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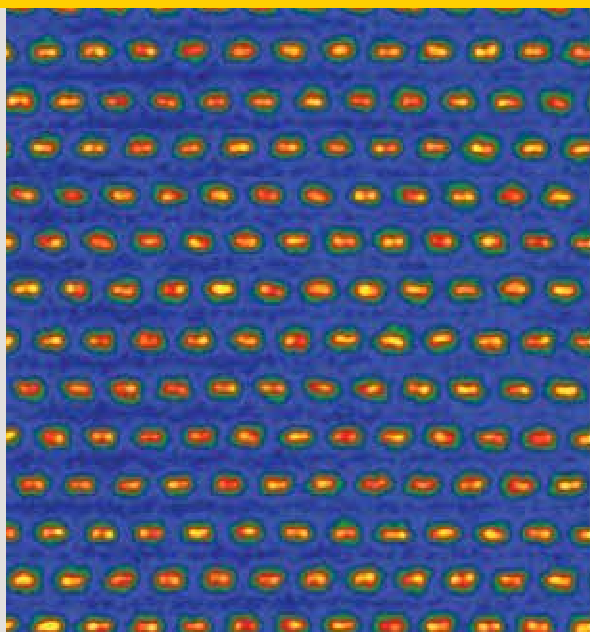
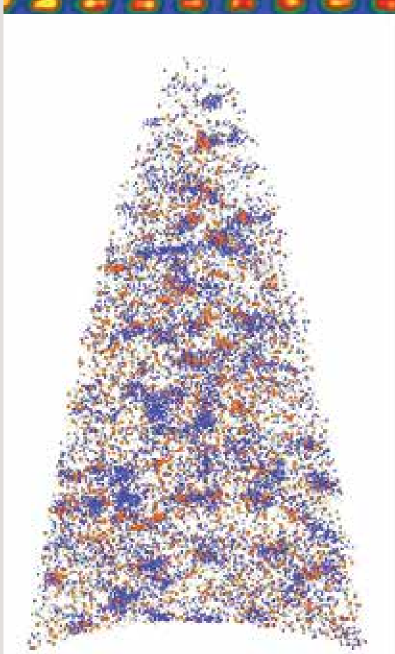
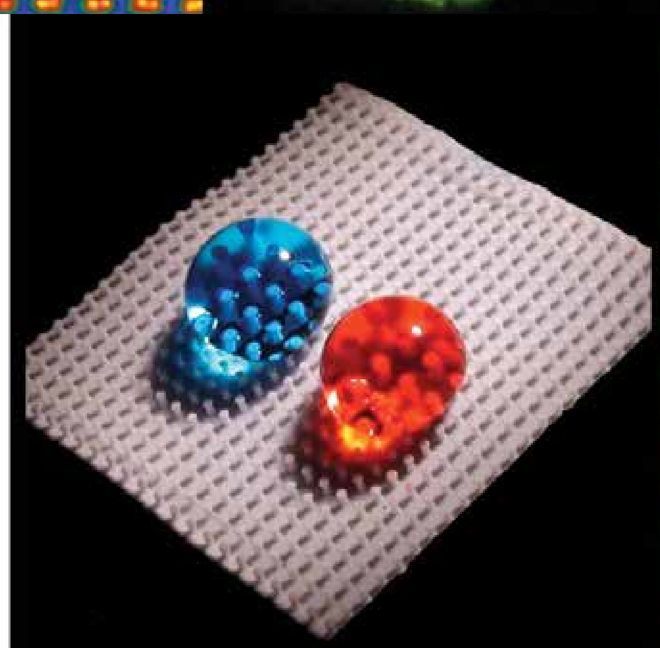
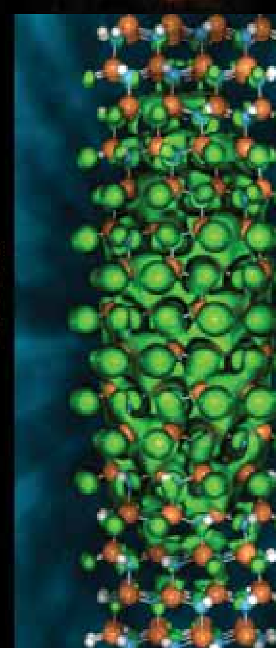
MSENews

In This Issue









Advanced Materials Design at Michigan

Dear Alums and Friends:

The increasing significance and breadth of materials applications in modern society presents new opportunities and challenges for MSE departments to develop the right balance and depth in both undergraduate and graduate curricula. With the launch of Materials Genome Initiative (MGI) in 2011, MSE as a discipline has perhaps never been so important as it is now. The MGI roadmap envisions that novel materials with enhanced functionalities will be central in the next-generation technologies in energy, transportation, national security, healthcare, etc. The MGI vision is to double the pace of materials discovery, development, manufacturing, and deployment.

Another national initiative impacting materials engineering is the National Network for Manufacturing Innovation (NNMI), which is building regional hubs that will accelerate the development and adoption of cutting-edge manufacturing technologies to spur innovation and entrepreneurship and revitalize the US economy in the 21st century. These national initiatives impact academic MSE departments in at least two significant ways. First, they make it critical for us to embrace the new paradigm in materials research based on a closed-loop theory-simulation-experiment approach. Second, they help us emphasize experiential learning and incorporate computational design and materials synthesis, processing, manufacturing, and characterization in our curricula to educate a world-class MSE workforce that is trained for careers in academia, national labs, and industry.

MSE faculty are engaged in leadership roles in several research centers and institutes based on these new initiatives, including:

- the PRedictive Integrated Structural Materials Science (PRISMS) Center, funded under the MGI initiative by the Department of Energy, Office of Basic Energy Sciences, (Professor John Allison, Director);
- the American Light-weight Materials Manufacturing Innovation Institute (ALMMII), funded this year by the Department of Defense, Office of Naval Research through the NNMI initiative, led by Professor Alan Taub in collaboration with Ohio State University and EWI;
- partnerships formed due to Professor Katsuyo Thornton's leadership in computational materials science including two Energy Innovation Hubs (the Joint Center for Energy Storage Research at Argonne National Laboratory and the Consortium for Advanced Simulation of Light Water Reactors at Oak Ridge National Laboratory), and one Energy Frontier Research Center: NorthEast Center for Chemical Energy Storage.

The success of MSE faculty with these large national initiatives highlights the rising significance of theory and computation in materials science and manufacturing research to bridge the gap between engineering innovations in academia and industry.

MSE faculty also showed leadership in other highly competitive sponsored research. For example, in the last year, three faculty members— professors Emmanuelle Marquis, Anish Tuteja, and Emmanouil Kioupakis—won National Science Foundation (NSF) Faculty Early Career Development (CAREER) awards.

MSE faculty have a track record of producing breakthrough materials research, and the year 2014 was no different. Professor Jinsang Kim's group reported two significant highlights: the development of polymers with 10X increase in thermal conductivity, and bright, metal-free, organic, phosphorescent light emitters. Professor Emmanouil Kioupakis' computational materials physics group predicted enhanced green light emission in Indium Nitride semiconductor nanowires, an extremely relevant finding toward the engineering of high-power light-emitting-diodes (LED).

With regard to teaching, the senior capstone design courses provide an example of how MSE is evolving its curricula. Taught by professors Max Shtein, Anish Tuteja, and Alan Taub, these courses, engage students in multidisciplinary team projects, sometimes with industrial support. Incorporation of the knowledge from the materials courses into real engineering design projects provides a higher level of experiential learning, and has already produced new levels of success, for example, a start-up company by the undergraduate students based on their senior design project. Another example is the innovative active learning pedagogy championed by Professor Steve Yalisove to teach large undergraduate classrooms. MSE faculty are also actively developing new courses to incorporate emerging topical areas into the curriculum; one example is Professor Emmanouil Kioupakis' new undergraduate course in Materials Innovation for a Sustainable Energy Future.

In the past year, MSE witnessed an increased presence at the University of Michigan's North Campus Research Complex (NCRC). The North Campus Electron Microbeam Analysis Laboratory (EMAL) is in the process of relocating to NCRC and now has a state-of-the-art JEOL 3100R05 aberration-corrected instrument that will push the frontiers of sub-Å resolution imaging and spectroscopy inside a Transmission Electron Microscope. Several MSE faculty affiliated U-M's BioInterfaces Institute, directed by Joerg Lahann (Professor of Chemical Engineering; and Professor of MSE), have also relocated their research groups to NCRC, as we continue our efforts for a new building on North Campus that will consolidate MSE and ChE departments.

Finally, I wish to thank Professor Peter Green for his invaluable service to MSE as Department Chair. Under his leadership, the department reached new levels of success and growth, doubling both its undergraduate and graduate enrollments.

I look forward to working with the MSE faculty, staff, students, and alumni in continuing our tradition of world-class academic research and education. I invite our alumni to engage with the department and support us in our mission to educate and train the next generation of the very best materials scientists and engineers.

Amit Misra

New Faculty

Amit Misra

joined the department as Professor and Department Chair in June 2014. Prior to that, he worked at Los Alamos National Laboratory, New Mexico (LANL) for almost 18 years. At LANL, his most recent appointment was Director of the Center for Materials at Irradiation and Mechanical Extremes, a US Department of Energy, Office of Basic Energy Sciences-funded Energy Frontier Research Center (EFRC).

Misra earned his B.Tech. degree in Metallurgical Engineering from the Institute of Technology, Banaras Hindu University (now IIT-BHU), India in 1989, and his PhD from the University of Michigan in 1994.

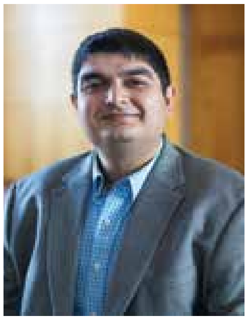
His primary research expertise is in processing-structure-property relations in metallic and composite materials. His research interests and skills include materials processing (solidification processing, severe plastic deformation, physical vapor deposition), nanomechanical behavior of materials, defects and interfaces in materials, and transmission electron microscopy. Misra has co-authored over 275 peer-reviewed publications, and mentored more than 30 early-career scientists and engineers, both postdocs and graduate students.

Notable awards/honors include:

- Fellow of the American Society of Metals (ASM) International
- Fellow of Los Alamos National Laboratory
- Distinguished Scientist/Engineer Award, TMS — Materials Processing and Manufacturing Division
- Distinguished Postdoctoral Mentor Award, LANL
- LANL Fellows' Prize for outstanding research in nanomechanics.

Research NSF Career Awards

Anish Tuteja receives NSF CAREER Award



Assistant Professor Anish Tuteja has been awarded the Early Faculty Career Development (CAREER) Award from the National Science Foundation for the large-scale, facile, and cost-effective manufacturing of a range of different monodisperse, multi-phasic, organic, and micro- and nanoparticles possessing virtually any size, shape, and chemistry using a novel and facile technique termed WETS (Wettability Engendered Templated Self-assembly). This project plans to use the WETS technique to fabricate a wide variety of such nanoparticles of complex shapes and sizes as small as 20 nm.

A goal is to produce nanoparticles that are below 50 nm to benefit from the unique properties available at that scale. Other objectives include: fabrication of a prototype system for automated, rapid, large-scale manufacturing, studying the self-assembly of the synthesized multiphasic particles under a variety of environmental conditions, understanding the effects of nanoparticle addition on the rheological and thermal properties of different polymer melts, and testing the suitability of the novel biodegradable multiphasic nanoparticles for targeting and killing ovarian and breast cancer cells.
If successful, this work will allow for the manufacturing of a range of different multi-phasic organic nanoparticles on a very large scale that will impact a wide range of fields including, polymer nanocomposites, semiconductor technology, drug delivery, biotechnology, energy, chemical, and biological detection.

Emmanuelle Marquis receives NSF CAREER award

Associate Professor Emmanuelle Marquis has been awarded the Early Faculty Career Development (CAREER) Award from the National Science Foundation for the investigation of the effects of alloying elements on the oxidation response of model Ni alloys.
The approach is to unravel and quantify the mechanisms that controls materials properties at the atomic scale and to incorporate this information into alloy design rules. The use of high spatial and chemical resolution characterization techniques in combination with theoretical modeling will provide quantitative information needed to answer long-standing open questions on the role of alloying.
This new understanding is critically important for validation of computational models and use in design of oxidation-resistant materials in a more efficient manner based on new alloy design approaches envisioned in the Materials Genome Initiative.
Environmental degradation is ubiquitous. This CAREER award will allow Marquis to develop an integrated educational and research plan expanding methods, concepts, and training to a larger range of materials where oxidation and corrosion issues are significant, while adding a cultural component to the project. Marquis and her group in collaboration with the New York Metropolitan Museum recently identified corrosion mechanisms responsible for loss of image detail and resolution in historical photographs (work to appear in Corrosion Science).

University of Michigan Wins Grant to Establish Lightweight Metals Manufacturing Institute

The University of Michigan has partnered with Ohio State University and EWI to win a $148M grant to establish a new nonprofit research organization called ALMMII (American Lightweight Materials Manufacturing Innovation Institute). ALMMII is one of four advanced manufacturing institutes that have been sponsored by the federal government. MSE will help lead the institute, with Professor Alan Taub as Chief Technology Officer and John Allison as the ICME Crosscut Technology leader. Other MSE faculty with be involved in project execution, including new faculty recruited in metals processing with a search in progess.

The institute is designed to establish an ecosystem to support the production of advanced lightweight metal components in a part of the country often considered the historic seat of American manufacturing. In addition to Michigan, four other midwestern states are part of the regional focus for ALMMII (Ohio, Tennessee, Indiana, and Kentucky). More than half of the 400,000 metalworking jobs in the US are located in these states, all of which which have committed resources for the institute.

More than 80 companies, universities, and nonprofits from around the country are also involved in this new public-private partnership. ALMMII headquarters, located in Corktown in downtown Detroit, has office and training facilities and over 80,000 square feet of hi-bay for the installation of pilot scale metals processing equipment. Ribbon-cutting took place in January 2015.

The institute will be the newest node in the National Network of Manufacturing Innovation, a White House initiative to help US manufacturers become more competitive. U-M faculty played pivotal roles in helping conceive and shape this network, including Sridhar Kota, Herrick Professor of Engineering, who held an appointment as assistant director for advanced manufacturing at the White House from 2009–12. President Emerita Mary Sue Coleman and engineering professor Jack Hu—now U-M's interim vice president for research—served on a working group of the Advanced Manufacturing Partnership. ALMMII is funded through the Lightweight and Modern Metals Manufacturing Innovation program.

It was selected through a competitive process led by the US Department of Defense, and will receive $70 million in federal funding over five years, matched by another $78 million from the consortium partners themselves. The funding includes $10 million from the Michigan Economic Development Corp.

The institute will conduct research and development projects as well as education and training programs to prepare the workforce needed for 21st-century metals manufacturing jobs. "Through this initiative, our region will build on its core strengths to become the nation's technology hub for lightweight materials and manufacturing," said U-M President Emerita Mary Sue Coleman. "Companies from around the country will come here not only because of our technological capabilities, but also because we have the workforce they need in their efforts to revitalize and transform domestic manufacturing."

ALMMII is charged with moving cutting-edge lightweight metals out of the research lab and into tomorrow's cars, trucks, airplanes, and ships for both the commercial and military sectors. Lighter vehicles have better performance and use less fuel. They can carry larger loads and travel the same distances at lower cost and with fewer carbon emissions.

The institute's efforts will encompass the entire transportation supply chain, nurturing innovations from conception through design, development, and production. It will contract more than $100 million in R&D projects with partner organizations. And by establishing science, technology, and engineering curricula for programs from grade school to graduate school, the institute will help educate the next generation of manufacturing operators and engineers.

"A vision of the institute is to prepare an eager workforce and equip them with 21st-century advanced manufacturing skills," said Lawrence Brown, executive director of ALMMII. "Through the integration of the region's workforce, education, and economic development assets, the institute will enable the availability of job-ready employees and maximize the transition of emerging technologies to small, medium, and large firms in the region and across the nation."

Many of the materials for weight reduction already exist, such as high-strength steels, aluminum, magnesium, and titanium, said Alan Taub, U-M professor of materials science and engineering and chief technology officer of the new institute. "The challenge is in optimizing component designs and developing the advanced processes to manufacture them robustly on a large scale at affordable cost," Taub said. "And each material needs its own tailored process."

Alan Taub, University of Michigan Professor and LIFT/ALMMII Chief Technical Officer with Larry Brown, LIFT/ALMMII Executive Director at the ribbon cutting ceremony on January 15, 2015.

LIFT/ALMMII headquarters located in Detroit, Michigan.

New Capabilities in EMAL

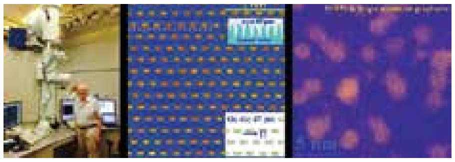
by Kai Sun

The Transmission Electron Microscope (TEM) that was featured in both the 2010 and 2011 MSE newsletters has finally been installed in the new EMAL lab at the North Campus Research Complex (NCRC) (see image (a)).It was put into general service in early July 2014. Previously known as the JEM-300NXT or JEM-CREST, the microscope was officially named JEOL JEM-3100R05.

The microscope has a Cold Field Emission Gun (C-FEG) which can be operated in Scanning Transmission Electron Microscopy (STEM) mode or Conventional Transmission Electron Microscopy (CTEM) mode at 300 keV, 200keV, or 80keV. . It is equipped with a condenser lens spherical aberration (Cs) corrector and an objective lens Cs corrector (Double-Cs-corrected), which are based on a new generation of Cs-corrected electron optics developed by the Japan Science and Technology Agency's team-based Core Research of Evolutional Science and Technology (CREST) project.

Spatial resolutions better than 50pm are achievable for both CTEM and STEM imaging. A spatial resolution better than 47 pm for STEM imaging has been demonstrated, as evidenced by the image in (b) during its final testing. Using such a TEM, single Pt atoms (orange color) on a multi-layered graphene support (blue color) can be easily "seen" as shown in (c). This can help to understand single atom catalysis mechanism for catalyst materials. This microscope can also be routinely used for Selected Area Electron Diffraction (SAED), Nanobeam Electron Diffraction (NBED), and Convergent Beam Electron Diffraction (CBED) for the study of materials crystal structures. Besides diffraction, it has a Gatan new generation image filter system (Gatan GIF 965) that can be used for both Energy-Filtered Transmission Electron Microscopy (EFTEM) and Electron Energy Loss Spectroscopy (EELS). Energy resolution of 0.28 eV for EELS has been achieved that can be used for measuring materials band-gaps. X-ray Energy Dispersive Spectroscopy (XEDS) is achieved using a JEOL Silicon Drift Detector (SDD) (active area = 60 mm2 capable of detecting elements with Z >5) system, All these techniques make the TEM a truly Analytical Electron Microscope (AEM).

The new AEM instrument has now provided EMAL with powerful cutting-edge capabilities, thereby furthering our understanding of the fundamental science of materials and devices at the atomic level. Researchers have been using this instrument to analyze the atomic structure, composition, and chemical bonding characteristics of individual defects, surfaces, interfaces, and nanostructures. Using a tomography TEM holder, some 3-D microstructures of nanostructured materials have been obtained. More detailed information of the new AEM can be found by visiting the EMAL website atemal.engin.umich.edu



(a) Emeritus Professor—and first EMAL director—Wilbur Bigelow pictured with the AEM

(b) A colored High Angle Annular Dark Field (HAADF) image taken using the AEM in STEM mode from a single crystal Ge sample along its [411] direction showing directly the separation of two Ge columns with a distance of 47pm (as indicated from the outlined profile). The inset in the bottom corner is projected 2D crystal structure of Ge along its [411] direction

(c) A color mixed image from a HAADF (orange) image and a STEM bright-field (BF, blue) image taken from a multi-layered graphene (blue color) supported Pt nanoparticles (orange color) from which single Pt atoms can be easily "seen"

Research Highlights

Ceramic electrolytes for all-solid-state batteries

Although lithium ion batteries have been around for several decades and many improvements on the active materials have been achieved since the first commercialization by SONY in 1991, not much has changed in terms of electrolytes, which are the origin of potential fire hazards.

Electrolytes used nowadays are lithium salts dissolved in organic carbonate solutions. The liquid itself is flammable, and under certain circumstances, it can decompose or react with active materials resulting in internal pressure build up and thermal runaway, hence explosion.

So far, it has been quite difficult to replace this component as it had to meet requirements such as 1) high lithium ionic conductivity, 2) ease of processing, and 3) low production costs. Hence, much attention has been given to installing safety mechanisms to the battery pack instead.

With the application of lithium ion batteries expanding to powering vehicles and storing harnessed renewable energy, the battery volume is expected to increase dramatically compared to those in portable electronics. As such, during the battery operation safety is becoming more crucial.

Oxide materials gained attention as candidates as substituents for liquid electrolytes as certain structures showed potential to reach high ionic conductivities. Furthermore, they are known for high thermal stability. NASICON (sodium superionic conductor)-type structures have long been investigated by doping super- or sub-valent metal ions in order to improve lithium ionic conductivities to rival liquid electrolytes. $LiTi_2(PO_4)_3$-based materials, in particular, have shown promise and are now commercially available from OHARA. However, current commercial products are produced by glass-ceramic processing which involves two high-temperature processing steps resulting in high costs, moreover film thicknesses cannot be reduced below 50 μm for high energy density battery packs. Finally a 2.5x2.5 cm by 150 μm thick membrane costs $250 making them prohibitively expensive.

To lower costs as well as to reduce membrane thicknesses, we have sought to produce lithium conducting $LiTi_2(PO_4)_3$ nanoparticles by flame spray pyrolysis (FSP) and cast nanoparticle suspensions by bar coating. FSP is widely used in both industry and academia for its versatility in producing single- or mixed-metal oxide nanoparticles. Advantages of FSP method include easy control of average particle size, uniform particle size distribution, high throughput, high purity, and so on. Commercially fumed silica, titania, and carbon black are produced in million tons/year quantities.

To date, Professor Laine and group have successfully produced lithium-conducting oxide thin films with thicknesses of 14 µm with ionic conductivities similar to liquid electrolytes. Since the conduction of lithium is a diffusional process through vacancy sites in the crystal structure, the ionic conductivities increase with temperature. While the temperatures of commercial lithium ion batteries are limited to < 80 °C by cooling systems, such would not be necessary for all-solid-state batteries, with performance only increasing with temperature.

The significance of our work lies in that we have produced thin films of lithium ion conductors using easily scalable and inexpensive FSP methods and bar coating which may be the answer to lowering the cost of solid electrolytes. Actual batteries have yet to be produced by placing active materials along with current collectors on each side of the membrane.

For further information please see: E. Yi, W. Wang, S. Mohanty, J. Kieffer, R. Tamaki, R. M. Laine, "Materials that can replace liquid electrolytes in Li batteries: Superionic conductivities in $Li_{1.7}Al_{0.3}Ti_{1.7}Si_{0.4}P_{2.6}O_{12}$. Processing combustion synthesized nanopowders to free standing thin films," *Journal of Power Sources,* 2014, 269, 577–588.

Metal-free, organic phosphorescent light emitters

Associate professor Jinsang Kim and his group have taken a major stride toward efficient lighting that is also relatively inexpensive to make.

Organic light-emitting diodes (OLEDs) are an important technology for flat-panel displays and general

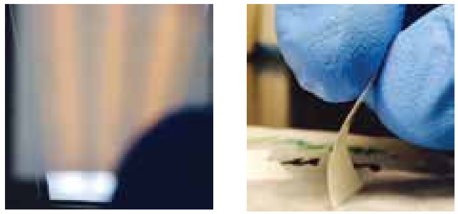


Figure 1. Translucent and gently bendable thin films of lithium ion conducting ceramic electrolytes.

lighting applications. In particular, phosphorescence OLEDs can have 100% internal quantum efficiency (IQE) since it utilizes both singlet and triplet excitons, leading to consuming significantly less power than its fluorescent OLED counterparts. Organometallic complexes such as iridium complexes are commonly used for phosphorescence emitters because the strong spin-orbit coupling due to the heavy metal atoms leads to efficient singlet-triplet state mixing, thus enabling to highly efficient room temperature phosphorescence (RTP). However, considering the high costs, unclear toxicities, and limited stability of high energy blue organometallic emitters, it is highly desirable to devise more abundant emitter materials.

Metal-free organic emitters have a great potential to overcome the fundamental instability of blue emitting organometallic phosphors. However, developing purely organic phosphorescence emitters is still challenging since the rate for the phosphorescence transition is usually very small without heavy metal atoms so that the most triplet excitons are consumed through radiationless processes such as vibrational dissipation at ambient temperature.

To address this challenge, the group sought to provide rigidity into the polymer matrix to suppress the vibrational dissipation pathway. They tweaked the design of the phosphorescence emitters so that they would form structural bonds with a transparent rigid polymer (polyvinyl alcohol, PVA). The team heated and dried a solution containing the newly devised light emitters (G1) and polymers (PVA), and the molecules self-assembled into a stiff thin film. This design allowed 24 percent of the injected photons to produce light. While this number is only about as good as fluorescent light, the team is working on a complementary way to further improve the efficiency. "We demonstrated that increasing the intermolecular bonding strength could efficiently suppress the vibrational loss of the phosphorescent light from purely organic phosphors," said Kim. "This finding provides an insight into molecular designs for achieving energy-efficient and inexpensive alternative light-emitters, ideal for practical devices."

This phosphorescent thin film can also have interesting sensory property. By dissolving the connections between the polymers and the embedded phosphors, water significantly lower the rigidity and weaken the bonding. Those bonds cause the light emitter to give off mostly phosphorescent light, which is green for this material, but when the bonds break, it switches to the fluorescent mode, emitting blue light.

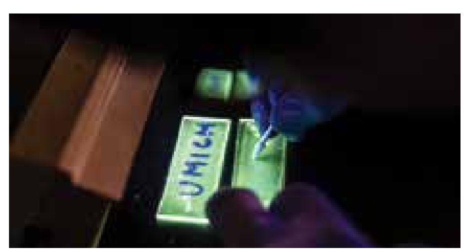
"We can see the change from phosphorescence to fluorescence, and we know some water is there," said Minsang Kwon, an MSE postdoc in Kim's lab.

This could lead to simple sensors for detecting water. As an example, Kim—along with Kwon, the first author of the paper reporting the development—said that dentists need a way to check that a cavity is totally dry before filling it to ensure a secure bond and minimize inflammation. A probe made with this material would change from green to blue on exposure to a small amount of water.

A paper on this work, "Tailoring Intermolecular Interactions for Efficient Room Temperature Phosphorescence (RTP) from Purely Organic Materials in Amorphous Polymer Matrices," was published in *Angewandte Chemie,* 2014, 53, 11177.

Nanowires for Greener LEDs

Nanostructures half the breadth of a DNA strand could improve the efficiency of light emitting diodes (LEDs) right where they need it, U-M engineers have shown. At present, efficiency plunges for green light, but semiconductor nanowires could change that.



The purely organic phosphorescent thin film can reveal the presence of water under UV light. Water breaks hydrogen bonding between polymer matrix and embedded phosphors, changing from phosphorescent light (green) to fluorescent light (blue). Image credit: Joseph Xu

"Our work suggests that indium nitride at the few-nanometer size range offers a promising approach to engineering efficient, visible light emission," said Emmanouil Kioupakis, assistant professor of materials science and engineering.

LEDs are semiconductor devices that emit light when an electrical current is applied. At low power, nitride-based LEDs (most commonly used in white lighting) are very efficient, converting most of their energy into light. But turn the power up to levels that could light up a room and efficiency plummets, meaning a smaller fraction of electricity gets converted to light. This effect is especially pronounced in green LEDs.

Better green LEDs could make direct red-green-blue color mixing practical in ambient lights. This would allow engineers to fine-tune the light to pleasing hues, or develop a way to control the warmth or coolness of the light according to the task or time of day. Instead, most white lighting today comes from blue LED light passed through a phosphor, a solution similar to fluorescent lighting and not a lot more efficient.

While the semiconductor indium nitride usually emits infrared light, Kioupakis and his PhD student Dylan Bayerl found that size matters. Using a supercomputer at the National Energy Research Scientific Computing Center, they simulated how the semiconductor would behave if grown in wires just one nanometer (0.000001 millimeters) across. They found that wires could glow green much more efficiently than current LEDs.

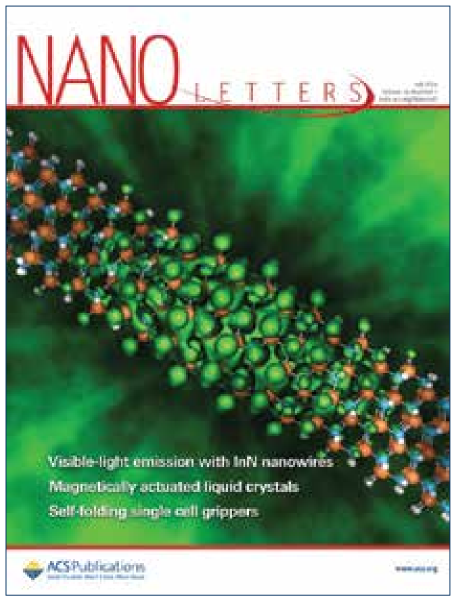
The shift from infrared to green light emission occurs because the thinness of the wires creates a different landscape for the electrons. Light emission starts with an electron taking some electrical energy and jumping up to a higher energy state. When the electron jumps back to its original state, the energy is released as light.

In the narrow confines of the wires, it takes more energy for the electron to jump from one state to another, which in turn means more energy goes into the emitted light. The extra energy moves the light from the infrared spectrum to visible colors.

"If we can get green light by squeezing the electrons in this wire down to a nanometer, then we can get other colors by tailoring the width of the wire," said Kioupakis. A wider wire should yield yellow, orange, or red—a narrower wire, indigo or violet.

The researchers believe that pure indium nitride nanowires improve efficiency in three ways. Semiconductor alloys in typical microchip LEDs contain variations in composition, and this takes a toll on efficiency. So does the mismatch in atom spacing between layers of different materials. Since the nanowires are all one material, they don't have either of these problems.

Finally, the reduction in space may help more electrons succeed in emitting light. When the electron jumps from one level to another, it leaves behind a positively charged "hole." If that hole is physically closer to the electron due to the tiny dimensions of the nanowire, it's more likely that the electron will be pulled back to the hole and emit light rather than releasing the energy as heat.



"Bringing the electrons and holes closer together in the nanostructure increases their mutual attraction and increases the probability that they will recombine and emit light." Kioupakis said. Other improvements over microchip LEDs include thinness, better flexibility, and higher resolution.

While this result points the way toward a promising avenue of exploration, the researchers emphasize that such small nanowires are difficult to make. However, they suspect their findings can be generalized to other types of nanostructures, such as embedded indium nitride nanocrystals, which have already been successfully produced in the few-nanometers range.

Their results, published online in February 2014 as "Visible-Wavelength Polarized Light Emission with Small-Diameter InN Nanowires," were featured on the cover of the July 2014 issue of *Nano Letters.*

The simulations ran at the US Department of Energy's National Energy Research Scientific Computing Center (NERSC), located at Lawrence Berkeley National Laboratory. Burlen Loring of NERSC's Analytics Group created visualizations for the study, including the journal's cover image. The researchers also used the open-source BerkeleyGW code, developed by NERSC's Jack Deslippe.

This work was supported as part of the Center for Solar and Thermal Energy Conversion, an Energy Frontier Research Center funded by the US Department of Energy Office of Science.

Making novel particles for drug delivery

Sai Pradeep Reddy Kobaku and Anish Tuteja

Polymeric nanoparticles offer many advantages as drug carriers over free-drugs, including encapsulation, targeting efficiency, and sustained release of drugs to a diseased site. This is of particular advantage in case of chemotherapeutics, where off-target toxicity is a big problem. The drug-delivery efficiency of the nanoparticles is governed by the composition, size, shape, and modulus of the particles.

In addition, combination therapy, which uses more than one medication to treat a disease, requires encapsulation and release of multiple drugs, ideally with independently controlled release kinetics. To address this challenge, nanoparticle drug-carriers should have multiple compartments, each being made of distinct polymer phases encapsulating different drugs. However, there hasn't been an easy way to fabricate monodisperse multi-phasic nanoparticles at large scale while precisely controlling geometry and dimensions of the particles.

In our recent work, we have developed one of the simplest methodologies to fabricate multiphasic particles using surfaces with patterned wettability as a template. The developed technique, termed 'Wettability Engendered Templated Self-assembly' (WETS) provides us with an unprecedented ability to manufacture, on a large-scale, monodisperse, multi-phasic particles (homogeneous particles, Janus particles, tri-phasic particles, and quad-phasic particles) of virtually any compositions with precise control over size and shape of the particles (Figure 1).

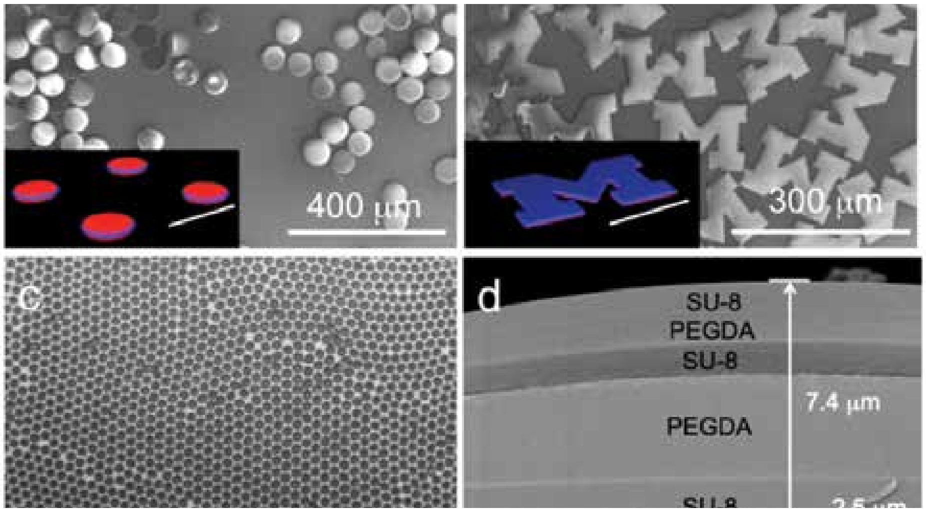


Figure 1. Multi-phasic particles fabricated using the WETS technique. (a) SEM image of 50 mm tri-phasic particles comprising SU-8 (dyed red) and PEGDA (dyed blue) polymers (b) and (c) SEM images of M shaped and 1.5 mm circular shaped bi-phasic particles comprising SU-8 and PEGDA (d) A cross-sectional SEM image for a penta-phasic particle composed of alternating layers of SU-8 and PEGDA, on top of the PSS sacrificial layer. The bottom insets in a and b show corresponding 3-D stacked fluorescence confocal microscopy images of the particles before release from the template. SU-8 is dyed red and PEGDA is dyed blue. Scale bars for the insets represent 100 µm.

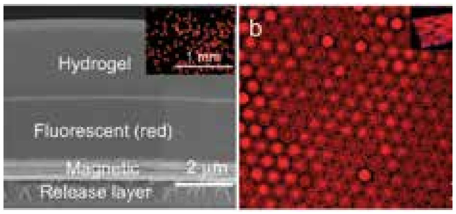


Figure 2. Multi-functional particles fabricated using the WETS technique. (a) A cross-sectional SEM image of a tri-functional particle comprising magnetic, fluorescent and hydrogel phases. Top inset shows a fluorescent microscope image of the tri-functional particles, released from the WETS template. (b) Two-dimensional self-assembly of bi-phasic amphiphilic particles at an oil (top)-water (bottom) interface. The top insets show corresponding 3D stacked fluorescence confocal microscopy image of the assembly. Scale bar in the inset represent 50 mm.

The fabricated monodisperse particles have different shapes and dimensions ranging from 25 nm–200 µm. To the best of our knowledge, the WETS technique is the only methodology that allows for the fabrication of monodisperse, multi-phasic particles of essentially any composition, and dimensions as small as 25 nm. Monodisperse particles within the size range of 10–100 nm, when used as drug carriers, exhibit high circulation time in blood and provide high tumor accumulation through EPR (Enhanced Permeation and Retention) effect.

The WETS methodology involves fabrication of a non-wettable surface patterned with monodisperse, wettable domains of different sizes and shapes. When such patterned templates are dip-coated (or spin-coated/spray-coated) with polymer solutions or particle dispersions, the liquids, and consequently the polymer or the particles, preferentially self-assemble within the wettable domains. Utilizing this phenomenon, we fabricate multi-phasic assemblies with precisely controlled geometry and composition through multiple, layered, depositions of polymers and/or particles within the patterned domains. Upon releasing these multi-phasic assemblies from the template using a sacrificial layer, we obtain multi-phasic particles.

The templates can then be readily reused for fabricating a new batch of particles, enabling a rapid, dip-coating based, inexpensive, and easily reproducible method for large-scale manufacturing of multi-phasic particles.

One of the most important features of the WETS technique is its ability to make multi-phasic particles from a wide choice of polymers. This ability stems from the universality of the patterned templates to assemble almost any polymer solution within the patterned wettable domains.

Nanoparticles are now increasingly being developed for theranostic applications where therapeutic and diagnostic agents are simultaneously encapsulated in a single nanoparticle. Given the significant differences in the physicochemical properties of these agents, their simultaneous encapsulation in a single nanoparticle is very difficult. However, this can be easily accomplished through loading the drugs and agents into separate compartments of multi-phasic particles. For example, Figures 2 shows a tri-functional WETS particle will three different phases: Hydrogel phase (drug carrier); Fluorescent phase (diagnosis); and Magnetic phase to aid in transportation of the particles in a biological environment. These WETS particles have tremendous potential in developing next-generation drug delivery systems.

This work, entitled "Wettability Engendered Templated Self-assembly (WETS) for fabricating multi-phasic particles," has been accepted for a publication in ACS Applied Materials and Interfaces. The university is pursuing patent protection for the intellectual property, and is seeking commercialization partners to help bring the technology to market.

Education

Doing Away with Lectures, Exams, Graded Homework

Laurel Thomas Gnagey, Michigan News
(A version of this article originally appeared in the *University Record,* and is reprinted with permission.)

The students sit at small tables of four to five, separated by whiteboards, waiting for questions to come up on their electronic devices, which are tapped into a program that knows which student is sitting in what seat.

The graduate student instructor decides to wait another minute for stragglers to the class on this Thursday in the Chrysler Center on North Campus.

This is not an exam. (The course promises there will be none of those. Professor Steven Yalisove's syllabus says right up front: "No lectures, no exams, and no graded homework—but you will learn much more…") Instead, this is a weekly test to check how well students understand the material in required reading.

"The individual round has started. You have 30 minutes. Good luck," GSI Kevin Golovin says over a microphone from the back of the class. Or is it the front? The somewhat unconventional layout of the room, designed to foster collaboration, makes the answer to this question unclear and irrelevant.

Yalisove the GSIs monitor the students' progress on the questions from their own computing devices, using a program called Learning Catalytics.

On one question the program reveals 51 responses with 63 percent correct. On another, out of 26 answers thus far only 19 percent are getting it right.

"They're struggling with this one," Yalisove said of the second. But the numbers don't concern him. Not only is this individual round just the beginning of the exercise—after the half-hour is up they will work on the same questions in small groups—but he expects they will struggle.

"They have to fail before they learn. They have to get frustrated," he said. "My job's not to make it easy for companies down the road to choose the best students. My job is to teach the students."

Feedback so far has been that students not only learn but they retain the material. This is exactly what Yalisove had in mind.

"I really like it," says Joe Wendorf, who earlier in the class had found a flaw in one of the test questions and received a "good catch" from the GSI. "I can teach my classmates things I already know, and they're going to teach me things I don't know," Wendorf said. "I definitely retain more information. It's more work on a day-to-day basis but as compensation I don't have to spent a lot of time studying for exams."

FA typical class in MATSCIE 220 this past fall term..

Lauren Kennedy agreed the different approach to learning engages her in new ways, but is not without its challenges.

"I am a big advocate for alternative learning styles," Kennedy said. "The projects in this class definitely engage you with the material. But 32 pages is a lot of reading, and sometimes it's difficult to know which parts I should be focused on."

She personally would like a few lectures, but said she and her classmates have the opportunity to ask for one anytime the material gets complicated.

In fact, that too is spelled out in the syllabus. When students want the professor to stop and "lecture" or explain a concept, they merely have to ask. Yalisove said this happens from time to time. If he senses they don't understand he'll stop and offer some explanation, although he said students might not recognize it as a lecture because he tries to make it more of an exploration of the material.

Yalisove, who received funding from the Third Century Initiative to develop the course, is working with five other faculty members in biomedical, environmental, and electrical engineering, to help them develop similar action-based collaborative approaches to teaching.

Golovin signals that little time is left in the group session and the volume in the room goes up.
"I know, I know. It's lower the viscosity and lower the melting point. Lower, lower," one student blurts.
"Can somebody just write their equation on the board," another student implores, as her team works to solve a complex problem.

At the end of the group round, the students will get a grade that factors in their individual and team responses.And that part about no graded homework? It doesn't mean there is no homework.

Students are expected to do the course readings and homework assignments, then share the latter with their peers. After class, students take their original homework and write a written reflection on what they learned, complete with an evaluation of their peers, and turn it in for credit. They also are required to electronically enter a comment or question on the reading assignment prior to the class in which it will be discussed.

Students also work in teams on three problem-based learning projects that take the form of a presentation, poster, and video.

Last year's class created posters to demonstrate their analysis of potential materials for Captain America's shield, Batman's cape, and Spiderman's web.
They considered all aspects: physical and material properties, product design, aesthetics, production, cost of materials—all while keeping in mind the potential failures of the materials, given the abuse they will take at the hands of these superheroes.

Devon Stanke is taking the class as an elective, and said because materials science is not her area of interest she sometimes feels in over her head. But she appreciates the style of teaching nonetheless.

"I would definitely zone out if it was all lecture," she said.
"With lectures I might have more definition knowledge," Kennedy said. "But I think this method is to have me wrestle with the material more." Exactly the point, Yalisove says.

"Most students focus on getting a good grade, not on learning the material," he said. "We want to change that. The whole idea is we want them to focus on learning the material and not the grade. Our real purpose here is to teach people things they'll remember five years from now. We really want to make them learn for the joy of learning."

Undergraduate Program Update

In the last few years, MSE faculty have fostered interest in our program by holding open houses and producing videos (see, for example, Prof. Steven Yalisove's videos at mse.engin.umich.edu/about/videos). To reach out to the broader student community, Prof. Emmanouil Kioupakis began teaching "Materials Innovation for a Sustainable Energy Future" this year. The course provides an introduction to materials science and engineering in the context of technological innovations in energy and sustainability.

As a result of our efforts, we have seen healthy growth in undergraduate enrollment; as of January 2015, our undergrad program now has 183 active declared students. But that success comes with challenges, and discussions of such topics as how to provide each student with hands-on lab experience are part of Undergraduate Committee meetings and a concern of the faculty at large.

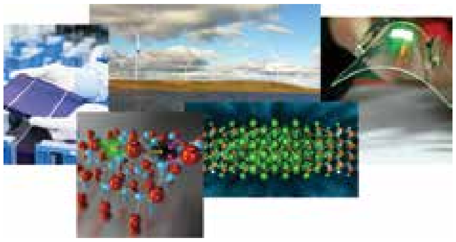
Enhancement of the Van Vlack Undergraduate Laboratory (VVUL) is an example of our initiative to maintain excellent undergraduate education. This year, we acquired an X-ray fluorescence spectrometer to enable chemical analysis. This is a significant investment that complements the Rigaku MiniFlex 600 that was acquired last year. This semester, our undergraduate students are analyzing unknown mixtures of inorganic compounds such as PbTe, PbSe, Bi2Te3, and Bi2Se3, and identifying compositions and phase fractions. The new laboratory module gives students experience with spectroscopy, in addition to the diffraction analysis already in place, and reinforces the concepts of phase equilibrium.

The computational facility at VVUL is an enabling factor in the expansion of computation in our curriculum. Computational approaches have now been incorporated into both semesters of the laboratory course sequence and in several required courses. In other courses, students also have opportunities to build a project based on computational tools. The senior level class on computational approaches has recently been chosen as one of the special topics courses within the MSE curriculum that students can take to fulfill their degree requirements. We hope to update the computational equipment in the coming year in order to meet the increased interest in computational materials science and engineering here at U-M and beyond.

New Course: MATSCIE 193 Materials Innovation for a Sustainable Energy Future

This new course offering by Assistant Professor Emmanouil ("Manos") Kioupakis is an introduction to the materials science and engineering behind technological innovations in energy and sustainability. It covers the science and engineering of materials for conventional and renewable energy production, efficiency, and storage. Prerequisites are a high-school knowledge of mathematics, physics, and chemistry.

The course was developed for non-MSE majors to explore the answers to questions such as: How is energy produced and used today? How has our consumption of energy altered the global environment? What are future challenges and opportunities in energy production, storage, and use?



Graduate Committee Report

The Graduate Committee continues to work on providing a top-quality graduate education program and working with our graduate students to build outstanding career development.

In Fall 2014, 19 PhD students and eight master's students joined our graduate program, chosen from among more than 400 applicants from top universities. Ten of the new PhD students are women. Seven PhD students were awarded the Rackham Merit Fellowship, and and two of the master's students received the College of Engineering (CoE) Masters Fellowship. The department provides fellowships, which cover costs for the first term, to all admitted PhD students; in later terms, a combination of fellowships, research assistantships, and instructorships will be provided.

Our graduate students have demonstrated continued excellence in research development and leadership roles. Many have received prestigious fellowships and awards, including the National Defense Science and Engineering Graduate Fellowship, Rickover Fellowship, Bob and Betty Beyster Fellowship, Rackham Predoctoral Fellowship, CoE Distinguished Academic Achievement Award, and CoE Distinguished Leadership Award.

The Graduate Committee worked with the Graduate Student Council to launch new information sessions to help our grad students prepare competitive fellowship application packages, and to foster their interest in academic careers. We also restructured the MSE graduate-student colloquium to include a lunch with the invited colloquium speaker, encouraging more interactive discussions on research and career development in an informal setting.

The Graduate Committee will continue recruiting top students, focusing on enhancing diversity, and helping our students to develop outstanding career plans in coming years.

Michigan STEM Academies Scholars Program

The University of Michigan has long been concerned with equity and access—and with increasing retention in STEM (science, technology, engineering, mathematics) disciplines. MSE's very own Joanna Millunchick has an important role in these endeavors as the academic director of M-STEM Academies in Engineering.

The mission of M-STEM is to strengthen and diversify the cohort of students who receive their baccalaureate degrees in STEM fields, with the ultimate goals of increasing the number of STEM students and enhancing the diversity of the STEM student body. This program has been available to students in the College of Engineering for the last seven years, and has recently expanded to biology, physics, chemistry, and math.

M-STEM Academies provide an integrated, holistic co-curricular support system for students from a wide diversity of backgrounds who have a strong ability and potential in science. M-STEM supports students in their transition from high school to U-M during the first two years on campus. They participate in a residential summer program with the dual goals of preparing students for the new expectations and requirements of rigorous college science courses, and establishing the social and academic support networks essential for students' future success.

During the first two years, academic coaches closely monitor the progress of M-STEM Scholars and help with academic planning, success strategies, and personal challenges. Scholars participate in carefully designed co-curricular activities to enrich their academic pursuits, and meet weekly in peer-led study groups associated with their science courses. Scholars also engage in a paid research or internship experience during the summer between their first and second years. M-STEM's approach is to use existing university programs and resources to provide many of these experiences and then knit them into an integrated program that builds a strong community of scholars whose members are committed to helping each other succeed.

Assessment of the initial cohorts of M-STEM Scholars indicates that students are performing academically at a higher level than would have been expected if not for their participation in the M-STEM program. For example, 2010 M-STEM Scholars in Engineering had significantly higher mean GPAs after their first semester than the general student population in the College of Engineering (MSTEM: 3.36, COE: 3.13, $p<0.02$). Even more encouraging is that the underrepresented minority students who participated in M-STEM performed better than those who did not participate in the program (MSTEM: 3.25, COE: 3.00, $p<0.03$). Other cohorts exhibited similar trends.

Millunchick's leadership in this program was recently recognized by the College of Engineering, which awarded her the 2014–2015 Raymond J. and Monica E. Schultz Outreach & Diversity Award.

NSF Funds Summer School for Integrated Computational Materials Education

Associate professor Katsuyo Thornton and assistant research scientist Larry Aagesen, along with UC-Berkeley professor Mark Asta, were awarded renewal funding for the Summer School for Integrated Computational Materials Education, which they founded in 2011. Aiming to "educate the educator" in order to enable rapid implementation of computational tools into the undergraduate materials science and engineering curriculum, this program equips participants with the knowledge, skills, and materials needed to incorporate computational materials science and engineering (CMSE) into existing undergraduate materials science core classes.

In addition to training participants to teach CMSE, the Summer School provides an overview of the field, fundamental theory, and advanced topics in CMSE. The Summer School was offered in 2011 and 2012 in Ann Arbor, and in 2014 at UC-Santa Barbara, and was attended by faculty, postgraduate researchers, and graduate students from MSE departments and programs throughout the US and around the world. Future offerings include 2015 and 2017 events in Ann Arbor, as well as a 2016 event at Berkeley. Please email icmed2015@umich.edu for more information.

A photo from the 2014 Summer School for Integrated Computational Materials Education. The 2015 event will be held from June 15 to June 26 in Ann Arbor. See http://icmed.engin.umich.edu for more information.

Diversity Summit

In July 2014, The Minerals, Metals and Materials Society (TMS) organized and hosted the first TMS Summit on Creating and Sustaining Diversity in the Minerals, Metals, and Materials Professions (DMMM1). The workshop brought together leadership from industry, government, and academic institutions with beginning and mid-career professionals in the materials community.

The purpose of the three-day workshop was to provide a forum for the exchange of new ideas and best practices aimed at promoting greater diversity and inclusion in the materials workplace. The workshop, held at the National Academies of Sciences in Washington, DC, attracted 120 participants. A summary of this inaugural effort, which had involvement from a number of societies, can be found on the TMS website at tms.org.

Several of the event organizers have Michigan MSE connections. Carnegie Mellon professor Elizabeth Holm (BSE 1987; PhD 1992), who served as TMS president in 2013, led the effort to make the summit a reality, and chaired the organizing committee. Jonathan Madison (MSE 2007; PhD 2010) also served on the organizing committee; Wayne Jones (MSE faculty) chaired the advisory committee, and Keith Bowman (PhD 1987), chair of the Mechanical, Materials and Aerospace Engineering department at Illinois Institute of Technology, served on the advisory committee.

U-M Bicentennial Celebration Preparations: Campus of the Future

In preparation for the University of Michigan's bicentennial celebration, MSE professor Joanna Millunchick is offering U-M students an unprecedented opportunity: the chance to rethink the university experience to better meet the needs of 21st-century learners.

Under the mentorship of Millunchick, along with Mika Lavaque-Manty from LSA's Political Science department, student teams will conduct projects related to designing instructional technologies and physical spaces that foster student centered-learning and new academic experiences. They will actively build solutions with the goal of achieving genuine transformation of the university experience. Participants will have the opportunity to engage in community-wide discussions and interact with international leaders in the academic transformation movement. Their work has the potential to shape the future of higher education at the University of Michigan and beyond.

Alumni who would like to participate in this exciting endeavor, whether as mentors, expert panelists, or donors, should contact Professor Millunchick at joannamm@umich.edu .

The American Society for Metals (ASM) Teachers Camp celebrates 13th year in Ann Arbor

Peg Jones & Manish Mehta

The Detroit Chapter of ASM and the U-M's Materials Science and Engineering Department hosted the 13th annual Teachers Camp in the Van Vlack labs July 14–18. This year's class of 29 teachers explored the structure and properties of solids, metals, polymers, ceramics, and glass through classroom instruction and extensive lab work. After heat-treating bobby pins and melting tin, we introduced the teachers to industrial scale metallurgy in a "once-in-a-lifetime tour" of Gerdau Steel's continuous caster and rolling mill. Campus lab tours featured:

- a visit with Harald Eberhart, U-M's scientific glass blower,
- mapping the position and valence state of atoms in the 3D atom probe,
- biomaterials research on why breast cancer cells change their behavior when the tumor recurs in bone tissue (does mechanical loading play a role in the cell biology?), and
- an introduction to flexible concrete inspired by the materials architecture of seashells.

In addition to the tireless support of the Van Vlack lab and MSE administrative staff, we also appreciate the hard work of Camp organizers Dr. Kathy Hayrynen and Dr. Peg Jones, and volunteers who helped in the lab and behind the scenes: Manish Mehta, Ron Gibala, Jatinder Singh, Thomas Kozina, and Dika Handayani. (Ask Manish about his heroic rescue mission to get a stranded teacher home when the bus to Toronto never showed up in Ann Arbor.) Although the Camp is free for the teachers, it's costly to run: the ASM Foundation spends about $750 per person for the week, and the 2014 Camp is running a deficit. To help plug that hole, an anonymous ASM member will match Detroit ASM members' 3rd- and 4th-quarter contributions up to a total of $2,000. Call Ginny Shirk at ASM headquarters (800-336-5152 ext. 5538) if you can make a tax-deductible contribution to the "Detroit ASM Challenge for the Ann Arbor Camp."

Here's your Class of 2014, re-energized and ready to go try new ideas in their classrooms this fall.

Financial sponsors of the Teachers Camp include: Detroit ASM and the ASM Materials Education Foundation, AFC Holcroft, Applied Process, Jason Coryell Element Materials Technology (Wixom), Ron Gibala, Gerdau Steel, Peg Jones, Kathy Hayrynen, Kolene, Bob McCune, Michigan Metrology, Bob Powell, Jim Schroth, Andy Sherman, Ginny Shirk, Gary Witt, and the always-generous "Anonymous."

"This was my first introduction to materials science. It was so much fun, and I can apply it even with my special-education students."

In-kind donations were provided by AFC Holcroft, American Colloid, Applied Process, Buehler, Carpenter Brothers, Elkem Metals, FEF, FIERF (Forging Foundation), Grede LLC, Hickman Williams, NACE, the U-M MSE Department, and WGF Global Services.

"I was showing my sons, ages 9 and 12, what we did yesterday and thought it would be a five-minute conversation. Two hours later they were still interested! I can't wait to share this with my 7th graders this fall—including my son, who will be in my class."

Oxidation-Reduction reactions are more fun when you apply them to make raku pots. Submerging the hot pot in a can with shredded newspaper reduces some of the metal oxides in the glaze, creating a unique metallic luster.

Leslie Burleson from Denby High School in Detroit pouring a binary tin alloy used to introduce eutectic phase diagrams. Scott Spohler, an ASM Master Teacher in training, is assisting. Scott teaches a high school materials science course in Ohio.

2014 C-PHOM High School Research Program

The Center for Photonic and Multiscale Nanomaterials (C-PHOM) High School Research Program celebrated its third year last summer. C-PHOM is a National Science Foundation Materials Research Science and Engineering Center, and involves MSE faculty and students in collaboration with others from science and engineering departments at U-M, Purdue, UT-Austin, and the City University of New York. Under the leadership of C-PHOM Education Director and MSE Professor Rachel Goldman, the C-PHOM Education program aims to enhance the recruitment and retention of a diverse student population in science via focused research-related educational activities. Thus, C-PHOM hosts both a High School Research Program and a summer Research Experiences for Undergraduates (REU) program. Both programs provide high school and undergraduate students an opportunity to conduct research with faculty and students in the fields of nanomaterials, nanophotonics, and nanophysics. The C-PHOM High School Research Program is an eight-week residential program for incoming high school seniors, with a focus on students from southeast Michigan. The C-PHOM REU program is a 10-week residential program for junior and senior transfer students. At the end of the summer residential programs, students will present at the U-M Summer Research Symposium, which includes summer research students from the C-PHOM HS and REU programs, the Physics REU program, the Biophysics REU program, and other U-M REU students. We look forward to hosting a new cohort of C-PHOM high school and REU students during the summer of 2015. We are also exploring opportunities to expand our high school research program to include students throughout the state of Michigan and beyond.

For more information and sponsorship opportunities, please contact Rachel S. Goldman, rsgold@umich.edu.

During the summer of 2014, seven incoming high school seniors from southeast Michigan participated in the C-PHOM high school research program.

Spring 2014 Graduation Dinner

Spring 2014 Materials Science and Engineering Undergraduate Graduation Dinner.

Faculty Kudos

Faculty Awards

John Allison
- Fellow, The Minerals, Metals and Materials Society (2014)

Samantha Daly
- Mechanical Engineering Department Achievement Award, University of Michigan, 2014
- 1938E Award, University of Michigan, 2014
- Journal of Strain Analysis Young Investigator Lecturer, 2014
- Best Paper of the Year, International Journal of Solids and Structures, 2014 (for Best Paper published in IJSS in 2013)
- NSF CAREER Award, 2013
- Robert Caddell Memorial Materials & Manufacturing Award (with graduate student Adam Kammers), The University of Michigan, 2013
- M. Hetényi Award, Society of Experimental Mechanics, 2013 (for Best Paper published in Experimental Mechanics in 2011)

Stephen Forrest
- National Academy of Inventors (2014)
- Named top 1% of researchers cited in the fields of both materials science and physics by Thompson Reuters (2014)
- Lady Davis Visiting Professorship, Technion-Israel Institute of Technology (2014)

Sharon Glotzer
- National Academy of Sciences (2014)
- MRS Medal (2014)
- Fellow, American Association for the Advancement of Science (2014)
- Finalist, World Technology Awards (2014)

Rachel Goldman
- Senior Fellow, Sweetland Writing Center, University of Michigan (2014)

Emmanouil Kioupakis
- Jon R. and Beverly S. Holt Award for Excellence in Teaching (2014)

Nicholas Kotov
- Best of What's New Award (Popular Science, 2014)
- MRS Medal (2014)
- Highly Cited Researcher in Materials Science (Thompson Reuters, 2014)
- Highly Cited Researcher in Chemistry (Thompson Reuters, 2014)
- Fellow, Materials Research Society (2014)
- MRL Seminar (California Institute of Technology, 2014)
- IIN Frontiers in Nanotechnology Lecture (Northwestern University, 2014)

Emmanuelle Marquis
- NSF Career Award (2014)

Joanna Millunchick
- Faculty Fellow, College of Engineering (2014–15)

Alan Taub
- RPI MSE Distinguished Lecture (2013)
- Keynote Address TMS Morris Fine Symposium (2013)

Katsuyo Thornton
- TMS Materials Processing & Manufacturing Division Distinguished Service Award (2015)

Michael Thouless
- Vulcans Education Excellence Award, College of Engineering (2013)
- Arthur F. Thurnau Professor, University of Michigan (2014)
- Otto Mønsted Guest Professorship, Danish Technical University (2013–14)

Anish Tuteja
- NSF Career Award (2014)
- Best Science Paper Award (Institute of Civil Engineers, 2014)

Steve Yalisove
- University of Michigan Provost's Teaching Innovation Prize (2014)
- Faculty Fellow, College of Engineering (2014–15)

Professional Service Awards

John Allison
- TMS Materials Genome Initiative Ambassador
- TMS Materials Innovation Committee, Vice Chair
- TMS Nominations Committee
- TMS ICME Committee
- Integrating Materials and Manufacturing Innovation, Editorial Board
- International Journal of Fatigue, Editorial Board
- ASM Gold Award Committee
- ASM Bronze Award (Mid-Career) Committee
- Madrid Institute for Advanced Materials Studies – Scientific Board

Michael Atzmon
- Steering Committee for International Symposium on Mechanically Alloyed, Nanocrystalline, and Amorphous Materials

Samantha Daly
- Board of Directors, Society of Engineering Science (SES)
- Board of Directors, ASM SMST
- Associate Editor, Experimental Mechanics
- Division Chair, Fatigue and Fracture, Society of Experimental Mechanics (SEM)
- DIC Challenge Board, Society of Experimental Mechanics (SEM)

Stephen Forrest
- Associate Editor, Physical Review Applied
- Associate Editor, Advances in Physics X
- Board of Directors, Applied Materials
- Vanderbilt University School of Engineering and Applied Sciences Board of Visitors
- Board of Directors Vice Chair: UMS
- Executive Committee: Michigan Economic Development Corp.
- Executive Committee: Ann Arbor SPARK
- Co-author: National Acadamies Report on on Flexible Electronics
- Co-author: National Acadamies Report on Solid State Lighting

Sharon Glotzer
- Chair-Elect, APS Division of Condensed Matter Physics
- Chair, APS Soft Matter Organizing Committee
- Associate Editor, AIChE Journal,
- NSF Advisory Committee for Cyberinfrastructure
- DOE Advanced Scientific Computing Advisory Committee
- DOE Basic Energy Sciences Grand Challenges Committee

Rachel Goldman
- MRS News Editorial Board (2012–present)
- Associate Editor, Journal of Electronic Materials (2002–present)
- Invited Organizer, Electronic Materials Conference (2010–present)
- Program Committee, International Conference on Molecular-Beam Epitaxy (2014)
- DOE Sun Shot Program Review Panel (2013)
- DOE Center for Functional Nanomaterials at Brookhaven National Laboratory Review Panel (2013)
- NSF Graduate Research Fellowship Review Panel (2014)
- NSF Electronic and Photonic Materials CAREER Panel (2014)

Peter Green
- Editor-in-Chief, MRS Communications
- Dean's Advisory Council, University of Florida, Gainesville
- External Advisory Board, Materials Science and Technology, Sandia National Laboratories
- MIT Corporation Visiting Committee for Materials Science and Engineering

- Advisory Board, Journal of Polymer Science, Polymer Physics
- Advisory Board, ACS Petroleum Research Fund (PRF)
- Vietnam Education Foundation (VEF)-a US Government agency: Scientific review team member
- Chair, Panel on Neutron Research, National Academies

John Halloran

- Editor-in-Chief, Journal of the American Ceramic Society
- Board of Directors of the American Ceramic Society
- Co-founder of DDM Systems, Atlanta GA

Wayne Jones

- WEPAN (Women in Engineering Proactive Network) Board of Directors
- University of New Hampshire ADVANCE Advisory External Advisory Board
- Chair, Advisory Committee for TMS Summit on Creating and Sustaining Diversity in the Minerals, Metals, and Materials Professions (2014)

Jinsang Kim

- UKC 2014 Chemistry Symposia Organizer and Chair, San Francisco (August 2014)
- Editor, Macromolecular Research, Springer (2014–present)
- Advisory Board, Hanwha Advanced Materials

Emmanouil Kioupakis

- Organizer and Chair, "Focus session: Computational studies of thermoelectric materials," Division of Computational Physics, American Physical Society March Meeting 2014, Denver CO (March 2014)

Nicholas Kotov

- Associate Editor of ACS Nano
- Advisory Board of ACS Journal Langmuir
- Advisory Board of RCS Journal Nanoscale
- Advisory Board of Wiley-VCH Journal Advanced Functional Materials
- Advisory Board of ACS Journal Chemistry of Materials
- Advisory Board of Wiley-VCH Journal Particle
- Advisory Board of MRS Journal Materials Letters
- Advisory Board of ACS Journal Nanocomposites
- Founder, Elegus Technologies, Ann Arbor, MI (2013–present)

Richard Laine

- Board of the Polymer Division of the American Chemical Society
- International Advisory Board, Japanese National Project "New Polymeric Materials Based on Element-Blocks" (http://element-block.org/en/)

Peter Ma

- Tissue Engineering and Regenerative Medicine International Society (TERMIS), Council Member
- TERMIS-AM, Meetings Committee Member
- TERMIS-AM, Dental and Craniofacial Group Chair
- International Chinese Musculoskeletal Research Society, Board Member
- International Association for Dental Research, Distinguished Scientist Award Committee Member
- World 3D Printing Technology Industry Alliance Council, Vice Chairman
- Scientific Advisory Committee (SAC) for the TERMIS-AM Annual Meeting (2014)
- Symposium Organizer and Chair: Biomaterials Microenvironment for Stem Cells and Tissue Regeneration. Annual Meeting of the Society for Biomaterials (2014)
- Symposium Organizer and Chair: Stem Cell Microenvironments for Dental and Craniofacial Tissue Regeneration. TERMIS-AM Annual Meeting (2014)
- Editorial board member of seven journals

John Mansfield

- Member of the Executive Committee of the International Federation of Societies for Microscopy 2015–2019
- President of Microscopy Society of America 2015
- Microanalysis Editor of the journal Microscopy and Microanalysis
- Member of Editorial Board of Microscopy and Microanalysis

Joanna Millunchick

- Program Committee, International Conference on Molecular Beam Epitaxy 2014

Amit Misra

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

Ferdinand Poudeu-Poudeu

- National Science Foundation: November 2014 — Panelist for Solid State Chemistry CAREER proposals.
- Associate Editor —Journal of Nanoscience Letters –July 2014–present
- Editorial Board- Magnetochemistry —Open Access Molecular Magnetism and Magnetic Materials Journal — August 2014–present

Alan Taub

- Chair, Visiting Committee Advanced Technology NIST (2013)

Katsuyo Thornton

- Technical Advisory Board, Center for Hierarchical Materials Design (CHiMaD), a NIST Advanced Materials Center of Excellence, 2014–present
- Condensed Matter and Materials Research Committee, National Research Council's Board on Physics and Astronomy, 2012–2014
- TMS Materials Innovations Committee, 2012–Present
- TMS Education Committee, 2012–Present
- Chair, Education Subcommittee, TMS ICME Technical Committee, 2014–Present
- Editorial Board, Computational Materials Science, 2014–Present
- Editorial Review Board, IMMI, 2012–Present

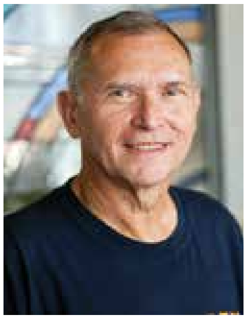
Michael Thouless

- Associate Editor of Journal of Materials: Design and Applications (published by IMechE in the UK)
- International Advisory Committee: International Conference of Fracture (13), Beijing, China (June 2013)

Steve Yalisove

- Editorial Board, MRS Bulletin
- Core member of MRS Energy Quarterly team, MRS Bulletin
- Chair MRS Education sub committee — MRS Academic Affairs
- Organized symposium AAA — MRS F14 meeting
- MRS Accreditation sub-committee member
- TMS Accreditation committee member
- ABET visitor — 2014

Professor Emeritus profile: Ron Gibala



Hello to all U-M MSE alums and others who have regular contact with our department. The 'hello' comes from the Gibala family winter home in Jupiter, Florida in early January at a time when it's about 80°F here and about 30°F in Ann Arbor! Our family consists of Ron, his wife Jan, and their dogs Schuster, an 11-year-old golden retriever, and Smoke, a 3 1/2-year-old border collie/golden retriever mix. For those who have known me through the dogs who are often with me in my office, our wonderful golden for many years, Cooper, died peacefully at the ripe old age of 16 in early October before we left for Florida. We miss him.

For alums who might not know much about me, I came to Michigan in 1984 and was the department chair from 1984 to 1994. Then, I was promoted (at least, it certainly felt that way!) and spent the next ten years as a regular faculty member in the department. I officially retired in 2004, after approximately 30 U-M students and postdocs had worked with me on many different research topics, including in part structure-properties-processing of refractory metals and intermetallic alloys; semiconductor heterostructures; polymer alloys and composites; environmental effects on materials; and mechanical behavior of materials. Perhaps most students remember (or can't forget) me because of my thermo courses. I recall one student's open-ended written evaluation: "I hated thermo before this course, I hated it while taking it, but I hate it much less now because of Professor Gibala." I still take that as a compliment!

I used the words "officially retired" because I've done a poor job of retiring since 2004, although I think I'm beginning to understand the concept. In 2004–2005, I continued co-teaching Engin 110, The Engineering Profession, to about 400 U-M engineering freshman students. Then, in the summer of 2005, I taught MSE 250, our introductory materials course, to about 100 mechanical engineering freshman students at Shanghai Jiao Tong University as part of the UM-SJTU Joint Institute. In 2005–2006, I was Interim Dean of Engineering of our College of Engineering, and soon after embarked on a very fruitful research project on first-principles calculations of hydrogen-defect interactions in iron and steels with Professor Chris Wolverton at Northwestern University. IRONically (please excuse the intended pun), hydrogen in iron was the first research topic I had undertaken way back in 1964 as an assistant professor at Case Western Reserve University, long before I imagined coming to Michigan. I guess it's true that what goes around, comes around.

An especially rewarding activity I've had in the past decade has involved ABET engineering accreditation visits to many universities, either as an evaluator of materials programs or a team chair/ABET commissioner supervising an entire visit for all engineering programs at a university. The 15–20 visits so far have taken me all over the United States and to countries in the Middle East. I've visited and evaluated engineering schools with hundreds of faculty members and others with as few as 10–20. It's been a fabulous learning experience that I hope to continue for a few more years.

Jan, Schuster, Smoke, and I typically spend May through October in Ann Arbor, and I'd be pleased to have you stop by my office in the Dow Building for a chat anytime. We're in Florida from November to April and would welcome visitors there if the timing is right and the guest bedrooms aren't already filled. I've been told that our home in Jupiter, where many celebrities have homes, is about two miles north and maybe $20 million south of one of Michael Jordan's. However, I've not verified this experimentally.

2013 Alumni Merit Award: David C. Martin

Professor David Martin is recognized as a leader in the study of the design, synthesis, and characterization of the integration of electronic biomedical devices in living tissue. A former member of our U-M College of Engineering faculty, Martin is currently the Karl W. and Renate Böer Professor and Chair of Materials Science and Engineering at the University of Delaware, where he is also a professor of biomedical engineering.

Among Martin's chief research interests are the investigation of high-resolution microscopy and impedance spectroscopy studies of defects in ordered polymers and organic semiconductors. His work holds promise in a variety of applications. It's been supported by the National Science Foundation, the Defense Advanced Research Projects Agency, the Army Research Office, and the National Institutes of Health.

Martin is a Fellow of the American Institute for Medical and Biological Engineering and a former Alexander von Humboldt Fellow at the Max Planck Institute for Polymer Research. He is currently Chair of the Division of Polymeric Materials Science and Engineering Division of the American Chemical Society.

From left: Jason Kramb, Dean David Munson, David Martin, and Peter Green at the 2013 Alumni Society Awards Dinner, held on October 4, 2013 . Photo courtesy of Dwight Cendrowski, College of Engineering Communications and Marketing.

2014 Alumni Merit Award: Paul Krajewski

Dr. Paul Krajewski is a globally recognized expert in lightweight materials, automobile lightweighting, and innovation. He received a bachelors ('89), master's ('91), and doctorate ('94) in Materials Science, all from the University of Michigan. Krajewski is currently a global manager and technical fellow for vehicle mass integration and strategy at GM, where he leads teams responsible for developing the vehicle lightweight strategy and mass reduction technology plan for future GM vehicles; her also has responsibility for mass integration on GM's global vehicles.

Krajewski was previously an engineering group manager and technical fellow for GM Product Engineering, where he was responsible for advanced technology body and exteriors and managed the Global Body Structures Leadership Team. Before that, he spent 15 years at GM Research & Development. He has led projects and production implementations with a variety of lightweight materials including aluminum, magnesium, and carbon fiber composites.

Krajewski has more than 75 publications to his credit, and has been awarded 38 US patents. He led a team responsible for designing and launching body panels for the Camaro ZL1 and Corvette Stingray. The carbon fiber hood scoop for the Camaro and carbon fiber hood for the Corvette won Innovation Awards from the Society of Plastics Engineers in 2012 and 2013 respectively. Krajewski has been recognized by *Fortune* Magazine ("40 under 40") and MIT's Technology Review (TR35) as a leading innovator, and was elected as a Fellow of ASM International in 2008. He was the first recipient of the Brimacombe Medal from The Minerals, Metals and Materials Society (TMS) in 2012 and won the Mathewson Medal from TMS in 2013 for outstanding published contribution to materials science. He has also appeared as a subject matter expert on the History Channel's "Modern Marvels" program. Krajewski recently led the development of the industry's first sheet magnesium decklid, which won the 2013 International Magnesium Association Award for innovative application of magnesium and the China Automobile & Parts Industry Development & Innovation Materials Innovation Award.

From left: Dean David Munson, Jason Kramb, Paul Krajewski, and Amit Misra at the 2014 Alumni Society Awards Dinner, held on October 31, 2014. Photo courtesy of Dwight Cendrowski, College of Engineering Communications and Marketing.

Student Excellence

Student start-up used for infant care, therapy for joint disease

(This article originally appeared in the *Michigan Daily,* and is reprinted with permission. Written by Emilie Plesset, *Daily* Staff Reporter.)

Professor After being diagnosed with joint disease, Fay Lum-Lee, a 58-year-old resident of California, experienced a great deal of pain when moving throughout her day and spent much of her time in bed. However, Warmilu, an advanced therapeutic warming technology created by university graduates, reduced her pain and allowed her to continue driving and moving around with her family.

The Warmilu technology was originally created to prevent hypothermia in preterm babies and help them retain or increase body heat to improve their chance for survival. The technology is now also being used as a non-pharmacological treatment for adults with osteoarthritis or chronic joint pain.

Warmilu CEO Grace Hsia, a University alum, who completed her Master's of Entrepreneurship in 2013, created the start-up idea during her senior year as an undergraduate in U-M's Material Science and Engineering program. Hsia said the technology generates warmth instantly for three and a half to five hours. The device, which is incorporated into heating pads and blankets, also has safety features that limit the maximum temperature so it doesn't burn or overheat the user.

"We're spreading the warmth to save infant lives," Hsia said. "But we're also using warmth to improve the lives of folks here in the US."

The start-up is looking into applying the technology to a wearable band so that it can be applied to joint pain more directly. For people like Lum-Lee, this technology has subdued joint pain and improved movement.

"For a lot of these folks who have a chronic condition like the chronic joint condition, that is amazing, it's liberating," Hsia said. "That's what we're able to do: provide this liberation and continued mobility and freedom for these baby boomers."

The start-up began manufacturing the technology two years ago and made its first sale in the last quarter of 2013. Depending on shipping, a warming pack can cost between $30 and $40, and a blanket is about $10. When Warmilu began in 2011, it was called M-Wrap. However, at the suggestion of a U-M professor, the company changed its name to better convey its vision of using warmth to transform lives around the world, and not just at the university.

"Parents love their children," Hsia said.

"Unfortunately their love is not enough to reduce the likelihood of death in these preterm infants. Warmth becomes the embodiment of the parent's love for these infants. That's why we're called Warmilu: it stands for 'I love you' at the end of the name."

To develop the technology, the Warmilu team tested out the warming blanket in India, where it positively improved the health of 20 infants. The organization is working to expand the use of their warming technology and is hoping to bring the blankets to Detroit-area hospitals.

The Warmilu team used many of the entrepreneurial ecosystem and resources available in the Detroit and Ann Arbor areas, including the School of Information and the Innovate Blue initiative, in order to create the technology and put it on the market.

"When you have a social venture, it means more than just making a product," Hsia said. "With start-ups you're addressing a problem with a potential product or solution that can be commercialized, but when you're a social venture you're looking at some social challenge that you're looking to address. There is a problem there that has to deal with people."

Hsia said social entrepreneurship involves listening to peoples' challenges and understanding social issues.

"As a social entrepreneur what you find yourself doing is not only trying to develop a product, but also really understanding the social systems and the gaps in the system that are creating social challenges," Hsia said. "You've got to have passion for it."

This is a preterm infant in the Warmilu infant warming blanket (IncuBlanket) from 2013 pilot clinical trials in Bangalore, India.

Alex Weidong Chen (COO), Grace Hsia (CEO), and Rachel Rademacher (CTO), discussing strategy before a pitch competition.

Warmilu Team at the sixth annual innovation and entrepreneurial showcase "Heading for the Big Leagues" presented by Midland's MidMichigan Innovation Center, BlueWater Angels and The Dow Chemical Company, Dow Corning and Midland Cogeneration Venture, in May 2014. The team pitched Warmilu to an audience of entrepreneurs, resources providers, and angel investors.

MMS Highlights from Fall 2014

- ASM Student/Professional Mixer: Members of the ASM Detroit Chapter gathered at Conor O'Neill's for the 3rd annual University Night mixer in early September. With over 30 members in attendance, students and professionals were able to discuss the future of Materials Science and Engineering and create connections for future jobs and internships.

- Expanding variety of speakers for weekly MMS luncheons: MMS strives to provide speakers on a wide range of current topics for the traditional weekly MMS luncheons. This year, invited speakers ranged from the CEO of a start-up company to one specializing in patent law.

- Semi-annual MMS picnic: Members from the MSE department were invited to attend the semi-annual MMS picnic, held at Professor Hosford's house. Attendees enjoyed fresh donuts and cider from the Dexter Cider Mill, hamburgers and hotdogs, and Professor Kioupakis' famous Greek salad, while getting to know their professors and fellow students.

- Dr. Sunniva Collins visits U-M: Sunniva Collins, the newly elected president of ASM International, visited U-M to connect with both undergraduate students and members of the ASM Detroit Chapter. Students had the opportunity to ask questions about Collins' plans for ASM International as well as give input from an undergraduate perspective.

Attendees from Sunniva Collins' visit to the University of Michigan.

Graduate Student Council

The Materials Science and Engineering Graduate Student Council (MSE GSC) is an organization that seeks to enhance the experience of graduate students in the MSE department. This is achieved through facilitating communication between the department and the graduate student community, hosting educational events, and organizing social activities. The GSC represents the graduate students in matters that affect their welfare, and provides a forum for the discussion of issues of concern to graduate students. The council comprises master's and PhD students from MSE; members are elected by the graduate student body.

Over the past year, the GSC has worked closely with the MSE department to make sure that the graduate students body's concerns are heard. We initiated semiannual meetings with the department chair, allowing the student body to voice comments and concerns about the department directly to the chair. Our involvement with the department extends to interactions with the various faculty committees. Most notably, we have been working toward a better curriculum for the graduate students. The combined efforts of the GSC and the faculty have increased the number and breadth of MSE courses.

The GSC has also hosted a number of events for the graduate student body. Social events have included study breaks, coffee hours, a haunted hayride, and viewings of the Olympics. The GSC has also hosted a chili cooking competition, giving graduate students a friendly yet competitive way to warm up in the cooler months. GSC hosts an annual information session that offers students currently applying for fellowships the opportunity to talk with individuals who have received grants and fellowships. We have hosted practice presentations for students before major conferences to help improve the communication skills of those in the department.

The Graduate Student Council is focused on continuing to foster a more enjoyable graduate experience. We are always looking for driven and inventive students to help us in our cause. If you are interested in getting involved with the GSC or have concerns you would like to see addressed, please contact us at mse.gsc@umich.edu.

Previous and Upcoming Luncheon Companies for Winter 2015

- Brady Corp
- TI
- Applied Processes
- Medtronic
- Warmilu
- Shell
- GE Aviation
- Federal Mogul Baxter
- Meritor
- Materion
- Energy Power Systems
- Ford
- Rolls Royce

Undergraduate Scholarships & Awards: 2014

Departmental Awards

Richard A. Flinn Scholarship
Xinyue Yang, Ruilin Zhang

Fontana-Leslie Scholarship
Edward DiLoreto

James W. Freeman Memorial Scholarship
Margaux Balagna, Justin Eszlinger, Azia Harris-Martin, Danqing Xia

John Grennan Scholarship
Jintao Chen, Elayne Thomas, William Turri

Jack J. Heller Memorial
Siyu Chen

William F. Hosford Scholarship
Sarah Doering, Justin Flietstra, Jillian Jackson, Trevor Jarriat, Laura Schickling, Melissa Sweeney

Schwartzwalder Memorial Scholarship
Kelsey Luibrand, Casandra Smith, Peter Su

Clarence A. Siebert Memorial Scholarship
Mitchell Burke, Hans Guo, Xiaofan Ji, Bridget Karsten

Alfred H. White Memorial Scholarship
Willilam Chen, Maureen Daum, Steven Marion

Brian D. Worth Prize
Elayne Thomas

Elayne Thomas with Professor John Allison. Elayne received the Brian D. Worth Prize at the 2014 Spring Graduation Dinner held at the Michigan League

MMS Anvil Award
Maureen Daum

James P. Lettieri Undergraduate Award
Patrick Milligan

Patrick Milligan with Professor Peter Green. Patrick received the James P. Lettieri Award at the 2014 Spring Graduation Dinner held at the Michigan League

College/University Awards

CoE Distinguished Leadership Award Undergraduate Student
Melissa Sweeney

CoE Distinguished Achievement Award
Melissa Sweeney

Graduate Fellowships & Awards: 2014

Departmental Awards

MSE Graduate Service Award for Recruiting
Alexander Chadwick, Marissa Linne, Juan Lopez, Aeriel Murphy

Best Overall Graduate Student Instructor
Erica Chen

Erica Chen, PhD Candidate, with Professor Jinsang Kim. Erica received the award for Best Overall Graduate Student Instructor at the 2014 Spring Graduation Dinner held at the Michigan League.

College/University Awards

Rackham Predoctoral Fellowship 2014–15
Olga Shalev

CoE Distinguished Academic Achievement 2014
Erica Chen

CoE Distinguished Leadership Award 2014
Katherine Sebeck

Bob and Betty Beyster Fellowship 2014–15
Dylan Bayerl

Engineering Graduate Symposium Poster Presentation
First Place: Materials and Chemical Technology Division
Kevin Golovin

External Awards

National Defense Science and Engineering Graduate Fellowship
Kevin Golovin

Rickover Fellowship
Justin Hesterberg

Gifts from Our Donors

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