

MSE *news*



COLLEGE OF ENGINEERING
MATERIALS SCIENCE & ENGINEERING
UNIVERSITY OF MICHIGAN

Winter 2025



CONTENTS

MRSEC Center for Materials Innovation	02
The "crown jewel" of NSF, MRSEC, comes home to Michigan.	
Materials Centers Updates	06
We check in with the Electric Vehicle Center, IceCycle, and PRISMS Center.	
Research Highlights	08
MSE research is working on everything from freeing the world of unwanted ice and snow to better battery manufacturing.	
Outreach	15
ICMed Summer School turns 10, ASM teachers' camp	
NSF Awards	16
Seven students—a record for MSE—receive NSF GRFP Awards.	
Faculty	18
Rachel S. Goldman and Liz Holm earn named titles, faculty awards and appointments	
Undergraduate Student News	20
Towsley Lounge gets makeover, Reverse Engineering projects, fellowship recipients, junior Devin Maples attends NSBE	
Graduate Student News	22
Graduate toolkits help 1st-year students, fellowship recipients	
2024 Graduation	24
Ninety-one students graduate in 2024 with their BSE, MSE or PhD.	
Senior Design Projects	25
This year's six projects tackle important industry issues.	
Alumni News	26
2024 MSE Alumni Merit Award, alums in the news, deaths	
Community News	28
New podcast explores materials education topics, staff news	

Front cover image:
Air plastron on super-hydrophobic coating forming the shape of an "M"

**Bozhong Zhuang/
Tuteja group**

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16

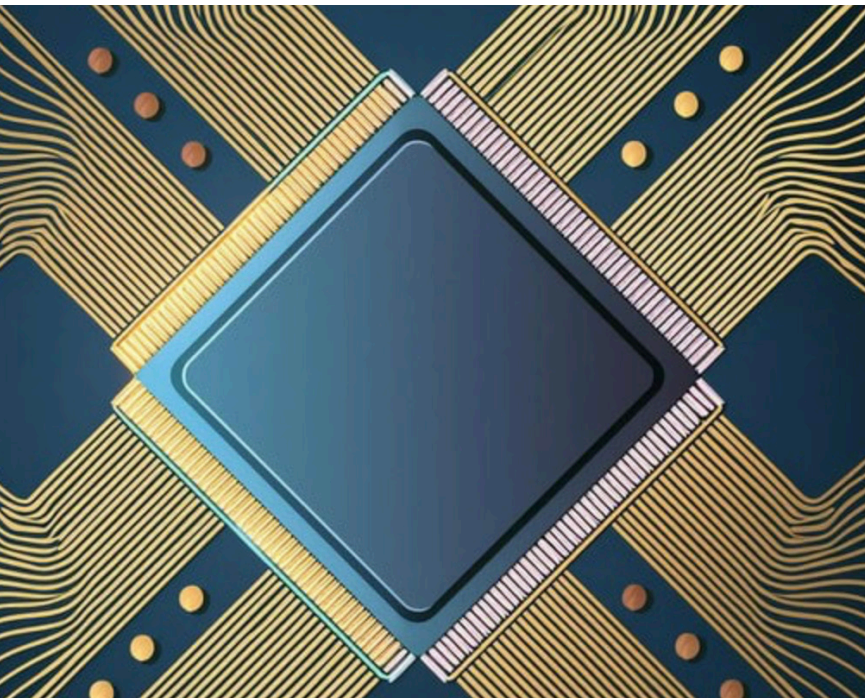
**Record number of
MSE students receive
NSF Awards in 2024**





02

Center for
Materials
Innovation



08

Research Highlights



24

2024 Graduation

“Crown jewel” MRSEC returns to Michigan

A molecular-beam epitaxy (MBE) system in the Goldman Group MBE Laboratory.

The U-M Center for Materials Innovation, an NSF-MRSEC, is building a campus-wide ecosystem for designing and manufacturing materials of the future while training a more representative workforce.

More efficient computing—potentially room temperature quantum computing—and recyclable rigid plastics are two projects to be undertaken by a new materials research science and engineering center (MRSEC) at the University of Michigan.

Funded with \$18 million from the National Science Foundation, the center seeks to build a campuswide ecosystem of researchers that converge on material solutions to problems facing society. Focusing on the integration of research and education, the center also aims to broaden participation in materials research through year-round opportunities for students and teachers. The center includes researchers from across the U-M campus and from the University of Colorado.

"By the year 2030, IT is expected to utilize 30% of all electrical energy. This is clearly not sustainable," said Rachel Goldman, U-M professor of materials science and engineering, who leads the Center for Materials Innovation at Michigan.

"Likewise, we've all seen photos of the Great Pacific Garbage Patch—plastics in the ocean. This is, in part, because only some thermoplastics are recyclable. Our center will help address both of these grand challenges."

The launch of CMI last year was the first MRSEC at Michigan in seven years and the second ever at U-M in the 60-year history of the MRSEC program.

"With MRSEC, there is tremendous opportunity for impact at U-M and the materials research community extending over multiple decades," said Goldman.

IRG 1: 2D Materials

The team's approach to more sustainable computing relates to both conventional and quantum computing. The new materials they propose could reduce the energy costs of both types. In addition, the proliferation of quantum computing would enable some types of problems to be solved in a fraction of the time.

For these purposes, the team will investigate a new class of layered materials in which the atoms in some of the layers are arranged in different crystal structures. Because these special layers are surrounded by layers with the same chemical composition, they are insulated from disturbances. The absence of disorder from their surroundings means these layers have new and enhanced properties that will make both classical and quantum computing more energy efficient.

"The disorder-free layers can for example exhibit stable quantum

states at room temperature that will make quantum computing at room temperature a reality. Currently, quantum computing can only take place in refrigerators," said Ageeth Bol, U-M professor of chemistry, who leads the layered materials project.

IRG 2: Sustainable Materials

The project to develop recyclable, yet strong and rigid plastics will make the hardening process reversible. Currently, the 'hardener' molecules that connect strands of molecules into crosslinked networks, as in epoxy, won't come undone. Instead, the team envisions crosslinks that can be reversed using heat or light. These new materials would match the strength of current crosslinked polymers, but they could be reshaped and repurposed on demand, and they would possess self-healing ability.

"A repair would not just be a patch—it would reconstitute the material to its original molecular structure," (continued)



Tony Chiang (center) explains to Yi-Hsin Shen (right) and Jiun-Yeu Chang (left) his measurement results on the electrical switching of charge density wave (CDW) in TaS₂ at a poster session during the MRSEC CMI Kick-off in January.



Center for Materials Innovation
NSF-Materials Research Science and Engineering Center
at the University of Michigan



Participants of the Teachers' Camp pose with Stephen Maldonado (far left), Associate Director of CMI.



REU participant Lily Mansfield, from Barnard College, explains her electron microscopy research with the Goldman lab at the Summer Research Symposium on August 1.

(cont'd from pg. 3)

That would extend the lifetime of the structure and reduce the amount of material that has to be discarded," said MSE Professor John Kieffer, who leads the sustainable plastics project.

As an example, Kieffer named wind turbine blades that could be repaired when cracks develop and then recycled at the end of their useful lives. Plastics like these would also be useful in space, where they could be sent up in a compact package and then built into large structures that could be reconfigured as needed. The team anticipates that beyond recycling and reuse, these networks could be designed for regulating materials properties when needed—for instance, to dissipate the blow on impact, vary heat transmission to prevent overheating, or switch EV batteries to high-conductivity states for fast charging.

Summer outreach projects

Fulfilling its goal of providing training

for teachers in cutting edge materials science and chemistry to take back to their classrooms, CMI held a weeklong teachers' camp on campus for Michigan high school instructors in July.

The short course for teachers focused on three objectives. First, the high school instructors were trained on how to synthesize (from scratch) organometallic perovskite films and the associated materials necessary for thin film photovoltaics. Second, the teachers were taught how to assemble those materials into a working device that can be measured and evaluated. Third, the teachers were able to revisit each day's activity and discuss how it could be performed by their students.

Over the summer CMI also hosted 10 undergraduates in their Research Experience for Undergraduates (REU) and nine high school students in their Research Experience for Youth (REY) programs, both of which are designed to integrate research and education while focusing on attracting and retaining

a diverse body of next-generation materials researchers.

With the student Research Experiences, participants spent 10 weeks and REY participants spent seven weeks performing materials science research focused on Semiconductors & 2D Materials or Sustainable Polymers.

Participants concluded their 2024 Summer Research Experiences with two major events, the MRSEC Affiliates' Day (July 31) and a joint Summer Research Symposium (August 1), which showcased the outstanding work accomplished by the students throughout the summer.

"This research experience has given me confidence in my abilities to think logically, solve problems, and effectively communicate findings," commented an REY participant. "It has solidified my plans to attend higher education and pursue a career in STEM."

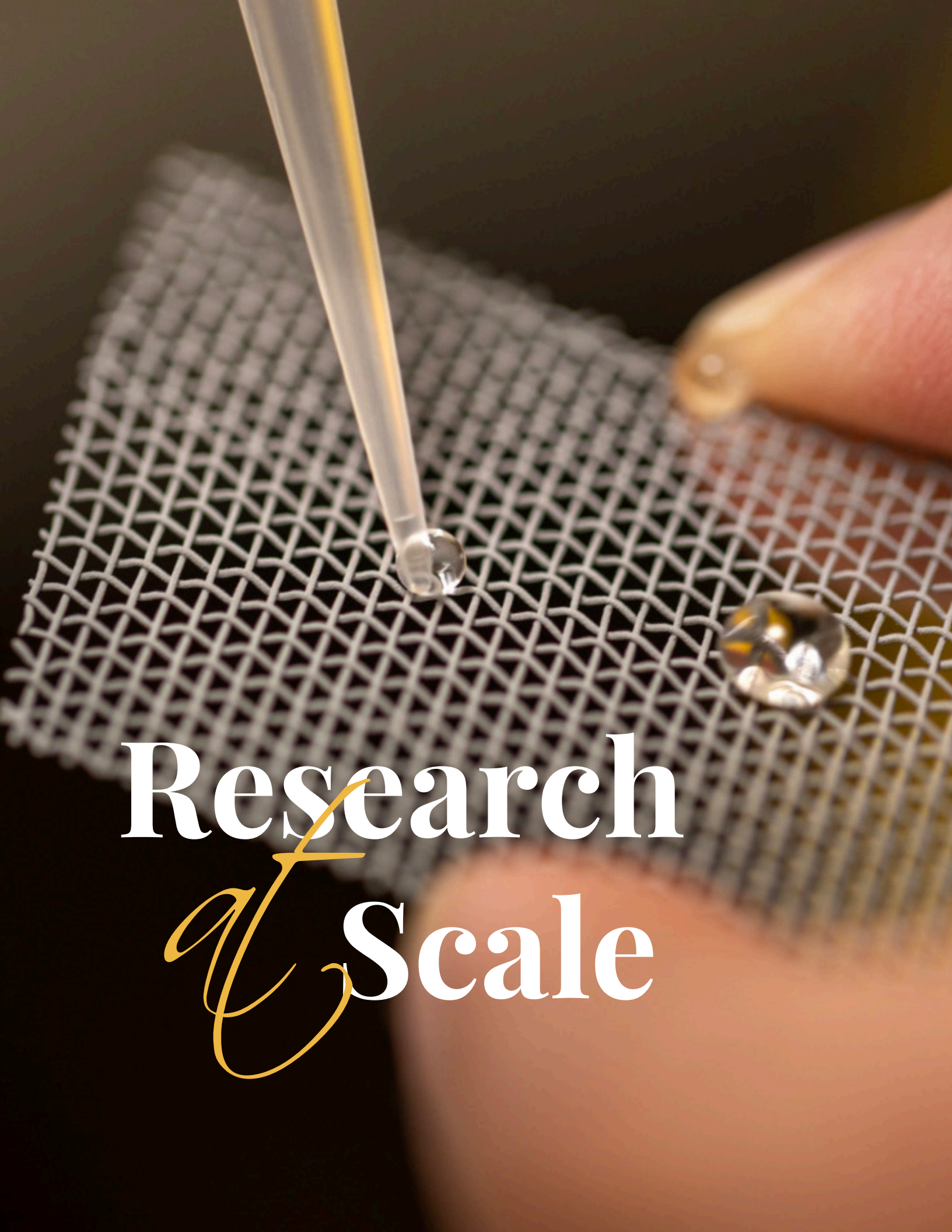
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"With MRSEC, there is a tremendous opportunity for impact at U-M and the materials research community extending over multiple decades."

—Rachel S. Goldman,
Director, Materials Center
for Innovation



Members of CMI gather together at Affiliates' Day on July 31.



Research *at* Scale

Our materials centers are driving EV tech, reimagining the way we live in the cold, and creating award-winning software for materials scientists around the world. And that's just the beginning.

Electric Vehicle Center (EVC)

The Electric Vehicle Center (EVC), under the leadership of director Alan Taub, Robert H. Lurie Professor of Engineering, continues to advance its mission to educate, innovate, and engage, driving EV tech and talent to make Michigan the E-Motor Capital.

In 2024, EVC prioritized key industry needs, including batteries, thermal management, and electric drives, hosting workshops to align research with real-world applications. Twelve technology projects have been prioritized and are being launched, the first one being led by Professor Li from MSE. The Center piloted an online course on Battery Manufacturing Fundamentals, advanced development of a Master's in Battery Engineering, and created career-focused videos for K-8 students.

Workforce efforts included launching Undergraduate Research Experiences in EV Tech and collaborating with Schoolcraft College on an EV Technician Curriculum. EVC also made significant progress on Battery Lab 2.0, adding advanced tools and infrastructure, and began planning for the new EVC building to expand research and workforce training.

These efforts highlight EVC's leadership in shaping the future of electric mobility.

IceCycle

The DARPA-funded IceCycle project has been ramping up, hiring nine additional postdocs this summer to help with the goal of controlling the physical properties of ice crystals to protect people and defense assets from extreme cold.

Spread out among three labs in the NCRC complex on North Campus, the project aims to find molecules that can be used to manipulate ice and snow in several ways, including changing the temperature at which water freezes,

increasing and decreasing how strongly ice adheres to surfaces, and inhibiting or encouraging ice crystals to grow on surfaces. Recent leaps in computing technology and digital imaging have opened up the new avenues of study upon which IceCycle is embarking. In its first year, researchers will crunch the data from the thousands of test molecules, using a combination of human analysis. The team then plans to narrow the field of potential molecules to around 75. These next-stage candidates will be subjected to a battery of additional tests, using more advanced (and more time-consuming) tools like Raman spectroscopy and differential scanning calorimetry to gather extremely precise information about exactly how each molecule influences the formation and adhesion of snow, ice and frost.

PRISMS Center

Under the leadership of John Allison, PRISMS Center continues to create high performance software for materials scientists around the world. PRISMS codes have been downloaded by more than 8000 researchers and increased by about 1500 users in 2024.

One of these codes, DFT-FE, was honored with the Gordon Bell Award last year, which is the top award for numerical modeling software.

PRISMS Center also provides the Materials Commons - a sophisticated site for collecting and storing research information, collaborating and sharing data with the world-wide materials community. Publicly available data has been viewed more than 28,000 times.

Major research accomplishments include developing new understanding of how alloying magnesium can influence complex deformation mechanisms (i.e., c+a slip and twinning) and control of the texture of wrought magnesium alloys and the effects of grain boundaries on alloy segregation and deformation.



The Electric Vehicle Center on North Campus.

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"One of PRISMS' codes, DFT-FE, was honored with the Gordon Bell Award last year, which is the top award for numerical modeling software."

AI could get a sense of time

Timekeeping in the brain is done with neurons that relax at different rates after receiving a signal; now memristors—hardware analogues of neurons—can do that too.

Artificial neural networks may soon be able to process time-dependent information, such as audio and video data, more efficiently. The first memristor with a ‘relaxation time’ that can be tuned was reported earlier this year in *Nature Electronics*, in a study led by MSE Associate Professor John Heron and EECS Professor Wei Lu, who has a courtesy appointment in MSE.

Memristors, electrical components that store information in their electrical resistance, could reduce AI’s energy needs by about a factor of 90 compared to today’s graphical processing units. Already, AI is projected to account for about half a percent of the world’s total electricity consumption in 2027, and that has the potential to balloon as more companies sell and use AI tools.

While Lu’s group had explored building relaxation time into memristors in the past, it was not something that could be systematically controlled. But now, Lu and Heron’s team have shown that variations on a base material can provide different relaxation times, enabling memristor networks to mimic this timekeeping mechanism.

The team built the materials on the superconductor YBCO, made of yttrium, barium, carbon and oxygen. It has no electrical resistance at temperatures below -292 Fahrenheit, but they wanted it for its crystal structure. It guided the organization of the magnesium, cobalt, nickel, copper and zinc oxides in the memristor material.

Heron calls this type of oxide, an entropy-oxide, the “kitchen sink of the atomic world”—the more elements they add, the more stable it becomes. By changing the ratios of these oxides, the team achieved time constants ranging from 159 to 278 nanoseconds, or trillionths of a second. The simple memristor network they built learned to recognize the sounds of the numbers zero to nine. Once trained, it could identify each number before the audio input was complete.

These memristors were made through an energy-intensive process because the team needed perfect crystals to precisely measure their properties, but they anticipate that a simpler process would work for mass manufacturing.

“So far, it’s a vision, but I think there are pathways to making these materials scalable and affordable,” Heron said.

Ice Aces

From on-demand ice caves to self-scraping windshields, IceCycle is reimagining life in the cold.

The IceCycle project, a 30-month, up to \$11.4-million effort funded by the Defense Advanced Research Projects Agency (DARPA) aims to reshape how humans interact with ice and cold.

It arrives at a time when climate change and geopolitical instability are drawing increased attention to the Arctic—home to 4 million people from eight countries and a vast number of indigenous communities.

In this frigid northern region, the United States military has identified challenges—and IceCycle researchers are looking for solutions. Their innovations could help prevent ice from sapping the efficiency of built infrastructure like military and cargo ships, wind turbines and refrigeration equipment. It could also seed new technologies to prevent frostbite, preserve human tissue and—maybe—ensure that you never have to scrape your car's windshield again.

"IceCycle opens up completely new research directions for us," What's also exciting is that it's structured to encourage the pursuit of applications outside the Department of Defense. I think broadly, there's going to be a lot of commercial impact from this work."

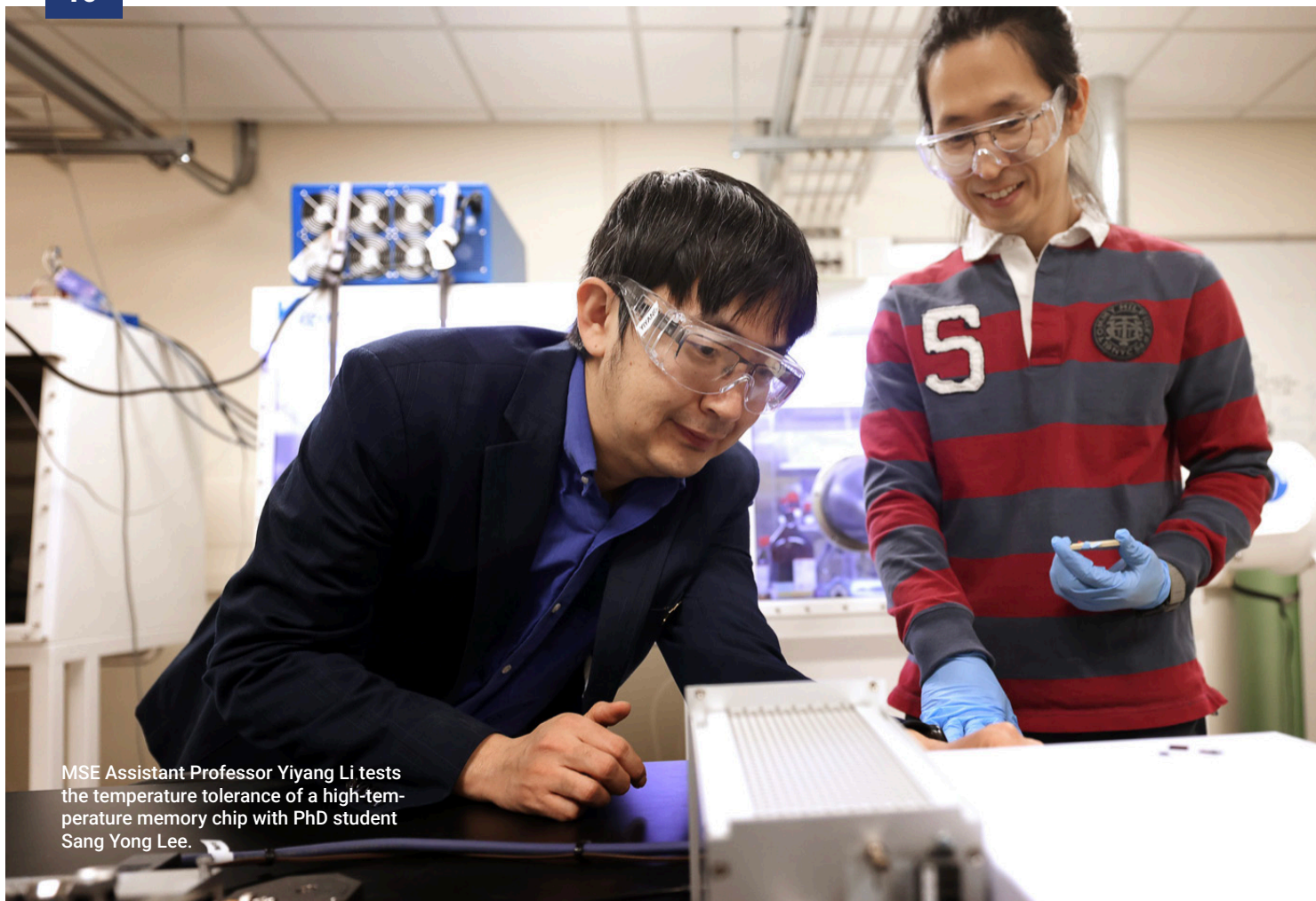
For decades, Tuteja has dedicated much of his research to developing coatings that can help free the built world from unwanted ice and snow. IceCycle is enabling his team to pursue that research on an unprecedented scale, doubling the size of his lab space and bringing in partners from across U-M, other universities and the private sector. The team includes researchers from the University of Minnesota and North Dakota State University, as well as RTX BBN Technologies, the tech and defense conglomerate behind companies like Raytheon and Pratt & Whitney.

As they look for solutions, the team is involving Native communities that have called the Arctic home for millennia. They're also gleaning know-how from other cohorts that have already mastered living in the region: Frogs. And fish. And insects. Even bacteria. Arctic organisms are masters at the three key abilities the IceCycle team is studying: preventing ice from forming, controlling how ice sticks to other surfaces, and promoting ice formation.



"IceCycle opens up completely new research directions for us...I think broadly, there's going to be a lot of commercial impact from this work."

—Anish Tuteja, Director, IceCycle



MSE Assistant Professor Yiyang Li tests the temperature tolerance of a high-temperature memory chip with PhD student Sang Yong Lee.

Battery-like computer memory keeps working above 1000° F

The material transports oxygen ions rather than electrons, creating heat-resistant voltages for both digital memory and in-memory computing.

Computer memory could one day withstand the blazing temperatures in fusion reactors, jet engines, geothermal wells and sweltering planets using a new solid-state memory device developed by a team of engineers led by MSE Assistant Professor Yiyang Li.

Unlike conventional silicon-based memory, the new device can store and rewrite information at temperatures over 1100°F (600°C)—hotter than the surface of Venus and the melting temperature of lead. It was developed in collaboration with researchers at Sandia National Laboratory.

"It could enable electronic devices that didn't exist for high-temperature applications before," said Li, the senior corresponding author of the study published

recently in *Device*, a Cell Press journal.

"So far, we've built a device that holds one bit, on par with other high-temperature computer memory demonstrations," Li said. "With more development and investment, it could in theory hold megabytes or gigabytes of data."

The research is funded by the National Science Foundation, Sandia's Laboratory-Directed Research and Development program, and the University of Michigan College of Engineering. The device was built in the Lurie Nanofabrication Facility and studied at the Michigan Center for Materials Characterization.

The authors have filed a patent based on this work to the US Patent and Trademark Office and are seeking partners to bring the technology to market.

Better battery manufacturing: Robotic lab vets new reaction design strategy

Mixing unconventional ingredients in just the right order can make complex materials with fewer impurities. The robotic lab that tested the idea could be widely adopted.

New chemistries for batteries, semiconductors and more could be easier to manufacture, thanks to a new approach to making chemically complex materials that MSE researchers and Samsung's Advanced Materials Lab have demonstrated.

Their new recipes use unconventional ingredients to make battery materials with fewer impurities, requiring fewer costly refinement steps and increasing their economic viability.

"Over the past two decades, many battery materials with enhanced capacity, charging speed and stability have been designed

computationally, but have not made it to market," said Wenhao Sun, the Dow Early Career Professor of Materials Science and Engineering and the corresponding author of the study published in *Nature Synthesis*.

"We designed a strategy to make impurity-free materials more reliably," said Jiadong Chen, the first author of the study and a PhD student in MSE and scientific computing. "The trick is to only work with two ingredients at a time, and deliberately make unstable intermediates that will react completely with the remaining ingredients."

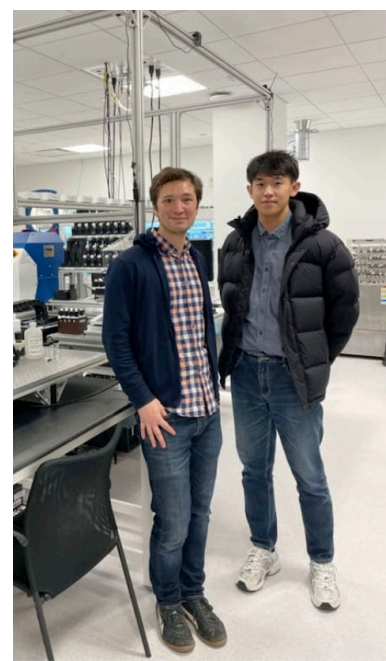
Sun's team designed 224 different recipes to create 35 different known materials containing

elements used in today's batteries and next-generation 'beyond-lithium' batteries.

The researchers then partnered with Samsung Semiconductor's Advanced Materials Lab in Cambridge, Mass., to test if their recipes produced these 35 materials with fewer impurities than conventional recipes.

The experiments confirmed that the new recipes improved the materials' purity by up to 80%.

Researchers say labs are within reach for most research institutions and could significantly speed up materials development.



Above: Testing recipes in Samsung's robotic lab. Right: Samuel Cross (left), a former Samsung engineer, stands in front of ASTRAL, Samsung's robotic lab, with co-first author Jiadong Chen (right), the study's computational lead and a U-M doctoral student.



"The CO₂ released while burning rice hulls comes from the same CO₂ the rice plant took up from the atmosphere during photosynthesis, making the electricity produced green and carbon neutral."

—Rick Laine



Rick Laine



Robert Hovden

Burned rice hulls could help batteries store more charge

New research finds hard carbon in rice hull ash, providing a cheap, domestic source of the material that can replace graphite in lithium-ion or sodium-ion battery anodes.

A closer inspection of ash from burned rice hulls, the hard outer layer of rice grains, revealed a form of carbon that could nearly double the energy density of typical lithium-ion or sodium-ion batteries.

This sustainable source of 'hard' carbon, which outperforms ordinary graphite in battery electrodes, was discovered by a collaboration between the MSE labs of Professor Rick Laine and Associate Professor Robert Hovden.

This is the first demonstration of hard carbon made through combustion. It was previously thought hard carbon could only be made by heating biomass, such as agricultural waste, to about 1200°C (2200°F) in an oxygen-free environment like nitrogen or argon.

Rather than importing graphite mined from China or Mexico, rice hull ash could provide a higher quality domestic material for making battery electrodes. The process is also more sustainable than producing graphite from biomass, which must be heated to 2000°C (3600°F) or higher—producing five to 10 tons of CO₂ for

every ton of battery-grade graphite.

Although most rice hulls end up in landfills, burning rice hulls provides a carbon neutral source of electricity. Wadham Energy LP in the Sacramento Valley of California generates 200,000 megawatt-hours of electricity per year by burning the agricultural byproduct—enough energy to power about 22,000 homes.

"The CO₂ released while burning rice hulls comes from the same CO₂ the rice plant took up from the atmosphere during photosynthesis, making the electricity produced green and carbon neutral," said Laine, corresponding author of the study recently published in *Advanced Sustainable Systems*.

With about 20 billion pounds of rice grown annually in the United States, there is plenty of room to scale up.

Turning agricultural waste into a valuable product, rice hull ash hard carbon can help meet the growing demand for batteries for use in electric vehicles and storing intermittent renewable energy while decreasing both cost and emissions.



Faster organic phosphorescence for better display tech

Layering an organic material on top of 2D materials achieves stable, fast phosphorescent light emission without using expensive and hazardous heavy metals.

Screens for TVs, smartphones or other displays could be made with a new kind of organic LED material developed by an international team, co-led by University of Michigan engineers. The material maintains sharp color and contrast while replacing the heavy metal with a new hybrid material.

Curiously, the material also seemed to break a quantum rule.

OLED devices currently on the market include heavy metal components like iridium and platinum, which improve the efficiency, brightness and color range of the screen. But they come with drawbacks—significantly higher cost, a shorter device lifetime and increased health and environmental hazards. In OLEDs, light emission through the more energy-efficient phosphorescence is preferred over fluorescence, but phosphorescence happens more slowly, taking milliseconds or longer without the heavy metal component. Speeding up phosphorescence to happen in microseconds is necessary to keep up with modern displays without producing a lingering “ghost” image. This is a key role of the heavy metals.

“We found a way to make a phosphorescent organic molecule that can emit light on the microsecond scale, without including heavy metals

in the molecular framework,” said Jinsang Kim, U-M professor and co-corresponding author of the study published in *Nature Communications*.

Pixel burnout is a particular problem for high energy blue light that has yet to be solved, but the research team hopes their new design approach can help work towards stable, blue phosphorescent pixels. Current OLEDs use phosphorescent red and green pixels and fluorescent blue pixels, avoiding blue pixel burnout at the expense of lower energy efficiency.

Beyond the potential applications, analysis of this molecular hybrid system measured something once thought to be impossible—paired electrons sharing an orbital seemed to have a combined spin under dark conditions, suggesting a forbidden ‘triplet’ state when instead their spins should cancel one another out. “We don’t yet fully understand what causes this triplet character in the ground state because this violates the Pauli Exclusion Principle. That is very impossible, but looking at the measurement data, yes, that seems to be the case,” Kim said. “That’s why we have a lot of questions about what really makes that happen.” The research team will explore how the material achieves triplet character ground states while also pursuing potential spintronics device applications.

Flexible screen stores and displays encrypted images without electronics

The screen uses magnetic fields to display images at the same resolution as a squid's color-changing skin.

A flexible screen inspired, in part, by squid can store and display encrypted images like a computer—using magnetic fields rather than electronics.

The screen could be used wherever light and power sources are cumbersome or undesirable, including clothing, stickers, ID badges, barcodes and e-book readers. A single screen can reveal an image for everyone to see when placed near a standard magnet, or a private, encrypted image when placed over a complex array of magnets that acts like an encryption key.

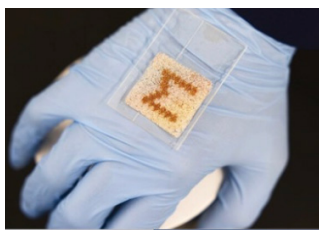
"This device can be programmed to show specific information only when the right keys are provided. And there is no code or electronics to be hacked," said MSE Assistant Professor Abdon Pena-Francesch, a

co-corresponding author of a paper published this fall in *Advanced Materials*. "This could also be used for color-changing surfaces, for example on camouflaged robots."

Shaking the screen erases the display—like an Etch-A-Sketch—except the image is encoded in the magnetic properties of beads inside the screen. It returns when the display is exposed to the magnetic field again.

Several private images can be displayed from a single public image, each with a unique key. The decoding keys can also be programmed to only work with specific encoding keys for extra security.

The team decided on the screen's resolution by studying squids and octopi, which change color by expanding and contracting pigment sacs in their skin.



Assistant Professor Abdon Pena-Francesch points out a section of squid skin to doctoral student Zane Zhang at the BioInspired Materials Lab.

Summer outreach programs arm instructors with materials know-how

ICMed Summer School celebrates 10 years of training instructors in materials computational concepts.

Twenty-five participants from around the globe attended the 10th Integrated Computational Materials Education (ICMed) Summer School June 10-21.

Led by MSE Professor Katsuyo Thornton, Associate Professor Liang Qi and Assistant Professor Wenhao Sun, the two-week program included a crash course on computational MSE and focus sessions on educational modules that could be adopted into undergraduate courses on thermodynamics, kinetics, mechanics, and physics of materials.

"This has been such a positive and comprehensive learning experience," commented one participant. "I can't wait to incorporate these concepts into my teaching curriculum."

ASM Teachers' Camp equips teachers with materials lessons to incorporate into their science curriculums.

In July, 13 middle and high school teachers from across the country attended the ASM Teachers' Camp held in the Van Vlack Lab.

This week-long, hands-on lab experience shows educators how to use applied materials engineering techniques in their classroom.

Hands-on activities – facilitated by MSE lab supervisor Sahar Farjami and lecturer Tim Chambers – included experiments with metals, ceramics, polymers, and composites.

"I absolutely loved all of the resources and support! This was one of the best professional development opportunities I have participated in during my 15 years in education," said one participant.



Above: Wenhao Sun, Dow Corning Assistant Professor of MSE, discusses computational concepts with a student during his Data Science Module at the ICMed Summer School in June. Below: Participants in this year's ASM Teachers' Camp gather together after a lesson in the Van Vlack Lab.





Record number of students receive NSF Awards

Seven MSE students—five graduate and two undergraduate—received Graduate Research Fellowships (GSRF) from the National Science Foundation (NSF) in 2024. With seven recipients, this year sets a record for MSE: the most NSF GRFP winners in one year in recent memory.

"The fact that seven MSE students were awarded prestigious NSF graduate fellowships underscores the exceptional quality of education and research opportunities we provide here at U-M," said Associate Professor Geeta Mehta, chair of the MSE graduate program.

Mehta went on to add that this year's success most likely correlates to the department's efforts to actively coach students applying for national awards like the NSF GRFP through bootcamps, a panel with successful NSF and other national award winners, and the opportunity to be paired one-on-one with a faculty member in a similar research area to provide critical pre-submission feedback.

"I think this infrastructure is important for ensuring success for our award winners," Mehta stated.

See the next page for a brief description of each winner's research.



Liam Cotter



Nicholas David



Daniel Delgado



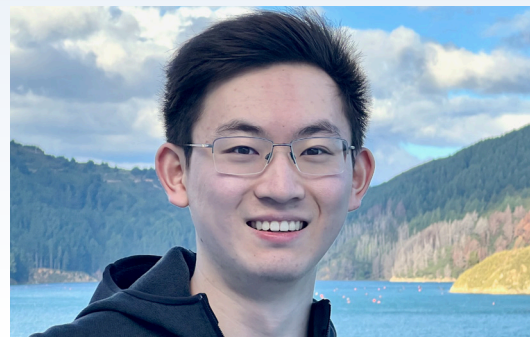
Caroline Harms



Reegan Ketzenberger



Nina Perry



Davy Zeng

Liam Cotter '24

Fluid accumulation within the peritoneal cavity, an abdominal space that houses the ovaries and other internal organs, follows ovarian cancer. We use tissue engineered constructs and a fluid shear stress bioreactor to recapitulate the mechanical and transport properties of the ovarian tumor microenvironment. This allows us to understand the mechanisms of ovarian cancer progression and highlight targets for novel therapies.

Nicholas David, 2nd year PhD student in the Sun group

There is currently a poor scientific understanding of what makes a predicted material synthesizable, or the best way to synthesize it. Hence, rapid prediction of novel materials is often followed by months of trial-and-error experimental efforts. My goal is to unravel those enigmatic, surprising aspects of chemical synthesis, using insights from both computation and theory, guided by big materials data.

Daniel Delgado, 2nd year PhD student in the Dasgupta group

I am exploring sustainable engineering solutions directed at combating the damaging effects of continual greenhouse gases emissions with the goal of answering the question—how can we create cleaner procedures for generating the fuels that power our economy? I am exploring both electrochemical and photocatalytic routes for CO₂ recycling, as well as investigating the mechanisms for light-induced ammonia synthesis. I hope it will ultimately inspire a push towards the implementation of cleaner fuels.

Caroline Harms, 1st year PhD student in the Pena-Francesch group

My research takes inspiration from nature to develop functional polymeric coatings that tailor interfacial interactions and behavior. While my work is primarily intended for environmental and healthcare applications, its projected insights into adhesive mechanisms and the structure-property relationships that dictate antifouling performance will broadly elucidate interfacial phenomena that are still not well understood.

Reegan Ketzenberger '24

Traditional methods of hydrogen production such as coal gasification and natural gas steam reforming rely on fossil fuels, but electrolysis, the reaction that involves splitting water with an electric current to produce hydrogen and oxygen, offers a clean alternative. My proposed research project seeks to understand the impact of porosity and tortuosity of sintered titanium porous transport layers on titanium passivation and in situ mass transportation limits in proton exchange membrane electrolyzers.

Nina Perry, 1st year PhD student in the Marquis group

My research aims to uncover and understand the mechanisms behind phase transformations and microstructural evolution in high entropy alloys (HEAs) and their impact on properties. My research has indicated that some HEAs undergo phase decomposition offering unique microstructures at low and intermediate temperatures. Thus, I hope to use characterization techniques to study the mechanisms behind these transformations. This constitutes an uncharted materials research frontier whereby unlocking a wider range of desirable material properties lies in the potential to tailor HEA microstructures.

Davy Zeng, 1st year PhD student in the Dasgupta group

My research is about studying the complex chemo-mechanical interfacial phenomenon associated with solid-state battery degradation. Atomic layer deposition is a technique that allows for the deposition of nanometer thick conformal coatings. I will use these coatings to tune the surface energy of the interface, with the goal to promote even lithium deposition and alleviate the issue of dendrite shorting. Ultimately, this will allow for the commercialization of solid-state batteries and help facilitate the electrification of the transportation sector in our fight against climate change.



"The fact that seven MSE students were awarded prestigious NSF graduate fellowships underscores the exceptional quality of education and research opportunities we provide here at U-M."

—Geeta Mehta, MSE graduate program chair

Goldman & Holm earn professorship titles

Rachel S. Goldman: Maria Goeppert Mayer Collegiate Professor



A leader in electronic and photonic materials research and education, **Rachel S. Goldman** was installed as the Maria Goeppert Mayer Collegiate Professor on January 23. The ceremony was held in the Johnson Rooms and officiated by interim Dean Steve Ceccio.

At the event, four speakers shared their insights on working with

Goldman, including: **Roy Clarke**, Marcellus L. Wiedenbeck Collegiate Professor and University Diversity and Social Transformation Professor, who was Goldman's U-M

undergraduate advisor; **Cagilyan Kurdak**, director of the Applied Physics program in LSA and longtime collaborator; **Karen Kavanagh**, Goldman's PhD advisor at UCSD who is now Professor of Physics at Simon Fraser University in Vancouver, and former group member **Christian Greenhill (PHD '21)**, now a senior research engineer at Dow.

Following the talks, Goldman presented "Adventures in Semiconductor Nanostructuring: from Atoms to Devices," where she shared her path from "academic brat" in Minnesota to physics major at U-M for undergrad, and back to U-M again after earning degrees at Cornell (MS) and UCSD (PhD). While there was a lot of semiconductor research, traveling and award winning along the way (and many miles run on track and cross-country teams), there was also a lot of fun and meaningful relationship-building.

"I learned at a very young age that when you love what you do for a living, your work is a hobby, your collaborators are close friends, and your students are part of your extended family," Goldman said.

Liz Holm: Richard F. and Eleanor A. Towner Professor of Engineering

On August 21, MSE chair **Liz Holm** was inducted as the Richard F. and Eleanor E. Towner Professor of Engineering. The ceremony was officiated by new Michigan Engineering Dean Karen A. Thole in her first official event as dean, and moderated by Professor John Allison.

Special invited speakers included Holm's younger brother and U-M alumnus John Holm, long-time collaborator and Carnegie Mellon Professor Tony Rollett, and David Srolovitz, Holm's former PhD advisor at U-M, now Dean of Engineering and Professor of Mechanical Engineering and Chair of Materials Theory at the

University of Hong Kong.

Following the speakers, Holm presented a talk, "We all might be giants: lending our shoulders to the next generation," in which, through a series of personal anecdotes, she encouraged attendees to remember to lift others up in what may seem like small and everyday acts. Of her remarkable career Holm said: "I'll just say there is great beauty in what nature brings us and there is great fulfillment in being a computational materials scientist who's able to tease out and in some special cases even display the beauty in a way that is compelling."





Anish Tuteja recognized for world- renowned research

Professor Anish Tuteja received the 2024 David E. Little Research Excellence Award from Michigan Engineering for his world-renowned work in the field of surface science. Utilizing polymers to fabricate innovative materials, Tuteja has engineered ice-phobic, ice-shedding and anti-fouling properties that are key to many exciting real-life applications.

Tuteja's work has been notably impactful as evidenced by the high number of citations (over

15,000 Google Scholar citations) and numerous publications in high-impact journals, such as *Science*, *Science Advances*, and *Nature Communications*. His research has been reported on by media outlets across the globe, including NBC, NPR, *The New York Times*, *Washington Post*, *The Wall Street Journal*, etc. His work on super-oleo-phobic surfaces was highlighted as one of the "top five new discoveries that will change the world."

“

"[Tuteja's] research has been reported on by TV, radio, and media outlets across the globe. His work on super-oleo-phobic surfaces was highlighted as one of the 'top five new discoveries that will change the world.'"

Special Faculty Awards and Appointments



Assistant Professor Yiyang Li awarded a 2024 Young Faculty Award from the Defense Advanced Research Projects Agency (DARPA).



Professor Rachel S. Goldman was elected Councilor of the APS Division of Materials Physics (DMP). Her term begins in January 2025.



Associate Professor Robert Hovden is the recipient of the 2024 MSE Faculty Outstanding Accomplishment Award for his stellar performance in materials research, teaching, and service to the department.

2024-25 Undergraduate Student Scholarships

Nathaniel L. Field Scholarship
Daniel Casey, Devin Maples,
Cameron Marteen

Richard A. Flinn Scholarship
Janice Huang

Fontana-Leslie Scholarship Fund
Erin Clingerman, Micah Gendich

**James W. Freeman Memorial
Scholarship**
Binh Nguyen, Tomas Peralta,
Adrian Sanchez-Jungo

John Grennan Scholarship
Manasi Londhe

**Jack J. Heller Memorial
Engineering Scholarship Fund**
Dayo Ogundipe, Priya Patel

William F. Hosford Scholarship
Dale Mouton, Madinabonu Nosirova,
Hannah Wolfe, Jennifer Yung, Zhang
Wuwei

**Schwartzwalder Memorial
Scholarship**
Avelo Cohen, Pranavi Gudi, Isabelle
Holden, Amiya Johnson

**Clarence A. Siebert Memorial
Scholarship**
Alex Cooper, Elizabeth Troia

**Alfred H. White Memorial
Scholarship**
Lauren Adams, Abigail Ahn,
Alan Shi



Towsley Student Lounge gets makeover

As part of the *Dow Right Now!* campaign, the Towsley Student Lounge got new carpet and furniture. MSE celebrated the lounge's "grand reopening" (pictured above) with a coffee bar for the whole MSE community on Oct. 1



"The revamp has made the space more warm, welcoming, and cozy. It's a great space for all of us to collaborate, study, and get homework done!"

—Manasi Londhe '24



Reverse Engineering projects impress with ambition and creativity

This year 10 teams reverse engineered a variety of items - from band aids to pickleball paddles - for their final MSE 365 projects.

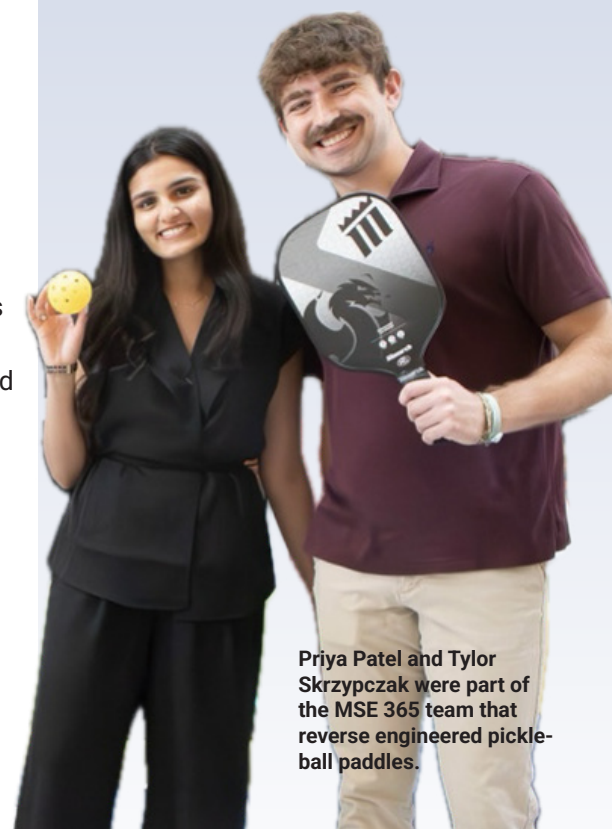
"Once again, the MSE 365 students impressed me with their ambition, commitment to their projects, and creativity in asking and answering complex engineering questions," said instructor Tim Chambers. "This year I got to see everything from the mozzarella-cheese-pull nature of bandage adhesive to the hydrophilicity of paint components to the sound of membrane materials in headphone speakers."

Devin Maples attends 50th annual NSBE Conference in Atlanta



Junior **Devin Maples** joined 18,000 engineers in Atlanta for the 50th Annual National Society of Black Engineers (NSBE) Conference in March. Founded in 1975, NSBE supports and promotes the aspirations of collegiate and pre-collegiate students and technical professionals in engineering and technology.

"Having the opportunity to attend this once-in-a-lifetime event has developed me personally, socially, and professionally," said Maples. "Gaining this lasting experience would not have been possible without the help of the MSE Department and its generous donors."



Priya Patel and Tylor Skrzypczak were part of the MSE 365 team that reverse engineered pickleball paddles.

Graduate toolkits provide important info for first-years

For the second year, the MSE graduate committee coordinated a full slate of graduate toolkits to help first-year graduate students navigate their graduate degree programs successfully.

"The toolkits were carefully crafted to provide practical, in-depth information and advice on areas pertinent to new students," said Geeta Mehta, MSE graduate program chair.

Toolkit topics from this fall included:

- Choosing Your Advisor
- Preparing Competitive NSF Fellowship Applications
- How to Read and Critique Scientific Papers
- Communicating with Your Advisor
- Creating Your Own Mentorship Board for Graduate School Success

“"The toolkits were carefully crafted to provide practical, in-depth information and advice on areas pertinent to new students."

—Geeta Mehta, MSE graduate chair



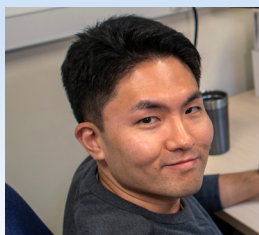
Special Graduate Student Awards



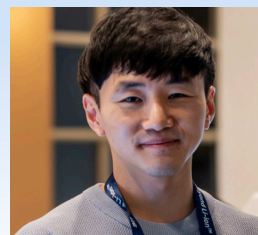
Avinava Roy
(Loebel group)
2024 American Heart Association Fellowship



Jonathan Goettsch
(Taub group)
DOE SCGR Fellowship



Joonsoo Kim
(Sun group)
Rackham Predoctoral Award; MRS Graduate Student Gold Award



Jinhong Min
(Li group)
Rackham Predoctoral Award



Vishal Subramanian
(Gavini group)
Rackham Predoctoral Award

2024-25 Graduate Fellowship Recipients

Kenneth and Judy Betz Fellowship

Daniel Blevins
Heather Hare
Hao-En Peng

CoE Endowed Fellowship

Daniel Blevins
Amanda Boahemaa
Heather Hare
Kayla Huang
Qingge Huang
Eunjeong Jo
Alp Kurbay
Ryn Oliphant
Hao-En Peng
Marisa Perez
Siddhesh Yeram

Harvey Ferrari Student Fellowship

Catherine Huang

Dr. Gerald I. and Joyce C. Madden Graduate Fellowship

Nicholas Redwing

Robert D. and Julie A. Pehlke Fellowship

Nicholas Redwing
Ayesha Ulde

Rackham Merit Fellowship

Salma Abdelgawad

Rackham Block Grant Fellowship

Nicholas Redwing
Ayesha Ulde

Frederick N. Rhines Fellowship

Alp Kurbay
Keegan Nitsch
Ryn Oliphant



Graduate students take a moment to pose together for a photo at the MSE holiday party on December 9 at the Michigan Union.



Po-Yu Kung
(Li group)

Rackham Predoctoral
Award/Rackham
International Students
Fellowship



Amanda Wang
(Kioupakis group)

Young Researcher Paper
Award International Workshop
on Gallium Oxide and Related
Materials (IWGO)



Catherine Haslam
(Sakamoto group)

Richard F. and Eleanor
A. Towner Prize for
Distinguished Academic
Achievement

Congratulations to all our 2024 graduates!



Undergraduate (B.S.E.)

Abigail Ahn
Ryan Blackburn
Laura Bonds
Vincent Bouwhuis
Aaron Brokaw
Liam Cotter
Andrew Danbury
Amanda Diddams
Joshua Dukes
Madison Forstner
Michah Gendich
Alexa Goldstin
Heather Hare
Zoe Hu
Sabrina Huyhn
Reegan Ketzenberger
Charles Khayat
Tyler Lindemann
Manasi Londhe
Kevin Masel
Collin McManus
Bennett Mejia
Andrew Novak

Alexis Parrish
Aaryan Patel
Priya Patel
Benjamin Poole
Benjamin Routhier
Thomas Rusli
Alan Shi
Luke Snudden
Penelope Springel
Tejaswini Reddy
Haley Whalen
Dashal Woack
Zekun Wu
Audrey Yung
Zetian Zhou

Master's (M.S.E.)

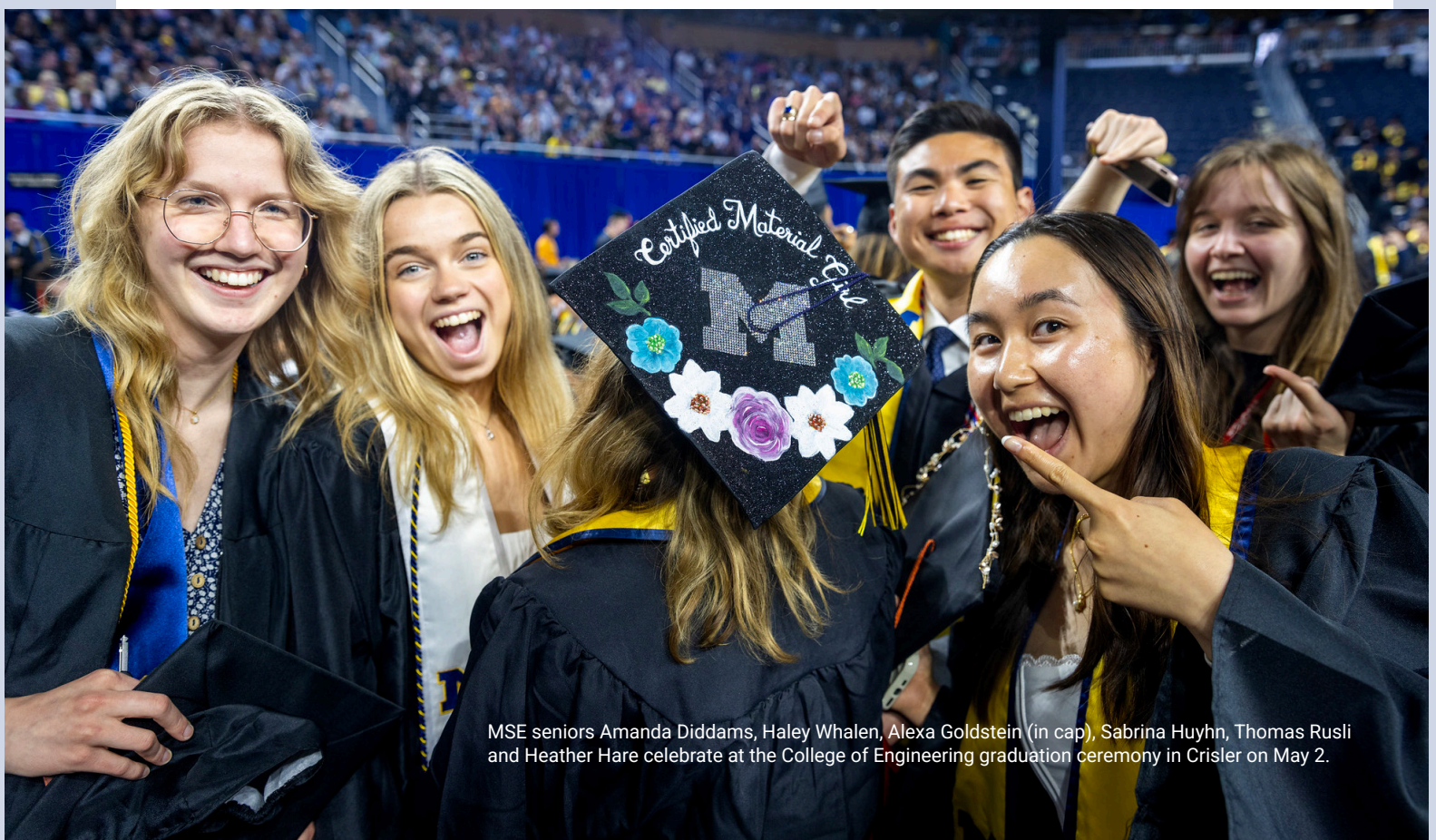
Archi Agrawal
Tiernan Baucom
Yushan Chen
Aaron Cooke
Yuxuan Deng
Alexandra Dewey
Leah Fleming
Vedant Gaikwad

Elliott Gorishek
Gabrielle Grey
Yimo Hou
Jindong Huang
Tzu-Yun Hung
Andrew Jalbert
Anto Jerish Jeyadimal
Jonah Jarczewski
Mahie Kakade
Jialong Ke
Makoto Kimura
Druva Krishnaswami
Austin Lan
Jason Landini
Zhan Liang
Yushen Liu
Chih-Jui Lung
Melissa Masforroll
Eli Rotman
Joshua Samuels
Mariella Samuels
Lingxia Shi
Rohan Somashekara
Dekota Thies
Mustafa Tobah

Chaobo Tong
Forrest Wissuchek
Zenan Zhang
Allen Zhou

Ph.D

Taylor Brandt
Jiadong Chen
Catherine Haslam
Tao-Yu Huang
Yiqiao Huang
Ariba Javed
Jingxian Li
Chung Man Lim
Ju Won Lim
Geordie Lindemann
Alexandra Moy
Taylor Repetto
David Speer
Thomas Valenza
Guangyu Wang
Matthew Webb



MSE seniors Amanda Diddams, Haley Whalen, Alexa Goldstein (in cap), Sabrina Huyhn, Thomas Rusli and Heather Hare celebrate at the College of Engineering graduation ceremony in Crisler on May 2.

Senior design projects tackle important industry issues

This year six teams worked with industry partners to design innovative solutions to problems ranging from product packaging to auto passenger safety.

"We are very excited that every MSE undergrad has the opportunity to work with an industry partner on their capstone design project," remarked course co-instructor Yiyang Li. "The students did a fantastic job applying their knowledge across diverse industries, including automotive, semiconductors, energy, and consumer products."

Optimizing General Motors' Car Door Beams to Ensure Passenger Safety

Industry partner: GM

Team: Alexis Parrish, Luke Snudden, Manasi Londhe, Aaryan Patel, Tyler Lindemann, Micah Gendich, Prita Gupta

Moisture Retention & Life Cycle of Fiber-based Yogurt Cups

Industry partner: General Mills

Team: Thomas Rusli, Alexa Goldstein, Priya Patel, Bennett Mejia, Alan Shi, Laura Bonds, Amanda Diddams

Characterizing the Repeatability of 3D Printers for Electrical Applications

Industry partner: Eaton

Team: Vincent Bowhuis, Audrey Yung, Drew Novak, Sabrina Hyunh, Heather Hare, Haley Whalen

Blinking Prosthetic Eyelid Using Magnetic Actuation

Industry partner: Kellogg Eye Center

Team: Tejaswini Reddy, Madison Forstner, Ben Routhier, Erin Clingerman, Abigail Ahn, Liam Cotter, Josh Dukes

Degradation Mechanisms in Hydrogen Electrolyzer

Industry partner: Evoloh

Team: Kevin Masel, Ben Poole, Charles Khayat, Reegan Ketzenberger, Collin McManus, Penelope Stringer, George Zhou

Thermal and Air Stability of Lithium Vanadium Oxide Fast-Charging Batteries

Industry partner: TYFAST Energy

Team: Andy Danbury, Madina Nosirova, Dashal Womack, Riley Hargrave, Zekun Wu, Zoe Hu

“

"The students did a fantastic job applying their knowledge across diverse industries, including automotive, semiconductors, energy, and consumer products."

—Yiyang Li, MSE 482 co-instructor



During the senior design final presentations, Alexa Goldstein (left) talks to Abigail Ahn and Erin Clingerman about their project for Kellogg Eye Center.

**2024 MSE Alumni
Merit Award
Recipient:
Clinique Brundidge
(BSE '06, MSE '09,
PHD '11)**

Hat-trick alumna Clinique Brundidge (BSE '06, MSE '09, PHD '11) returned to campus during Homecoming Weekend to accept the 2024 MSE Alumni Merit Award and speak at a special MSE luncheon with faculty and students. Now a manager with the Rapid Capabilities Pillar of the Naval Surface Warfare Center in San Diego, Brundidge outlined her career journey and how she used the decision tree analysis whenever she needed to make a big career decision.

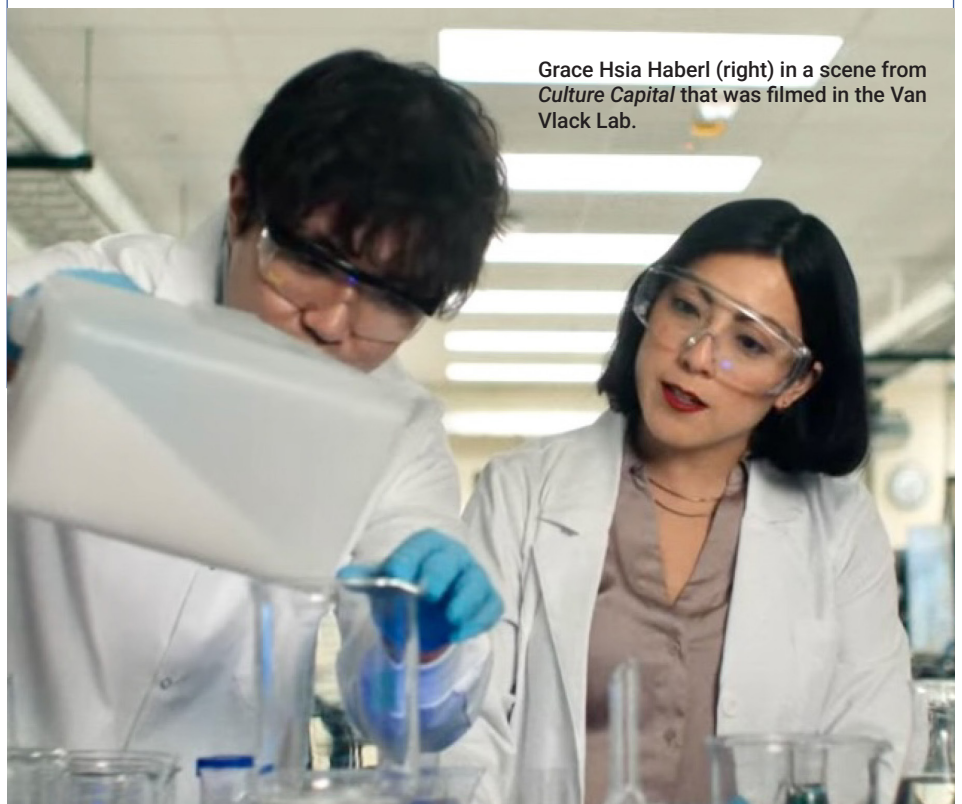


Grace Hsia Haberl (BSE '12) featured in docuseries *Culture Capital*

Grace Hsia Haberl (BSE '12), founder of the company Warmilu, is one of nine diverse entrepreneurs featured in a new 3-part docuseries called *Culture Capital*. Warmilu, which grew from Grace's senior design project as an MSE undergrad, is a global non-electric warming technology manufacturing company. The ingenious blankets Warmilu makes are used by organizations like Doctors Without Borders and annually warm more than 11,000 babies born in 106 hospitals in 23 countries.

"It was honor as a female and minority founder to be at the table with game-changing entrepreneurs," Haberl commented about the documentary. "I love how we took turns sharing lessons and methods to turn visions into legacies."

You can watch the Culture Capital docuseries on Comcast/Xfinity, Peacock or Xumo Play.



Grace Hsia Haberl (right) in a scene from *Culture Capital* that was filmed in the Van Vlack Lab.

Alums making news



Nikhilesh (Nik) Chawla (PHD '97) has been named the inaugural associate dean for engineering at Purdue University in Indianapolis. A pioneer in the field of 4D materials, Chawla will be responsible for strategizing, prioritizing and coordinating all engineering programs at Purdue's new capital city campus.

During his time in the Shtein lab, **Brian Iezzi (PHD '22)** participated in the prestigious NSF I-Corps Teams program. Iezzi and his work with Fibarcode, a technology that enables engineered fibers to be interwoven directly into a textile, were featured in a fall issue of an I-Corps publication. Iezzi is currently an Innovation Crossroads Fellow at Oak Ridge National Laboratory in Knoxville, Tenn.



Matt Stevenson (BSE '95) is part of an NS Nanotech team that just released a new device that can safely disinfect high-risk spaces like ambulances and school buses.



Dr. Catherine K. Kuo (BSE '97), an associate professor of bioengineering at the University of Maryland, reports that she received two special awards in 2024:

Tissue Engineering and Regenerative Medicine International Society (TERMIS) - Americas Chapter 2024 Education, Training and Outreach Award, and Poole & Kent Teaching Award for Senior Faculty in the Clark School of Engineering.



Earlier this year the Department of Energy Computational Science Graduate Fellowship (DOE CSGF) committee selected

Kyle Bushick (PHD '23) as a recipient of the 2024 Frederick A. Howes Scholar in Computational Science award. The annual prize goes to select recent fellowship alumni in recognition of their research accomplishments and outstanding leadership, integrity and character. A DOE CSGF fellow from 2019-2023, Bushick currently works as a postdoctoral researcher in Lawrence Livermore National Lab's Quantum Simulations Group where he develops code to support atomic-scale simulations that can study how elements behave under extreme conditions.

Alumni deaths

1950

Charles W. Vigor (BSE)

1954

Donald J. Groff (BSE)

1962

Ronald D. Tait (BSE)

1970

Patrick J. VanderVeen

1973

Michael G. Wyzgoski

1977

Thomas J. Lahiff

2014

Anna A. Belsky (PHD)

Share your updates with us!

Whether personal or professional, we want to hear your news! Please send your updates to Kristen Freshley at krisfres@umich.edu.

Podcast explores hot materials education topics

MSE's *Undercooled: A Materials Education* podcast is currently in its second season. Hosts Steve Yalisove and Tim Chambers explore best practices in MSE education and interview innovative leaders in the field. New episodes drop every Sunday. You can find the podcast on any podcast platform by simply searching for "Undercooled." Video versions can be found on YouTube.



Undercooled podcast host Steve Yalisove and Tim Chambers interview UCSB Professor Tresa Pollock when she was on campus in October for the Van Vlack Lectureship.

Staff News

2024 Staff Service Awards



Meghan Connolly



Sahar Farjami



Shelley Fellers



Maya Mulchandani

2024 Staff Incentive Awards



Huimin Ponchart



Tina Longenbarger

New Hires



Xiang Gao
Engineer in
Research



Maya Mulchandani
Administrative
Assistant



Ying Qi retires

In October, faculty and staff gathered to thank and wish Ying Qi well on her retirement. Qi, senior research project engineer, is moving on after 26 years of service to MSE.

Connect with us!

Pick your favorite platform(s) and follow us to keep up with all the latest MSE research, faculty/student news, and more!



myumi.ch/XGgyR



myumi.ch/pk9kX



[@ummse](https://www.instagram.com/ummse)



[@ummse](https://twitter.com/ummse)

Wear your MSE spirit!

Check out all the MSE-branded apparel and accessories, including Nike polos and North Face fleeces, available on our online store. A portion of each sale goes directly to the MSE department. Show your pride and support MSE. Stock up today! Go to:

myumi.ch/3QV5P

The interfacial SEM image showing the molecular alignment of liquid crystal networks (orange) and the porous network of squid ring teeth protein-based motors (yellow). Image by Chuqi Huang, a PhD student in the Pena-Francesch group.



**MATERIALS SCIENCE
& ENGINEERING**
UNIVERSITY OF MICHIGAN



And the Oscar for *Best Extra* goes to...



If they had given an Oscar for “Best Extra” at the Academy Awards last spring, the winner (in our opinion) would have been MSE alum **Ben Derby (PHD '20)**, who worked as a background actor in the blockbuster *Oppenheimer* when it was filmed in Los Alamos, N.M. in 2022. Derby, who works as a scientist at LANL, said of the experience: “To see, interact, and even shake the hands of the biggest stars in Hollywood will be something I will share with my kids and grandkids someday. Plus, how often do you get to make a movie about the town you live in and the institution that you work for? Especially it being an Oscar-winning Christopher Nolan movie! To learn about movie- making through this process was amazing, and it continues to influence how I present my science as a compelling story to this day.”

mse.engin.umich.edu:

