Analysis (CEMAS) recently added two new tools to enhance their collection of sample preparation equipment – a Vitrobot and a Lecia ACE600. The FEI Vitrobot™ Mark IV is an automated device for vitrification (rapid cooling) of aqueous (colloidal) samples, and is being used at CEMAS to freeze samples for cryoTEM analysis. The critical vitrification parameters, such as temperature, relative humidity, blotting pressure and time, can be precisely controlled and a simple, easy to use touch-screen user interface and programmable vitrification process allow for consistent and high-yield sample output.

The Leica ACE600 is an advanced high-vacuum sample coating and preparation system. It can produce thin sputter coatings, thin carbon films and glow discharge samples in an oil-free turbo-pumped high-vacuum environment. The rotary stage enables uniform coatings on rough surfaces, and the recipes feature provides the capability to have custom reproducible sample treatments.

The rotary stage allows for coating irregular surfaces such as shown in Figure 1. Sputter coating with gold is most common. The high vacuum permits a finer grain than in conventional sputter coaters. In the ACE600, a 5nm coating of gold gives 10-15nm grains (Figure 2). This coating is not completely continuous but it does eliminate sample charging. Iridium produces a finer grained coating for ultra-high resolution imaging. The Ir grain size is about 5nm (Figure 3).

Not only can the ACE600 sputter coat samples, it can also accurately deposit thin carbon films. When doing EDX analysis, the metal sputter coatings will contribute to the X-ray signal as well as absorbing X-rays that have been generated within the sample. Carbon coatings have much less effect on the detected spectrum. With the built-in quartz crystal thickness monitor, we can deposit coatings down to 1nm thickness though we generally use a bit thicker coating. With this ability to deposit ultra-thin coatings, we can also coat TEM sample to improve conductivity and sample stability. The coatings are thin enough that they have little or no effect on resolution.

The glow discharge function of the coater exposes the sample to an energetic plasma that reacts with the sample surface. This is commonly used to render carbon surfaces hydrophilic, a necessary characteristic for depositing TEM samples of biological or nanosized materials. The glow discharge also removes hydrocarbon contamination from a sample surface prior to SEM or TEM examinations. The discharge can also be used to etch polymer or biological SEM samples to provide surface relief for SEM imaging. Since the glow discharge is part of the same unit as the sputter coater, an etched sample can be sputter coated without breaking vacuum.

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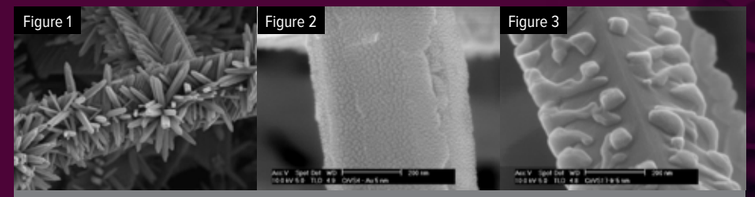

Examples of work done at CEMAS with the new Leica ACE600 advanced high-vacuum sample coating and preparation system.

Materials Facilities Updates (continued from page 7)

Semiconductor Epitaxy and Analysis Laboratory (SEAL) - http://emdl.ece.ohio-state.edu/seal.html

New Equipment for the Dreese Lab Cleanroom

The new wire bonder now located within the SEAL facility

To pattern the DBC substrates, a manual screen printer has been installed in the DLC. For the process of attaching and testing the bare die, a die bonder capable of 130gm bonding force, and a shear/pull strength tester with 500gm force of pulling/shearing strength are available. Finally, a wire bonder with manual/semi-auto wire bonding capabilities set up for 20-mil aluminum wire is available to create connections between the bare die and the circuit substrates. Additional equipment is scheduled to arrive and be installed in the coming months to allow full system fabrication of these devices.

The team is also looking into the design and process of bond-wire less power module structure using flip-chip and 3D packaging technology, the new equipment includes a flip-chip bonder for this research purpose. For questions or inquiries concerning this equipment, contact Prof. Fang Luo (luo.571@osu.edu) or DLC lab manager, Mark Brenner (brenner.34@osu.edu).

Professor Fang Luo has moved new equipment into the Dreese Lab Cleanroom (DLC) to conduct research on high power electric circuitry, packaging and testing. These device systems differ from the micro-electronics devices typically fabricated in the DLC because they require much higher currents loads, much greater voltage isolation and the ability to handle a large amount of heat during operation. Specifically, new wide band gap (WBG) power device module designs target operating at temperatures up to 200°C. The high power electronic circuits commonly consist of a bare die device (SiC) attached to a substrate which can handle the systems electrical needs. A common substrate is direct bonded copper (DBC) consisting of an insulator (Al2O3) sandwiched by copper plates where the top plate is patterned and the bottom plate remains intact. Prof. Luo has acquired several pieces of equipment to accomplish these needs and produce his circuits within the DLC.

SEAL Lab Manager Mark Brenner (left) in the lab with Fang Luo's research group

IMR Member News

Heather Allen, Professor of Chemistry and Biochemistry, is the recipient of a Humboldt Research Prize. This award is presented by Germany's Alexander von Humboldt Foundation to internationally renowned scientists whose work has had significant impact in their fields and promises continued leading-edge advancements. Awardees receive $60,000 (EUR) and an invitation to conduct research with German colleagues. Allen will begin work in Germany during 2015.

Lisa Hall, the H.C. "Slip" Slider Assistant Professor of Chemical and Biomolecular Engineering, received a five-year, $475,000 NSF Faculty Early Career Development (CAREER) award for her research to understand how polymer structure controls overall materials properties. The CAREER award is the National Science Foundation's most prestigious award in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of both. Hall's research involves theoretical and computational studies of polymeric materials for potential applications as non-flammable polymer electrolytes in a new generation of safe, lightweight batteries. The goal is to develop and use innovative computational and theoretical tools to model ionic conductance in block copolymer based materials. Part of the grant funding will be used to support Hall's outreach and education efforts to help communicate to all ages what polymers are and how their structure impacts material properties.

Christopher Jaroniec, Professor of Chemistry and Biochemistry, has received the 2015 American Chemical Society Physical Division Early-Career Award in Experimental Physical Chemistry. The award recognizes outstanding contributions in physical chemistry by young investigators. Jaroniec was recognized "for the development and application of solid-state nuclear magnetic resonance methods in the study of structure and mechanism in complex biological assemblies." The award carries with it a $1,500 prize, and recipients will be honored in a special awards symposium at the 250th ACS National Meeting in Boston.

Michael Mills, McDougal Professor and interim Chair of Materials Science and Engineering, was named a Fellow of the Minerals, Metals & Materials Society (TMS). The highest award bestowed by TMS, it recognizes members for outstanding contributions to the practice of metallurgy, materials science and technology. Mills was recognized for "leadership and significant contributions in elucidating the deformation mechanisms of high-temperature structural materials using advanced characterization and modeling." His primary research interests focus on the relationship between microstructure and properties of materials, with special emphasis on transmission electron microscopy techniques which make it possible to the study the structure and chemistry of materials down to atomic dimensions.

Andre Palmer, Professor and interim Chair of the William G. Lowrie Department of Chemical and Biomolecular Engineering, was recognized for his contributions to the profession by being elected to the College of Fellows of The American Institute for Medical and Biological Engineering (AIMBE). AIMBE's College of Fellows features 1,500 individuals who have distinguished themselves through significant and transformative contributions in research, education and industrial practice, representing the top 2% of the medical and biological engineering community in the country. Professor Palmer's research interests encompass the development of novel hemoglobin-based oxygen carriers for a variety of applications in transfusion medicine and tissue engineering. He has engineered tense and relaxed state variable molecular weight polymerized hemoglobins for use as red blood cell substitutes; variable molecular weight polymerized human serum albumins for use as plasma expanders; and a high payload drug delivery system that specifically targets monocytes and macrophages. His lab is also developing non-heme based plasma expanders, red blood cell storage solutions and monocyte/macrophage targeted drug delivery systems.

Hannah Shafaat, Assistant Professor of Chemistry and Biochemistry, has been awarded a CAREER grant from the National Science Foundation for her work on "Probing Metalloenzyme Mechanisms with Resonance Raman Spectroscopy." The Faculty Early Career Development (CAREER) Program is a Foundation-wide activity that offers the National Science Foundation's most prestigious awards in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research within the context of the mission of their organizations. Such activities should build a firm foundation for a lifetime of leadership in integrating education and research. Dr. Shafaat is in her 2nd year at OSU.

Jessica Winter, Associate Professor of Chemical and Biomolecular Engineering, was elected as a Fellow of the American Associate for the Advancement of Science (AAAS). Winter received this honor for her distinguished contributions in the field of chemical and biomedical engineering. In particular, her work with synthesis and development of magnetic quantum dots for cell imaging and separations was recognized. Through this work, Winter stands as an established leader in nanobiotechnology. Her primary research includes exploring the relationship between nanoparticles and biological elements, as well as cell and tissue engineering and neural prosthetics.

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. For more information about CEM, visit their website: http://cem.osu.edu/.

$17.9 Million NSF Grant Renewal Funds Center for Emergent Materials' Broad Impact Science

The National Science Foundation (NSF) announced in December that it has renewed funding for Ohio State's Center for Emergent Materials (CEM): an NSF Materials Research Science and Engineering Center (MRSEC). The six-year, $17.9 million grant funds Ohio State's adventurous, long-term studies of forward-looking new materials that are on the very edge of the possible.

"This is not about short-term funding that has clearly-defined achievable goals. Rather, the focus is on adventurous, foundational research that enables far-reaching technologies. Great science is the heart of this funding," said P. Christopher Hammel, Ohio Eminent Scholar, physics professor and CEM Director.

After a rigorous, uber-competitive review process, only 12 MRSECs were funded. These NSF Flagship institutions form a national network of top materials research programs at top research institutions — Princeton, Harvard, MIT, Ohio State — capable of performing complex and ambitious multi-disciplinary sciences.

The driving idea behind the MRSEC program is to identify and fund collaborative materials research by teams of researchers from multiple disciplines that have the ability to address difficult, fundamental problems in science and engineering. These teams, called Interdisciplinary Research Groups, or IRGs, consist of eminent faculty and their students and postdoctoral researchers. Together, they tackle scientific problems that are too large and/or complex for one person or one group to make an impact.

"This approach allows us to bring together groups of researchers with diverse skill sets and expertise that can handle the challenges of multi-faceted scientific issues, integrating materials synthesis and growth, characterization, novel probe development and theory and modeling," Hammel explained. The main challenge is to enhance technology and improve energy efficiency through discovery of new materials, novel phases of matter and innovative spin science. Established by NSF funding in 2008 rooted in Ohio State's Targeted Investment in Excellence Program (T.I.E.), the Center for Emergent Materials has a recognized track record in diverse fields, which served it well in the rigorous renewal process.

The NSF grant renewal funds three powerful Interdisciplinary Research Groups led by proven research teams poised to make breakthrough discoveries:

Spin-Orbit Coupling in Correlated Materials: Novel Phases and Phenomena, is co-led by physicist Nandini Trivedi, and chemist Patrick Woodward. The group has a long record of successful collaboration, establishing fundamentals for understanding and prediction in this area. It includes physicists, chemists and materials science engineers from Ohio State, Iowa State and the University of Tennessee. The grand aim is to design a new class of tailored quantum materials with tunable magnetic and electric properties that would impact technology and society.

Control of 2D and 1D Electronic Structure by Surface Functionalization of Group-IV Graphane Analogues, is co-led by chemist Joshua Goldberger and physicist Roland Kawakami. Group members are leading experts in creating and manipulating single-atom sheets. The team includes chemists, electrical and computer engineers, materials science engineers and physicists from Ohio State, UC-Berkeley, and Case Western. The flexibility of these new materials will find broader applications in science and technology including new opportunities in materials by design, platforms for chemical sensing and information processing.

Nonlinear Interactions between Spin Flux and Engineered Magnetic Textures, is co-led by Jos. Heremans, mechanical and aerospace engineering and physics; and physicist Fengyuan Yang. Group members are leaders in the theory of spin dynamics and dynamic spin transport and include physicists, mechanical engineers, materials science engineers and electrical and computer engineers from Ohio State, Iowa and UCLA. This research could enable transformative technologies that move beyond current spintronics concepts and technologies.

It would be difficult to overstate the benefits that the Center for Emergent Materials' infrastructure investments provide Ohio State and the state of Ohio. Eleven Ohio companies have benefited directly from the availability of cutting-edge materials' research tools that the CEM-supported NanoSystems Laboratory provides to university and industrial researchers. Two of the three projects funded by the NSF grant were developed through the integrated OSU Materials Research Seed Grant Program. Seed grants complement IRG research by supporting emerging developments in materials research. The program also identifies and nurtures future leaders, which extends CEM impact beyond IRG membership.

"One of our goals," Hammel said, "is to increase the quantity and quality of scientists and engineers prepared to contribute to and lead research, development and commercialization in materials-related fields." CEM researchers are doing that through focused, coordinated and sustained activities that engage groups extending from elementary school students through faculty ranks. Initiatives include using cognitive research to enhance classroom education, and providing undergraduates with immersive, authentic research experiences. Diversity enhancement efforts are tightly interwoven with every educational and outreach activity. "We are absolutely committed to increasing diversity in science and engineering by eliminating barriers to the success of underrepresented groups," Hammel said.

CEM Celebrates Renewal with Kickoff Event

CEM Kickoff Poster Session, Physics Research Building, February 27, 2015

On February 27th, the CEM hosted a kickoff to celebrate the achievement of renewal and introduce the new center. CEM Director P. Chris Hammel gave an introduction to the center's new participants and goals. The gathering brought CEM faculty and students together with the broader OSU community along with the university leaders who were instrumental in enabling the CEM to be renewed: President Drake, Dr. Whitacre (Vice President for Research), Deans Manderscheid (Arts and Sciences), Williams (Engineering), and Vice Provost Osmer (The Graduate School).

The poster session featuring 25 CEM students held following the presentations highlighted new and current research, offering opportunities for interaction and a more detailed presentation of the center's science.

CEM Education and Outreach Lead Awarded 2015 Impact Grant

Dr. Andrew Heckler, physics

In December Dr. Andrew Heckler, professor of physics and CEM's Lead for Education and Outreach, was selected as an Impact Grant recipient for 2015 by the Office of Distance Education and eLearning (ODEE). Projects were selected for funding from a competitive pool by a team of faculty, staff, and students assembled from throughout the university. Recipients will work with ODEE to develop their projects, which will debut in pilot sections of courses during Autumn 2015.

Dr. Heckler's work will extend and improve an online platform that enables introductory physics students to practice fundamental mathematical skills. With 6,000 students piloting and ODEE support, the system will be extended to include additional material, designed for better user experience, integrated with other campus systems, and made fully accessible for students with disabilities.

Students Benefit from Industry Internship Opportunities

Following an informative and successful industry seminar last year with Jeff Childress of HGST, Childress partnered with CEM to offer two graduate students the opportunity of interning at HGST in San Jose, California. HGST, a Western Digital Company, specializes in cutting edge magnetics for storage solutions. Last year Michael Page and Shane White, both fourth year graduate students in physics, were competitively interviewed and selected from a pool of talented CEM students for the first internships in summer 2014.

Shane White (left) and Michael Page (right), fourth year graduate students of physics, spent summer 2014 at HGST, a Western Digital Company

Michael and Shane were enthusiastic in their evaluations of the experience: "I view my participation in an internship at HGST as a key experience in my career development," Michael explained. "Three quarters of all employees at HGST hold PhD degrees and half of those have earned them at top 10 U.S. institutions. My employment at HGST gave me the opportunity to join a prestigious group of professionals and allowed me to network with the best scientists and engineers in industry." Shane agreed, "there was a diverse group of people available to connect with, which was incredibly useful personally and professionally." Michael went on to elaborate that "in academia, there is a sense of competition, even with collaborators and coworkers... At HGST, it is a really great experience to be part of a team that is really invested in the success of everyone around them. Competition exists, but it is directed towards some other company, and within your working environment, every single person's best interest is the success of their coworkers."

CEM is optimistic that connections with HGST will offer continued opportunities for collaboration and internship. This summer HGST will host two interns studying non-volatile memory. "To those who have not had the opportunity to venture outside of academia, I highly recommend taking the chance on an internship." Shane urged. "HGST is a wonderful company to work at, due to the diverse and friendly staff, as well as the quality of research available to participate in."

Institute For Materials Research

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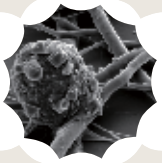
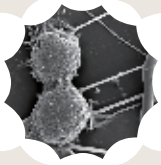
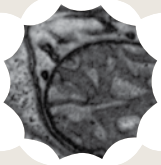
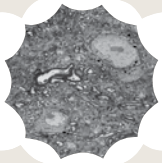

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