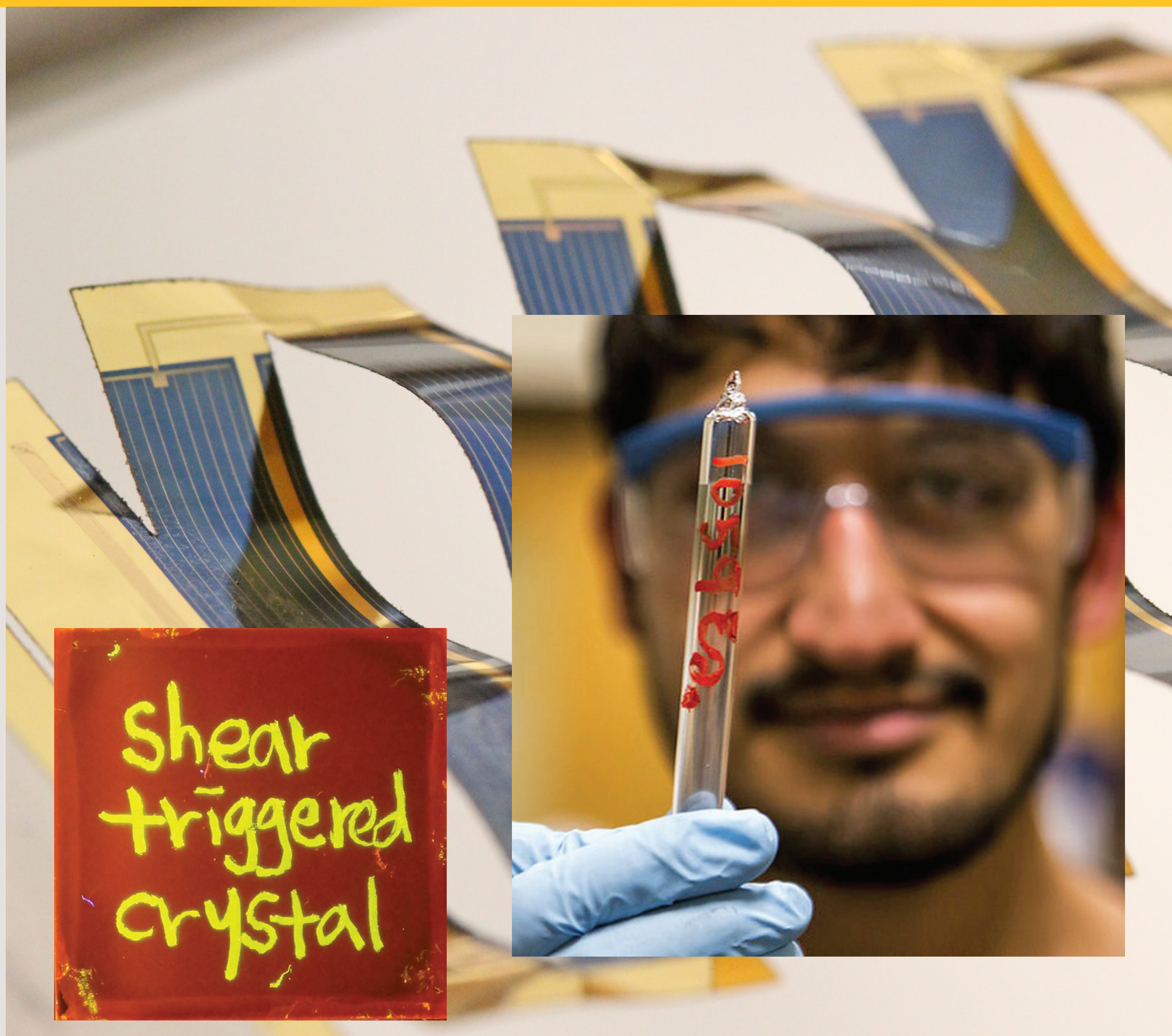
Michigan Engineering
University of Michigan

Materials Science and Engineering   College of Engineering   **Winter 2016**

MSE*news*



In This Issue

Dear Alumni and Friends:

As the calendar year 2015 wound down, the December (special) issue of MRS Bulletin titled “Materials & Engineering: Propelling Innovation” presented a collection of high-level review articles from experts all over the world highlighting the intimate relationship between materials and engineering. In the past few decades, the advances in the fundamental understanding of “Making, Measuring and Modeling Materials” have catalyzed technologies in defense, energy, transportation, electronics, communication, medicine, consumer products, etc., resulting in a transformative impact on the quality of life. Interdisciplinary materials technologies will continue to dominate in the twenty-first century. MSE departments at academic institutions have the responsibility to educate and train the next generation of leaders in the field and continue to perform innovative research that pushes the frontiers of science and technology.

Our department continues to grow and with the success of the current faculty and the new hires, we strive to maintain world-class undergraduate and graduate programs. The breadth of the articles in the *MRS Bulletin* December issue is indicative of the diversity of expertise and capabilities that a modern MSE department must possess in manufacturing, characterization and modeling of advanced structural and inorganic and organic functional materials, as well as innovative approaches to education and entrepreneurship.

Given the inherent diversity of MSE as a discipline, we need the best and brightest students and faculty from all segments of society since diverse teams bring new ideas and transformative solutions to challenging interdisciplinary materials and engineering problems. Our department continues to champion the strong commitment to diversity, equity, and inclusion made by the College of Engineering and the University.

In 2017, the University of Michigan will celebrate its bicentennial—two centuries of existence since the University was founded in 1817. I invite you to join us in the celebration and to reach out to me with ideas on how to enhance the profile of our department internationally as we prepare to enter the third century of the University of Michigan.

Amit Misra

Xplore Engineering

Alumni bring their children and grandchildren to the 2015 Xplore Engineering. Find out more about the 2016 program at engin.umich.edu/mconnex/info/alumni/xplore-engineering

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Qi Joins MSE as Assistant Professor

Liang Qi joined the Department of Materials Science and Engineering as an assistant professor in winter 2015. Qi studied Materials Science and Engineering at Tsinghua University in China. He earned his master's degree at Ohio State University and his doctoral degree in computational materials science at University of Pennsylvania. He continued his postdoctoral research at University of Pennsylvania and Massachusetts Institute of Technology. During these times, his research focused on modeling and simulation of catalysis/electrocatalysis in fuel cells and nanostructured materials in collaboration with in-situ TEM characterizations. Most recently, he worked as an assistant project scientist at University of California, Berkeley, where he performed first-principles and meso-scale simulations to study the deformation mechanisms and microstructures of advanced metallic alloys, and the materials chemistry related to nuclear fuels. There he found the intrinsic ductility of bcc refractory metals is determined by the symmetry-related electronic structure that can be tuned by alloying. He also collaborated with experimentalists and found that the profound strengthening effect of Ti from oxygen impurities is due to the interaction of oxygen interstitial solutes with the core of mobile screw dislocations.

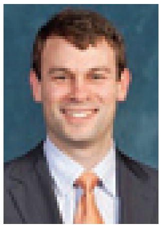
At Michigan, Qi will continue studies on computational materials sciences by applying theoretical and computational tools, including first-principles calculations, atomistic simulations and multiscale modeling. His research interests are quantitative understanding of the intrinsic electronic/atomistic mechanisms for the mechanical deformation phase transformation, and chemical stabilities of structural and functional materials. By working with the outstanding students, researchers and faculty at U–M, he plans to integrate these electronic/atomistic results with multiscale simulations and experimental investigations in order to design materials with improved mechanical performance and chemical stabilities.

Welcome to our Courtesy Faculty

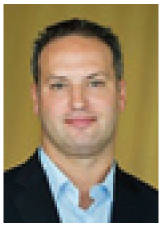
In 2015, four CoE faculty were offered courtesy appointments in Materials Science and Engineering

Vikram Gavini, associate professor with tenure in Mechanical Engineering, joined MSE through a courtesy appointment in fall 2015. Vikram received his PhD from California Institute of Technology in 2007 and has been at University of Michigan since fall 2007. His research expertise is in the development of advanced methods for first principles calculations.

Jeff Sakamoto came to the University of Michigan in winter 2015 as associate professor with tenure in Mechanical Engineering and associate professor (by courtesy) in MSE. He earned his PhD in 2001 in Materials Science and Engineering from University of California, Los Angeles. Prior to joining the University of Michigan, he was on the faculty staff at Michigan State University from 2007-2014 and was also a senior engineer at the California Institute of Technology, Jet Propulsion Laboratory from 2001-2007. His research expertise is in battery and energy storage materials.



Donald Siegel, associate professor with tenure in Mechanical Engineering, joined MSE through a courtesy appointment in fall 2015. Don received his PhD from University of Illinois at Urbana-Champaign in 2001 and has been at University of Michigan since Fall 2009. His research expertise is in the development of high-capacity materials and systems for energy storage applications.



Henry Sodano joined the University of Michigan in fall 2015 as associate professor with tenure in Aerospace Engineering and associate professor (by courtesy) in MSE. He received his PhD in May 2005 in mechanical engineering from Virginia Tech. He moved to Michigan from University of Florida where he had joint appointments in the Departments of Mechanical and Aerospace Engineering and Materials Science and Engineering. His research expertise is in multifunctional composite materials.

"Supercool" Material Glows When You Write On It

By Kate McAlpine, Marketing & Communications, College of Engineering

A new material developed at the University of Michigan stays liquid more than 200 degrees Fahrenheit below its expected freezing point, but a light touch can cause it to form yellow crystals that glow under ultraviolet light.

Even living cells sitting on a film of the supercooled liquid produce crystal footprints, which means that it's about a million times more sensitive than other known molecules that change color in response to pressure.

The material could have applications as a new kind of sensor for living cells, while the mechanism behind its unusual properties may guide the development of electronics and medicines. "As you know, water freezes around zero degrees Celsius. It changes to ice. It's as if the water remained a liquid down to -100 degrees Celsius," said Kyeongwoon Chung, doctoral student in macromolecular science and engineering and first author on the paper published in *ACS Central Science*.

Electronics manufacturers are interested in glass-like carbon-based materials—known as amorphous organic materials—like the one produced at U–M. These materials are cheaper, easier to work with and are more flexible than inorganic semiconductors such as silicon. Because they don't have a crystal structure that must be broken up, they also dissolve well in the body, which improves their effectiveness as pharmaceuticals.

"We would like to understand better molecular design principles to control the crystallization tendency of organic molecules," said Professor Jinsang Kim, whose group discovered the unusual molecule. "Most organic materials have a strong driving force to crystallize, but they don't always form the same quality crystal, making quality control difficult."

The team investigated a family of organic molecules widely used in pigments and electronic devices, like solar cells, LEDs and transistors, looking for ways to streamline the production of their amorphous forms. These molecules can be described as a rigid core flanked by two flexible side chains. If the chains are short, the core molecules drive crystallization, but if they are long, the chains interact to form a different kind of crystal.

The team found that by varying the lengths of the side chains, they could cause a stalemate between two modes of crystallization."We found that the core unit and side chains are working in opposite directions," said Kim, who is also an professor of chemical engineering, biomedical engineering, macromolecular science and engineering, and chemistry.

As a result, the molecule remained liquid even when cooled below its melting temperature of 273 degrees Fahrenheit. Typically, this would also be the material's freezing point. Instead, the molecules stay in a stable, "supercooled" liquid state down to 41 degrees Fahrenheit, at which point the molecules solidify into a glass.

In addition to the unusually broad temperature range for the supercooled liquid state, the group found that it crystallized when rubbed with a stylus, changing from dark red to bright yellow. The rubbing broke the stalemate between the two ways for the molecules to connect, allowing the side chains to link up.

At temperatures around 212 degrees Fahrenheit, when the molecules move freely, just a touch can make the entire film or droplet crystallize. "It's like a domino effect," Kim said. But at room temperature, the thicker supercooled liquid crystallizes only where the stylus makes contact, allowing Chung to scrawl messages such as "shear-triggered crystal" or a secret note to his wife.

Kim's group is pursuing using this molecule in biosensors, which might reveal characteristics of cells for medical diagnosis. The ability to write and erase luminescent information also suggests the potential for use in a memory that encodes information with light rather than magnetism. Such "optical memory" still needs more development, however.

This interesting material development was published in a new ACS flagship journal, *ACS Central Science*; "Shear-triggered Crystallization and Light Emission of a Thermally Stable Organic Supercooled Liquid" *ACS Central Science* 2015, 1, 94.

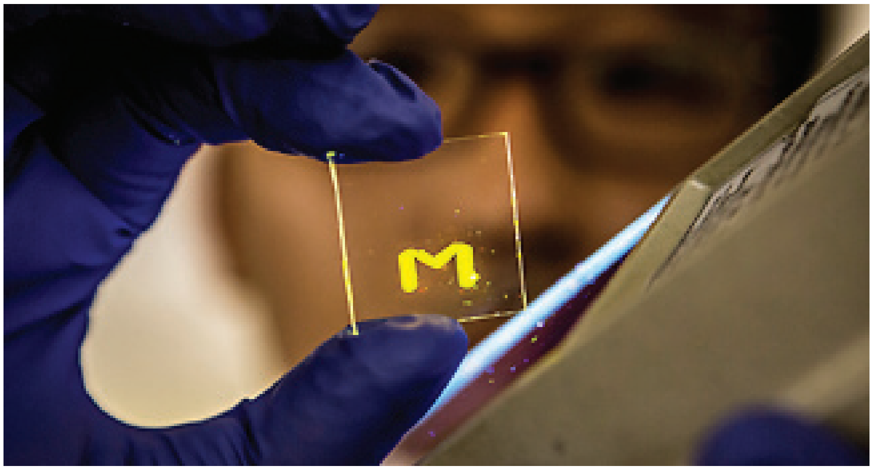
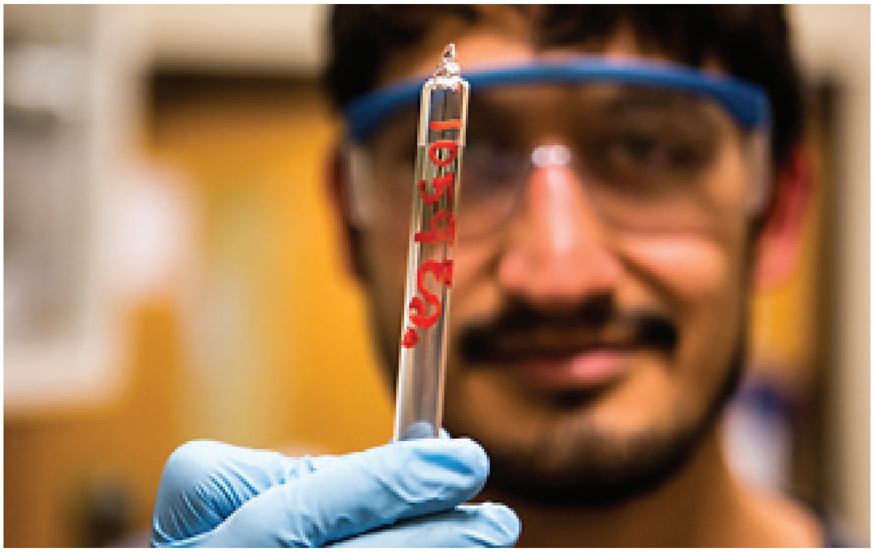


Photo: Shear-triggered fluorescent "M" crystal.



New Semiconductor Moves "Spintronics" Toward Reality

By Gabe Cherry, Marketing & Communications, College of Engineering

A groundbreaking semiconductor compound is bringing fresh momentum to the field of spintronics, a new breed of computing device that may lead to smaller, faster, less power-hungry electronics. Created from an entirely new "low symmetry" crystal structure, the compound is the first to build spintronic properties into a material that's stable at room temperature and easily tailored to a variety of applications. It could eventually be used as the base material for spintronic processors and other devices, much like silicon is the base for today's computing devices. The new compound is detailed in a paper published online in the *Journal of the American Chemical Society*.

Spintronics use both the presence or absence of electrical charge and the "up" or "down" magnetic spin of electrons to store information, where today's electronics use only electrical charge. Spin-based circuits can be smaller than charge-based circuits, enabling device makers to pack more circuits onto a single processor. This is a key advantage, since traditional electronics are approaching their physical size limits.

"You can only make an electronic circuit so small before the charge of an electron becomes erratic," said Associate Professor Ferdinand Poudeu. "But the spin of electrons remains stable at much smaller sizes, so spintronic devices open the door to a whole new generation of computing."

Spintronics can also retain data even after power is shut off, unlike today's processors and computer memory. This may enable device makers to combine functions that today require separate components in computing devices. For example, instead of using a processor to make calculations, RAM memory for primary storage and a hard drive for secondary storage, a single spintronic chip could handle all three functions, dramatically reducing the size and power consumption of computers.

But spintronic semiconductors require precise control over both magnetism and conductivity in order to control both the spin and the charge of electrons. Researchers have struggled to create a semiconductor that can be easily "tuned" to the levels required and that maintains its properties over a range of temperatures. Poudeu explains that the root of the problem lies in the crystalline structure that makes up semiconductors.

"Today's semiconductors are made of crystals with simple, symmetrical patterns, like a microscopic lattice that repeats over and over. We control the properties of those semiconductors by adding atoms of different elements to the holes in that lattice. For example, we can add bismuth to increase conductivity, or iron to increase magnetism," he said. "To make spintronic semiconductors, we need to add atoms of different sizes, and we need flexibility in where we place those atoms. But in most commonly used crystals, the holes are all similarly sized and regularly spaced. That gives us a very limited amount of control."

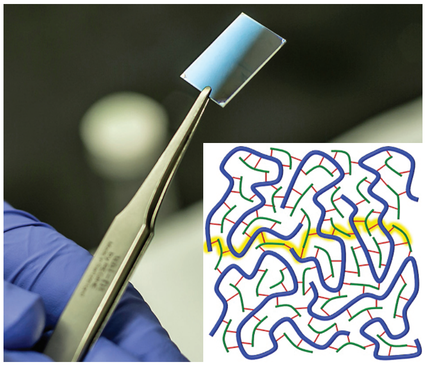
Researchers have been working for years to solve this problem by finding new ways to add atoms to commonly used crystalline structures. But Poudeu's team took a different approach, creating an entirely new structure. They used a mixture of iron, bismuth and selenium to create a complex crystal that offers much greater flexibility. The new structure looks more like Swiss cheese than a lattice, with holes of varying size placed at varying distances in multiple, overlapping layers.

"Ordinarily, conductivity and magnetism are linked together, so you can't change one without affecting the other," said Juan Lopez, a doctoral student in materials science and engineering who worked on the project. "But this new compound changes that. It enables us to arrange atoms in a huge number of different combinations so that we can manipulate conductivity and magnetism independently. That level of control is going to open a whole new set of possibilities in spintronics."

Photo: Juan Lopez, a PhD student in the Poudeu group, holding a sealed quartz tube containing crystals of the new compound.

Heat-Conducting Plastic Developed

By Nicole Casal Moore, Marketing & Communications, College of Engineering



The spaghetti-like internal structure of most plastics makes it hard for them to cast away heat, but a University of Michigan research team has made a plastic blend that does so 10 times better than its conventional counterparts.

Plastics are inexpensive, lightweight and flexible, but because they restrict the flow of heat, their use is limited in technologies like computers, smartphones, cars or airplanes—places that could benefit from their properties but where heat dissipation is important. The new U–M work could lead to light, versatile, metal-replacement materials that make possible more powerful electronics or more efficient vehicles, among other applications.

The new material, which is actually a blend, results from one of the first attempts to engineer the flow of heat in an amorphous polymer. A polymer is a large molecule made of smaller repeating molecules. Plastics are common synthetic polymers.

Previous efforts to boost heat transfer in polymers have relied on metal or ceramic filler materials or stretching molecule chains into straight lines. Those approaches can be difficult to scale up and can increase a material's weight and cost, make it more opaque, and affect how it conducts electricity and reflects light. The U–M material has none of those drawbacks, and it's easy to manufacture with conventional methods, the researchers say.

"Researchers have paid a lot of attention to designing polymers that conduct electricity well for organic LEDs and solar cells, but engineering of thermal properties by molecular design has been largely neglected, even though there are many current and future polymer applications for which heat transfer is important," said Kevin Pipe, U–M associate professor of mechanical engineering and corresponding author of a paper on the work published in the current issue of *Nature Materials*.

Pipe led the project with Jinsang Kim, another corresponding author and professor of materials science and engineering.

The yellow line represents heat traveling through a new plastic designed by Michigan Engineering researchers. The plastic is a blend of long (blue) and short (green) polymer chains, and because the polymers form strong bonds (red), heat has an easy path to escape. Heat energy travels through substances as molecular vibrations. For heat to efficiently move through a material, it needs continuous pathways of strongly bound atoms and molecules. Otherwise, it gets trapped, meaning the substance stays hot.

"The polymer chains in most plastics are like spaghetti," Pipe said. "They're long and don't bind well to each other. When heat is applied to one end of the material, it causes the molecules there to vibrate, but these vibrations, which carry the heat, can't move between the chains well because the chains are so loosely bound together."

The Pipe and Kim research groups devised a way to strongly link long polymer chains of a plastic called polyacrylic acid (PAA) with short strands of another called polyacryloyl piperidine (PAP). The new blend relies on hydrogen bonds that are 10-to-100 times stronger than the forces that loosely hold together the long strands in most other plastics.

"We improved those connections so the heat energy can find continuous pathways through the material," Kim said. "There's still a long way to go, but this is a very important step we made to understand how to engineer plastics in this way. Ten times better is still a lot lower heat conductivity than metals, but we've opened the door to continue improving."

To arrive at these results, the researchers blended PAP plastic strands separately with three other polymers that they knew would form hydrogen bonds in different ways. Then they tested how each conducted heat.

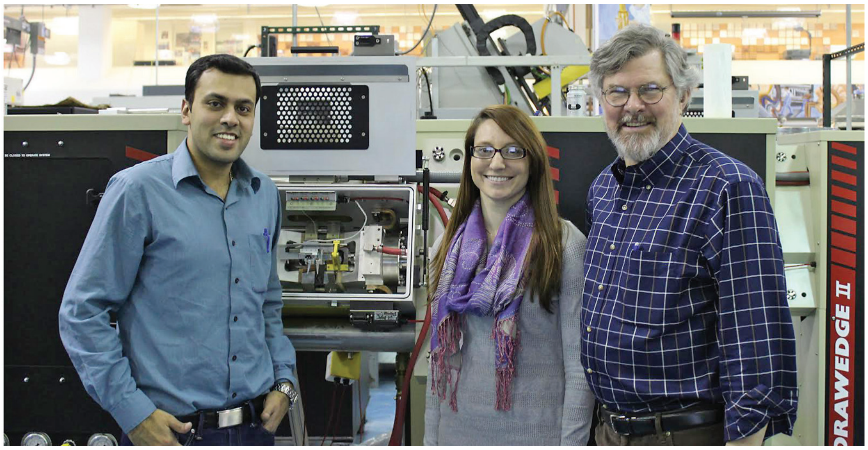
New polymer that disperses heat better than other polymers"We found that some samples conducted heat exceptionally well," said Gun-Ho Kim, first author of the paper and a postdoctoral fellow in mechanical engineering and materials science and engineering. "By performing numerous measurements of the polymer blend structures and their physical properties, we learned many important material design principles that govern heat transfer in amorphous polymers."

Two other first authors are Dongwook Lee and Apoorv Shanker, graduate students in macromolecular science and engineering. The paper is titled "High thermal conductivity in amorphous polymer blends by engineered interchain interactions."

The research was funded by the U.S. Department of Energy, Office of Basic Energy Sciences as part of the Center for Solar and Thermal Energy Conversion in Complex Materials, an Energy Frontier Research Center. Gun-Ho Kim has also received a fellowship from the U–M Energy Institute.

Photo: Thin layer coating of the heat-conducting polymer blend on a glass substrate, inset: Illustration of homogeneous distributions of thermally conductive interchain connections.

Lightweight Innovations for Tomorrow in Third Year



Riddhiman Bhattacharya (post-doc in Allison Group), Anna Trump (PhD candidate in Allison Group) and John Allison pictured with the new Gleeble simulator.

In 2014, the University of Michigan partnered with Ohio State University and EWI to win a $148M grant establishing a new nonprofit research organization called LIFT (Lightweight Innovations for Tomorrow) operated by ALMMII (American Lightweight Materials Manufacturing Innovation Institute). LIFT, as part of a new national network of manufacturing innovation institutes, is focused on developing advanced approaches for manufacturing lightweight metal components for the machines that move people and goods on land, sea, and air.

Over 100 companies, universities, and non-profit organizations are supporting the institute. A number of Michigan faculty are playing leadership roles in LIFT including Vice President for Research, Jack Hu, as a board member, Professor Alan Taub, as Chief Technology Officer, and Professor John Allison as the ICME Crosscut Technology leader.

LIFT is sponsoring a portfolio of research projects at companies and universities across the country. To date, almost $25M of technology projects have been launched with partner organizations. University of Michigan faculty are involved in almost every LIFT project and have been awarded over $7M in contracts. The technologies being investigated in those projects include:

- Reducing the wall thickness of castings by 40%
- Developing manufacturing simulation tools for thermo-mechanical processing of aluminum and titanium alloys that can reduce by half component design time
- Advancing the manufacturing readiness of a new agile sheet forming process known as incremental forming
- Developing a model for corrosion protection of metallic structures
- Reducing the distortion of welded steel plate used in ship hulls

LIFT is located in the up and coming Corktown neighborhood in downtown Detroit. Over 10,000 square feet of office and meeting rooms have been operational since January 2015. In the over 80,000 square foot hi-bay, procurement and installation of pilot scale metals processing equipment is underway using $8.5M from the Michigan Economic Development Corporation.

The new state-of-the-art equipment under development include a flexible robotic joining cell and metal powder injection and consolidation machines. LIFT is also establishing its process capability through equipment donation. The University of Michigan has transferred two metal stamping presses with variable binder load capability to LIFT headquarters.

In support of LIFT, the University of Michigan is also procuring advanced manufacturing equipment that is being installed in the Wu Manufacturing Center in the H.H. Dow Building. Professor John Allison is supervising the installation of a new state-of-the-art Gleeble elevated temperature, thermo-mechanical simulator.

University of Michigan faculty are also participating in the various LIFT activities aimed at developing science, technology, and engineering curricula for programs from grade school to graduate school to educate the next generation of manufacturing operators and engineers.

"The journey of moving from project award to a new headquarters building to R&D project initiation has been both challenging and rewarding. I am looking forward to seeing the weight reduction technologies developed on the LIFT projects being implemented by our company members leading to higher performance, more environmentally friendly transportation," said Alan Taub, professor of materials science and engineering and mechanical engineering, and chief technology officer of the new institute.

Professors Alan Taub (left) and Stephen Forrest (right) meet with Senator Gary Peters (center) in Washington, D.C. where they participated in the Senate Committee panel on Commerce, Science, and Transportation Innovation and Competitiveness. Photo Credit: Madeline Nykaza.

Art-Inspired Solar Cells

By Kate McAlpine, Marketing & Communications, College of Engineering

Solar cells capture up to 40 percent more energy when they can track the sun across the sky, but conventional, motorized trackers are too heavy and bulky for pitched rooftops and vehicle surfaces. Now, by borrowing from kirigami, the ancient Japanese art of paper cutting, researchers at the University of Michigan developed solar cells that can have it both ways.

"The design takes what a large tracking solar panel does and condenses it into something that is essentially flat," said Aaron Lamoureux, a doctoral student in materials science and engineering and first author on the paper in *Nature Communications*.

Residential rooftops make up about 85 percent of solar panel installations in the U.S., according to a report from the Department of Energy, but these roofs would need significant reinforcing to support the weight of conventional sun-tracking systems. A team of engineers and an artist developed an array of small solar cells that can tilt within a larger panel, keeping their surfaces more perpendicular to the sun's rays.

"The beauty of our design is, from the standpoint of the person who's putting this panel up, nothing would really change," said Max Shtein. "But inside, it would be doing something remarkable on a tiny scale: the solar cell would split into tiny segments that would follow the position of the sun in unison."Solar cell researchers think of tracking in terms of how much of a solar panel the sun can "see." When the panel is at an angle, it looks smaller. By designing an array that tilts and spreads apart when the sun's rays are coming in at lower angles, they raise the effective area that is soaking up sunlight.

To explore patterns, the team of engineers worked with paper artist Matthew Shlian, a lecturer in the School of Art and Design. Shlian showed Lamoureux and Shtein how to create them in paper using a plotter cutter. Lamoureux then made more precise patterns in Kapton, a space-grade plastic, using a carbon-dioxide laser.

Although the team tried more complex designs, the simplest pattern worked best. With cuts like rows of dashes, the plastic pulled apart into a basic mesh. The interconnected strips of Kapton tilt in proportion to how much the mesh is stretched, to an accuracy of about one degree.

To make the solar array, Kyusang Lee, a doctoral student in electrical engineering, built custom solar cells in the lab of Stephen Forrest, the Peter A. Franken Distinguished University Professor of Engineering and Paul G. Goebel Professor of Engineering. He and Lamoureux attached them to an uncut piece of Kapton, leaving spaces for the cuts. Then, Lamoureux patterned the Kapton with the laser cutter.

The design with the very best solar-tracking promise was impossible to make at U–M because the solar cells would be very long and narrow. Scaling up to a feasible width, the cells became too long to fit into the chambers used to make the prototypes on campus, so the team is looking into other options.

Cuts in a flexible backing for solar cells allow a flat solar panel to separate into many small cells that can track the sun across the sky. Tracking provides a 20 to 40 percent improvement in the amount of energy captured by the cells.

The optimized design is effective because it stretches easily, allowing a lot of tilt without losing much width. According to the team's simulations of solar power generation during the summer solstice in Arizona, it is almost as good as a conventional single-axis tracker, offering a 36 percent improvement over a stationary panel. Conventional trackers produce about 40 percent more energy than stationary panels under the same conditions, but they are bulky, prone to catching the wind and ten or more times heavier, said Shtein.

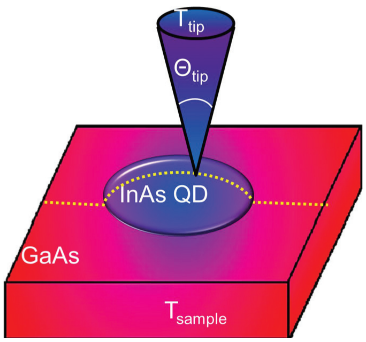
"We think it has significant potential, and we're actively pursuing realistic applications," said Shtein. "It could ultimately reduce the cost of solar electricity."

The paper on this work is titled "Dynamic kirigami structures for integrated solar tracking." The study was funded by the National Science Foundation and NanoFlex Power Corporation. The University of Michigan has applied for a patent and is seeking partners to bring the technology to market.

Photo above: Side profile of dynamic kirigami structure capable of solar tracking, consisting of monolithically integrated, single crystalline yet flexible, gallium arsenide solar cells on a polyimide sheet. The angle of tilt of each solar cell is controlled uniformly as a function of stretching. Photo by Aaron Lamoureux.

Scanning Thermoelectric Microscopy Locates Extra Electrons Outside Quantum Dots

Semiconducting quantum dots (QDs) can be used to enhance the performance of a variety of devices encompassing optoelectronic, thermoelectric, and alternative energy technologies. Often, a small amount of another element must be added to the semiconducting QDs to provide extra electrons and improve conductivity. At the nanoscale, these extra electrons are difficult to locate. Rachel Goldman and her colleagues have now opened the door to a new technique for such measurements.



Schematic of the scanning thermoelectric microscope setup, which consists of a room-temperature probe tip in contact with a heated sample. The yellow dashed line represents the measurement points of the thermoelectric voltage at each tip-sample contact.

The schematic is reproduced with permission from Appl. Phys. Lett. 106, 192101 (2015); DOI: 10.1063/1.4919919.

As reported in the May 11 issue of *Applied Physics Letters* (DOI: 10.1063/1.4919919; 192101), the researchers used scanning thermoelectric microscopy to locate electrons in semiconducting QDs on surfaces. Beginning with high-purity solid Ga, As_2, and In as the raw materials, they used molecular beam epitaxy and employed Stranski–Kraskov growth to fabricate InAs QDs on a GaAs substrate. Such structures can be doped with another element, such as Si, to provide extra electrons. However, it is difficult to predict how many of the dopants will incorporate into a QD rather than into the surrounding layers. Each QD is believed to contain fewer than 10 dopant atoms, making them particularly challenging to locate.

The researchers then used a scanning thermoelectric microscope (SThEM) with a specially prepared tungsten tip. The measurements were performed in ultra-high vacuum, and the sample was heated a few Kelvin above room temperature for several hours to achieve a uniform temperature in the QD, surrounding layers, and substrate. Upon contact, the SThEM tip locally cools the QD, causing the extra electrons in the hot sample to travel toward the cold tip, generating a thermoelectric voltage. Since this voltage depends on the number of electrons, the research team was able to locate those extra electrons using measurements at several points across the QD.

Specifically, the dependence of the thermoelectric voltage on the thermopower allowed the researchers to locate the extra electrons: they found fewer electrons within the interior of the QD than in the surrounding substrate, which could mean that the silicon "dopants" prefer to stay outside the QD.

"We were really interested in measuring the thermopower, since QDs are considered promising for thermoelectric," PhD student and NSF Fellow Jenna Walrath wrote of her original goals for the research. Goldman and Walrath were surprised by the unusual behavior of the QD thermopower, and their efforts to explain it led them to locating the extra electrons.

"While the answer wasn't that exciting for thermoelectrics, understanding how dopants incorporate into nanostructures is unprecedented. The lessons learned from this work provide a pathway toward strategic placement of just a few dopants at a time," Walrath says.

Their work could be extended to other nanostructures such as quantum wells and nanowires. "The potential of SThEM is just beginning to be explored," Goldman says, "so I expect it will continue to play a central role in bridging atoms to devices." This article originally appeared in the September issue of the *MRS Bulletin*.

Welcome to the Michigan Center for Materials Characterization

The North Campus Electron Microbeam Analysis Laboratory (EMAL) has undergone significant changes in an effort to broaden its mission and modernize its operation and equipment. In 2014, the laboratory moved to a new location in Building 22 of the North Campus Research Complex (NCRC) where the microscopes are now housed in temperature and humidity controlled rooms. EMAL changed its name and became the Michigan Center for Materials Characterization, or (MC)2 , and is the new College of Engineering's shared microscopy and characterization facility. Professor Emmanuelle Marquis, as Director of (MC)2, leads the changes and the team in this period of transition and a new center manager and instrument scientist will soon be hired to complement the existing staff.

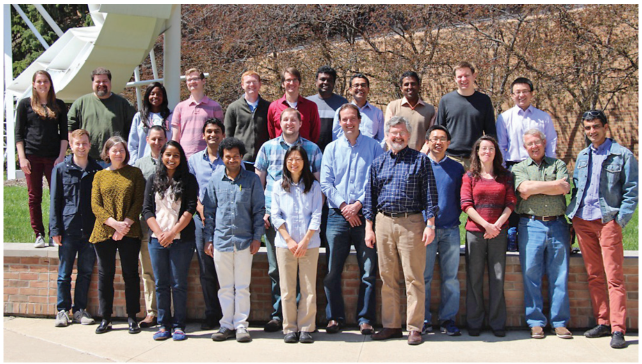
The mission of (MC)2 is to provide cost effective, efficient, safe, and socially responsible access to advanced characterization equipment and expertise thereby promoting, enabling, and encouraging cutting-edge education, research, and business development. The Center is also looking to broaden its mission to include education and experiential learning in advanced materials characterization. In his new role as the senior director of education and engagement, Dr. John Mansfield, formerly laboratory manager and associate director of EMAL, teaches a graduate level electron microscopy course, and a series of tutorial seminars targeting new students, industrial researchers, and users looking to expand their knowledge base about advanced electron microscopy, diffraction, and spectroscopy techniques.

(MC)2 houses state-of-the-art equipment, including two aberration corrected transmission electron microscopes, three dual beam focused ion beam / scanning electron microscopes, an x-ray photoelectron spectrometer, an atomic force microscope, and an atom probe tomography instrument. The newest additions are an Hysitron tribo-indenter and a picoindenter, both acquired last year.

(MC)2 supports a diverse multi-disciplinary user-base of more than 500 users from various colleges and departments across the U–M campus, more than 100 internal research groups, and 20 non-academic companies.

For more information: http://mc2.engin.umich.edu/ or twitter @ Umich_MC2

Materials Genome Initiative - PRISMS Center



PRISMS Center Faculty and Staff at the annual PRISMS Workshop.

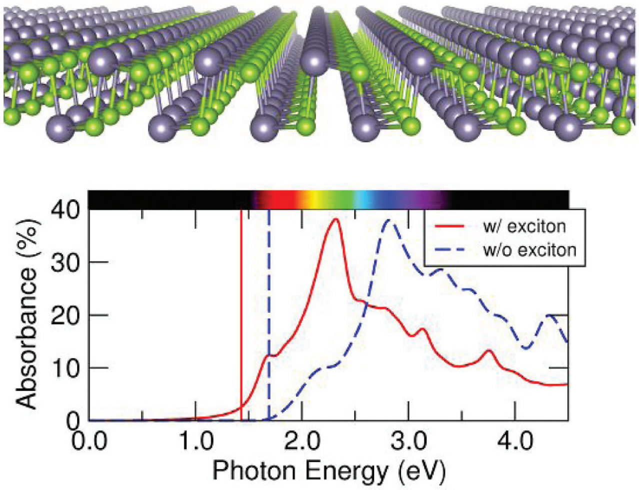
The MSE Department is playing a major role in the Materials Genome Initiative (MGI) and the PRISMS Center (PRedictive Integrated Structural Materials Science Center) is a center-piece of this activity. Since 2012, when U–M won a major national competition for an MGI Software Innovation Center and launched the PRISMS Center, we have been making major contributions to this presidential initiative. The center involves faculty, research staff and students from across the university, including MSE faculty John Allison, Samantha Daly, Vikram Gavini, Wayne Jones, Emmanuelle Marquis, Amit Misra and Katsuyo Thornton and MSE Research Staff Brian Puchala, Stephen DeWitt and Sravya Tamma. John Allison serves as the center director.

The primary objective of the PRISMS Center is the development and demonstration of a unique scientific platform for enabling accelerated predictive materials science. We are developing a suite of open-source integrated multi-scale computational tools for predicting the microstructural evolution and mechanical behavior of structural metals. These computational methods are being integrated with quantitative measurements from advanced experimental methods to determine model inputs, fill gaps in theory and validate simulation predictions. This new capability is being demonstrated by providing improvements to the quantitative and predictive understanding of magnesium alloys, in particular precipitate evolution and the influence of microstructure on monotonic and cyclic mechanical behavior. An important component of the PRISMS Center is the development of “The Materials Commons,” a knowledge repository and virtual collaboration space for the broader materials community.

In the past year some of the major highlights are

- Over 90 people attended our annual PRISMS Workshop in September 2015. This workshop included technical presentations by PRISMS faculty, staff and students as well as presentations from other experts in magnesium, mechanical behavior and computational materials science.
- In conjunction with the annual workshop, we trained over 25 new users of PRISMS codes.
- Released four major new PRISMS open-source software tools. These state-of-the art massively parallel computational software tools include:
  - Statistical mechanics software for predicting phase equilibria
  - Phase field software for simulating how microstructures evolve
  - Crystal plasticity simulation code for predicting how metals behave when they are deformed
- Integrated the results of high-resolution TEM imaging and PRISMS-statistical mechanics calculations to define a new approach for understanding the precipitation sequences in Mg-rare earth alloys.
- Completed the first use of dislocation dynamics simulations to calculate strengthening from precipitates in Mg alloys.
- Developed novel in-situ ultrasonic fatigue instrumentation to examine fatigue crack initiation and small crack growth in Mg alloys and linked with crystal plasticity models to simulate cracking mechanisms.

2D Materials with Strong Light Absorption and Anisotropic Spin-Polarized Electron Transport



A SnSe monolayer has unusually strong absorbance in the visible range (up to 38%) and is a promising material for ultrathin photovoltaic applications. Image from G. Shi and E. Kioupakis, Anisotropic Spin Transport and Strong Visible-Light Absorbance in Few-Layer SnSe and GeSe. *Nano Letters* 15, 6926 (2015).

Graduate student Guangsha Shi and Professor Emmanouil (Manos) Kioupakis have discovered that atomically thin tin selenide (SnSe) and germanium selenide (GeSe) exhibit an unusually strong light absorption in the visible range and directionally dependent spin-transport properties. The results have been published in the journal *Nano Letters* [Shi and Kioupakis, Anisotropic Spin Transport and Strong Visible-Light Absorbance in Few-Layer SnSe and GeSe.15, 6926 (2015)]. This finding could pave the way for novel applications of 2D materials in solar cells and spintronics.

Atomically thin materials have been the subject of extensive research during the past few years. Graphene, the subject of the Nobel Prize in Physics in 2010, is made up of an atomically thin honeycomb layer of carbon. It is the prototypical 2D material with extraordinary mechanical strength, high electrical conductivity, and transparency for visible light. However, pristine graphene does not have a band gap and is therefore not immediately useful for applications in electronics, solar cells, or light-emitting devices.

Recently, attention has focused on transition metal dichalcogenides such as molybdenum disulfide (MoS_2) and tungsten diselenide (WSe_2), layered semiconducting materials whose atomic layers are weakly attached with Van der Waals bonds and can easily be exfoliated to form 2D materials. These materials have led to devices such as atomically thin transistors, solar cells, and LEDs.

Another promising class of layered chalcogenide materials is the IV-VI family of compounds, which includes SnSe and GeSe. These materials also crystalize in layered structures and can be grown in atomically thin samples with a thickness of just 1 nanometer.

Recently, SnSe has been demonstrated to show a record thermoelectric conversion efficiency of converting waste heat to useful electricity. Kioupakis and Shi have also investigated the electronic and thermoelectric properties of bulk SnSe with first-principles calculations to better understand the origin of its record efficiency [Shi and Kioupakis, Quasiparticle Band Structures and Thermoelectric Transport Properties of p-Type SnSe. *Journal of Applied Physics*, 117, 065103 (2015)].

In the present work, Guangsha Shi and Professor Kioupakis applied high-performance atomistic calculations to investigate the electronic and optical properties of SnSe and its related compound GeSe when their thickness is reduced to one or two monolayers. They found that the band gap is direct in single-layer and double-layer GeSe, but it is indirect in single-layer and double-layer SnSe. Moreover, they uncovered that the interplay of spin–orbit coupling and lack of inversion symmetry in the monolayer structures results in anisotropic spin splitting of the energy bands, which has potential applications in directionally dependent electron spin transport.

The research team also found that single-layer and double-layer SnSe and GeSe exhibit unusually strong optical absorbance in the visible range, reaching values up to 38% in single-layer and 47% in double-layer SnSe. The findings suggest that atomically thin SnSe and GeSe are promising materials for ultrathin-film photovoltaic applications with theoretical upper bounds to the energy conversion efficiency that approach the efficiency records currently realized in organic and dye-sensitized solar cells.

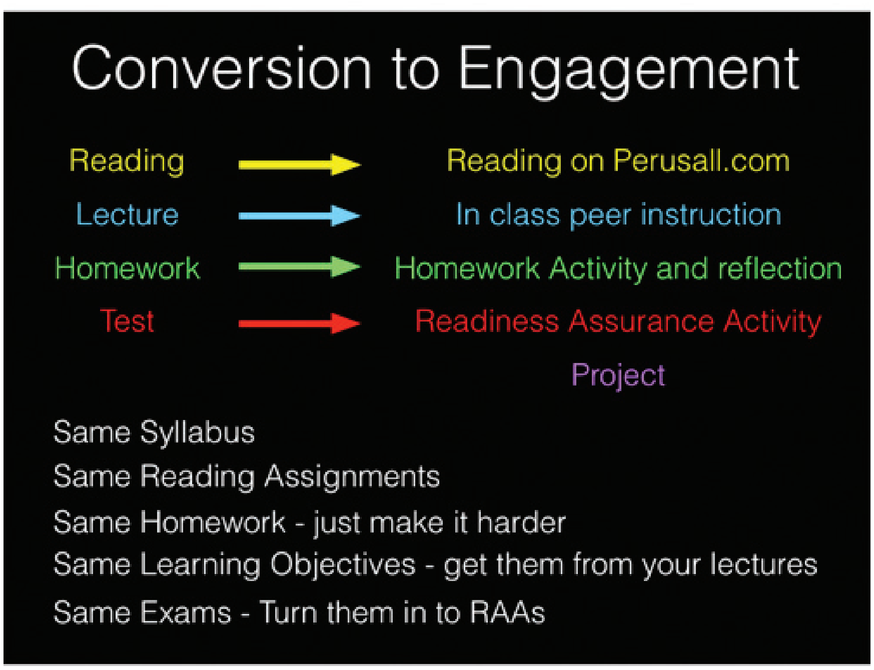
The work was supported by the National Science Foundation CAREER Award through Grant No. DMR-1254314. The high-performance first-principles calculations were performed at the National Energy Research Scientific Computing Center, which is supported by the Office of Science of the U.S. Department of Energy.

Transforming Lecture into a Deep, Engaged Learning Environment

Last winter, Steve Yalisove was asked to coach six other CoE faculty members as they adopted many of the pedagogical approaches to teaching that he had been experimenting with for the last several years. This was part of the new Faculty Fellows program sponsored by the College of Engineering. These pedagogies were mostly gleaned from the team-based/project-based learning communities and also incorporated a large number of active learning strategies. What was unique was the emphasis on discovering a new way to first introduce the material to the student as an alternative to lecture as well as focusing on formative assessment (no penalty if a student gives the wrong answer) and feedback as opposed to summative (exams). Yalisove also developed a website (http://java.engin.umich.edu/deep) that is intended to provide resources to any other faculty member based on his experience last winter.

His approach to eliminating lecture as the first introduction of the material was to have the students do something rather old-fashioned: read the book. What is new is that tools exist that can actually make sure that all students have read the book before coming to class. Web based tools like nb.mit.edu and Perusall.com allow students to highlight parts of the text and then write about what they highlighted. The other students can see the annotations and they can annotate each other's annotations - kind of like Facebook. This way, students read the book as a team, help each other answer questions, and learn how to read more critically.

The annotations are graded for quantity, timeliness, and quality (Does the annotation demonstrate thoughtful reading?). This simple first step is magical. Students grumble at first because they rarely read textbooks anymore, let alone read them critically. But soon they realize that they are learning—all by themselves. When they get to class, the instructor no longer has to go over the definitions, simple derivations and examples. This buys significant amounts of time and allows for active learning activities without having to scale back on the syllabus.



In-class active learning activities are delivered electronically but solved on whiteboards by each team of 5 students. This allows the instructor to see how the entire class is performing and provide help where needed. Homework and tests are transformed into formative assessment and feedback activities. In addition, 2-3 projects are added. Each of these components are fully explained at http://java.engin.umich.edu/deep .

The goal of the faculty fellows project was to assess if coaching would enable other faculty to adopt some of these methods while greatly reducing the learning curve and apprehension of trying something new. A workflow (left) to convert an existing lecture-based course into a team-based/project-based course was developed to make the process relatively easy. Each faculty member met with Yalisove for a few hours so he could show them how to use the tools (annotation software, bring your own device clicker systems, team making and peer review software, etc.). In addition, meetings were held every other week to discuss progress and solve problems.

All six faculty are still using these methods and more. All faculty improved their student evaluation scores and half of them significantly. They also all report continued excitement in what they perceive to be improvements to teaching.

Course Asks Students to Imagine the Campus of the Future

By Laurel Thomas Gnagey, Michigan News

If you want to transform the campus learning experience to suit the needs of today's students, who better to ask what that should look like than the people who will benefit from the changes? This is the premise behind a course called Campus of the Future, co-taught by Joanna Mirecki Millunchick, professor of materials science and engineering, and Mika LaVaque-Manty, Arthur F. Thurnau Professor of Political Science.

"We professors don't always remember what it's like to be an undergraduate. We have our own ideas about what a classroom should look like and what engaged learning should look like as well," Millunchick said. "I think listening to the student voice is really important." The course and its professors challenged students to think about what reinvention of higher education would require in terms of pedagogy and physical transformation.

"What caught my eye is that we got to be actually involved in the process of trying to make the university more 21st-century friendly," said Colby Orse, a recent graduate who took the course as a senior. Orse's project would match alumni with new students for a university-career-long mentorship, perhaps leading to internships and jobs.

Millunchick said the first students in the course were given a wide-open call to redesign the university experience. Each chose to focus on engaged-learning experiences instead of physical spaces."It became obvious that students are just craving these kinds of engaged-learning opportunities," Millunchick said. LaVaque-Manty said they gave students a free hand. "We have to encourage them and say anything goes," he said, "And once they get that they actually have no limitations they produced some really interesting ideas."

The proposals include an enhanced orientation that particularly addresses first-generation students, a required meaningful experience (service or hands-on learning), and a multidisciplinary project that gives students the opportunity to solve problems for clients. While they all dreamed big, students were realistic about their solutions.

In a recent class Rachel Jaffe, dual master's student in the School of Information and Taubman College of Architecture and Urban Planning, acknowledged that the campus might not be ready for all of their transformational ideas. "A lot of our projects are going to step on toes," she said. Her project, an app called Aether (pronounced Eh-ther), would connect people with common interests. She calls it a Tinder-like program that could get people together for a research project or a social activity. "I really see the future of education being so much more flexible, so much more collaborative and so much more social," Jaffe said.

With a somewhat similar goal, Adam Levick and Michelle Fiesta want to expand the scope of orientation to reach students before they get to campus and link them according to interests. Levick, a master's student in the School of Information, sees future students engaged in activities inside or outside of the classroom that tackle such issues as sustainability, health disparities or educational inequity." Around the world we have these really large, complex problems," he said. "One of the ways we see orientation in the future is creating communities around some of these large problems."

Part of the student experience in the class involved working with campus leaders in their respective areas. "It's always a great idea to get that person involved from the very beginning, from the design period," Levick said.

LaVaque-Manty has been a champion of engaged and alternative learning approaches for years, recognized for his work using principles from video games to allow students to choose their own paths to success. He agreed to teach the course with Millunchick beyond his workload to keep the dialogue going on campus.

While he admits it sometimes is like swimming upstream to think about offering these experiences within a university structure that has existed for decades, he is energized by the students' enthusiasm for change."It's been fun to think about it," he said. "The students sincerely want to produce ideas the university can use. It's important to think about risks," LaVaque-Manty told the students during class. "It's easy to get depressed. Let's be realistic but at the same time optimistic."

Fiesta, a School of Information student, was concerned about leaving her orientation project unfinished. "The biggest risk is that students next semester don't pick up your project," she said.

Millunchick said the next class will focus on physical spaces, but she and LaVaque-Manty hope some of this semester's projects will be carried forth by future students.

Orse wants hers to come to fruition so that she can be one of the alumni to mentor a student through the program she initiated. "It makes me feel excited, definitely, to know that you made the difference," she said. "It's not just about the grade but knowing that you're helping other students."

The course will be offered again in the fall and will focus on designing the Classroom of the Future. If you are interested in participating, please contact Professor Millunchick (joannamm@umich.edu).

Undergraduate Program Report

The undergraduate program continues to be recognized as among the best materials science undergraduate programs in the nation, ranked at #5 by U. S. News and World Report in 2015. Currently, there are 158 students enrolled as MSE majors.

In recognition of the fact that a solid foundation in and knowledge of materials science and engineering is crucial to a wide range of disciplines and applications, the department is proposing a minor. If approved by the College, eligible students could declare the minor by completing a minimum of 17 credit hours of selected MSE courses. The faculty anticipates that a reasonable number of students would elect this option in the future, raising the awareness and reputation of the department across the college and in industry.

The department is continually striving to improve the curriculum even more so that our graduates continue to be the leaders and best. This year, the faculty is concentrating specifically on strengthening connections between courses. For instance, MSE 360 Materials Laboratory I was reorganized in order to make more explicit connections between theory and computational approaches to hands-on experimentation. In the fall of 2015, the students cast a number of Al alloys at Joyworks, a local casting research, design, and prototyping facility, owned by alumnus John (Chip) Keough. They characterized their microstructure, and measured their mechanical properties using a number of different techniques available in the Van Vlack Undergraduate Laboratory. The activities in the lab made explicit links to material in the students' coursework. Other courses are also undergoing similar reorganizations to better connect theoretical concepts and hands-on activities.

The restructured laboratory experience would not be possible without the participation of dedicated and enthusiastic alumni like Chip.

At Keough's Joyworks Studio, MSE 360 students enjoy the work of transferring molten metal from the furnace, to the ladle, to be poured back into ingots.

Graduate Program Report

The Graduate Committee has continued focusing on providing a high quality graduate education program and to help our graduate students advance to outstanding careers.

Our graduate students have excelled in research development and leadership roles. During the past year, many of our graduate students received prestigious fellowships and awards including the National Science Foundation Graduate Student Fellowships, College of Engineering Distinguished Achievement Award, and College of Engineering Distinguished Leadership Award.

Fourteen new PhD students and thirteen MS students with record high GPA and GRE scores joined the department in Fall 2015. They were selected and admitted from among more than 400 applications from top U.S. universities and renowned schools from all over the world. Our students received Rackham Merit Fellowships and the newly established College of Engineering Masters Fellowship. Furthermore, fellowships were given to all admitted PhD students from the department to fully cover at least the first term or two. Support in the following years will be provided through a combination of fellowships, graduate student research assistantships, and graduate student instructorships.

Sixteen PhD students have successfully defended their dissertations and graduated over the summer 2015 and fall 2015 semesters, and have accepted positions at various employers such as Samsung, Dow Chemical, Oak Ridge National Laboratory, NIST, Argonne National Laboratory, Northwestern University and UCSB.

The graduate committee revised the coursework requirement for PhD candidacy in the past year so that students can achieve candidacy faster. The committee will thoroughly revise the graduate core courses and qualifying exam in the coming years. We will to recruit top quality students for our graduate program and will particularly focus on enhancing diversity. We also aim to help our outstanding graduate students to foster their interests in academic careers in coming years.

Faculty Awards

INTERNAL AWARDS

Anish Tuteja, Associate Professor, was the recipient of the 2015 MSE Outstanding Achievement Award. The award is presented annually to a faculty member for their stellar performance in materials research and teaching, and service to the department. A single recipient is chosen every year by the department chair. The winner is recognized at the annual CoE faculty honors dinner dance and the MSE graduation dinner. Anish has gained international recognition for his innovative research and scholarship in superomniphobic surfaces.

Katsuyo Thornton, Professor, was the recipient of the 2015 Jon R. and Beverly S. Holt Award for Excellence in Teaching. Based on recommendation from the department, this award is presented annually by College of Engineering to one faculty member in Materials Science and Engineering and one in Industrial and Operations Engineering to recognize outstanding teaching. Katsuyo has championed the development and incorporation of computational modules in the MSE undergraduate curriculum.

Joanna Millunchick, Professor, received the 2015 Raymond J. and Monica E. Schultz outreach and diversity award from the College of Engineering. Joanna has been a tireless advocate for women in science and through her leadership in M-STEM academies, she has worked to improve the diversity of STEM students across the campus.

Kai Sun, Associate Research Scientist, Michigan Center for Materials Characterization and MSE, received the 2015 Kenneth M. Reese outstanding research scientist award from the College of Engineering. Sun has a prolific publication record and has distinguished himself as an independent researcher through his many contributions to electron microscopy characterization of advanced materials.

Stephen Forrest

- Peter A. Franken Distinguished University Professorship, University of Michigan (2015)
- Distinguished University Innovator, University of Michigan (2015)

Sharon Glotzer

- John W. Cahn Distinguished University Professorship, University of Michigan (2015)

Victor Li

- Rackham Distinguished Graduate Mentor Award, University of Michigan, Rackham Graduate School

Michael Thouless

- Janine Johnson Weins Professor of Engineering, College of Engineering, University of Michigan (2015)

EXTERNAL AWARDS

Vikram Gavini

- Gallagher Award, United States Association for Computational Mechanics (USACM) (2015)

Rachel Goldman

- 50th Anniversary Distinguished Alumna, Electronic Device and Materials Group, Electrical and Computer Engineering, UC-San Diego

Peter Green

- Fellow, The American Association for the Advancement of Science (2015)

John Halloran

- Academician, World Academy of Ceramics (2015)

Richard Laine

- Fellow, American Chemical Society (2015)
- Governor of Michigan's Green Chemistry Award (2015)

Victor Li

- International Innovation Grand Prize Award, Construction Industry Council

Peter Ma

- Fellow, Materials Research Society (2015)

Amit Misra

- TMS Materials Processing and Manufacturing Division Distinguished Service Award (2016 Annual Meeting)

Pierre Ferdinand Poudeu Poudeu

- Guest Professor, State Key Laboratory of Advanced Technology for Materials Synthesis and Processing, Wuhan University of Technology, China (2015)

Max Shtein

- Emerging Luminary Award, Department of Energy (2014)

Donald Siegel

- VELUX Visiting Professor, Technical University of Denmark

Alan Taub

- Keynote Address TMS Summit on Integrated Manufacturing and Materials Innovation
- Keynote Address ASM International Heat Treating Society's Conference and Exposition

Michael Thouless

- Archie Higdon Distinguished Educator Award, Mechanics Division, ASEE

Professional Service

John Allison

- TMS Materials Genome Initiative Ambassador
- TMS Materials Innovation Committee, Chair
- TMS Nominations Committee
- TMS ICME Committee
- *Integrating Materials and Manufacturing Innovation*, Editorial Board

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Faculty

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- *International Journal of Fatigue*, Editorial Board (2015)
- ASM Gold Award Committee
- ASM Bronze Award (Mid-Career) Committee
- Madrid Institute for Advanced Materials Studies – Scientific Board

Michael Atzmon

- Past President, International Mechanochemical Union (member society of the International Union of Pure and Applied Chemistry)
- Steering Committee, International Symposium on Metastable, Mechanically Alloyed and Nanocrystalline Materials
- TMS Chemistry and Physics of Materials Committee
- U.S. Advisory Committee, Bulk Metallic Glass International Conference (BMG XI)

Stephen Forrest

- Distinguished Visiting Professor of Electrical Engineering, Technion Israel Institute of Technology (2015-present)
- National Academy of Sciences Flexible Electronics Committee (2010-present)
- *ChemSusChem,* Editorial Board (2007-present)
- *ACS Nano*, Editorial Board (2007-present)
- The Technion, Israel Institute of Technology Board of Governors (2012-present)
- *Physical Review Applied*, Editorial Board (2014-present)

Vikram Gavini

- Chair, USACM technical thrust area on Nanotechnology and lower scale phenomena (2015-present)

Sharon Glotzer

- ACS Nano, Associate Editor
- APS Division of Condensed Matter Physics, Chair
- National Academy of Sciences Board on Chemical Sciences and Technology (2015-2018)
- DOE Advanced Scientific Computing Advisory Committee
- DOE Basic Energy Sciences Grand Challenges Committee
- Unifying Concepts in Glass Physics, January 2015, Co-chair

Rachel Goldman

- *MRS News*, Editorial Board (2012-present)
- *Journal of Electronic Materials*, Associate Editor (2002-present)
- Invited Organizer, Electronic Materials Conference (2010-present)
- NSF Electronic and Photonic Materials CAREER Panel (2015)
- NSF Science and Technology Center Panel (2015)
- NSF Engineering Research Center Panel (2015)

Peter Green

- Chair, Panel for National Academies of Sciences, Engineering and Medicine Committee, “An Assessment of the National Institutes of Standards and Technology Center for Neutron Research.” Performed for the Laboratory Assessment Board. The report is available on the National Academies Press website: www.nap.edu.
- Co-PI, NSF Grant (along with Sossina Haile, Northwestern Univ., and Simon Billinge, Columbia Univ.). The primary activity is an intensive two-week school in Africa, on the topics of materials for energy, sustainability and technology, with instruction by world-renowned researchers. The school will be held in Arusha, Tanzania, May 29-June 14, 2016. This institute is the second Joint Undertaking for an African Materials Institute (JUAMI). The goal is the development of joint materials research and education activities between universities in Africa, the US and Europe.
- *MRS Communications*, Editor-in-Chief
- Dean’s Advisory Board, University of Florida
- External Review Board for Materials Research, Sandia National Laboratories
- Advisory Board, ACS Petroleum Research Fund
- Member of the US Liaison Group-International Union of Pure and Applied Physics

Jinsang Kim

- Associate Editor, Macromolecular Research (Springer)
- Advisory Board, Hanwha Advanced Materials Faculty Award

Emmanouil Kioupakis

- Co-organizer and Session Chair, “Focus Session: Theory and simulation of excited-state phenomena in semiconductors and nanostructures,” American Physical Society March Meeting 2015
- Steering Committee, Michigan Institute for Computational Discovery and Engineering (MICDE).
- J. Robert Beyster Computational Innovation Graduate Fellowship Selection Committee (2015)

Richard Laine

- Polymer Division of the American Chemical Society, Board Member, and chief organizer of new ACS approved test in Polymer Science and Engineering
- Director, Macromolecular Science and Engineering Program, University of Michigan (2006-2015)
- Editorial Board, Polymer International
- Organizer, Symposium on Hybrid Materials, Pacific Polymer Conference (2015)

Peter Ma

- Council Member, Tissue Engineering and Regenerative Medicine International Society
- Chair, Tissue Engineering and Regenerative Medicine International Society, Americas Dental and Craniofacial TWIG
- Board Member, International Chinese Musculoskeletal Research Society

CONTINUED ON PAGE 16

- Distinguished Scientist Award Committee Member, International Association for Dental Research
- Advisory Board Member,Chinese Association for Biomaterials
- Grant Reviewer for NSF, NIH and National Research Foundation of Korea

John Mansfield

- Member of the Executive Committee of the International Federation of Societies for Microscopy (2015–2019)
- President of Microscopy Society of America (2015)
- *Journal Microscopy and Microanalysis*, Microanalysis Editor
- Microscopy and Microanalysis, Member of the Editorial Board

Amit Misra

- *MRS Bulletin*, Editorial Board,
- MRS Broader Impacts Program Development Subcommittee
- *Materials Research Letters,* Editor

Pierre Ferdinand Poudeu Poudeu

- Co-Chair of the DOE 2015 Synthesis and Processing Science Principal Investigators' Meeting, Gaithersburg, Maryland, November 2-4, 2015

Donald Siegel

- Member, Executive Committee, American Physical Society (APS) Group on Energy Research and Applications
- Review Panelist, U.S. Department of Energy Hydrogen Program and Vehicle technologies Program Annual Merit Review
- Review Panelist, National Science Foundation Division of Chemical, Bioengineering, environmental, and Transport Systems
- Affiliate Member, U.S. DRIVE Hydrogen Storage Technical Team
- Faculty Advisor, University of Michigan Society of Automotive Engineers Student Chapter
- Member of the Directorate, Joint Center for Energy Storage Research

Alan Taub

- NAE Committee on Membership
- MIT Corporation Visiting Committee for materials Science and Engineering
- Dean's Advisory Council, University of California Davis
- Panel Session for U.S. Senate Competes Act
- Keynote Panel Michigan Minority Procurement Conference

Katsuyo Thornton

- Member, Advisory Board, MRS Communications
- Technical Advisory Board, Center for Hierarchical Materials Design (CHiMaD), a NIST Advanced Materials Center of Excellence (2014-present)
- TMS Materials Innovations Committee (2012-present)
- TMS Education Committee (2012-present)
- Chair, Education Subcommittee, TMS ICME Technical Committee (2014-present)
- *Computational Materials Science*, Editorial Board (2014-present)
- *IMMI*, Editorial Review Board, (2013-present)

Steven Yalisove

- *MRS Bulletin*, Member, Editorial Board
- *MRS Bulletin*, Energy Quarterly, Member, Core Editorial Board
- MRS Academic Affairs
- Chair, MRS Education Sub-Committee Academic Affairs
- TMS Accreditation Committee
- ABET Volunteer
- Program Committee for "Laser Applications in Microelectronic and Optoelectronic Manufacturing" at Photonics West, February 2016
- Co-Organized Symposium on "Ultrafast Bandap Photonics" at the SPIE Defense + Security Meeting in Baltimore, April 2016

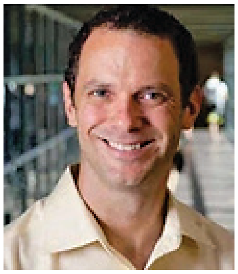
ASM Teacher Camp

Teachers have been enjoying the ASM Teacher Camp program at Michigan for the past fourteen years. Teachers from across the country come to Michigan to learn about materials and methods of including materials into their high school curriculum. While some of these teachers have developed complete materials science programs for their high schools, others have incorporated materials into their chemistry and physics or other curriculum. With the continued support of the Detroit Chapter of ASM and the Master Teachers they supply, we look forward to many more years of this camp.

Alumni News

Don Nolan (BSE '82, MBA '91) received the 2015 CoE Alumni Merit Award. Nolan joined Kennametal Inc. in November 2014 as president and chief executive officer. Kennametal is a global industrial technology leader and at the forefront of advanced materials innovation for more than 75 years in areas such as metal working tools, surface engineering for wear, abrasion and corrosion resistance, powder metallurgy, and manufacturing of mining and construction equipment. Prior to joining Kennametal, Nolan served as president of Avery Dennison's $4.5 billion Materials Group. Don has more than 30 years of experience in diverse, global industries in specialty engineering materials.

He serves on the board of directors of Apogee Enterprises, Inc. and is a member of the University of Michigan's Engineering Advisory Council. Don also has an MBA from the University of Michigan, a master's degree in mechanical engineering from Rensselaer Polytechnic Institute and most importantly, a bachelor's degree in materials and metallurgical engineering from the University of Michigan.



Materials Science Engineering alumnus, **Jay Whitacre** (MSE '97, PhD '00), has received the 2015 Lemelson-MIT Prize for his work in inventing the Aqueous Hybrid Ion battery, a durable, non-toxic battery often used to store electrical energy. The Lemelson-MIT Prize honors outstanding mid-career inventors improving the world through technological invention and demonstrating a commitment to mentorship in science, technology, engineering and mathematics (STEM).

Whitacre founded Aquion Energy in 2008 to commercialize the first-of-its-kind battery technology, which uses safe and abundant materials like salt, water and carbon. Now fully commercialized, the battery is manufactured in Mt. Pleasant, Pennsylvania and distributed across the globe.

He is currently a professor at CMU and is also the CTO of Aquion Energy, His work at CMU has been focused on developing and analyzing new materials and systems for electrochemical energy storage and conversion. He has numerous honors to his name, including the 2014 Caltech/Resnick Sustainability Institute Resonate Award, and was listed as one of the top 25 Eco-Innovators in the world by *Fortune* magazine in 2014.

MSE alumnus, **Aaron Crumm**, (MSE '97, PhD '00) joins Michigan's Center for Entrepreneurship as its first entrepreneur in residence. Crumm will play an active role in CFE's entrepreneurship and research acceleration programs. Beyond teaching courses, he will be serving as an advisor to student startups and looking for opportunities to translate technology into the energy industry.

He has extensive experience in launching his own technology company, Adaptive Materials, Inc. (AMI), out of the research he completed as a PhD student at Michigan. He not only applies this experience to helping students and faculty transition research to real-world application, but also serves as a faculty member and mentor.

Crumm's simple, yet radical, business proposition was to develop a portable solid oxide fuel cell system that ran off of readily available fuel. His success in leveraging research grants as part of AMI's business acceleration strategy was integral to the company's ability to remain privately held and focused on fuel cell product development. The company was acquired by defense industry giant Ultra Electronics in 2010.

MSE alumnus, **Jon Madison** (MSE '07, PhD '10), won the Black Engineer of the Year Award (BEYA) for Most Promising Scientist. BEYA is a program of the national Career Communications Group, an advocate for corporate diversity, and is part of its STEM (science, technology, engineering and math) achievement program. The awards annually recognize the nation's best and brightest engineers, scientists and technology experts.

A native of Wichita, Kansas, he is a graduate of Clark Atlanta University, one of the nation's Historically Black Colleges and Universities, where he earned a bachelor's degree in engineering science. He then headed to U-M to complete his master's and doctorate in materials science and engineering.

Madison joined Sandia in 2010. His work centers on destructive and non-destructive techniques to understand microstructure in three dimensions, and using that information in experiments and simulations.

Madison is a Campus Executive Fellowship mentor and works with interns from around the country. "I take mentoring really seriously," he said. "It is our responsibility as scientists to mentor the next generation. It's close to my heart because I was groomed by mentors."

MSE & ChE Holiday Fundraiser/Social Event

Graduate students in MSE and ChE hosted the first fundraiser/social event for the graduate students, faculty and staff of the MSE and ChE departments on December 8, 2015. MSE and ChE share many of the same buildings and resources on campus and this event was an opportunity to build networking relationships by bringing them together for a fun evening involving dinner, an ugly sweater contest, and sugar cookie decorating. Another important aspect of the event was a food drive to raise dry goods for the local community. Eighty-one people attended the event and donated over 100 items of food to Food Gatherer's in Ann Arbor. This event was made possible by the College of Engineering and the MSE and ChE departments.

Graduate Student Council

The Graduate Student Council (GSC) hosted a Chili and Cornbread cook-off in November. The purpose was to give students a break from their busy schedules and come together with their colleagues for an hour of food and fun. Prizes were awarded to the student who got the most votes for either their chili or cornbread. The GSC also hosted a study snack break for the department in December just in time for finals. Students came together in the MSE lounge for laughter and light refreshments. The GSC hosted a "CV to Resume" workshop for all graduate students in January 2016. The workshop was taught by a professional academic coach who provided one-on-one critiques and an interactive presentation for students.

Congratulations to the Class of 2015!

Materials Science and Engineering BSE Graduating Class of 2015, with department faculty at the annual graduation dinner held at the Michigan Union on April 14, 2015.

MMS Highlights from Fall 2015 and Winter 2016

MMS will be hosting a total of 16 companies to come in and speak on a wide range of topics for the weekly MMS luncheons. These speakers hail from a variety of backgrounds, including aviation, energy storage, automotive, and even consulting. The MMS weekly luncheons draws around 50 students every week, connecting them with members of industry as well as their peers across all age levels (see list below).

The ASM Student/Professional Mixer gave MSE students the opportunity to meet, chat, and eat great food in downtown Ann Arbor at Conor O'Neill's in early September. There were representatives from multiple companies, faculty and staff from the department, and approximately 20 students that attended the event. It was a great opportunity for students to discuss the potential their MSE background holds in a casual setting.

MMS, in partnership with the MSE department, hosted the first ever MSE Career Fair. The fair was the first of its kind, connecting small, local Michigan-based companies seeking MSE students for a variety of positions. The fair featured six companies: Gerdau, XALT Energy, Tekton (Michigan Industrial Tools), Constellium, L&L Products, and Novelis Aluminum. Fifty-nine students participated in the four hour event, connecting with professionals of industry. The event was held in the G.G. Brown Building in the Borg Warner Atrium.

MMS Luncheon Companies for 2015-2016

Texas Instruments
Johnson & Johnson
Meritor
GE Aviation
Gerdau
Grid Logic
XALT Energy
L&L Products
Timken
Nucor Steel
Asahi Kasei Plastics
NTN Bearing
Accenture
Ford
Toyota
Federal Mogul

The 2015-2016 MMS Board

Timothy Chan – President
Angelica Okorom – Vice President
Andrew Cronin – Co-Treasurer
Teresa Vasievich – Co-Treasurer
Samantha Raney – Secretary
Henry Grierson – Social Chair
Sara Beck – Undergraduate Committee Representative
Megan Liu – Undergraduate Committee Representative
Clare Hyde – Undergraduate Student Advisory Board Representative
Jack Hu – Undergraduate Student Advisory Board Representative
Kristen Ige – Internal Development Facilitator
Rachel Shifman – Junior Representative
Eleanor Coyle – Graduate Representative

Student Honors

Undergraduate Awards

Richard A. Flinn Scholarship

Daniel Lee, Samantha Raney, Chuxuan Xiong

Fontana-Leslie Scholarship

Azia Harris-Martin, Andrea Mathew

James W. Freeman Memorial Scholarship

Elizabeth Bohen-Meissner, Andrew Hartman, Denise Jones, Adam Lundquist, Tyler Zhang

John Grennan Scholarship

Emily Burgess, Jeremy Lipshaw, Allison Ward

Jack J. Heller Memorial

Joseph Casamento, Timothy Chan

William F. Hosford Scholarship

Andrew Burek, Daniel Nara, Boning Qu, Connor Saukas, Casandra Smith, Zhenjie Yao, Yuxiang Zhang

Schwartzwalder Memorial Scholarship

Haolun Fang, Clare Hyde, Rachel Levenson, Elena Schwarz, Erica Siismets, Pengyuan Xiu

Clarence A. Siebert Memorial Scholarship

Katrina Cribbins, Edward DiLoreto, Justin Eszlinger, Henry Grierson, Betelihem Tizazu, Katherine Vaidya, Tong Xuan

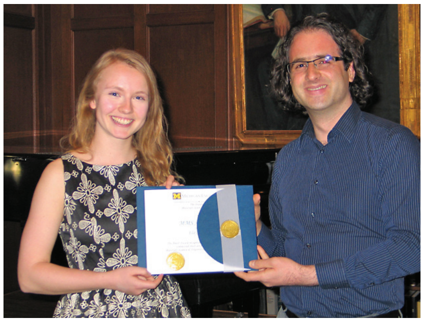
Alfred H. White Memorial Scholarship

Kaiyuan Cao, Rebecca Cohn, Jack Hu, Bryce Kriegman, William Turri, Wenxuan Zhang, Zhiheng Zhou

Brian D. Worth Prize

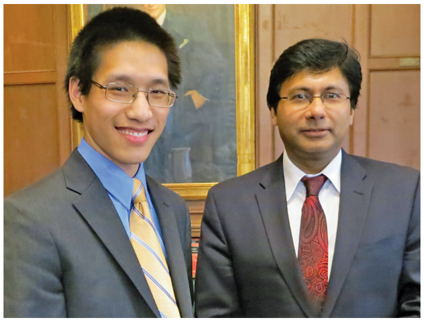
Samantha Raney, recipient of the Brian D. Worth Prize, with Professor J. Wayne Jones.

MMS Anvil Award



Elaine Thomas, recipient of the MMS Anvil Award, with Assistant Professor Emmanouil (Manos) Kioupakis.

James P. Lettieri Undergraduate Award



Peter Su, recipient of the James Lettieri Undergraduate Award, with Professor Amit Misra.

College/University Awards

CoE Distinguished Achievement Award

Elayne Thomas

Graduate Awards

MSE Graduate Service Award for Recruiting

Elaina Anderson, James Proctor, Erica Salem, Sarah Snyder and Jill Wenderott

Best Overall Graduate Student Instructor

Kiersten Batzli

College/University Awards

CoE Harry Benford Award for Entrepreneurial Leadership 2015

Nicholas Moroz

CoE Distinguished Academic Achievement 2015

Guangsha Shi

CoE Distinguished Leadership Award 2014

Bradley Wing

Engineering Graduate Symposium Poster Presentation

First Place, Materials and Chemical Technology Division

Ji-Young Kim

External Awards

National Science Foundation Graduate Fellowship

Juan Lopez and Sarah Snyder

Staff Retirements and Departures

Georgia Knope, MSE department manager, retired January 1, 2016 from the University of Michigan after over 42 years of service. In her distinguished career, she worked in the Departments of Chemical Engineering and Mechanical Engineering from 1973 to 1982, and in MSE from 1982 to the present. She served as MSE unit administrator/department manager for over 3 decades and worked with six department chairs. She won the MSE outstanding service award twice and provided invaluable service to numerous CoE committees, workshops and United Way campaign. Post-retirement, Knope will continue to be involved with the department on a part-time basis.

Bonni Viets, MSE research process manager, retired in December 2015 from University of Michigan after over 25 years of service. She worked in the Department of Materials Science and Engineering from 1989 to present. In her distinguished career, she served as the MSE research manager for over two decades, mentoring new faculty and staff on the details of grant and contract management. Nominated for many awards over the years, she received the MSE outstanding staff service award three times and received the College of Engineering Excellence in Staff Service Award in 2013. She also provided invaluable service to numerous CoE and University committees and workshops. In her retirement, Viets plans to travel and spend time with her family.

Justin Scanlon left the department last spring after ten years of service. Scanlon will be devoting his time to raising Christy's and his four boys—no small feat. Justin grew in his role in the department to provide excellent support to both undergraduate and graduate students alike. He became a reliable asset for students needing assistance in all operations in the Van Vlack lab while assisting professors in their teaching roles. Scanlon's support and ability to relate to the students made him a first choice for support in both sample prep and analysis. We thank him for his support of the students and the labs and wish him the best in his current endeavors.

Introducing New Staff

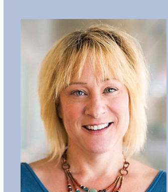
Todd Richardson joined MSE as department manager in December 2015. He replaces Georgia Knope who retired this year. Richardson earned his BS degree in electrical engineering from the University of Michigan in 1993, and MBA in finance from Indiana University in 1998. He worked at the University of Michigan health system since 2002 and was division administrator in the Department of Surgery before coming to MSE.

Tim Chambers joined our department in Spring 2015. He completed his BS in physics here at the University of Michigan, and his Ph.D. in physics at the University of Arizona, specializing in physics education research. He also taught at the secondary level for four years and conducted postdoctoral work in STEM education research and curriculum design before coming to MSE. Chambers' primary efforts are focused on supporting all users of the Van Vlack Undergraduate Laboratory, with emphasis on the experimental courses—the junior labs, MSE 360/365, and the senior design courses, MSE 480/489. In addition to teaching students to use the equipment and helping them with their lab work, he helps design and implement outreach and demonstration events involving the VVUL. In fall 2015, he worked with Professor Joanna Millunchick to develop a new curriculum for MSE 360 that combines evidence-based teaching practices with a semester-long engineering challenge: the synthesis, characterization, and application of a material system. Chambers looks forward to finding new ways to support the department's educational and service missions in the future.

Greg Young joined MSE as research process manager in November 2015. Greg replaces Bonni Viets who retired this year. He has worked in the area of research administration at the University of Michigan since 2010, holding positions in the Departments of Aerospace Engineering, Mechanical Engineering and Computer Engineering before moving to MSE.

STAFF SERVICE

2014 staff service awards were presented at the staff/faculty holiday luncheon in December 2014 to the following staff:



Shelley Fellers for her diligent service in hosting the MSE graduate seminar series.

Renee Hilgendorf for her commitment and outstanding achievements as MSE graduate program coordinator.

2015 staff service awards were presented at the staff/faculty holiday luncheon in December 2015 to the following staff:

Debra Johnson for her excellent service as MSE procurement specialist.

Jeanette Johnson for her committed service overall and in particular, with the faculty hiring, reappointment, tenure and promotion casebooks.

Gifts from Our Donors

Individual

David P. Adams
Robert P. Badrak
Bruce A. Barth
Karl and Patricia Betz
Kenneth and Judy Betz
William M. Boorstein
John E. Brokloff
John Q. Cheng
Matthew J. Daniels
Raymond F. Decker
William E. Dowling
Obiefune K. Ezekoye
James W. Fruehling
G.K. & E.M. Rasmussen Trust
Ronald Gibala
Susan E. Hartfield-Wunsch
William F. Hosford
Mark J. Jagner
John R. Keough
Michael M. Kirka
Peter J. Krajewski
Robert G. Lang
Sanford J. Lewis
Joyce C. Madden
Michelle N. McClaughry
Robert C. McCune
Eileen B. Mikulski
Mikus Family Trust
D. Keith Patrick
A. Murray Patterson
Barbara L. Putney
Leonard H. Radzilowski
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William A. Thompson
Liya Wang
Emily B. Warchuck
James F. Watson
Janine Johnson Weins
Michael J. Weins
Sharon M. Worth

Industry

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General Electric Company
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Materion Corporation
University of Electronic Science

For online giving to The University of Michigan's Department of Materials Science and Engineering, please visit:

giving.umich.edu/give/mse

Van Vlack Lectures

The 2014 Van Vlack lecture, rescheduled from September 2014, was presented in April 2015. The speaker was Professor Joanna Aizenberg from Harvard University, and her public lecture was titled "Stealing from Nature: Bioinspired Materials of the Future."

The 2015 Van Vlack lecture was presented in October 2015 by Professor Peter Voorhees from Northwestern University, titled "Watching Microstructures Evolve in Three Dimensions."

Both these lectures can be watched at the Michigan MConneX website at www.engin.umich.edu/mconnex/lectures/depts (select Materials Science & Engineering)

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