COLLEGE OF ENGINEERING
MATERIALS SCIENCE & ENGINEERING
UNIVERSITY OF MICHIGAN

MSE*news*

Elevating materials research and education in U-M's third century

UNIVERSITY OF MICHIGAN BICENTENNIAL 1817 2017

Bicentennial issue/Winter 2018

WELCOME to our special Bicentennial issue!

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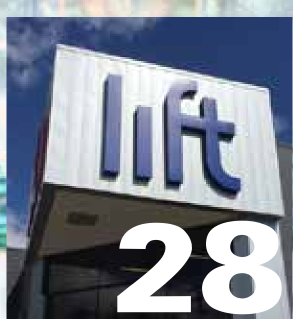
Front cover: Two droplets of water repelled by an ultra-durable water-repellent coating. The droplet on the left is sitting on a surface that has been abraded by a machine. Photo by Kevin Golovin.

Right: HAILstorm! projection onto Rackham as part of U-M's Bicentennial celebration during Homecoming 2017. Photo by Joseph Xu, Michigan Engineering



A note from the MSE Department Chair

The year 2017 was celebrated as the Bicentennial year at the University of Michigan – the 200th year since the school was founded in 1817. The department marked the occasion with a special two-day Bicentennial Symposium in October highlighting the broad impact of advanced materials research on society through a series of keynote lectures from some of the most distinguished materials researchers at U-M.

The field of engineered materials is currently evolving at a more rapid pace than at any other point in history and its evolution and societal impact continuously occurs through collaborations between materials scientists/engineers and other disciplines such as biology, medicine, physics, chemistry and other areas of engineering and manufacturing. As we begin U-M's third century, we look forward to a new era of collaboration on campus that will accelerate the discovery, design, development and deployment of advanced engineering materials to improve the quality of life on our planet.

The year 2017 also celebrated the distinguished career of Professor Wayne Jones, our longest serving faculty member, who retired after 39 years on the faculty.

We welcomed new faculty and staff and MSE continued strategic growth. The alumni engagement strengthened this year with new membership on our external advisory board and new endowments to support the department's mission. I welcome our alumni and friends to reach out to me and visit us anytime. Your engagement and support is highly valued. Together we can elevate the materials research and education at U-M to a new level in the university's third century!

Go Blue!

Amit Misra
Department Chair,
U-M Materials Science & Engineering

"The field of engineered materials is currently evolving at a more rapid pace than at any other point in history."

Robert Hovden joins faculty as assistant professor

Robert Hovden's research can be broadly described as "the photography of atoms—a privilege afforded by precisely sculpted sub-Angstrom electron beams."

Utilizing electron microscopy, he unveils new understanding of how structure at the atomic and nanoscale determines material properties at the macroscale—spanning a wide class of systems including two-dimensional materials, next-generation energy devices, and biominerals."Probing matter across sub-Angstrom to micron length scales in both two and three dimensions is integral to the hierarchical engineering and design of future materials," he said.

Hovden's work has pushed the limits of 3D measurement with electron tomography for the optimization of hydrogen fuel cell catalysts. More recently, he uncovered the control of charge density waves down to the ultrathin limit of TaS_2 using cryogenic scanning transmission electron microscopy.

Hovden received his PhD in Applied Physics at Cornell University where he focused on the physics of aberration corrected scanning transmission electron microscopy for the study of materials. After completing his doctoral work in atomic resolution characterization under Prof. David Muller, he pursued low temperature measurements of atomic structure under the expertise of Prof. Lena Kourkoutis.

Here at U-M, Hovden's lab will continue working with sub-Angstrom electron beams to uncover structural insights spanning the length scale of a single atom to billions of atoms in two and three dimensions.

For more information: roberthovden.com or mse.engin.umich.edu/people/fac/hovden

Introducing two new staff members...

Ellen Hou, Contract & Grant Specialist

Ellen is responsible for proposal preparation, account reconciliation, monitoring research expenses, and general support to faculty. Ellen supports the research administration needs for the following faculty: John Halloran, John Kieffer, Jinsang Kim, Manos Kioupakis, Richard Laine, Brian Love, Emmanuelle Marquis, Ferdinand Poudeu-Poudeu, Liang Qi, Kathleen Sevener, and Ashwin Shahani.

Kristen Freshley, Marketing Communications Specialist

A writer, designer and photographer, Kristen joined our staff in October and brings 20+ years of educational marketing/communications experience to her new role. She is a liaison with our faculty research groups to spread the word out about all the developments in research and oversees all marketing materials, including the newsletter, website, and social media content.

Joanna Millunchick takes on new role as associate dean for undergraduate education

Joanna Millunchick, an Arthur F. Thurnau Professor in MSE and a Presidential Bicentennial Professor, was appointed by the U-M Board of Regents as associate dean for undergraduate education at the College of Engineering. Her new appointment took effect on July 1.

In her new position, Millunchick expects to draw on one of her key areas of research: studying whether participating in co-curricular activities benefits students, and determining how to use those benefits to attract traditionally underrepresented groups to the STEM fields.

“As one of the Bicentennial Professors, I’ve spent the last year talking to students, faculty, and staff about how the college experience will evolve in coming years. Their passion and enthusiasm is truly inspiring, and I can’t wait to work with them to create a more vibrant, engaging and inclusive community of scholars,” Millunchick said.

In her new role, Millunchick will oversee curriculum development; assessment; teaching and pedagogy; first year courses; and Michigan Engineering’s cross-disciplinary academic programs. Those include international programs, technical communications, team projects, the multidisciplinary design program, honors and engagement programs. She will also oversee the ENGR subject courses within Michigan Engineering.

“Joanna’s strengths will be most beneficial as we seek to define and develop the best educational experiences for students,” said Alec D. Gallimore, the Robert J. Vlasic Dean of Engineering, Arthur F. Thurnau Professor and Richard F. and Eleanor A. Towner Professor of Engineering.

Millunchick also studies semiconductor materials – manipulating matter on the nanometer scale to uncover new structures for optoelectronics such as solar cells.

She succeeds EECS professor Brian Noble as associate dean for undergraduate education.

2017 Staff Service Awards

Greg Young, research process manager, and Kathy Kuhn, contract and grant specialist, received the 2017 staff service awards presented on Dec. 20 at the annual department holiday luncheon. Young has been with MSE for two years and Kuhn has been on staff for three years.

Professor Wayne Jones retires with 39 years of service to MSE

Professor Wayne Jones receives a standing ovation after making some parting remarks at his retirement celebration May 31.

Professor Tresa Pollock (a former colleague who's now at UCSB) estimates that Jones has lectured around 3,500 hours, mentored at least 55 graduate students and post-docs, published 200+ papers, and impacted tens of thousands of undergraduates.

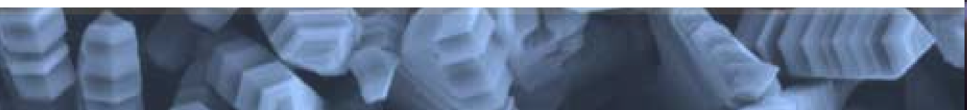
On May 31, a packed house of more than 60 people celebrated Jones' 39-year tenure (the longest in the department) with a catered luncheon, a parade of speeches, and special gifts.

An MSE professor since 1978, Jones leaves the faculty ranks with a reputation for being a brilliant scholar, teacher, administrator, diversity champion, and researcher, particularly in the area of failure of metallic materials under creep or fatigue conditions. In their respective remarks, Alec Gallimore, dean of Michigan Engineering, and past MSE department chairs Professor John Halloran and Professor Ron Gibala thanked Jones for his service to the college and MSE the past four decades.

There was anything but fatigue, however, in his long and exceptional career, as MSE Chair Amit Misra noted in his opening remarks: "With 39 years of distinguished career at U-M, he is the longest serving faculty member in MSE, but perhaps the youngest at heart. After over four decades of teaching fatigue, he himself has not fatigued."

Far from it.

In her presentation, Professor Tresa Pollock (a former MSE colleague who's currently a Distinguished Professor at UC-Santa Barbara) estimated that in his 39 years, Jones has lectured somewhere around 3,500 hours, mentored at least 55 graduate and post-doc students, published 200+ papers, and impacted tens of thousands of undergraduates.







Speakers and gift-givers at Wayne Jones' retirement party included post-doc Qianying Shi, College of Engineering Dean Alec Gallimore, Tresa Pollock, a former colleague who's now at UCSB, and former student Dr. Paul Krajewski, director of the Vehicle Systems Research Laboratory at General Motors. At the start of the celebration (far right) Jones visited with Professor Emeritus Bob Pehlke, who hired Jones in 1978.

"The point I want to make is that there are some people in academics who are not necessarily there for the students, and that was never true of Wayne," Pollock said. "He was always all about the students."

One of those students, Dr. Paul Krajewski '89, '91, and '94, now Director of the Vehicle Systems Research Laboratory at General Motors, agreed. "You had a huge impact on me and a lot of students at the time," he told Jones. "It was phenomenal working for you. You always had the students' interests at heart."

Also at the heart of Jones' career was promoting diversity on campus. In 2007, Jones received the Harold R. Johnson Diversity Service Award from U-M, arguably the university's highest honor given to individuals for the pursuit of diversity, equity and inclusion. The award acknowledged, among other things, his part in helping raise $10 million for diversity initiatives and scholarships for the Minority Engineering Program Office (MEPO). He also led the formation of the College of Engineering's first written diversity plan in 1997, and from 2008-2013 served as the associate director of U-M's ADVANCE Program and director of the College of Engineering's ADVANCE Program.

Written remarks from the current director of ADVANCE, Jennifer Linderman, Professor of Chemical Engineering, read at the luncheon by Amit Misra, recognized Jones for his impactful service to the program that works on faculty recruitment, retention, climate and leadership – especially around issues of excellence and diversity, and in making U-M a better place for all faculty.

"Certainly Wayne has been incredibly generous with his time and so wisely counseled many of us," Linderman wrote. "So I want to say thank you to Wayne from all of ADVANCE, and on behalf of all the faculty he supported and advised in that role."

"Wayne did tremendous things for diversity and the university, and for that we are extremely grateful," added Pollock in her remarks.

Though Jones will now transition to a far less involved role as emeritus faculty, there's still no fatigue in his retirement forecast as he plans to spend more time pursuing his outside interests like hiking and photography.

"Wayne is the consummate teacher," concluded fellow professor and friend John Allison, who's known Jones for more than 40 years. "He doesn't lecture, he teaches, and he has taught us all so very much, whether it's metallurgy, photography, diversity, and many, many other things. We are all better off for having been his students."

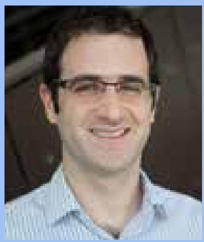
"Wayne doesn't lecture, he teaches, and he has taught us all so very much... We are all better off for having been his students."
—Professor John Allison

John Halloran teaches his last class

On December 11, retiring Professor John Halloran taught his last class, after which the department celebrated with a small impromptu party. A full retirement luncheon to formerly and properly celebrate Halloran's 27-year MSE career is planned for May 25, 2018.

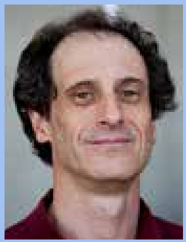
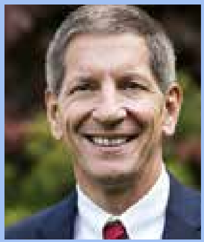
Assistant Professor John Heron congratulates Professor John Halloran at a celebration after Halloran's last class on Dec. 11.

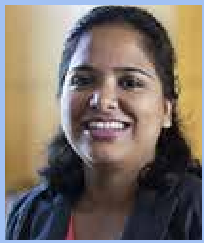
Faculty News



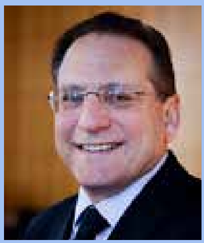
Manos Kioupakis is the 2017 recipient of the CoE 1938E award for junior faculty. The 1938E Award, endowed by the CoE Class of 1938, is presented in "recognition of an outstanding teacher in both elementary and advanced courses. The recipient is an understanding counselor of students who seek guidance in their choice of career, a contributor to the educational growth of his/her College, and a teacher whose scholarly integrity pervades his/her service to the University and the profession of Engineering teachers."

The Consortium for Advanced Simulation of Light-Water Reactors (CASL) team is the recipient of the College's Ted Kennedy Family Faculty Team Excellence Award. The team includes **Katsuyo Thornton, Michael Thouless and Gary Was.**

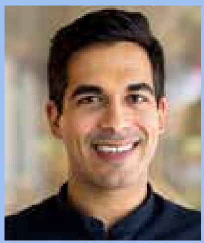






Geeta Mehta has been named MSE's Dow Corning Assistant Professor. She will hold the position for a three-year term, until December 31, 2019. Mehta is also an assistant professor of biomedical engineering.



Alan Taub is the recipient of the 2017 MSE Department Outstanding Accomplishment Faculty Award.



Ashwin Shahani was awarded a Young Investigator Research Award from Air Force Office of Scientific Research for his proposal on Chiral Metamaterials by Design. The AFOSR received more than 285 proposals and selected 43.

In August 2017 **Brian Love** published a textbook entitled *Biomaterials, A Systems Approach to Engineering Concepts* through Elsevier and Academic Press.

External Awards

John Allison received the TMS Leadership award, which recognizes an individual who has demonstrated outstanding leadership in the national and international materials community.

Sharon Glotzer was elected a Fellow of the Materials Research Society (MRS).

Richard M. Laine was honored in August at the 2017 International Symposium on Silsesquioxanes-Based Functional Materials (SFM 2017) organized by Shandong University in Jinan, China.

Amit Misra was designated a 2017 TMS Brimacombe Medalist. This award recognizes individuals with sustained excellence and achievement in business, technology, education, public policy, or science related to minerals, metals, or materials science and engineering, and a record of continuing service to the profession.

Gary Was was named a Fellow of The Minerals, Metals & Materials Society (TMS).

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
- 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)
- Management Committee, Michigan Institute for Computational Discovery in Engineering (2016-present)
- Steering Committee, Center for Data-driven Computational Physics (2016-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

- Scientific Advisory Committee, Center for Integrated Nanotechnologies, Department of Energy, 2017-2019
- Education Directors Committee, NSF Materials Research Science and Engineering Centers, 2011-2017
- Associate Editor, Journal of Applied Physics, 2017-present
- Editorial Board, MRS News, 2012–present
- Executive Committee, Electronic Materials Conference, 2016-2019
- Associate Editor, J. of Electronic Materials, 2002-2017
- Proposal Review Panel, ARPA-E, 2017
- SCGSR Review Panel, DOE, 2017
- Proposal Review Panel, NSF-DMR, 2017
- Proposal Review Panel, NSF-ECCS, 2017
- Associate Director, Applied Physics, 2010-2019
- Member, President's Honorary Degree Advisory Committee, 2017-2020
- Member, Dean's Advisory Committee on Female Faculty, 2017-2020
- Member, CoE Executive Committee, 2014-2017
- Member, LSA Sweetland Writing Center Exec. Committee, 2015-2018

Peter Green

- Member, the Massachusetts Institute of Technology Corporation Visiting Committee for the Department of Chemical Engineering
- MRS Communications, Editor-in Chief
- External Review Board for Materials Research, Sandia National Laboratories
- Advisory Board, ACS Petroleum Research Fund

John Heron

- Lead organizer of MRS Symposium Spring 2017: Symposium ES10: "Frontiers in Oxide Interface Spintronics Magnetoelectrics, Multiferroics and Spin-Orbit Effects"
- Co-organizer of EMA (Electronic Materials and Applications) Conference 2017: "Energy Sustainable Optoelectronics and Magnetoelectronics"
- Member, American Ceramics Society, Materials Research Society
- American Physical Society

Jinsang Kim

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

Emmanouil Kioupakis

Coorganizer at the American Physical Society March Meeting 2017, New Orleans (March 2017) for:

(cont'd)

Love's Cuban classroom

In Winter 2017, MSE Professor Brian Love taught a class entitled "Design in a Resource Constrained Environment" to 22 undergraduates across the college including three in MSE. The course was authorized under the auspices of the International Programs in Engineering (IPE) office and received further funding from the Center for Socially Engaged Design (C-SED).

"This was the first class to offer a spring break engagement on site in Havana, and one of the more productive interactions that broadened the IPE mission beyond simply facilitating study abroad programs for undergraduates," Love said.

While in Cuba, students met with researchers from several state-sponsored institutes, representatives from Cuba Solar, a public/private partnership, and the Lombao Design Center, a growing private enterprise. Students broke into teams and researched aspects of the current infrastructure, food and agriculture, technological gaps in their economy, and other cultural elements, and presented their output in terms of posters and photographs.

Professional Service (cont'd)

Emmanouil Kioupakis (cont'd)

-Tutorial: "Electron Phonon Interactions," Division of Computational Physics-Invited Session: "Predictive Modeling of Electron-Phonon
Coupling in Condensed-Matter Physics," Division of Computational Physics
-Focus Session: "First-Principles Modeling of Excited-State Phenomena in Materials," Divisions of Computational Physics, Chemical Physics, and Materials Physics

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
- Organizer, Polymers and Nanotechnology Workshop, 2017

Brian Love

- Sandia National Laboratories Center for Integrated Nanotechnologies (CINT) External Proposal Advisory Board
- Chair of the Advisory Committee for Financial Affairs for the University of Michigan, last four years

Peter Ma

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

Amit Misra

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

Pierre Ferdinand Poudeu-Poudeu

- Co-chair of the DOE 2015 Synthesis and Processing Science Principal Investigators' Meeting

Jeff Sakamoto

- DOE-BES, Basic Research Needs Workshop Panel Lead, Electrochemical Energy Storage (March 2017)

Jeff Sakamoto (cont'd)

- NASA Space Power Systems Review Board Member
- Keynote Presentation, Kyoto, Japan, MRS-J, "Transitioning solid electrolytes into manufacturable solid-state batteries for EVs," August, 2017.
- Member, Materials Research Society

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, U-M Society of Automotive Engineers, Student Chapter
- Member of the Directorate, Joint Center for Energy Storage Research

Alan Taub

- NAE Committee on Membership
- Member, DOE USDrive Review Committee
- MIT Corporation Visiting Committee for MSE
- Dean's Advisory Council, University of California Davis
- Panel Session for U.S. Senate Competes Act
- Keynote Panel Michigan Minority Procurement Conference

Katsuyo Thornton

- Technical Advisory Board, Center for Hierarchical Materials Design (CHi- MaD), an NIST Advanced Materials Center of Excellence (2014-present)
- Chair of Advanced Research Computing Advisory Team (ARCAT), providing guidance and advice to the Vice President and Chief Information Officer and the Associate Vice President for Advanced Research Computing on strategic directions relating to the advanced research cyberinfrastructure

Steve Yalisove

- MRS Bulletin, Member, 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 Opto-electronic Manufacturing" at Photonics West, 2016
- Co-organized Symposium on "Ultra-fast Bandap Photonics" at the SPIE Defense + Security Meeting in Baltimore, 2016

Summer School provides 'incredible experience' for educators learning computational MSE

For two weeks, June 5-16, 25 university educators became students again – taking notes and absorbing concepts like finite difference methods – at the sixth annual Summer School for Integrated Computational Materials Education (ICMEd) held in U-M's West Hall.

Founded in 2011 by MSE Professor Katsuyo Thornton, Summer School for ICMEd spends 10 days training faculty, postdocs and graduate students who intend to teach computational MSE to undergraduates.

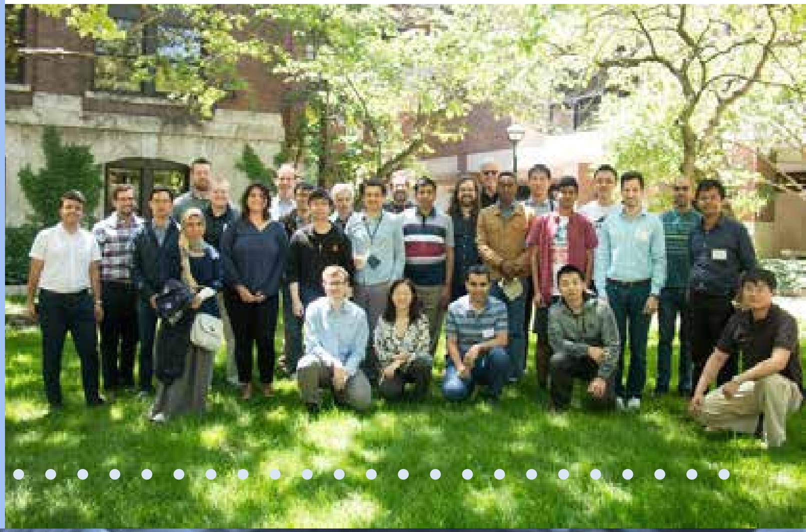
The summer program grew out of Thornton's efforts to bolster engineering education. Over the past two decades, Thornton explains, curricula have struggled to keep up with the ever-increasing advances in science and engineering technology – technology that can dramatically enhance learning and materials research and innovations.

"Computational materials science is a perfect example," she said. "Computational tools can provide a virtual laboratory that can help students better visualize the material processes and bring them to 'life.'"

Since 2011, the Summer School for ICMEd program has attracted more than 130 participants from the U.S., Europe and Asia, who have in turn reached an estimated 1,600 students worldwide.

This year's ICMEd participants, who hailed from universities across the U.S., as well as Egypt, South Korea and India, agreed that after ICMEd they were ready to return to their classrooms as ambassadors of computational MSE.

"During the course of two weeks, I transferred from someone who had no idea about Density Functional Theory (DFT) to someone who ran a DFT code," said Youness Alvandi-Tabrizi, a PhD candidate from NC State University.



Mathew Boban, Macromolecular Science & Engineering PhD student, and Kevin Golovin, MSE PhD student, test a superhydrophobic surface by burning it as part of its resistance testing against water.

SURPRISE! A WATER-REPELLENT COATING THAT'S ULTRA DURABLE

A self-healing, water-repellent spray-on coating developed at U-M is hundreds of times more durable than its counterparts and could enable waterproofing of vehicles, clothing, rooftops and countless other surfaces for which current waterproofing treatments are too fragile. It could also lower the resistance of ship hulls, reducing the fuel consumption of the massive ships that transport ninety percent of the world's cargo.

The developers say the new concoction is a major breakthrough in a field where decades of research have failed to produce a durable coating. While water-repellent coatings are available at present, they tend to be far too fragile for applications like clothing or ship hulls. This discovery changes that.

The coating is made of a mix of a material called "fluorinated polyurethane elastomer" and a specialized water-repellent molecule known as "F-POSS." It can be easily sprayed onto virtually any surface and has a slightly rubbery texture that makes it more resilient than its predecessors.

If it is damaged, the coating can heal itself hundreds of times. It can bounce back "even after being abraded, scratched, burned, plasma-cleaned, flattened, sonicated and chemically attacked," the researchers noted in a paper published in *ACS Applied Materials & Interfaces.*

In addition to recovering physically, the coating can heal itself chemically. If water-repellent F-POSS molecules are scraped from the surface, new molecules will naturally migrate to the surface to replace them. That's how the coating can renew itself hundreds of times. Its healing ability is limited only by its thickness.

The discovery is being commercialized by HygraTek, a company founded by Associate Professor Anish Tuteja with assistance from the U-M Office for Technology Transfer.

Beyond the coatings detailed in the paper, the project produced what amounts to a recipe that researchers can use to optimize future coatings to a specific application's requirements for cost, durability and other factors. So, while the coating detailed in the study is costly to produce, the team says their research should enable other makers to easily tweak the formula, for example to produce a version that's only slightly less effective but far less costly.

As lead author and U-M doctoral student Kevin Golovin explains, the team used a process that was radically different from previous research in the field. "Most materials science researchers have focused on identifying one specific chemical system that's as durable and water-repellent as possible. We approached the problem differently, by measuring and mapping out the basic chemical properties that make a water-repellent coating durable. Some of the results surprised us."

For example, most hydrophobic coatings are made of two main ingredients: an active molecule that provides the water-repellency and a binder. Generally, researchers have assumed that using more durable ingredients would make a more durable coating. But Tuteja's team found that that's not necessarily the case.

They discovered that even more important than

> "Thousands of superhydrophobic surfaces have been looked at over the past twenty or thirty years, but nobody has been able to figure out how to systematically design one that's durable."
>
> — Associate Professor Anish Tuteja

A superhydrophobic surface is burned as part of its resistance testing against water in the NCRC. Photos by Joseph Xu, Michigan Engineering

durability is a property called "partial miscibility," or the ability of two substances to partially mix together. Chemicals that are more compatible with each other make a much more durable product, even if they're less durable individually.

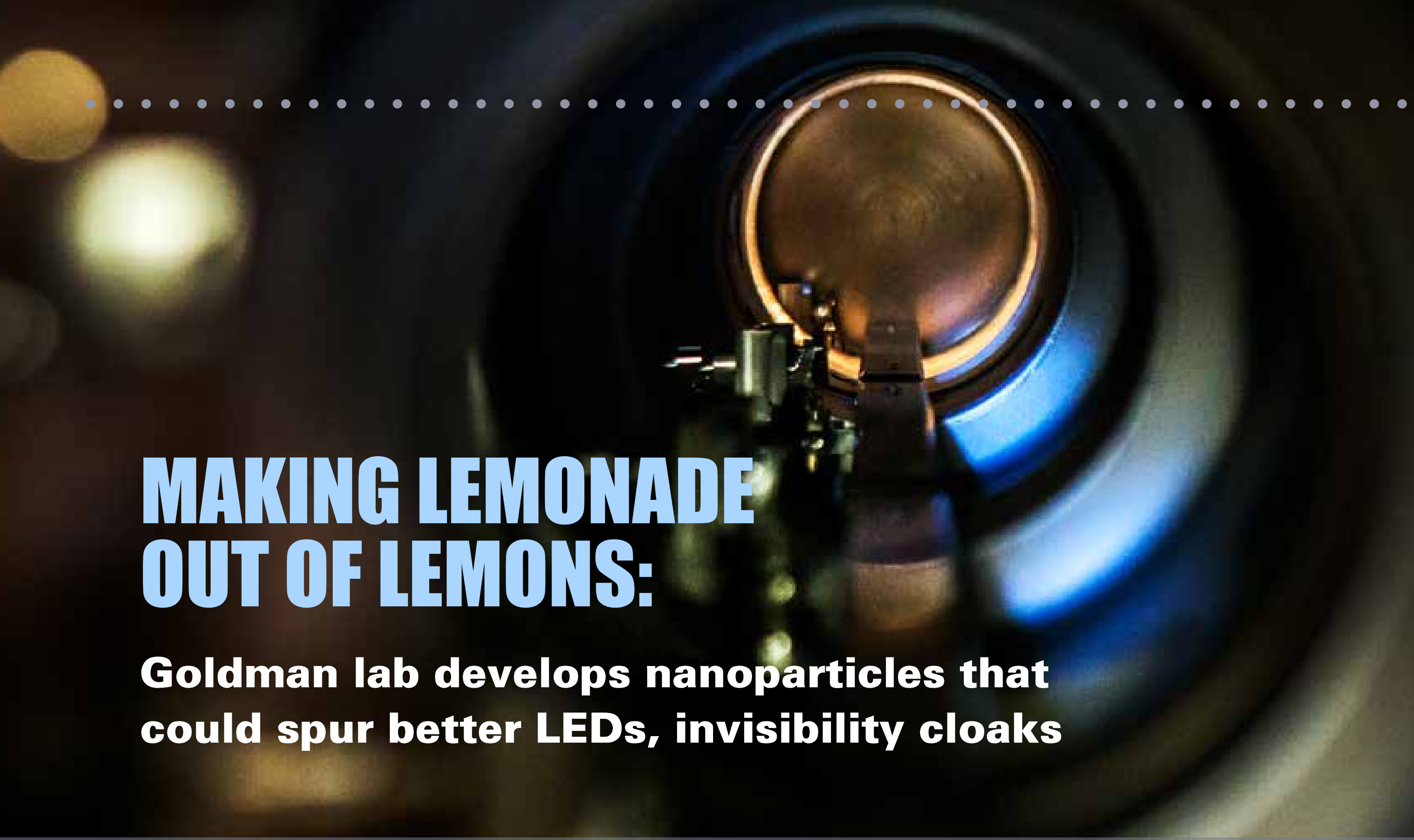
The other key variable the team discovered is the stability of the water-repellent surface. Most water-repellent coatings work because their surface has a very specific geometry, often microscopic pillars. Water droplets perch on the tips of these pillars, creating air pockets underneath that deny the water a solid place to rest and cause it to roll off easily. But such surfaces tend to be fragile—slight abrasion or even the pressure of the water itself can damage them.

The team's research found that a surface that's slightly pliable can escape this pitfall—even though it seems less durable, its pliable properties enable it to bounce back from damage. The importance of this property came as another surprise to the research team.

Tuteja estimates that the coatings will be available for use soon for applications including water-repellent fabrics and spray-on coatings that can be purchased directly by consumers.

The paper is titled "*Designing self-healing superhydrophobic surfaces with exceptional mechanical durability*." Support for the research was provided by the Office of Naval Research, the Air Force Office of Scientific Research and the National Science Foundation. HygraTek and the University of Michigan have applied for patent protection for the technology.

—Story by Gabe Cherry



MAKING LEMONADE OUT OF LEMONS:

Goldman lab develops nanoparticles that could spur better LEDs, invisibility cloaks

The inside of the main concourse of the molecular beam epitaxy apparatus, used to make the advanced nanoparticle-infused gallium nitride semiconductors. The semiconductors could boost LED efficiency by up to 50%, and lead to invisibility cloaking devices.

In an advance that could boost the efficiency of LED lighting by 50 percent and even pave the way for invisibility cloaking devices, Professor Rachel Goldman's team has developed a new technique that peppers metallic nanoparticles into semiconductors.

It's the first technique that can inexpensively grow metal nanoparticles both on and below the surface of semiconductors. The process adds virtually no cost during manufacturing and its improved efficiency could allow manufacturers to use fewer semiconductors in finished products, making them less expensive.

The metal nanoparticles can increase the efficiency of LEDs in several ways. They can act as tiny antennas that alter and redirect the electricity running through the semiconductor, turning more of it into light. They can also help reflect light out of the device, preventing it from being trapped inside and wasted.

The process can be used with the gallium nitride that's used in LED lighting and can also boost efficiency in other semiconductor products, including solar cells. It's detailed in a study in the *Journal of Applied Physics*.

THE KEY INNOVATION

The idea of adding nanoparticles to increase LED efficiency is not new. But previous efforts to incorporate them have been impractical for large-scale manufacturing. They focused on pricey metals like silver, gold and platinum. In addition, the size and spacing of the particles must be very precise; this required additional and expensive manufacturing steps. Furthermore, there was no cost-effective way to incorporate particles below the surface.

Goldman's team discovered a simpler way that integrates easily with the molecular beam epitaxy process used to make semiconductors. Molecular beam epitaxy sprays multiple layers of metallic elements onto a wafer. This creates exactly the right conductive properties for a given purpose.

Researchers applied an ion beam between these layers—a step that pushes metal out of the semiconductor wafer and onto the surface. The metal forms nanoscale particles that serve the same purpose as the pricey gold and platinum flecks in earlier research.

Their size and placement can be precisely controlled by varying the angle and intensity of the ion beam. And applying the ion beam over and over between each layer creates a semiconductor with the nanoparticles interspersed throughout.

"If you carefully tailor the size and spacing of nanoparticles and how deeply they're embedded, you can find a sweet spot that enhances light emissions," said Myungkoo Kang, a former graduate student in Goldman's lab and first author on the study. "This process gives us a much simpler and less expensive way to do that."

Researchers have known for years that metallic particles can collect on the surface of semiconductors during manufacturing. But they were always considered a nuisance, something that happened when the mix of elements was incorrect or the timing was off.

"From the very early days of semiconductor manufacturing, the goal was always to spray a smooth layer of elements onto the surface. If the elements formed particles instead, it was considered a mistake," Goldman said. "But we realized that those 'mistakes' are very similar to the particles that manufacturers have been trying so hard to incorporate into LEDs. So we figured out a way to make lemonade out of lemons."

TOWARD INVISIBILITY CLOAKS

Because the technique allows precise control over the nanoparticle distribution, the researchers say it may one day be useful for cloaks that render objects partially invisible by inducing a phenomenon known as "reverse refraction."

Reverse refraction bends light waves backwards in a way that doesn't occur in nature, potentially directing them around an object or away from the eye. The researchers believe that by carefully sizing and spacing an array of nanoparticles, they may be able to induce and control reverse refraction in specific wavelengths of light.

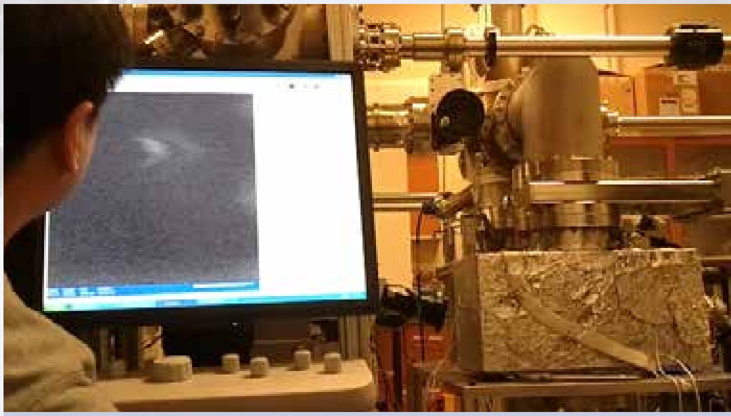
The team is now working to adapt the ion beam process to the specific materials used in LEDs—they estimate that the higher-efficiency lighting devices could be ready for market within the next five years, with invisibility cloaking and other applications coming further in the future.

The study is titled "*Formation of embedded plasmonic Ga nanoparticle arrays and their influence on GaAs photoluminescence*." The research was supported by NSF through the Materials Research Science and Engineering Center at U-M.

—Story by Gabe Cherry

"This is a seamless addition to the manufacturing process, and that's what makes it so exciting. The ability to make 3-D structures with these nanoparticles throughout is going to open a lot of possibilities."

—Professor Rachel Goldman



Myungkoo Kang, a former graduate student in Goldman's lab, operates a focused ion beam controller attached to the GenII molecular beam epitaxy apparatus.

DEVELOPING A NEW WAY TO MAKE HEAT-CONDUCTING PLASTICS

Advanced plastics could usher in lighter, cheaper, more energy efficient product components, including those used in vehicles, LEDs and computers—if only they were better at dissipating heat. A new technique that can change plastic's molecular structure to help it cast off heat is a promising step in that direction.

Developed by Professor Jinsang Kim's team, the process is inexpensive and scalable, and the concept can likely be adapted to a variety of other plastics. In preliminary tests, it made a polymer about as thermally conductive as glass—still far less so than metals or ceramics, but six times better at dissipating heat than the same polymer without the treatment.

"Plastics are replacing metals and ceramics in many places, but they're such poor heat conductors that nobody even considers them for applications that require heat to be dissipated efficiently," said Kim. "We're working to change that by applying thermal engineering to plastics in a way that hasn't been done before."

The process is a major departure from previous approaches, which have focused on adding metallic or ceramic fillers to plastics.

Plastics are made of long chains of molecules that are tightly coiled and tangled together like a bowl of spaghetti. As heat travels through the material, it must travel along and between these chains—an arduous journey that impedes its progress.

The team, which also included U-M associate professor of mechanical engineering Kevin Pipe, ME graduate researcher Chen Li and MSE graduate student Apoorv Shanker, used a chemical process to expand and straighten the molecule chains, giving heat energy a more direct route through the material. To accomplish this, they started with a typical polymer—or plastic. They dissolved the polymer in water, then added electrolytes to the solution to raise its pH, making it alkaline.

The individual links in the polymer chain—called monomers—take on a negative charge, which causes them to repel each other. As they spread apart, they unfurl the chain's tight coils. Finally, the water and polymer solution is sprayed onto plates using a common industrial process called spin casting, which reconstitutes it into a plastic film.

The uncoiled molecule chains within the plastic make it easier for heat to travel through it. The team also found that the process has a secondary benefit—it stiffens the polymer chains and helps them pack together more tightly, making them even more thermally conductive.

"Polymer molecules conduct heat by vibrating, and a stiffer molecule chain can vibrate more easily," explains Shanker. "Think of a tightly stretched guitar string compared to a loosely coiled piece of twine. The guitar string will vibrate when plucked, the twine won't. Polymer molecule chains behave in a similar way."

Pipe says that the work can have important consequences because of the large number of polymer applications in which temperature is important.

"Researchers have long studied ways to modify the molecular structure of polymers to engineer their mechanical, optical, or electronic properties, but very few studies have examined molecular design approaches to engineer their thermal properties," Pipe said. "While heat flow in materials is often a complex process, even small improvements in the thermal conductivities of polymers can have a large technological impact."

The paper is titled "*High thermal conductivity in electrostatically engineered amorphous polymers*."

—Story by Gabe Cherry

A sample of heat-conducting polymer is tested for thickness in U-M's Lurie Nanofabrication Facility. Photos by Joseph Xu, Michigan Engineering

"Plastics are replacing metals and ceramics in many places, but they're such poor heat conductors that nobody even considers them for applications that require heat to be dissipated efficiently. We're working to change that by applying thermal engineering to plastics in a way that hasn't been done before."

—Professor Jinsang Kim

Research News

PRINTED MEDS COULD REINVENT PHARMACIES, DRUG RESEARCH

Evaporated fluorescein is combined with nitrogen and then jetted, much like a 3D printer, onto a variety of cooled surfaces. This technique could possibly print ultra-precise doses of multiple medications into one dose and make life easier for patients who must take multiple medicines daily.

A new study led by MSE Professor Max Shtein and Olga Shalev, a recent graduate who worked on the project while a doctoral student in MSE, showed that the pure printed medication can destroy cultured cancer cells in the lab as effectively as medication delivered by traditional means, which rely on chemical solvents to enable the cells to absorb the medication. Their study was published in the journal *Nature Communications*.

The technique was developed through a collaboration between the Michigan Engineering departments of chemical engineering and biomedical engineering, as well as the College of Pharmacy and the Department of Physics in the College of LS&A.

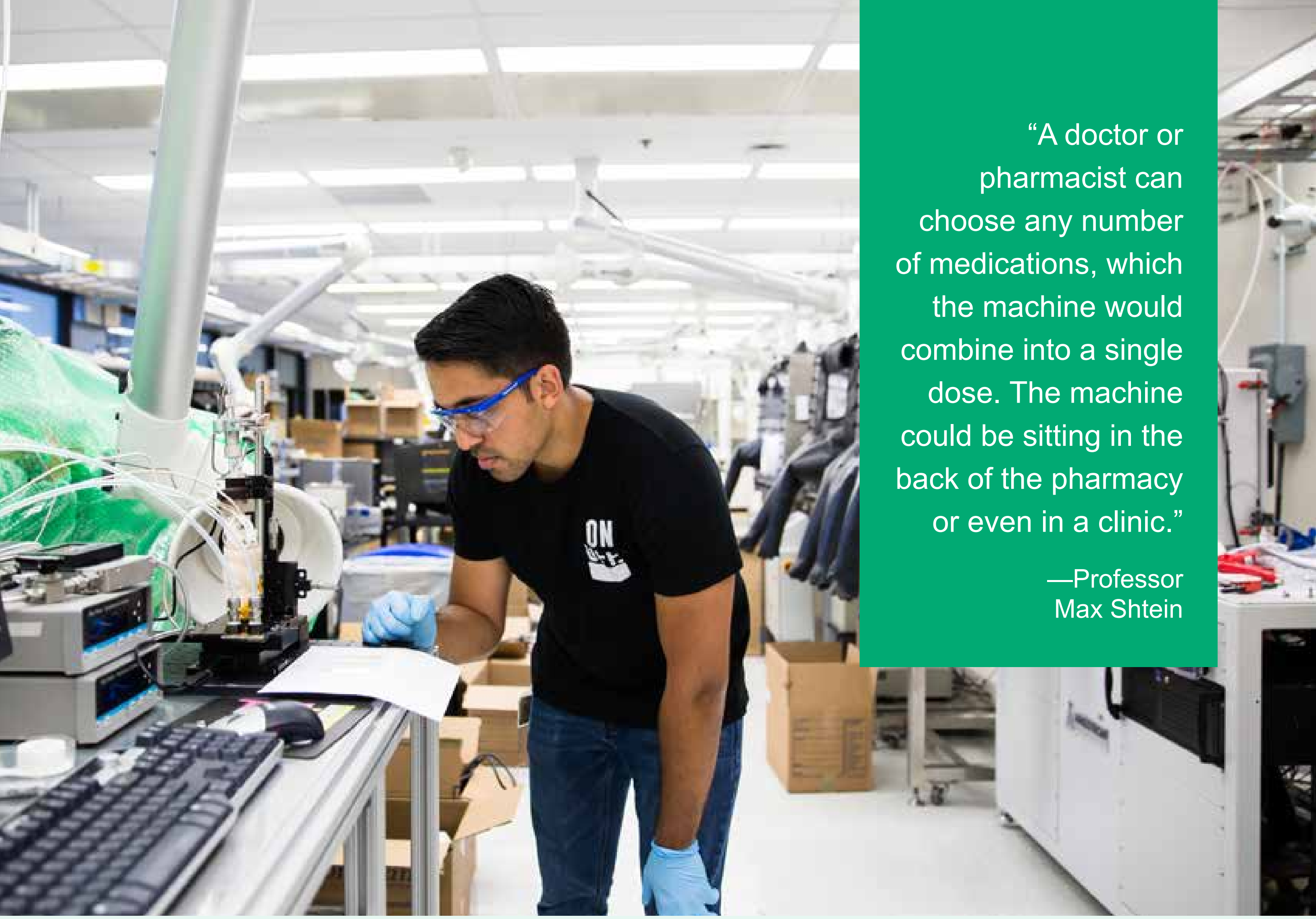
The researchers adapted a technology from electronics manufacturing called organic vapor jet printing. One key advantage of the technique is that it can print a very fine crystalline structure over a large surface area. This helps printed medications dissolve more easily, opening the door to a variety of potential new drugs that today are shelved because they don't dissolve well when administered with conventional approaches, including pills and capsules.

"Pharma companies have libraries of millions of compounds to evaluate, and one of the first tests is solubility," Shtein said. "About half of new compounds fail this test and are ruled out. Organic vapor jet printing could make some of them more soluble, putting them back into the pipeline."

The process begins by heating the active pharmaceutical ingredient—usually a powder—and evaporating it to combine it with a stream of heated, inert gas-like nitrogen. The evaporated medication travels, along with the gas, through a nozzle pointed at a cooled surface. The medication then condenses, sticking to the cooled surface in a thin crystalline film. The formation of the film can be tightly controlled by fine-tuning the printing process. The process requires no solvents, no additives and no post-processing.

"Organic vapor jet printing may be useful for a variety of drug delivery applications for the safe and effective delivery of therapeutic agents to target tissues and organs," said Geeta Mehta, the Dow Corning Assistant Professor of Materials Science and Engineering and Biomedical Engineering and a co-author on the paper.

The tight control over solubility may also be useful later in the drug testing process, when potential new drugs are applied to cultured cells in a lab. Today, most compounds must be dissolved in a chemical solvent before they're



> “A doctor or pharmacist can choose any number of medications, which the machine would combine into a single dose. The machine could be sitting in the back of the pharmacy or even in a clinic.”
>
> —Professor Max Shtein

Graduate student research assistant Siddharth Suresh Borsadia prints fluorescein crystals onto a cooled glass plate using organic vapor jet printing. Photos by Levi Hutmacher, Michigan Engineering

applied to cells. The new technique could enable printed medications to dissolve easily in the water-based medium used to culture cells, without the need for a solvent.

“When researchers use solvents to dissolve drugs during the testing process, they’re applying those drugs in a way that’s different from how they would be used in people, and that makes the results less useful,” said Anna Schwendeman, an assistant professor of pharmaceutical sciences at U-M and an author on the paper. “Organic vapor jet printing could make those tests much more predictive, not to mention simpler.”

While printing mass-market drugs is likely years away, Shtein believes that the drug characterization and testing applications may come to fruition more quickly—internally in pharmaceutical companies.

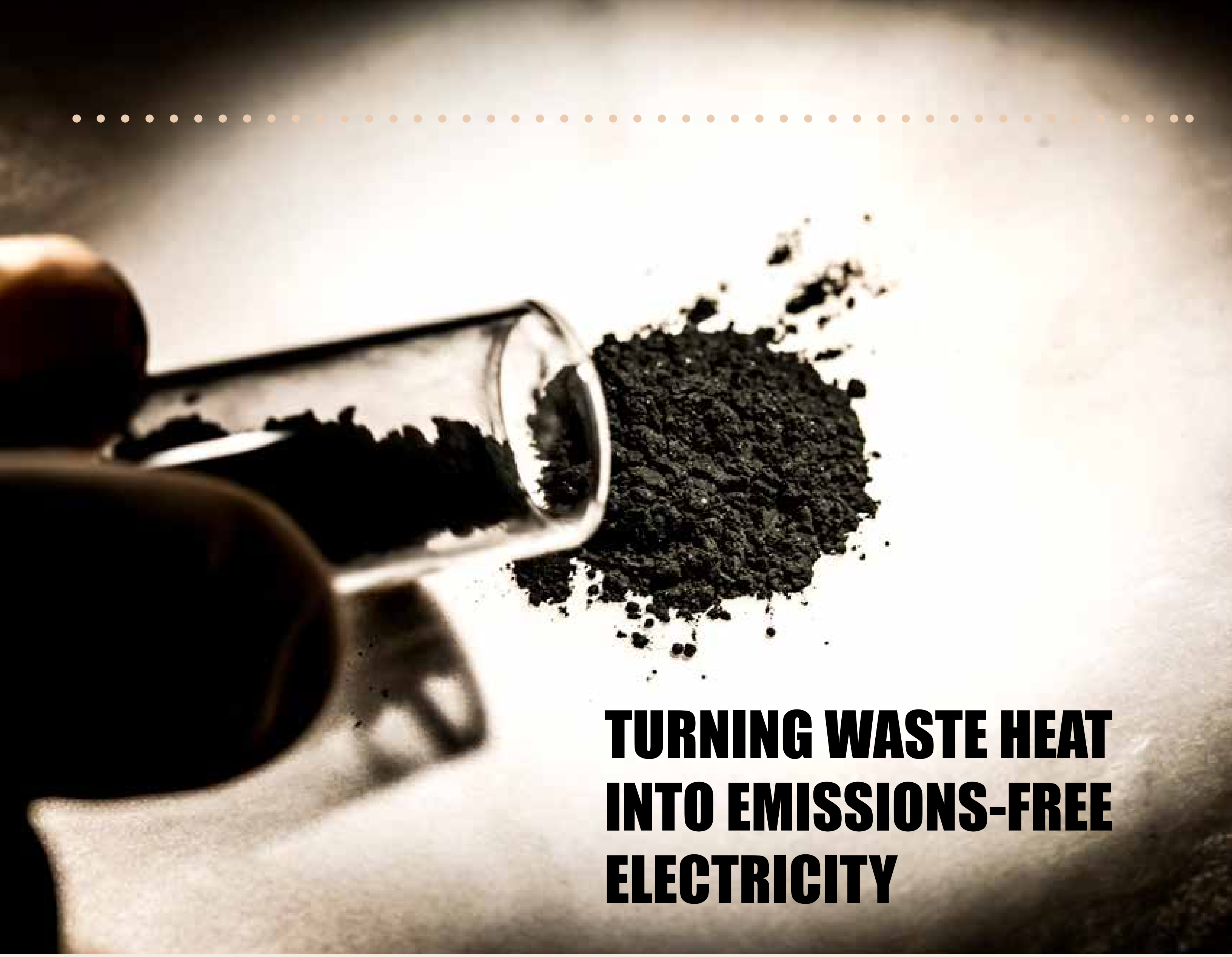
“One of the major challenges facing pharmaceutical companies is speed to clinical testing in humans,” said Gregory Amidon, a research professor in the U-M College of Pharmacy and an author on the paper. “This technology offers up a new approach to accelerate the evaluation of new medicines.”

The team is exploring additional applications for the technology and plans to collaborate with experts in pharmaceutical compound design and manufacturing, as well as those working on treatments. Eventually, they envision vapor jet printing being scaled to mass production, including roll-to-roll continuous manufacturing.

The paper is titled "*Printing of small molecular medicines from the vapor phase.*" The research was supported by the Air Force Office of Scientific Research, the National Science Foundation, and the U.S. Department of Energy Office of Science User Facility.

—Story by Gabe Cherry

TURNING WASTE HEAT INTO EMISSIONS-FREE ELECTRICITY



A mix of copper, selenium and indium, the new compound is the first stable copper selenide material that can turn waste heat into electricity.

A long-sought chemical cocktail developed by U-M materials science researchers could turn waste heat in some of the world's most energy-hungry industries into a new source of emissions-free electricity.

While the compound could be used in cars and to power small household devices, the researchers expect it to have the biggest impact in sectors like steel, glass and cement manufacturing. They account for about a third of industrial power usage, and today, much of that energy is simply lost to the atmosphere as heat.

Applied to a hot pipe in a glass factory or metal processing plant, the new material begins pumping out electricity when exposed to about half as much heat as previous thermoelectric generators. It's also less toxic and much less expensive than its counterparts.

Researchers have known for years that copper selenide can generate electricity from heat because of a principle known as the Seebeck Effect. When one side of a thermoelectric material is heated, electrons move away from the hot end toward the cool end, creating an electric current. But in order for thermoelectric generators to continue working, the hot side has to stay hot while the cool side stays cool. So materials with high electrical conductivity but low heat conductivity work well.

Copper selenide fits the bill, and it works far better than today's thermoelectric compounds, which are expensive, inefficient and made of toxic materials like lead. But copper selenide has historically had one big shortcoming.

"It stays together just long enough for us to measure its impressive thermoelectric efficiency, and then turns into a useless blob," Poudeu said. "Copper selenide generates electricity most efficiently at about 1,340 degrees Fahrenheit, but when it reaches about 260 degrees, the copper begins to ooze out like Playdoh. This is because the copper atoms in the compound have a lot of room to move around in the lattice structure. That's good for electricity generation, but bad for high-temperature stability."

Poudeu's graduate researcher, Alan Olvera, proposed a solution. He hypothesized that filling some of the empty space in the atomic lattice structure with indium nanoparticles would give the copper atoms less room to move, making the compound more stable at high temperatures. So the team milled the copper, selenium and indium together, making a powder that they then compressed into pellets in a furnace.

Tests proved that the compound stayed stable under high temperature and intensive electrical generation. The team was surprised to discover that it was even less thermally conductive and more electrically efficient than the copper selenide that had been used previously, enabling it to generate electricity at still lower temps.

"Copper atoms conduct heat by vibrating, and when we add indium, the copper atoms can't vibrate as easily." said Olvera. "When the copper atoms are localized in one place, electrons are able to move more freely, producing more electricity. So we get a material that's more stable, less thermally conductive and more electrically conductive."

Earlier iterations of thermodynamic generators are already in use in a few industrial applications, and Poudeu says the new compound could be used in many of those places immediately—it's simply a matter of replacing one material with another. The new compound could also lead to wider use of thermoelectric generation in industry, as well as their use as auxiliary generators in cars and to power small household items like cell phones.

Poudeu's team is working to commercialize the technology, either by licensing it to a manufacturer with the assistance of the U-M Office of Technology Transfer or by manufacturing it directly through Suematek, LLC, a startup he founded.

The new material is detailed in a paper published in the July 1, 2017 issue of *Energy & Environmental Science*. The paper is titled "*Partial indium solubility induces chemical stability and colossal thermoelectric figure of merit in* Cu_2Se."

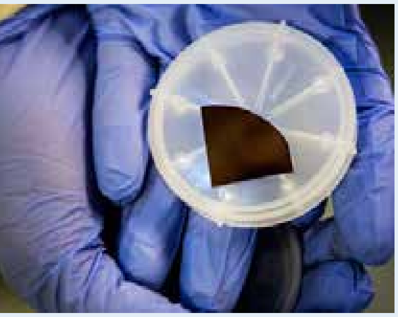
The research was supported by the Department of Energy, Office of Basic Energy Science under award DE-SC-0008574 and the U-M MCubed program.

—Story by Gabe Cherry

Assistant Professor Pierre Ferdinand Poudeu-Poudeu (left) and MSE PhD student Alan Olvera seal off glass vacuum tubes during the process of constructing a stable copper selenide material. Photos by Joseph Xu, Michigan Engineering

"Energy-intensive industries have been waiting for a low-cost, low-toxicity thermoelectric generation material. They already have applications waiting, so I think this will go into use very quickly."

— Associate Professor Pierre F. Poudeu-Poudeu



"'Magic' is not a word we use often as materials scientists. But that's what it felt like when we finally got it right."

—Professor Rachel Goldman

'MAGIC' ALLOY COULD SPUR THE NEXT GENERATION OF SOLAR CELLS

In what could be a major step forward for a new generation of solar cells called "concentrator photovoltaics," a team of University of Michigan researchers has developed a new semiconductor alloy that can capture the near-infrared light located on the leading edge of the visible light spectrum.

Easier to manufacture and at least 25 percent less costly than previous formulations, it's believed to be the world's most cost-effective material that can capture near-infrared light and is compatible with the gallium arsenide semiconductors often used in concentrator photovoltaics.

Concentrator photovoltaics gather and focus sunlight onto small, high-efficiency solar cells made of gallium arsenide or germanium semiconductors. They're on track to achieve efficiency rates over 50 percent, while conventional flat-panel silicon solar cells top out in the mid-20s.

"Flat-panel silicon is basically maxed out in terms of efficiency," said Professor Rachel Goldman, whose lab developed the alloy. "The cost of silicon isn't going down and efficiency isn't going up. Concentrator photovoltaics could power the next generation."

Varieties of concentrator photovoltaics exist today. They are made of three different semiconductor alloys layered together. Sprayed onto a semiconductor wafer in a process called molecular-beam epitaxy—a bit like spray painting with individual elements—each layer is only a few microns thick. The layers capture different parts of the solar spectrum; light that gets through one layer is captured by the next.

But near-infrared light slips through these cells unharnessed. For years, researchers have been working toward an elusive "fourth layer" alloy that could be sandwiched into cells to capture this light. It's a tall order; the alloy must be cost-effective, stable, durable and sensitive to infrared light, with an atomic structure that matches the other three layers in the solar cell.

Getting all those variables right isn't easy, and until now, researchers have been stuck with prohibitively expensive formulas that use five elements or more.

To find a simpler mix, Goldman's team devised a novel approach for keeping tabs on the many variables in the process. They combined on-the-ground measurement methods including X-ray diffraction done at U-M and ion beam analysis done at Los Alamos National Laboratory with custom-built computer modeling.

Using this method, they discovered that a slightly different type of arsenic molecule would pair more effectively with the bismuth. They were able to tweak the amount of nitrogen and bismuth in the mix, thereby eliminating an additional manufacturing step that previous formulas required. And they found precisely the right temperature that would enable the elements to mix smoothly and stick to the substrate securely.

The advance comes on the heels of another innovation from Goldman's lab that simplifies the "doping" process used to tweak the electrical properties of the chemical layers in gallium arsenide semiconductors. During doping, manufacturers apply a mix of chemicals called "designer impurities" to change how semiconductors conduct electricity and give them positive and negative polarity similar to the electrodes of a battery. The doping agents usually used for gallium arsenide semiconductors are silicon on the negative side and beryllium on the positive side.

The beryllium is a problem—it's toxic and it costs about ten times more than silicon dopants. Beryllium is also sensitive to heat, which limits flexibility during the manufacturing process.

But the U-M team discovered that by reducing the amount of arsenic below levels that were previously considered acceptable, they can "flip" the polarity of silicon dopants, enabling them to use the cheaper, safer element for both the positive and negative sides. "Being able to change the polarity of the carrier is kind of like atomic 'ambidexterity'," said Richard L. Field, a former U-M PhD student who worked on the project. "Just like people with naturally born ambidexterity, it's fairly uncommon to find atomic impurities with this ability."

Together, the improved doping process and the new alloy could make the semiconductors used in concentrator photovoltaics as much as 30 percent cheaper to produce, a big step toward making the high-efficiency cells practical for large-scale electricity generation.

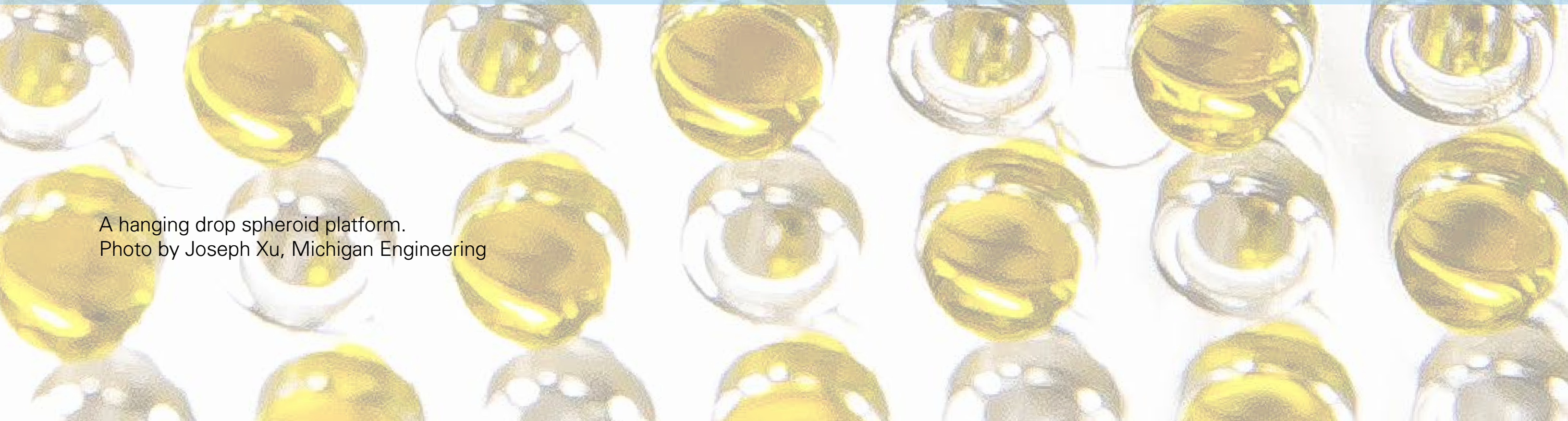
The new alloy is detailed in a paper titled "*Bi-enhanced N incorporation in GaAsNBi alloys*," published June 15 in *Applied Physics Letters*. The research is supported by NSF (grant number DMR 1410282) and the U.S. Department of Energy Office of Science Graduate Student Research. The doping advances are detailed in a paper titled "*Influence of surface reconstruction on dopant incorporation and transport properties of GaAs(Bi) alloys*." It was published in the December 26, 2016 issue of *Applied Physics Letters.* The research was supported by NSF (grant number DMR 1410282).

—Story by Gabe Cherry

Jordan Occena, a U-M graduate researcher and Sunyeol Jeon, a former U-M graduate student researcher, calibrate the molecular-beam epitaxy apparatus. The apparatus is used for spray painting the "magic" chemical cocktail onto blank gallium arsenide wafers. Photos by Joseph Xu, Michigan Engineering

FIGHTING CANCER WITH CANCER

Pooja Mehta, research laboratory tech associate, constructs a hanging drop spheroid platform. Photo by Joseph Xu, Michigan Engineering



A hanging drop spheroid platform.
Photo by Joseph Xu, Michigan Engineering

3D CULTURED CELLS COULD DRIVE PRECISION THERAPY

Honeycomb-like arrays of tiny, lab-grown cancers could one day help doctors zero in on individualized treatments for ovarian cancer, an unpredictable disease that kills more than 14,000 women each year in the U.S. alone.

A team of researchers led by MSE Assistant Professor Geeta Mehta has devised a process that can grow hundreds of cultured cell masses, called spheroids, from just a few tumor cells derived from a patient. Grown in a U-M-developed structure called a 384-hanging drop array, each spheroid is encased in a tiny droplet of a special culturing medium. This 3-D method yields cells that grow and multiply just as they would inside the body.

Eventually, those spheroids could serve as a testing ground where doctors could quickly try out many different medications, finding the best combination for an individual patient and adjusting on the fly as the disease evolves. This could help them stay one step ahead of the tumor cells inside the patient's body.

"Today we're limited to two-dimensional cells grown in bovine serum that's derived from cows. Cells grown this way often don't respond to medication the same way as ovarian cancer cells inside the body," said Mehta."Three-dimensional cultured spheroids provide a much more predictive way to test many different medications, and a way to grow many cultured cells from just a few of the patient-derived cells."

In a recent study, researchers administered cancer drugs to the cultured cancer spheroids and compared their response to that of ovarian cancer cells that had been removed from the same patient and implanted into mice. They showed that the response of the cultured spheroids accurately mirrored that of the natural cells implanted in the mice. The findings are detailed in the journal *Clinical Cancer Research.*

Mehta explains that even among cancers, ovarian cancer is particularly menacing. Its free-floating spheroids shuttle cancer through the abdomen, able to form new tumors wherever they go—the liver, the intestines, the abdominal wall. And the cells within those spheroids mutate often and unpredictably, quickly creating new strains that resist chemotherapy drugs.

Ovarian cancer's deadly adaptability contributes to a 70-percent relapse rate among patients who have had surgery to remove a tumor. It's these patients who Mehta believes may one day benefit.

The hanging drop array's hundreds of individual compartments make it possible to grow many spheroids at once and quickly gather data about multiple drugs. This is key, as chemotherapy treatment often requires complex cocktails of multiple drugs administered together. The cells could provide a way to test many such cocktails simultaneously.

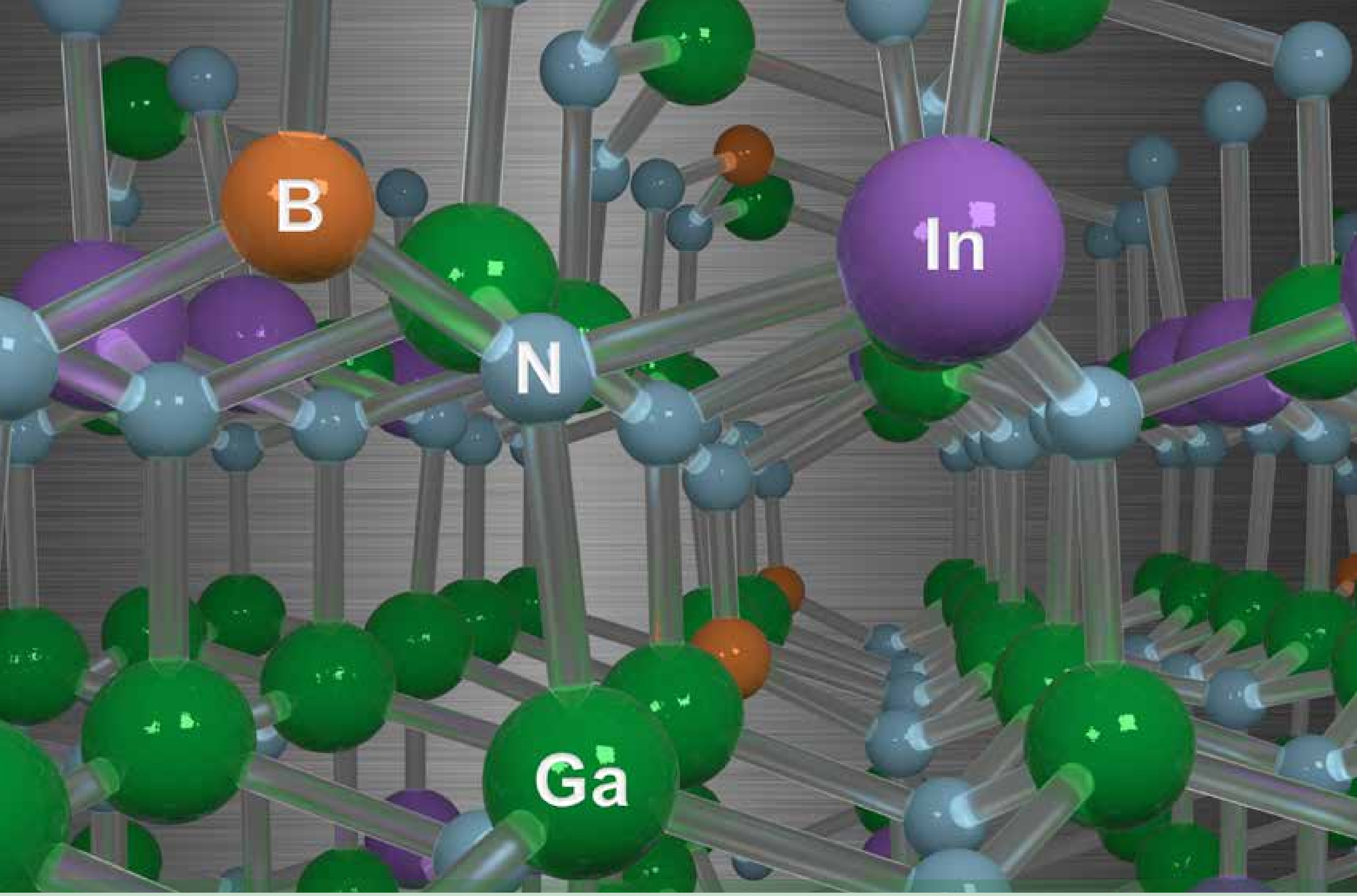
While widespread clinical use is likely years off, Mehta says the team now plans to do more extensive testing, culturing cells from patients who are undergoing chemotherapy, then administering the same chemotherapy drugs to the cultured cells and measuring their response.

"This is a really important step to expedite personalized medicine for cancer patients," said Ronald Buckanovich, a professor of medicine at the University of Pittsburgh and a senior co-author of the study. "The ability to take patients' samples, rapidly grow them in a more physiologic manner and study their response to therapy, without using mice, will be a faster, cheaper and more humane way to rapidly test a patient's response to dozens of therapeutics."

The study is titled "*Personalized medicine-based approach to model patterns of chemoresistance and tumor recurrence using ovarian cancer stem cell spheroids*." The research was supported by the Department of Defense Ovarian Cancer Research Program Early Career Investigator Awards and by the National Cancer Institute of the National Institutes of Health, award number P30CA046592.

—Story by Gabe Cherry

Ovarian cancer's deadly adaptability contributes to a 70-percent relapse rate among patients who have had surgery to remove a tumor. It's these patients who Mehta believes may one day benefit.



Crystal structure of a BInGaN alloy. (Image credit: Michael Waters and Logan Williams)

ATOMISTIC CALCULATIONS PREDICT THAT BORON INCORPORATION INCREASES THE EFFICIENCY OF LEDS

High-power white LEDs face the same problem that Michigan Stadium faces on game day — too many people in too small of a space. Of course, there are no people inside of an LED. But there are many electrons that need to avoid each other and minimize their collisions to keep the LED efficiency high. Using predictive atomistic calculations and high-performance supercomputers at the NERSC (National Energy Research Scientific Computing Center), researchers Logan Williams and Assistant Professor Emmanouil Kioupakis found that incorporating the element boron into the widely used InGaN (indium-gallium nitride) material can keep electrons from becoming too crowded in LEDs, making the material more efficient at producing light.

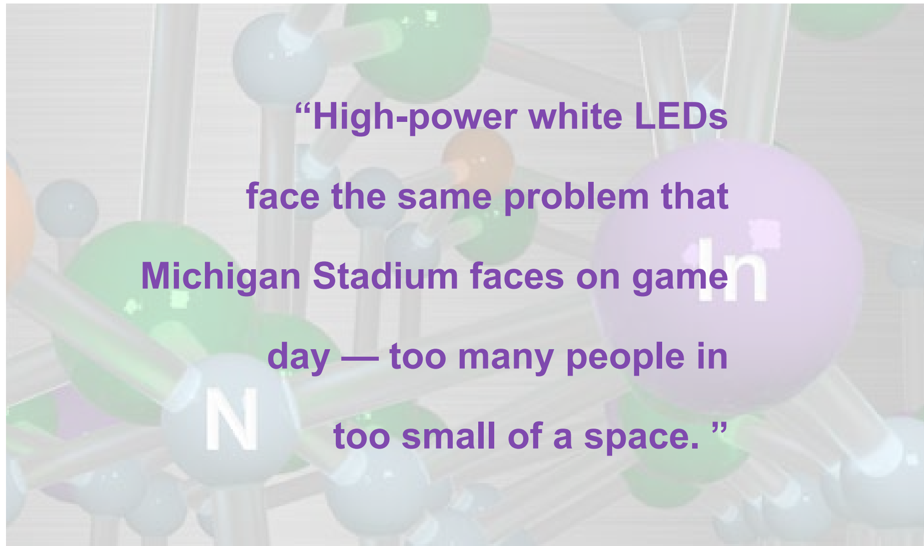
Modern LEDs are made of layers of different semiconductor materials grown on top of one another. The simplest LED has three such layers. One layer is made with extra electrons put into the material. Another layer is made with too few electrons, the empty spaces where electrons would be are called holes. Then there is a thin middle layer sandwiched between the other two that determines what wavelength of light is emitted by the LED. When an electrical current is applied, the electrons and holes move into the middle layer where they can combine together to produce light. But if we squeeze too many electrons in the middle layer to increase the amount of light coming out of the LED, then the electrons may collide with each other rather than combine with holes to produce light. These collisions convert the electron energy to heat in a process called Auger recombination and lower the efficiency of the LED.

A way around this problem is to make more room in the middle layer for electrons (and holes) to move around. A thicker layer spreads out the electrons over a wider space, making it easier for them to avoid each other and reduce the energy lost to their collisions. But making this middle LED layer thicker isn't as simple as it sounds.

Because LED semiconductor materials are crystals, the atoms that make them up must be arranged in specific regular distances apart from each other. That regular spacing of atoms in crystals is called the lattice parameter. When crystalline materials are grown in layers on top of one another, their lattice parameters must be similar so that the regular arrangements of atoms match where the materials are joined. Otherwise the material gets deformed to match the layer underneath it. Small deformations aren't a problem, but if the top material is grown too thick and the deformation becomes too strong then atoms become misaligned so much that they reduce the LED efficiency. The most popular materials for blue and white LEDs today are InGaN surrounded by layers of GaN. Unfortunately, the lattice parameter of InGaN does not match GaN. This makes growing thicker InGaN layers to reduce electron collisions challenging.

Williams and Kioupakis found that by including boron in this middle InGaN layer, its lattice parameter becomes much more similar to GaN, even becoming exactly the same for some concentrations of boron. In addition, even though an entirely new element is included in the material, the wavelength of light emitted by the BInGaN material is very close to that of InGaN and can be tuned to different colors throughout the visible spectrum. This makes BInGaN suitable to be grown in thicker layers, reducing electron collisions and increasing the efficiency of the visible LEDs.

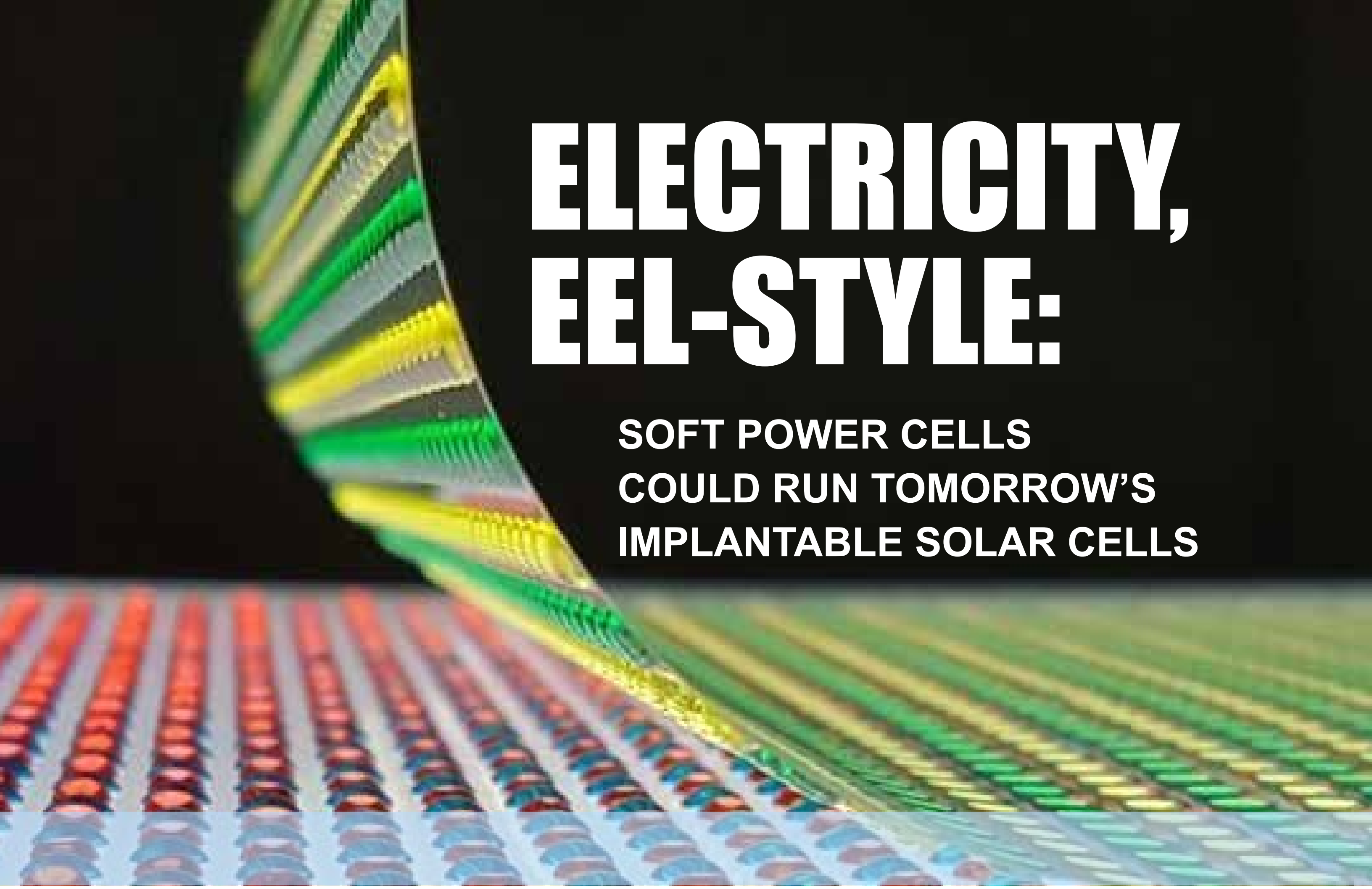
Although this material is promising to produce more efficient LEDs, it is important that it can be realized in the laboratory. Williams and Kioupakis have also shown that BInGaN could be grown on GaN using the existing growth techniques for InGaN, allowing quick testing and use of this material for LEDs. Still, the primary challenge of applying this work will be to fine tune how best to get boron incorporated into InGaN at sufficiently high amounts. But this research provides an exciting avenue for experimentalists to explore making new LEDs that are powerful, efficient, and affordable at the same time.



"High-power white LEDs face the same problem that Michigan Stadium faces on game day — too many people in too small of a space."

This work was supported by the Designing Materials to 282 Revolutionize and Engineer our Future (DMREF) Program under Award No. 1534221, funded by the National Science Foundation. This research used resources of the National Energy Research Scientific Computing (NERSC) Center, a DOE Office of Science User Facility supported under Contract No. DE-AC02-05CH11231.

—Story by Andrew McAllister and Assistant Professor Emmanouil Kioupakis



ELECTRICITY, EEL-STYLE:

SOFT POWER CELLS COULD RUN TOMORROW'S IMPLANTABLE SOLAR CELLS

Inspired by the electric eel, a flexible, transparent electrical device could lead to body-friendly power sources for implanted health monitors and medication dispensers, augmented-reality contact lenses and countless other applications.

The soft cells are made of hydrogel and salt, and they form the first potentially biocompatible artificial electric organ that generates more than 100 volts. It generates a steady buzz of electricity at high voltage but low current, a bit like an extremely low-volume but high-pressure jet of water. It's perhaps enough to power a small medical device like a pacemaker.

While the technology is preliminary, Michael Mayer, a professor of biophysics at the Adolphe Merkle Institute of the University of Fribourg in Switzerland and the corresponding author on the paper, believes it may one day be useful for powering implantable or wearable devices without the toxicity, bulk or frequent recharging that come with batteries. Further down the road, it could even lead to bioelectric systems that could generate electricity from naturally occurring processes inside the body.

The device can't hold a candle to the electric eel, which can pump out far more power in short bursts to zap prey or defend itself. But the researchers say they've taken an important first step that advances fundamental understanding of soft power sources. The team includes researchers from the University of Michigan, the Adolphe Merkle Institute at the University of Fribourg and the University of California San Diego. The work is detailed in a paper published in the December 14 issue of *Nature*.

"The eel polarizes and depolarizes thousands of cells instantaneously to put out these high voltages," said Professor Max Shtein, a co-author on the paper. "It's a fascinating system to look at from an engineering perspective—its performance metrics, its fundamental building blocks and how to use them."

One secret to the eel's success is a phenomenon called trans-membrane transport. Specialized electrical organs contain thousands of alternating compartments, each with an excess of either potassium or sodium ions. The compartments are separated by selective membranes that, in the eel's resting state, keep the two ions separate. When the eel needs to create a jolt of electricity, the membranes allow the ions to flow together. This creates a burst of power.

The researchers built a similar system, though instead of sodium and potassium, they used the sodium and chloride that are naturally combined in common table salt, dissolved in water-based hydrogel. Using a specialized printer at the Adolphe Merkle Institute, they printed thousands of tiny droplets of the salty gel on a plastic sheet, alternating them with hydrogel droplets of pure water. The alternating droplets are similar to the eel's compartments, and their differing salinity can be used to produce electricity.

Next, the team needed to mimic the eel's selective membrane that keeps the compartments separate. They used a second sheet of alternating droplets, this one made of charge-selective hydrogel. Each droplet allows either positively charged sodium or negatively charged chloride to pass, excluding the other.

To generate power, the two sheets are pressed together, connecting saline and freshwater droplets across the charge-selective droplets in series. As the salty and fresh solutions mix, the charge-selective droplets move the sodium and chloride ions in opposing directions, producing an electric current.

The researchers took one final trick from the eel: its thousands of compartments can shuffle ions instantaneously, producing a coordinated jolt just when it's needed. The researchers needed to do something similar with their thousands of alternating cells, combining them all in exactly the right order, simultaneously.

Shtein, along with graduate students Anirvan Guha of the Adolphe Merkle Institute and Thomas Schroeder and Aaron Lamoureux of U-M, solved the problem with an origami technique called a Miura fold. Invented by a Japanese astrophysicist, the Miura fold is already used to fold solar panels into satellites at launch, then unpack them into large sheets once they're in space.

They used the idea in reverse, alternating all four droplet types in a precise pattern on a flat sheet that had been laser-scored in a Miura pattern. When pressure was applied, the sheet quickly folded together, stacking the cells in exactly the right positions.

Eel Power

The Tennessee Aquarium is home to an electric eel that uses its electrical discharges to post from its own Twitter account. Named Miguel Wattson, the eel's exhibit is wired to a small computer that sends out a prewritten tweet when it emits electricity at a high enough threshold.

"The electric organs in eels are incredibly sophisticated; they're far better at generating power than we are," Mayer said. "But the important thing for us was to replicate the basics of what's happening. You need two ionic solutions of different strengths and two membranes with selectivity for different ions. If you can assemble and disassemble a large number of these four compartments in a repeating sequence in a fast and coordinated fashion, you're creating—in a minimalistic and robust way—essential parts of what the eel does."

For now, the team is working to improve the device's efficiency.

"The eel's membranes are extremely efficient at selecting between different ions, and we believe making our membranes ion-selective rather than charge-selective may get us some improvements," Schroeder said.

The paper is titled "*An electric-eel-inspired soft power source from stacked hydrogels*." The research was funded by the Air Force Office of Scientific Research and by the National Institute of General Medical Sciences of the National Institutes of Health, award number T32GM008353.

—Story by Gabe Cherry

Inspired by electric eels, researchers have developed a new soft power source that could one day provide implantable power for devices like health monitors and medication dispensers.

LIFT OFF!

ADVANCED MANUFACTURING LAB OPENS IN DETROIT

Michigan Governor Rick Snyder cuts the ribbon at the opening of the new IACMI/LIFT manufacturing facility in Detroit. From left: Office of Naval Research Program Manager Johnnie DeLoach, Congresswoman Brenda Lawrence, Senator Debbie Stabenow, Director of the IACMI Vehicle Scale Up Facility Ray Boeman, IACMI Interim CEO John Hopkins, Snyder, Deputy Director of the Department of Energy Advanced Manufacturing Office Rob Ivester, LIFT Executive Director Larry Brown, LIFT Technology Development Committee Chair Jeffrey Nichols, and Detroit Mayor Mike Duggan.

A $50 million lightweighting research and development lab that U-M helped to jumpstart opened its doors this fall in Detroit's Corktown district.

LIFT—Lightweight Innovations For Tomorrow—and IACMI, The Composites Institute, unveiled the 100,000-sq.-ft. facility, a cornerstone of LIFT's effort to establish a regional manufacturing ecosystem that moves advanced lightweight metals out of the research lab and into tomorrow's cars, trucks, airplanes and ships for both the commercial and military sectors.

Expected to contribute to economic development and positive job impact in Detroit and beyond, LIFT opened this past fall with much fanfare. MSE Professor Alan Taub serves as LIFT's Chief Technology Officer.

"The metalworking industry in our country already employs almost half a million people," said LIFT Chief Technology Officer and MSE Professor Alan Taub. "Through LIFT technology advances and education, we are enabling further growth."

LIFT, formerly the American Lightweight Materials Manufacturing Innovation Institute (ALMMII), launched in 2014 as a partnership among U-M, Ohio State University and Ohio-based manufacturing technology nonprofit EWI. The institute is a node in the National Network of Manufacturing Innovation, an Obama administration White House initiative to help U.S. manufacturers become more competitive. It is now called Manufacturing USA. U-M faculty played pivotal roles in helping to conceive and shape this network.

With more than 74 member organizations, LIFT is expected to contribute to economic development and positive job impact in Detroit and eventually stretching to the five-state region of Michigan, Ohio, Indiana, Tennessee and Kentucky over the next five years. Most of these jobs will be in the metal stamping, metalworking, machining and casting industries that are dominant in the Midwest region.

Beyond its R&D efforts, the institute aims to help educate the next generation of manufacturing's technical workforce. LIFT will engage workforce partners from across the region to strengthen education and training pathways to high quality jobs in all transportation manufacturing sectors, including the automobile, aircraft, heavy truck, ship, rail and defense industries.

PRISMS Center secures DOE funding for 3 years

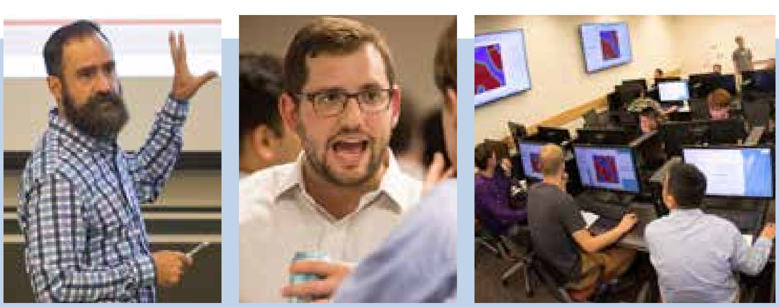
Founded in 2012, the PRISMS Center is a major Materials Genome Initiative materials software innovation center, and the only one of its kind focused on structural metals. The center is funded by the Department of Energy (DOE-BES) and the big news this year was that funding has been renewed for an additional three years.

PRISMS also released a new code this year, DFT-FE, which solves density functional calculations in real space using a unique finite element framework. This is being used to simulate and study dislocation core structures in aluminum and magnesium. We also released next generation versions of all of the PRISMS software for statistical mechanics, phase field and crystal-plasticity simulations. The codes, which are available for free, are currently being used by more than 600 researchers worldwide.

On the science side, PRISMS continues to investigate microstructural evolution and mechanical behavior of advanced, high strength magnesium alloys. Very significant progress was made in the past year in understanding the complex precipitation processes that occur in Mg-rare earth alloys, including documentation of a new precipitation sequence in Mg-Nd type alloys. This required the combined efforts of experimentalists and use of PRISMS statistical mechanics and phase field codes. On the property front, the results of the PRISMS crystal plasticity code were coupled with those from advanced experimental methods to quantify and predict the influence of precipitate structures on strength and fatigue.

In addition to the PRISMS software, another major effort was a major upgrade to the PRISMS information repository and collaboration platform known as the Materials Commons. All experimental data from the PRISMS Center is being made available to the public using this new repository. It is also available to the broader technical community for publishing information.

In keeping with its community outreach priority, PRISMS held two workshops this year to train new users and exchange technical information. Over 75 researchers from around the globe attended. The next workshop will be Aug 6-10. For more information: www.prisms-center.org.



Events from the PRISMS Workshop in August: (left) Dr. Corbett Battaile, from Sandia National Laboratories, gives a presentation, (middle) Center member Steve DeWitt at a poster presentation, and (right) a PRISMS-PF training session in Beyster.

(MC)² gets an upgrade

MC)², the Michigan Center for Materials Characterization, reports another productive year of training students and researchers, supporting cutting edge research on campus and at nearby universities and local industry, and participating in outreach events in museums and middle and high schools around the Ann Arbor area.

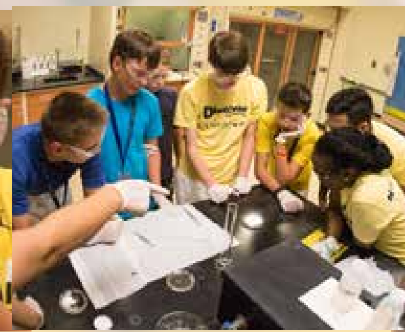
Earlier in the year (MC)² upgraded its atom probe tomography instrument with a new detector by swapping its Cameca LEAP 4000 XHR with a Cameca LEAP 5000HR. They expanded their capabilities with a Zeiss Xradia 520 Versa tool, which enables them to conduct 3D x-ray microscopy and computed tomography. An NSF-MRI-funded multi-modal scanning electron microscope has also been ordered and will be delivered early 2018.

(MC)² upgraded its atom probe tomography instrument with a new Cameca LEAP 5000HR.

In October (MC)² hosted the Michigan Microscopy & Microanalysis Society Annual meeting featuring talks from Prof. Hovden (MSE), Prof. Ohi (LSI), Prof. Li (Earth Env Sci), Prof. Goldberg (Oakland U.), and Dr. Carroll (Eaton Corp.), spanning a broad spectrum of applications and techniques.

Current information regarding access, training, instruments, seminars and other events can be found on the center's website: mc2.engin.umic.edu. Center Director Emmanuelle Marquis encourages people to contact them, "whether for materials analyses, to use our instruments or acquire your own instruments, attend our seminars, or simply share ideas."




Xplore Engineering

"Whoooooa, that's so cool!"
"Can I touch it? Can I touch it?"
"Is my ice cream warm enough to eat now?"

On June 22 and 23, the Van Vlack Lab was bustling with kids aged 8-13 participating in hands-on materials science activities during the college's annual Xplore Engineering event, which this year drew hundreds of alumni families to campus. Xplore Engineering is designed for alumni and the children in their life entering the 4th-7th grade. Through a series of experiential workshops, participants get hands-on experience in a variety of engineering disciplines.

The MSE workshop, called eXtraordinary Materials and led by Dr. Tim Chambers, included three interactive activities: "Microscopy of Unknown Materials," "The Iron Wire," and (definitely the sweetest one) "Cryogenic Ice Cream."

"I tried to pick activities that would show that the world of MSE can be delicious, fun, educational, and exciting all at the same time," said Chambers.

Clearly his goal was achieved as evidenced by one father, who, on his way out stopped to tell Chambers, "I think you just lit something in my son's brain. He's never thought about this stuff before, so thank you."

"I tried to pick activities that would show that the world of MSE can be delicious, fun, educational, and exciting all at the same time."

—Tim Chambers

Discover Engineering

When Discover Engineering students walked into the Van Vlack Lab this summer, they were greeted by the following message sprawled across a big, free-standing whiteboard:

"Welcome to the room where we BREAK things (and then analyze them)."

For two days, July 27 and 28, students discovered the joy of not only breaking things, but also poking and prodding hydrogels and cutting kirigami structures – all part of Discover Engineering 2017, an annual program designed for alumni and 8th–10th grade kids who want to explore various engineering disciplines.

"Our goal was to teach students about MSE – what it is, what it's sub-fields are, how it is useful in daily life, and what some of the common applications are that they might be familiar with," explained Assistant Professor Geeta Mehta, who organized this year's MSE events. "We gave the many opportunities to learn about MSE-centric topics with hands-on experiences."

"The kids responded so well," summed up graduate student Rose Cersonsky, who led a workshop where kids got to break materials using both a hammer and tensile tester. "Kids love to break things, and were blown away at the fact that MSEs learn so much from breaking things."

Education Outreach





Elementary Science Olympiad

This past spring, MSE Professors Katsuyo Thornton and Max Shtein captivated elementary students with the physics of light during four hands-on workshops held in conjunction with the 2017 Washtenaw Elementary Science Olympiad (WESO). The sessions, which took place in March, were held at Scarlet Middle School to train students and their coaches from across the Washtenaw County who were preparing for the category "Photon Phun."

Aimed at raising interest in science in Washtenaw County, WESO is the largest Science Olympiad at the elementary level in the U.S. (and in all likelihood the world), attracting more than 2,500 2nd-5th graders this year from more than 40 elementary schools.

At the final WESO competition, held June 4 at Pioneer High School, Professors Thornton and Liang Qi hosted a materials science booth to share some of the activities from the workshops as well as additional materials relevant to crystal structures and phase transformations. Later in the afternoon, Thornton and Shtein helped hand out medals at the fourth-grade awards ceremony.

"It can't be overstated how important it is to engage students in science at an early age to increase the pool of future scientists and engineers."

ASM Teacher's Camp

This past July, UM-MSE hosted the annual ASM Teacher's Camp. High school and college teachers came from across the country and around the world to develop their knowledge of MSE content, to learn new lessons and experiments to bring back to their own students. The camp was led by ASM Master Teachers Andy Nydam, Debra Goodwin, and Todd Bolenbaugh, with a large support crew, including Keith McIntyre and Tim Chambers from our department.

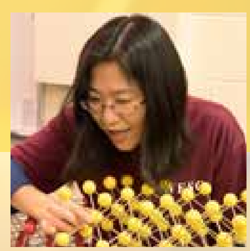
Attendees spent five days performing experiments, enjoying presentations, and holding discussions in MSE classrooms and the Van Vlack Lab. Some highlights included prototyping lightweight concrete beams, learning about electron microscopy, drawing fiber optic cables, and glazing pottery using reduction-oxidation reactions.

Many of the teachers were second-year attendees preparing to launch materials science classes at their own schools, or who had recently started materials science programs in their home schools and were eager to expand their offerings.

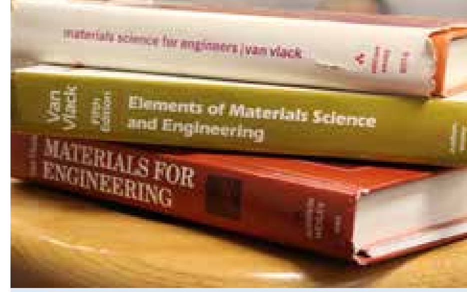
"It is our hope that these teachers will bring this understanding to their students, preparing them to continue exploring and appreciating the world of materials well beyond their high school years," said Chambers.

"It can't be overstated how important it is to engage students in science at an early age to increase the pool of future scientists and engineers."

—Prof. Katsuyo Thornton



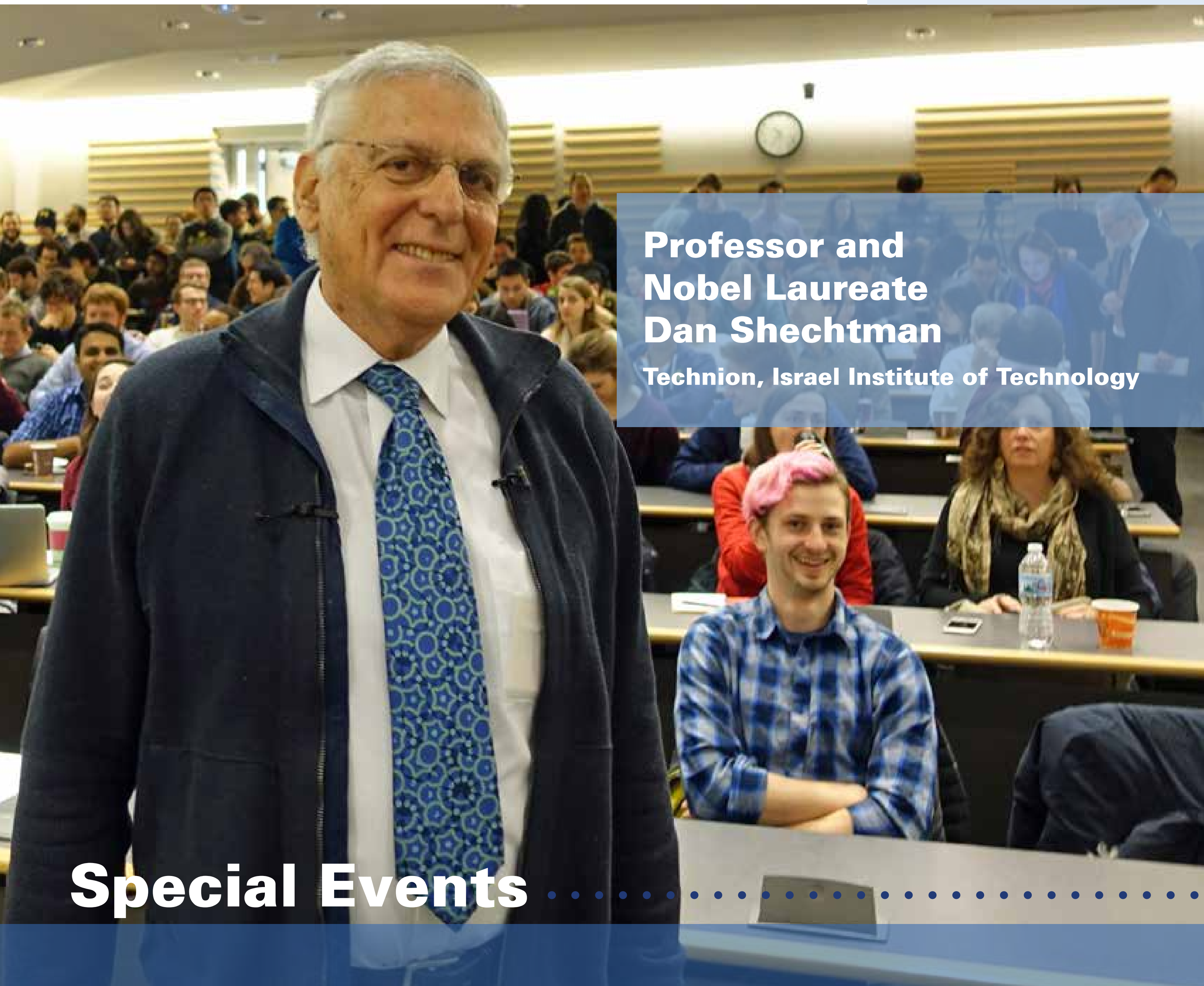
UNIVERSITY OF MICHIGAN BICENTENNIAL



Van Vlack Lecture Series features two lecturers

The Van Vlack Lecture Series featured two engaging speaker presentations this year. In honor of the Bicentennial, Professor and Nobel Laureate **Dan Shechtman**, from Technion, Israel Institute of Technology, presented "Quasi-Periodic Crystals - A Paradigm Shift in Crystallography" on February 10. Then, on September 28 and 29, Professor **Ramamoorthy Ramesh** (Dept. of Materials Science & Engineering and Dept. of Physics, Univ. of California, Berkeley, Materials Sciences Division, Lawrence Berkeley National Laboratory) presented "Energy: The True Final Frontier" and "Electric Field Control of Magnetism." To watch Ramesh's presentation online, go to bit.ly/2mORXbv

The Van Vlack Lecture Series was established in honor of L. H. Van Vlack, to provide a distinguished lecture series from the outstanding leaders in the field of Materials Science & Engineering.



Professor and Nobel Laureate Dan Shechtman

Technion, Israel Institute of Technology

Special Events

Professor Ramamoorthy Ramesh

Dept. of MSE and Dept. of Physics, Univ. of California, Berkeley

Materials Sciences Division, Lawrence Berkeley National Laboratory

On September 28, in the Gerald R. Ford Library, Professor Ramamoorthy Ramesh began his hour-long Van Vlack Lecture by harkening back to 1969 and how energized and motivated the entire nation was listening to the first moon landing through crackling radios. He argued that we need to be that motivated again—both individually and collectively—especially when it comes to today's pressing energy-related materials science needs.

"Let's not forget, this is the most creative country in the world," Ramesh told the audience.

In 2010, Ramesh was tapped by an Obama-era Department of Energy project called the Sunshot Initiative, which was tasked with shrinking the costs of solar energy. It was a challenge he was more than happy to take on.

"As an immigrant it was the best way I knew to serve the nation that had been so incredibly good to me," said Ramesh.
His experience with the Sunshot Initiative gave him insight into program management ("It's all about the people"), as well as the urgent need for innovation in the energy field, including thinking outside the lithium box with batteries and energy storage. "What we need from materials scientists is an understanding of the interaction of protons with chemical species and how to store energy and retrieve it at some other point," Ramesh said.

Another burgeoning arena is microelectronics, a field that currently makes up only four percent of our total energy consumption. But, Ramesh warned, the semiconductor field, currently a $300 billion industry, is estimated to balloon to $5 trillion by 2030. "There's a revolution happening that no one's paying attention to," he said, adding that the global competition the U.S. is facing is 'fierce.'

Ramesh ended his lecture by playing an audio recording of John F. Kennedy's "Ask not what your country can do for you, but what you can do for your country" speech. "Never has it been more appropriate for our country," Ramesh stated. "It's the embodiment of what every American should be thinking."

"There's a HUGE need for energy innovation right now. People should be going gangbusters making new materials, looking at new structures, new composites... In fact, after this lecture we should all leave and go straight to the lab."

M@M17 Speakers

Engineered Matter: Beyond the Materials Genome
Prof. Sharon Glotzer, Dept. Chair, Chemical Engineering

Materials for Drug Delivery
Prof. Ron Larson, Chemical Engineering

Materials for Tissue Engineering
Prof. Peter Ma, Dentistry

Materials for Energy Conversion and Storage
Prof. Ted Goodson III, Chemistry

Organic Materials for Optoelectronics
Prof. Stephen R. Forrest, ECE

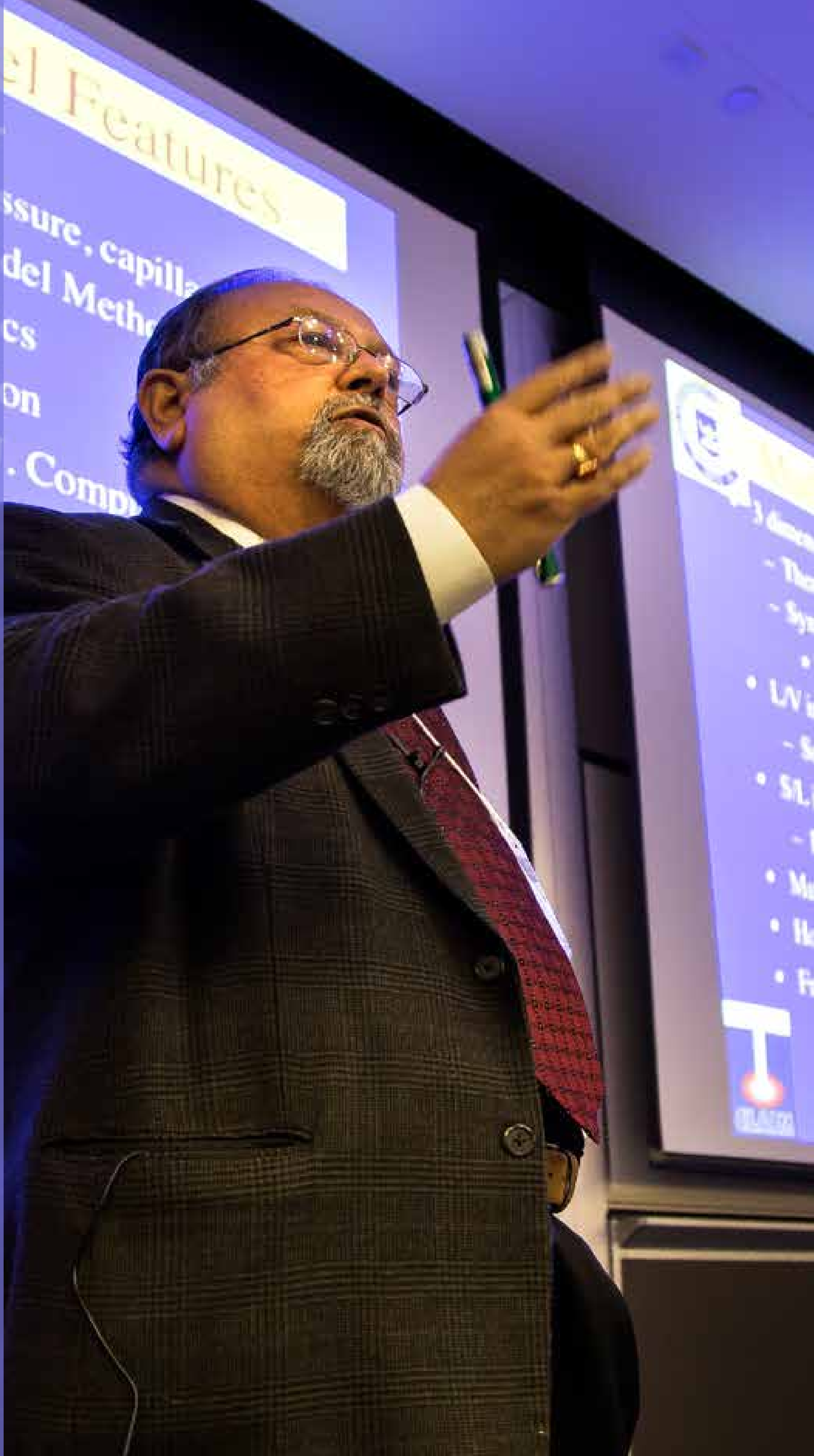
Materials for Energy Efficient Optoelectronics
Prof. Pallab Bhattacharya, ECE

Ultrafast - Ultrasmall: Nano-materials from Femtosecond Lasers
Prof. Roy Clarke, Physics

Lightweight Materials for Transportation
Prof. Alan Taub, MSE

Laser-Engineered Materials for Transportation and Infrastructure
Prof. Jyoti Mazumder, ME

Integrated Computational Materials Engineering
Prof. John Allison, MSE



MSE Professor Jyoti Mazumder during his Laser-Engineered Materials for Transportation and Infrastructure presentation.

Special Events

UNIVERSITY OF MICHIGAN BICENTENNIAL

MATERIALS AT MICHIGAN

M@M 17

In conjunction with the University's Bicentennial celebration, MSE presented a special two-day Materials at Michigan (M@M) Symposium on October 16 and 17. The symposium celebrated the broad impact of advanced materials research on society with a series of keynote lectures from some of the most distinguished materials researchers at U-M. The special event also featured talks and posters from selected graduate students from different programs across the U-M campus engaged in advanced materials research. To watch the M@M presentations, go to http://bit.ly/2B3jLgM


Rachel Goldman


Sharon Glotzer


Alan Taub


Steve Ceccio, Vincent T. and Gloria M. Gorguze Professor and Associate Dean for Research, makes some introductory remarks on Oct. 16.

Materials Research Graduate Symposium winners

Oral Presentations

Alan Olvera, MSE - Gold Award

Mathew Boban, MACRO - Silver Award

Chengang Ji, EECS - Silver Award

Saeed Kazemiabnavi, ME - Silver Award

Poster Presentations

William LePage, ME - Gold Award

Chen Li, ME - Silver Award

Aeriel Murphy, MSE - Silver Award

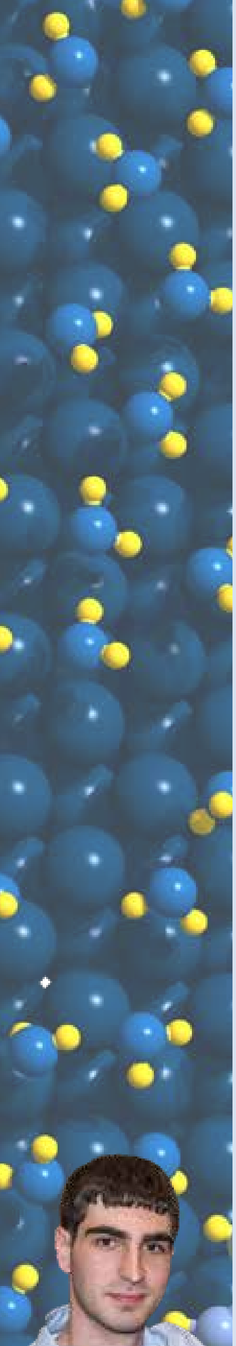
Jill Wenderott, MSE - Silver Award

Student News

MMS Update

MMS has started off the year strong with our weekly luncheons every Friday. We've had speakers present for us from General Mills, 3M, BASF and more. Our annual ASM Professional/Student Mixer at Conor O'Neill's was a big success and great opportunity for students to meet professionals. Looking forward to this semester, we will be hosting a department outreach event centered around discovering materials science through chocolate! If you are interested in having your company speak at a weekly luncheon, please contact michiganmaterialssociety@umich.edu.

—*Sahil Dagli, president of MMS*



Undergraduate student awards

Richard A. Flinn Scholarship
Hamza Haque, Catherine Haslam

Fontana-Leslie Scholarship Fund
Nicole Chiu, Rebecca Cohn

James W. Freeman Memorial Scholarship
Tristan Blanzy, Allison Podnar, Luis Rangel DaCosta

John Grennan Scholarship
Carli Huber, Matthew Sweers

Jack J. Heller Memorial Engineering Scholarship Fund
Chandler Humphrey

William F. Hosford Scholarship
David Frank, Ron Keinan, Megan Liu, Morgan Meade, Magel Su

Schwartzwalder Memorial Scholarship
Zheng Dong, Leah Hummel, Brendan Warren, Elizabeth Zwier

Clarence A. Siebert Memorial Scholarship
Aaron Adiwidjaja, Asia Dillard, Alycia Gerber, Ashlynn Stanley

Alfred H. White Memorial Scholarship
Sahil Dagli, Kuan-Hsiang Hsu, Declan Shannon

Brian D. Worth Prize
Catherine Haslam

MMS Anvil Award
Clare Hyde

James P. Lettieri Undergraduate Award
Xiaoer Hu

CoE Distinguished Achievement Award
Rebecca Cohn

Undergraduates (front) Kimberly Kyanka, Clare Hyde, Allison Ward, (middle) Gina Sancricca. Erica Siismets, Colette Verch, Elyse Fleck, (back) Connor Rittman, Nicholas Folz, Daniel Lee, and Graham Keep gather at the 2017 MSE Graduation and Awards dinner on April 13.

Robotics Blacksmithing team takes 3rd in national competition

In May the Michigan Robotics Blacksmithing team captured third place in the first-ever national LIFT Robotic Blacksmithing Competition. Sponsored by LIFT—Lightweight Innovations For Tomorrow—the competition challenged students to program robots to make two of the following three forms: a horseshoe, a goblet, and a bracket out of plasticine.

"LIFT sponsored the competition as a way to excite students about the new agile manufacturing processes that are starting to emerge in the structural metals components industry," said LIFT Chief Technology Officer and MSE Professor Alan Taub.

This was the first time a Capstone Engineering Design course project participated in a nationwide competition.

The team consisted of students from MSE, ME and EECS and required all of their respective disciplines to select the right materials, design the tools, and program the robot to produce the prototype component.

"The team had fun, even in the last minute crunch, getting the robot to execute its final movements in time," said Taub.

Team members Alexander Mills (EECS), Alissa Recker (MSE), Yang Pan (MSE), Carli Huber (MSE), Colton Wood (ME), Brian Schultze (ME), with ME Professor Elijah Asibu and MSE Professor Alan Taub.

Harris-Martin wins CoE's prestigious Rumler Prize

Analyzing water filtration systems for the Flint water crisis, marketing a diabetes sock, and starting a community girls' club are just a few of the accomplishments of Azia Harris-Martin (BSE '17), recipient of this year's prestigious Hugh G. Rumler Prize, an award presented annually by the College of Engineering to an outstanding senior "on the basis of sincerity, integrity and goodwill." Harris-Martin is the first MSE student in more than 13 years to win the prize, which comes with a $10,000 stipend.

"I was really shocked and humbled by the award," stated Harris-Martin, who is pursuing a master's in public health this fall at Emory University in Atlanta.

My New Zealand Experience

by Matt Sweers '18

Our work in New Zealand was on a tract of land in the Auckland suburb of Orakei. The land was given back to the Maori people a few decades ago by the New Zealand government. The major project we helped with was an attempt to restore native forests to a large region of grassland.

This project, started 17 years ago, has made immense progress and the forest is off to a very strong start. What were once fields of grass are now a dense forest of trees and shrubs native to the area—all accomplished without the use of insecticides and fertilizer. Still, there is much work to be done. The trees only cover about a third of the total land and only stand about 20 feet tall. A few native birds, whose coming will signify that the forest was successfully restored, have yet to appear.

The best part of working on the forestry project was talking to the people who work there daily. It was a joy to talk to each of them and learn about their lives not only as Maori, but as young adults who enjoy the same things we do. We had many arguments about which video games were superior, which rappers had better lyrics, and which basketball team would win the NBA finals. These conversations broke any preconceived assumptions we had about their lifestyle.

The New Zealand trip was an incredible experience. The work we did was meaningful and allowed us to gain more cultural awareness.

2017 Employer List

Our 2017 graduates matriculated to the following employers:

Accenture
AK Steel
Alcea Houmet
Avery Dennison
Bettis Atomic Power Lab
Boeing
Corning Corp.
Cymer
Diamler Trucks
Dow Chemical
DTE
Eaton Corp.
Element Materials
Epic
Exponent
Fiat Chrysler
Ford
Fraunhofer CLA
GE Aviation
General Mills
General Motors
Gerdau
Google
Harris Corp.
Honda of South Carolina
Intel
Janssen Pharmaceuticals
Kautex Textron
Kraft Heinz
Lam Research
LBNL
Lear Corporation
Lockheed Martin
Manhattan Associates
Meritor Inc.
MGA Research
Microsoft
Moeller Aerospace
Novelis
NSK
Nucraft Furniture
PPG
Pratt & Whitney
Proctor and Gamble
Rockwell Automation
Schlumberger
Scientific Anglers
Shell
SpaceX
Texas Instruments
Timkin
Toyota
Trynex Int'l
Whirlpool

U-M SWE: Making an impact in Liberia

In August 2017, four graduate students and four undergraduates from the U-M's Society of Women Engineers (SWE) chapter travelled to Monrovia, Liberia, to implement the third annual professional, leadership, and academic development camp for undergraduate Liberian women engineers at the University of Liberia. Of the U-M students who travelled to Liberia, three were from the MSE department: PhD candidates Aeriel Murphy and Jill Wenderott, and senior undergraduate Becca Cohn. The camp historically was born out of a collaboration between UM-SWE and the recently-formed Liberia-SWE chapters. The two-weeklong camp centered around interactive workshops in the classroom, engineering demonstrations, and social activities. The workshops ranged from applying to graduate school and mentoring to setting and achieving goals and conflict resolution. The engineering demonstrations were also diverse and included building bottle rockets and hoverboards, re-creating a coastal oil seep in a plastic cup, and producing reinforced concrete hockey pucks. A new element integrated into this year's camp was the creation of a case study by small teams to propose solutions for the waste management issue in Liberia. During the evenings, there were activities, like movie night, talent shows, and kickball games to promote cultural exchange and relationship-building. The camp deeply impacted all participants, and we would like to personally thank the MSE department for their support of this camp.

—Jill Wenderott and Aeriel Murphy

Becca Cohn, Aeriel Murphy, Jill Wenderott

Jill Wenderott (center) celebrates with her team during a kickball game with undergraduate women engineers at the University of Liberia.

Graduate Student Council update:
Uniting the graduate community with professional and social events

Mujan Seif and Avi Bregman, winners of the ugly sweater contest at the GSC holiday party.

The school year was an exciting year for the Graduate Student Council (GSC). The group kicked the year off with the annual Graduate Student Chili and Cornbread Cook-off. Next they planned a Holiday Party with the Chemical Engineering Graduate Student Council. The party consisted of a dinner, cookie decorating station and an ugly sweater contest. To help graduate students looking for a job in industry, the group hosted a "How to turn your CV to a resume" workshop where students could get live feedback on their resumes from an expert. The group ended the school year with an annual meeting with MSE Chair Amit Misra to discuss issues and concerns in the MSE graduate student community. For the upcoming school year the group will continue to host events that unite the graduate student community through professional and social interactions.

Graduate student awards

MSE Graduate Student Council

Erika Salem, Jill Wenderott, Kathleen Chou, Ashley Hilmas, Keara Saud, Ben Swerdlow, Avi Bregman, Aeriel Murphy

MSE Graduate Service Award for Recruiting

Brian Tobelmann, Keara Saud, Erin Evke, Peter Meisenheimer

CoE Distinguished Leadership

Erika Salem

Rackham Predoctoral Award

Jihang Lee

National Defense Science and Engineering Graduate Fellowship (NDSEG)

Ben Swerdlow

MSE 1st Publication Award

- Class of 2015 – Kelsey Mengle
- Class of 2014 – Yichen Wang
- Class of 2013 – Christopher Ryan Tait

Engineering Graduate Symposium

Ben Derby - 1st prize, Chemical Physics
Jill Wenderott - 1st prize, Functional Material Research
Catherine Snyder - 2nd prize, Functional Material Research
Anurag Panda - 6th prize, Optics, Photonics, and Solid-State Devices
Talia Barth - 2nd prize, Structural Material Research
Bryan Van Saders - 3rd prize, Structural Material Research

Aeriel Murphy inducted into Bouchet Graduate Honor Society

Aeriel Murphy, a PhD candidate in Prof. Allison's group, was inducted into the Bouchet Graduate Honor Society. The prestigious society honors the legacy of Dr. Bouchet who was the first African American to complete a PhD in the United States, in physics at Yale University in 1896. In April she traveled to Yale University with the fellow members of the 2016 class of inductees from around the country for the official Induction Ceremony. By virtue of this honor she has become part of a national network of scholars that are setting the pace for the central roles of diversity, excellence, and innovation in graduate education.

2017 Alumni Merit Award winner Kim Flesner ’84

Finding success in engineering failures

Kim Flesner ’84 shared her experiences analyzing engineering accidents – including the Exxon Valdez – while on campus October 27.

The career inspiration for Kim Flesner (BS ’84 Materials and Metallurgical Engineering), this year’s MSE Alumni Merit Award winner, came to her, well, by accident.

“It was my sophomore year and my first materials class,” Flesner explained to faculty and students at the start of her award lecture on October 27. “I was sitting in the front row and Dr. (Dick) Flinn came in on a Monday morning and shared how he had testified the Friday before as an expert at a trial involving material failure analysis, and I’m there in the front row going, ‘COOL!’ I was struggling to figure out a major and after I got 100 percent on my first materials test, I switched to MSE (then Metallurgy) the very next day. I thought, ‘This metallurgy is for me.’”

And indeed, it was.

A failure analyst for more than 30 years, Flesner currently serves as leader of Materials Engineering and Forensic Practices and principal at Stress Engineering Services, an employee-owned company in Houston where

Alumni Achievements

Dr. Dawn Bonnell (BSE '83, MS '84, PhD '86), Vice Provost for Research at the University of Pennsylvania, presented the second Distinguished Alumni Lecture on April 14. Established in 2016, the Distinguished Alumni Lecture is an award that recognizes alumni who have made seminal contributions to materials research, as evident by published scholarship, patents/technology transfer, mentoring of early career materials researchers, and service to the materials profession.

The American Foundry Society (AFS) Board of Awards unanimously awarded **John (Chip) Keough** (BS '77 Materials and Metallurgical Engineering) the Thomas V. Pangborn Gold Medal. Keough will accept the award in April at the 122nd Metalcasting Congress in Fort Worth. In 2005, Keough founded Ann Arbor-based Joyworks LLC, a prototype design and casting studio (specializing in casting conversions). Currently an MSE adjunct professor, Keough also serves on the department’s External Advisory Board and in 2004 earned MSE’s Alumni Merit Award.



Kim Flesner presents an overview of her career on Oct. 27. At the far left she poses with Jody Hall, her former U-M roommate and current EAB member. Hall was named the MSE Alumni Merit Award recipient in 2007.

she has worked since 1999. Throughout her career her roles have primarily involved analyzing failures and investigating accidents in the oil and gas industry -- assignments that she says were often dirty, greasy and tick-infested.

"Not at all like you see on TV," she quipped.

One of her earliest and most notable jobs was conducting accident reconstruction work on the infamous Exxon Valdez, an oil tanker that in March 1989 struck a reef, spilling almost 11 million gallons of oil into Alaska's Prince William Sound. Fresh out of graduate school at the time, Flesner was tasked with determining how much damage existed immediately after impact, which meant watching 27 VHS tapes (each six hours long) of divers filming the ship's hull. It took her two and a half months and several bouts of sea sickness to view them all, but she said it was one of the "most fun" jobs she's ever worked on.

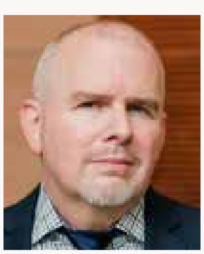
Drawing on her experience analyzing the Valdez and countless other engineering accidents, Flesner warned students that companies and society cannot afford disasters, which means the onus is on them. "Engineers must be right in all phases of a project," she stated, "from design to analysis testing, fabrication, operation, and maintenance."

An MSE degree, though, she added, will give them an all-important career edge. "The world is your oyster," she said. "You don't realize all the things you can do with this degree."

But after her engaging front-row look at failure analysis, students say they definitely now have a better idea.

MSE graduate student Ben Derby agreed: "Using failure analysis to assess the critical materials' deficiencies in the Exxon Valdez oil spill disaster is not usually what we envision a material scientist doing. Hearing an alumna using the knowledge and skills she gained right here in our department was truly encouraging. I am heartened that the skills I gain here will not only serve me well in my career, but could also have a broad and positive impact on society as a whole."

"The world is your oyster. You don't realize all the things you can do with this degree."



Dr. Keith Bowman (PhD '87) was appointed dean of the College of Engineering and Information Technology at University of Maryland, Baltimore County. Previously Bowman served as dean of the College of Science & Engineering at San Francisco State University for two years, following his leadership as chair of the Department of Mechanical, Materials, and Aerospace Engineering at Illinois Institute of Technology for nearly four years, and nearly five years leading the Purdue School of Materials Engineering.

Dr. Qinghuang Lin (PhD '94), a research staff member of the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y., was honored by SPIE (The International Society for Optical and Photonics Engineering) with a promotion to the rank of a 2017 SPIE Fellow in January. This was the third Fellowship title he has received. Dr. Lin was promoted to an SPIE Fellow "for achievements in materials and processes for lithography." One of 71 new inductees, Lin received his SPIE Fellow plaque at the SPIE Advanced Lithography Symposium held on Feb. 27 in San Jose, Calif.

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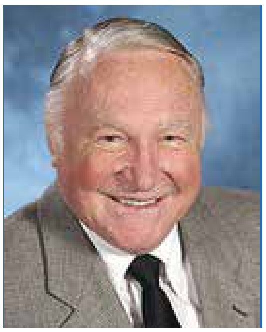
MSE receives special donor gifts

Generous donor gifts in 2017 include three new graduate fellowships, a lectureship, and two new lab furnaces



The Robert D. & Julie A. Pehlke Endowed Fellowship Fund & The Robert D. Pehlke Lectureship in Materials Processing

Robert D. (BSE MetE '55) and Julie A. Pehlke have provided a gift to endow the Robert D. and Julie A. Pehlke Endowed Fellowship Fund. Pehlke has also endowed the Robert D. Pehlke Lectureship in Materials Processing. This lecture will feature topics about or concerning materials processing, and the endowment fund will cover expenses related to the lecture, such as speaker honorarium, transportation, lodging, and hospitality. A professor emeritus, Pehlke joined the U-M faculty in 1960 and served several terms as chair of MSE. He has received many awards and honors for his contributions to the field of materials engineering, including the 2005 MSE Alumni Merit Award.

"My father and I both ... have been grateful for the high quality education U-M provided and the doors it opened for exciting careers built upon a foundation in materials science and engineering. I'm pleased that my wife and I can express our gratitude to the College by funding some of the education of future students."

—Dr. Walden C. Rhines

The Frederick N. Rhines Fellowship Fund

Dr. Walden C. (BSE Met.E. '68) and Paula H. Rhines provided a gift of endowment to establish the Frederick N. Rhines Fellowship Fund. The Rhines created this fund in honor of Dr. Rhines' father, Dr. Frederick N. Rhines (BSE ChE '29). Both Dr. Rhines and his father graduated from the U-M College of Engineering, with degrees in Chemical/Metallurgical Engineering. Since 1993, Dr. Rhines has served as the CEO and chairman of Mentor Graphics, a leader in worldwide electronic design automation. He is a recognized spokesperson for the semiconductor and electronic design automation industries with over 40 years of experience in this field. His father, Dr. Frederick N. Rhines, was an engineering professor at the University of Florida. He founded the Department of Materials Science and received the prestigious 1972-73 Scholar of the Year award by the University of Florida.

Keough Family Foundation Donates New Lab Furnaces

"We are so excited about the new furnaces in the Van Vlack Lab," said Tim Chambers, MSE engineering technician.

One furnace is a large-capacity air melt furnace for projects such as casting prototypes of metal parts and components. The other is a vacuum-induction furnace, which will enable precise control of chemical composition and environment for alloy development.

MSE plans to incorporate both furnaces into the upper-level curriculum to give students the opportunity to create and test their own alloys and to make metal components in their design and research projects.

The Harry Ferrari Student Fellowship Fund

The Estate of Harry M. Ferrari (MSE '55, PhD '58) provided a gift for endowment to establish the Harry Ferrari Student Fellowship Fund. Born in Detroit, Dr. Ferrari joined the Westinghouse Electric Atomic Power Division after receiving his doctorate degree from U-M. At this company, he was instrumental in developing nuclear fuel materials and designs that power nuclear plants worldwide today. As a prolific author of technical articles, Dr. Ferrari lectured around the world and received many prestigious awards. Dr. Ferrari also founded Gamma Sports, a global manufacturer of tennis equipment, combining his interests in tennis and the innovation of new materials.

From top: EAB Chair Jason Hertzberg, Ray Decker, and Sue Hartfield-Wünsch.

The External Advisory Board sets new goals

October 27 was a full day for MSE's External Advisory Board (EAB) as members received a comprehensive overview of the department from various faculty members, met in private with College of Engineering Dean Alec Gallimore, and set goals for the new year. As EAB Chair Jason Hertzberg (PhD '97) explained:

"When we met in October we focused on two specific activities, career guidance and recruitment," said EAB Chair Jason Hertzberg. "With respect to career guidance, the board felt that there would be considerable value added by encouraging alumni activity on the department website as well as forming a panel to interface with students by way of an informational session and a follow up/breakout session for various career paths (entrepreneurial, academia, industry, consulting). In terms of recruitment, the board felt that there were multiple avenues to pursue, including outreach to those teachers and schools involved in the ASM Teachers Camp as well as STEM."

"The EAB session was extremely productive," said MSE Chair Amit Misra. "We look forward to working closely with the board to achieve the goals they have established for 2018 and beyond."

2018 External Advisory Board: Gerald Madden, Elizabeth Holm, Keith Bowman, Dan Gamota, Ray Decker, Jason Hertzberg (chair), Jerry Hoffman, Kim Flesner (2017 Alumni Merit Award recipient), Chip Keough, Jonathan Madison, Jody Hall, Susan Hartfield-Wünsch, and Aaron Crumm. Not pictured: Jeff Carbeck

Calling all MSE alumni!

In keeping with the EAB Board's goals, we're currently exploring new ways for you to connect with MSE students (sharing career stories, offering industry advice, etc.). More details will be coming soon! Join us on Linkedin (linkedin.com/groups/3849299/profile) to stay up to date.

MSE faculty and staff with the 2017 spring graduates at the MSE Graduation and Awards dinner April 13. As the MSE Distinguished Alumni Lecturer, U-Penn Professor Dawn Bonnell (front row, fourth from the right), was the evening's guest of honor.

Your support of MSE is anything but immaterial.

The graduate and undergraduate programs of the Department of Materials Science and Engineering are among the most highly ranked in the country. Our research programs in both structural and functional materials and facilities are world-class. Our graduates span the globe as leading scientists and engineers in industry and academia, entrepreneurs and business leaders.

Your gifts help us maintain our high standards of excellence in our research labs and classrooms, provide financial support for truly outstanding students in need and enhance the visibility of our department through distinguished seminars, workshops and outreach events. We need to keep attracting the best and brightest materials faculty, staff and students so that we can continue to exceed the accelerating demand for quality materials research and education.

Donate today!

Simply fill out the enclosed envelope and mail it to us, or go online to mse.engin.umich.edu/alumni/giving

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Oxygen-sniffing core-shell phosphor nanoparticles emit light in oxygen-deficient environments. Researchers hope that because tumors are oxygen-deficient, these nanoparticles will help doctors more precisely measure and analyze tumors.

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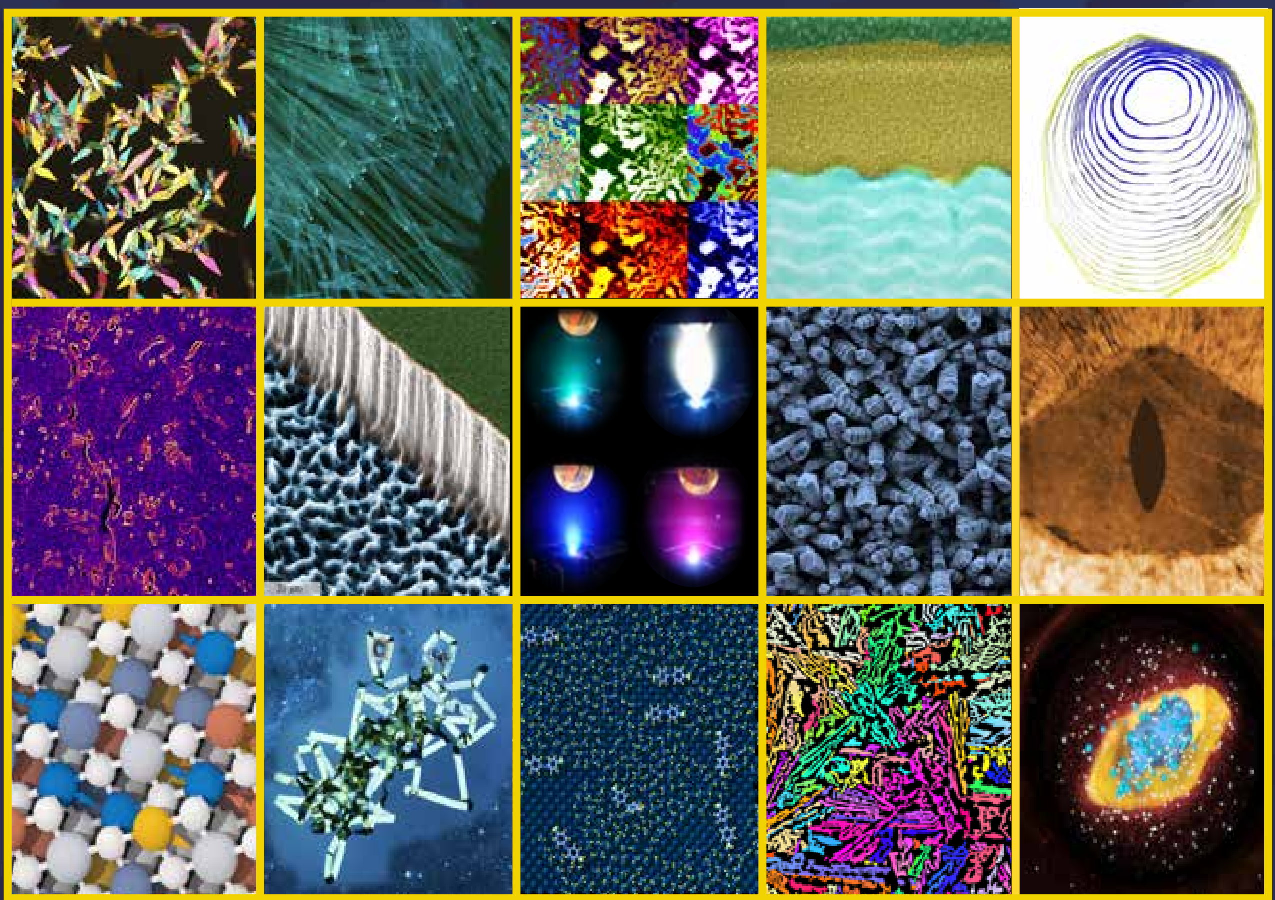

Top row: Birefringence image of purely organic phosphor crystals fabricated by drop-casting (Seong-Jun Yoon/Kim)/ Photoluminescence image of purely organic phosphor microwire crystals (Seong-Jun Yoon/Kim)/Warhol display of Bi/Sn alloy: surface potentials of Bi/Sn alloy measured with Kelvin probe force microscopy (Jill Wenderott/Green)/ Wavy Cu/Mo multilayer and the Pt deposition at the top present a beautiful beach view (Yuchi Cui/Misra)/Electron diffraction pattern of a solid decagonal quasi-crystal phase (Insung Han/Shahani). **Second row:** Microstructure of our heat-treated Aluminum 356 sample (Andra Chen/MSE 360)/A microfabricated roughened trench in silicon, colored to resemble the White Cliffs of Dover (Mathew Boban/Tuteja)/The long-range antiferromagnetic order of (MgCoNiCuZn)O entropy-stabilized oxide despite significant chemical disorder and magnetic frustration (Peter Meisenheimer/Heron)/Titanium Dioxide Nanowires: Recolored SEM image of titanium dioxide nanowires grown during thermal oxidation of pure titanium (Kathleen Chou/Marquis)/An HAADF (atomic number contrast) STEM image of a hierarchical Cu-Mo thin film made to look like the Eye of Sauron from the Lord of the Rings (Ben Derby/Misra). **Third row:** A high energy plasma is created through laser ablation to deposit magnetic and ferroelectric oxide thin films. Building materials from the atomic level allows an additional energetic constraint when synthesizing new phases. (Peter Meisenheimer/Heron)/"Space Robot:" Self-assembled gold nanostructure inspired from the art of paper folding (Origami) with patterned creases (Wonjin Choi/Kotov)/Water and 4,4′-oxydianiline molecules diffused out of a polyimide bulk, crossed an empty vacuum layer, and condensed on the underside of the copper substrate in a molecular dynamics simulation of a polyimide/Cu interface (Eleanor Coyle/Kieffer)./EBSD orientation map of Na-modified Al-Ge eutectic alloy. The Ge lamellae are colored according to their crystallographic orientations (Saman Moniri/Shahani)/The Helix Nebula: A 3D atom probe reconstruction of a phosphorous and silicon cluster (blue+white) enveloped by chromium (orange) in an iron-rich matrix (red) (Elaina Reese/Marquis).