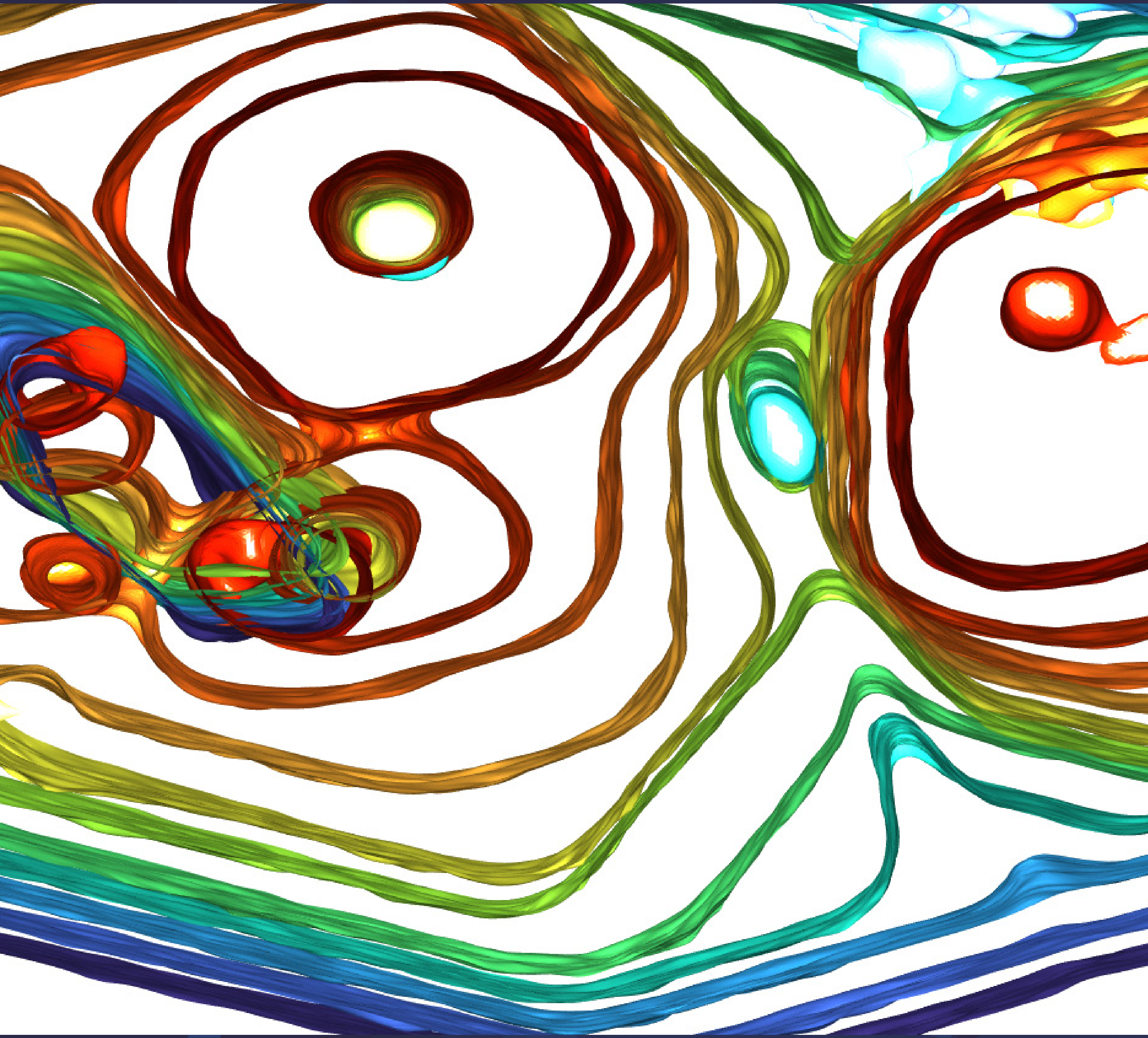
MSE*news*

COLLEGE OF ENGINEERING
MATERIALS SCIENCE & ENGINEERING
UNIVERSITY OF MICHIGAN

Winter 2022



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Front cover: An X-ray tomography visualization shows a top-down view of two quasicrystals as they start to meld together during cooling. Image: Shahani Group

Opposite page: Students enjoy a game of cornhole at the annual all-department Welcome Back Picnic on September 3 at Gallup Park. After months of remote learning, students, faculty and staff were happy to get back to in-person activities.

A note from the MSE Department Chair

2021 was a true hybrid experience. Winter'21 classes and activities (including graduation) were all remote/virtual. Everything from classes to advisory meetings to Ph.D. defenses were conducted virtually via Zoom. Innovation in our community continued to shine in 2021, from our groundbreaking research to novel ways to keep us feeling connected. The department welcomed two new Assistant Professors, Abdon Pena-Francesch (polymers and soft robotic materials) and Claudia Loebel (biomaterials), who officially joined in Winter '21 and Fall '21, respectively.

In Fall '21, the campus returned to in-person learning (with safety measures such as indoor mask requirements and vaccine mandate). Students and faculty alike were happy to get back to a more "normal" academic experience, as evidenced by the higher-than-normal turnout for our annual Welcome Back Picnic, held September 3 at Gallup Park. Our student organizations, MMS and GSC, organized numerous professional development activities and social events throughout the year for the MSE community.

Special events in 2021 included a virtual Van Vlack technical lecture with 2019 Nobel laureate (chemistry) Stanley Whittingham and the inaugural Symposium of the Michigan Materials Research Institute held in November, which drew over 120 attendees hailing from a wide variety of materials-related fields and departments.

Milestones this year included the first Ph.D. graduations for Assistant Professors Robert Hovden and John Heron. In the fall two staff members - Renee Hilgendorf and Kevin Worth - celebrated 25 years with MSE, and in December, Debbie Johnson retired as our purchasing clerk after 14 years with the department. We wish her well!

Along with the happy times, we also experienced profound loss with the passing of important members of our community: Faculty Emeritus Edward Hucke in late 2020, Professor Jyoti Mazumder in Spring'21, and alumnus and EAB member Jerry Madden in late Fall '21 We will miss their presence but will always be extremely grateful for the impact they made on the department as well as the contributions they made to the field.

We were also grateful to our dedicated alumni who came to campus to share their experience and advice with students: Dr. Michelle Griffith, the 2020 MSE Alumni Merit Award winner, who visited during homecoming in September, and Dr. Jody Hall, who spoke at an MMS luncheon in early December.

I applaud all of our students, faculty and staff for keeping a positive attitude and facilitating a seamless transition from remote learning back to in-person activities on campus. To all MSE alumni and members of MSE community, I thank you for your continued invaluable support and wish you good health and happiness in this new year. I look forward to welcoming you on campus soon.

Go Blue!

"I applaud all of our students, faculty and staff for keeping a positive attitude and facilitating a seamless transition from remote learning back to in-person activities on campus."

—Amit Misra,
MSE Chair

Inaugural MMRI Symposium *takes on* 21st Century Challenges

CoE Dean Alec Gallimore (left) and MMRI director Alan Taub (center) give opening remarks. CHE Professor Nicholas Kotov (right) presents "Emergence of Complexity in Chiral NanoAssemblies" at the inaugural MMRI Symposium on Nov. 10.

> "This Symposium is about plotting a course to a bright, sustainable and just future."
> —Dean Alec Gallimore

From lithium-ion batteries to tissue engineering, the Michigan Materials Research Institute's first-ever Symposium showcased just how ready MMRI is to tackle the planet's greatest threats.

"As we enter into the heart of the 21st century, we face existential challenges pertaining to climate change and the finite resources of our planet, as well as our vulnerability to disease and natural threats," said MSE Assistant Professor and Symposium organizer Ashwin Shahani in his opening remarks. "Today's Symposium presentations will address some of these challenges with new technologies and with new materials with exotic functionalities. They will also highlight the wealth of opportunities for future generations of materials scientists and engineers."

The event kicked off at NCRC with a student poster presentation on November 9 with 50+ graduate researchers participating, followed by a virtual keynote address by Arizona State University's Alexandra Navrotsky titled, "Materials Science - What's New and Exciting in the Universe."

In his opening remarks the next day, Michigan Engineering Dean Alec Gallimore praised the MMRI as having "transformative potential [for Earth's sustainability] that is exciting and undeniable." He commented that the Symposium "is about plotting a course to a bright, sustainable and just future."

Eleven select U-M faculty and external speakers then presented on their domains of materials expertise and visions for the future (see list on next page).

In all, more than 120 people registered for the Symposium representing an array of disciplines in addition to MSE, including: mechanical engineering, electrical engineering and computer science, civil and environmental engineering, macromolecular science and engineering, chemical engineering, nuclear engineering and radiation sciences, physics, and dentistry.

"The symposium exceeded my expectations," Shahani remarked. "MMRI achieved its goal in uniting materials scientists across the various disciplines."

1. Symposium organizer Ashwin Shahani welcomes attendees. 2. Aditya Sundar (Taub) points out a highlight of his research to Professor John Allison. 3. EECS Associate Professor Becky Peterson begins her presenation. 4. Ph.D. precandidate Alex Moy explains her research during the poster presentation on Nov. 9. 5. MSE Professor Katsuyo Thornton begins her lecture.

Symposium Speakers

Stephen Forrest – U-M Electrical Engineering and Computer Science – "Thin film conformable electrons based on epitaxial transfer,"

Becky Peterson – U-M Electrical Engineering and Computer Science – "Scalable Atomic Layer Deposition for P-type and N-type Oxide Semiconductor TFTs,"

Amit Misra – MSE – "Mechanical Behavior of Hierarchial Metallic Nanocomposites,"

Chinedum Okwudire & Wenda Tan – U-M Mechanical Engineering – "Physics-based and data-driven modeling and control of process and microstructure in metal AM,"

Elizabeth C. Dickey – Carnegie Mellon University Materials Science & Engineering – "Electroceramics for Energy Storage and Conversion: Design and Control of Defect-Mediated Properties,"

Stephen Maldonado – U-M Chemistry – "Electrochemical liquid phase epitaxy of Hyperdoped Crystalline Si,"

Paul V. Braun – UIUC MSE, Self-Assembly & Energy – "Opportunities in Solid-State Batteries Enabled by Dense and Crystallographically Controlled Cathodes,"

Katsuyo Thornton – MSE – "Material Genome Approach to Enable Breakthroughs in the Fast-Charging Performance of Li-ion Batteries,"

Nicholas Kotov – U-M Chemical Engineering – "Emergence of Complexity in Chiral NanoAssemblies," and

Kenichi Kuroda – U-M Dentistry – "Biomaterials and Tissue Engineering."

Stephen Forrest

Top poster honors

With more than 50 poster entrie, it was a tight competition, but judges ultimately selected the following winners:

1st Place

Catherine Haslam (Sakamoto) - "The effect of aspect ratio on the mechanical behavior of Li metal in solid-state cells"
Aditya Sundar (Qi/Chandran, ME) - "Screening the mechanical properties of multicomponent BCC refractories"
Megan Trombley (Allison) - "Size Effect on the Ultrasonic Fatigue Behavior of Laser Powder Bed Fusion 316L"

2nd Place

Rajani Bhat (Kuroda Lab, School of Dentistry) - "Role of Peptide-Mimetic Anionic groups in Amphiphilic Copolymers"
Ming-Hsun Lee (Peterson) - "Ex situ Doping on AlxGa2-xO3 with Si-ion Implantation and the Demonstration of Ohmic Contacts Formation"
Geordie Lindemann (Shahani) - "Microstructural stability of a three-phase eutectic examined via 4D X-ray nano-tomography"
Anshul Singhal (Taub) - "Improved extraction of natural fibers for polymer composite applications"

"In my view, the winning posters conveyed a depth of understanding of a materials challenge; they were also notably successful in advancing new research towards a plausible solution," commented Symposium organizer Ashwin Shahani.

Students swarm around Assistant Professor Abdon Pena-Francesch to hear about his biomaterials research at the MSE Undergraduate Open House on September 9.

Faculty Promotions, Awards & Recognition

Anish Tuteja
was promoted to
Professor

Liang Qi
was promoted to
Associate Professor, with tenure

Ashwin Shahani
received the 2021 MSE Faculty Outstanding Accomplishment Award.

Nicholas Kotov
was honored by MRS as the 2021 David Turnbull Lecturer

Yalisove, Chambers earn national teaching awards

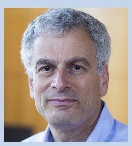
Professor Steve Yalisove and **Dr. Tim Chambers** were recognized in July by the Materials Division of American Society of Engineering Education (ASEE). Yalisove, who joined the MSE faculty in 1989, received the 2021 Michael Ashby Outstanding Materials Educator Award. Yalisove was selected for his “extensive innovations in active and team-based pedagogies,” and for his “enthusiastic creation of web-based tools to enhance student learning.” Chambers, who came to U-M in 2015, earned the 2021 New Materials Educator Award for his “extremely impressive and obvious dedication to educational excellence.”

Faculty External Professional Service 2021

John Allison

· National Academy of Engineering, Materials Engineering Section, Chair
· TMS Fellow Committee, Chair
· TMS Materials Innovation Committee, Member
· TMS ICME Committee, Member
· Integrated Materials & Manufacturing Innovation, Editorial Board

Michael Atzmon

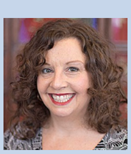


· Past President, International Mechanochemical Union (member Society of the International Union of Pure and Applied Chemistry)
· Steering Committee, International Symposium on Metastable, Mechanically Alloyed and Nanocrystalline Materials

Stephen Forrest

· Distinguished Visiting Professor of Electrical Engineering, Technion Israel Institute of Technology (2015-present)
· National Academy of Sciences Flexible Electronics Committee, (2010-present)
· Proceedings of the National Academy of Sciences, Associate Editor (2017-present)
· ChemSuSChem Editorial Board (2007-present)
· ACS Nano, Editorial Board (2007-present)
· Physical Review Applied, Lead Editor (2017-present)
· Nano Energy, Editorial Board (2014-Present)
· HKUST Key State Laboratory Advisory Committee
Purdue University School of Engineering Advisory Board (2018-present)
· University Musical Society, Sustaining Board of Directors (2018-present)
· The Technion, Israel Institute of Technology Board of Governors (2012-7, 2019-present)
· Universal Display Corp. Scientific Advisory Board (1996-Present)
· Applied Materials Growth Technology Advisory Board (2020-Present)
· National Academy of Engineering National Materials and Manufacturing Board (2015-9, 2020-Present)
· National Academy of Engineering Section 7 Vice Chair (2018-2020); Chair (2021-Present)

Sharon Glotzer

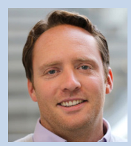


· Member, National Academy of Sciences Division on Engineering and Physical Sciences Board
· Associate Editor, ACS Nano, 2015-present
· Member, XSEDE SDSC Expanse Advisory Committee

Rachel Goldman

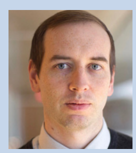
· Chair, Scientific Advisory Committee, Center for Integrated Nanotechnologies, Department of Energy
· Chair Line, Division of Materials Physics, American Physical Society, 2019-2023
· Chair, APS DMP Fellowship Selection Committee, American Physical Society, 2020
· Chair, Adler Award Committee, American Physical Society, 2019
· Associate Editor, Journal of Applied Physics, 2017-present
· Editorial Board, MRS News, 2012-present
· Los Alamos National Laboratory Materials Capability Review Committee, 2021
· External Review Committee, Department of Physics, University of North Carolina - Chapel Hill, 2020
· NAS/NAE Panel Extramural Basic Research at the Army Research Laboratory, 2019-2020
· Scientific Advisory Board, Nanoscale Science Research Center Recapitalization (DoE), 2020
· Executive Committee, Electronic Materials Conference, 2016-2022
· Steering Committee, NSF-AGEP-GRS Virtual PI and Student Meeting, 2021

John Heron



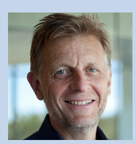
· Lead organizer of ACerS EMA Meeting, "Frontiers in Ferroic Oxides: Synthesis, Structure, Properties, and Applications," Jan. 2022
· Member, American Ceramics Society, Materials Research Society, and American Physical Society
· Chair of the NIST Center of Neutron Research Beam Time Allotment Committee

Robert Hovden



· DOE Proposal Review Board at the Lawrence Berkeley National Electron Microscopy Center and the Brookhaven National Center for Functional Nanomaterials.
· Symposium Chair for APS March Meeting 2020 Denver, Co., M&M 2020 Milwaukee, Wis., M&M 2019 Portland, Ore.

John Kieffer

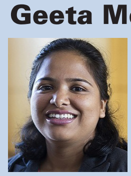


· Board of Directors of the American Ceramic Society
· 2020 Alfred R. Cooper Distinguished Lecturer

Emmanuelle Marquis

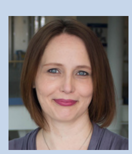
· TMS awards committee, member
· TMS nuclear materials committee, member
· TMS chemistry and physics of materials committee, member

Geeta Mehta



· NIH review panel
· NSF review panel

Joanna Millunchick



· Big Ten Academic Alliance Leadership Fellow (2019-20)
· Taubman College of Architecture and Urban Planning Advisory Board (2019-)

(Continued on pg. 8)

Remembering Jyoti Mazumder

Jyoti Mazumder, Robert H. Lurie Professor of Engineering, Department of Mechanical Engineering and the Department of Materials Science and Engineering, Director of the Center for Laser-Aided Intelligent Manufacturing at U-M and Director of the NSF I/UCRC for Lasers and Plasmas for Advanced Manufacturing, U-M, died April 10, 2021. He was 70.

With an extraordinary career spanning 41 years, Professor Mazumder spent 16 of those at the University of Illinois, Urbana-Champaign, and 25 at the University of Michigan, Ann Arbor where he conducted groundbreaking research in the areas of materials processing using lasers and the non-equilibrium synthesis of materials with tailored properties along with their evaluation and characterization.

Throughout his prolific career he published 400 papers, co-authored various books, and held more than 25 patents. He is known as a pioneer in additive manufacturing and took his research to market by commercializing Direct Metal Deposition (DMD) technology and recently developing in-situ sensors for 3-D printing and welding that have the capability to detect defects, composition, and phase transformation.

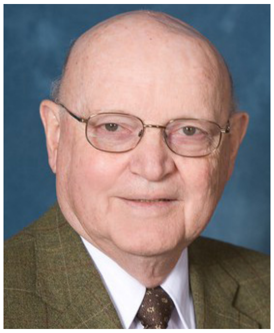
"Professor Jyoti Mazumder was a distinguished colleague and mentor and a world-leader in laser-basemanufacturing. His passing is tragic and he will be missed by all who worked with him," said Amit Misra, Edward DeMille Campbell Collegiate Professor and Department Chair, U-M Materials Science and Engineering. "He dreamed big and had a vision for positioning Michigan Engineering at the forefront of additive manufacturing research."

Jyoti Mazumder presents at the Materials at Michigan Symposium held in October 2017.

Four MSE faculty/alumni earn 2021 TMS awards


Amit Misra


Katsuyo Thornton


Ray Decker


Liang Qi

Four members of our community received awards in 2021 from The Minerals, Metals and Materials Society (TMS): **Amit Misra**, the Cyril Stanley Smith Award; **Katsuyo Thornton,** the Julia and Johannes Weertman Educator Award; **Ray Decker**, Fellow Award; and **Liang Qi**, a Young Leaders Professional Development Award. All were officially recognized at the virtual TMS Annual Meeting last March.

Faculty External Professional Service (cont'd)

Amit Misra

· Materials Research Letters, Editor
· Editor, Materials Research Letters
· Chair, Editorial Board, MRS Bulletin
· Chair, University Materials Council
· Member, MRS Program Development Subcommittee
· Member-at-large, TMS Innovation Committee
· Chair, External Advisory Board: Beyond Fingerprinting, Sandia National Labs
· Member, Scientific Advisory Committee, EFRC FUTURE, Los Alamos National Laboratories
· Member, Digital Metallurgy Initiative External Review Committee, Oak Ridge National Laboratory

Becky Peterson

· General Chair (2022), Technical Program Chair (2021) and Vice Chair (2020), Device Research Conference
· Treasurer (2019-2021), Electronic Materials Conference
· Chair, IEEE Southeastern Michigan Trident Chapter IV (Joint Chapter of Electron Device Society/APP/MTT/Photonics) (2018-present)

Ashwin Shahani

· Member of International Council on Materials Education, July 2021-present
· Member of Scientific Advisory Committee for FXI Beamline at National Synchrotron Light Source II (NSLS-II), Sept. 2021
· Guest editor of *MRS Bulletin* thematic issue: "Processing Metallic Materials Far from Equilibrium" November 2020
· Key reader, Metall. Mater. Trans. A, September 2018 to present
· Member of ASM Emerging Professionals Committee, August 2018-present
· Member of TMS technical committees: Solidification Committee and Phase Transformations Committee (Materials Processing & Manufacturing Division), March 2017-present
· Member of Proposal Review Panel for National Synchrotron Light Source II (2019-2022)

Alan Taub

· NAE - Council member and chair Audit Committee
· ASM - Awards Committee
· MIT Visiting Committee for Materials Research Lab (MRL)
· MainForum Conference Organizing Committee

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
· Contributor, Report on Creating the Next-Generation Materials Genome Initiative Workforce (TMS)

Steve Yalisove

· Materials Education Symposium Advisory Committee
· MRS Fall 2021 Symposium Organizer for "Developing an open source textbook for the materials community"
· MS&T Fall 2022 Symposium Organizer for "Developing an open source textbook for the materials community"

Remembering Professor Emeritus Edward Hucke

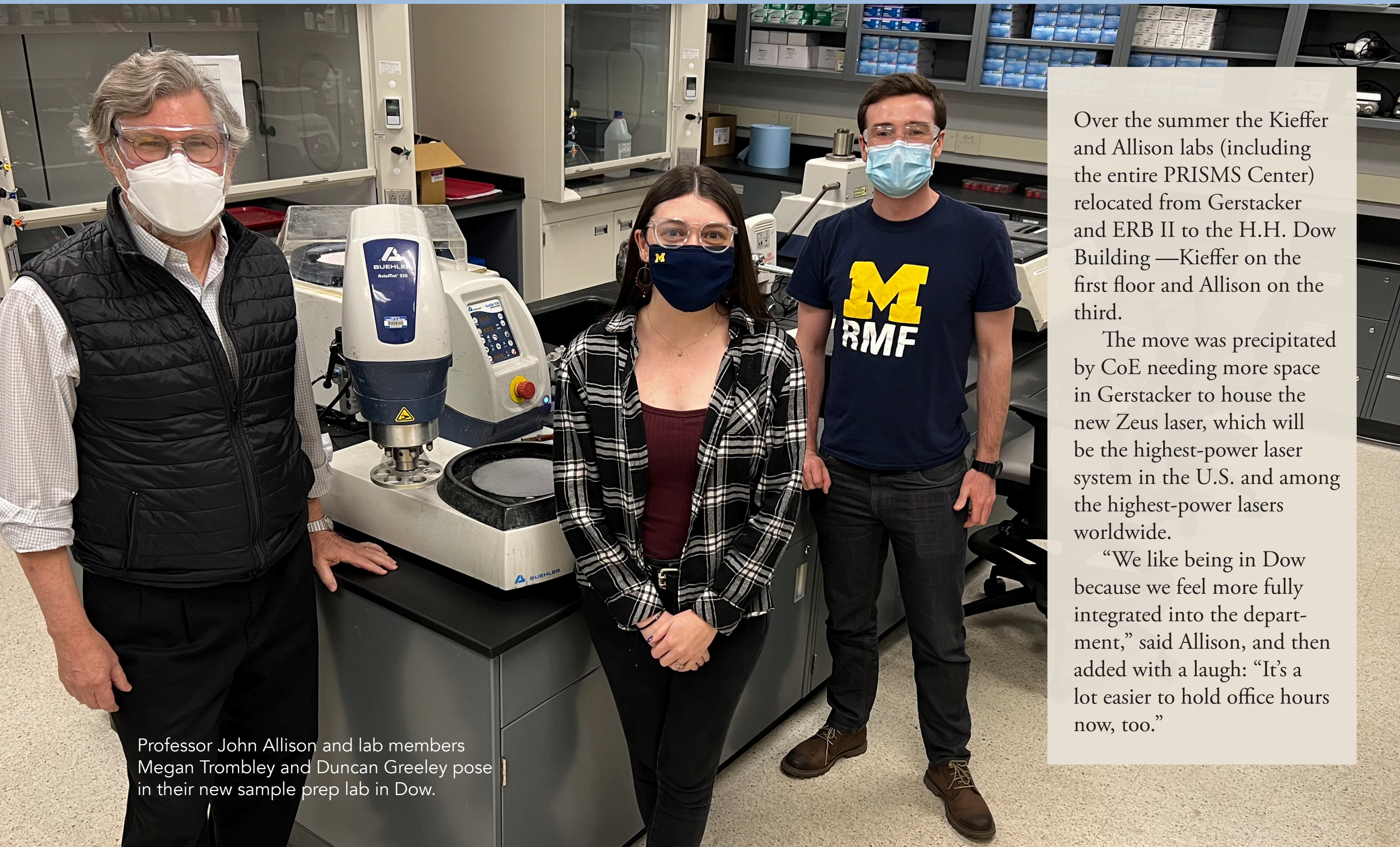
Professor Emeritus Edward Hucke died in his home in La Jolla, Calif. on November 7, 2020 at the age of 90.

Professor Hucke received his S.B., S.M., and Sc.D. degrees from the Massachusetts Institute of Technology in 1951, 1952, and 1954, respectively. After a two-year tenure as director of research and development at the Locomotive Finished Materials Company in Atchison, Kansas, he joined the faculty of the Department of Chemical and Metallurgical Engineering in the College of Engineering as an assistant professor in 1955. He was promoted to associate professor in 1958 and to professor in 1961.

Professor Hucke received prestigious awards for his teaching and research accomplishments, including the Gustav Lilliequist Award of the Steel Founders Society in 1956, the Outstanding Young Engineer Award of the Engineering Society of Detroit in 1961, and the Bradley Stoughton Award of the American Society of Metals in 1963. He was a fellow of the American Institute of Chemists and ASM International.

In 1991, Professor Hucke retired to La Jolla, Calif. where he was active in the local tennis community.

Allison and Kieffer Labs get new homes in Dow Building



Professor John Allison and lab members Megan Trombley and Duncan Greeley pose in their new sample prep lab in Dow.

Over the summer the Kieffer and Allison labs (including the entire PRISMS Center) relocated from Gerstacker and ERB II to the H.H. Dow Building —Kieffer on the first floor and Allison on the third.

The move was precipitated by CoE needing more space in Gerstacker to house the new Zeus laser, which will be the highest-power laser system in the U.S. and among the highest-power lasers worldwide.

"We like being in Dow because we feel more fully integrated into the department," said Allison, and then added with a laugh: "It's a lot easier to hold office hours now, too."

STAFF NEWS

Debbie Johnson retires after 14 years with the department


Debbie Johnson (center) with Todd Richardson (left) and Amit Misra at the Faculty/Staff Holiday Luncheon Dec. 13.

Debbie Johnson began her long career with the university in 1976 in an administrative role in Staff Records. She joined MSE in 2007 as a Procurement Clerk, helping out with contracts and grants. She is looking forward to her retirement so that she can spend more time with family and volunteering with her church.

The department recognized Debbie and her service to MSE at the annual Faculty/Staff Holiday Luncheon on December 13. "What I enjoyed most about working with Debbie was her kind spirit. She was personable and always had a warm, welcoming smile," commented HR generalist Cassandra Franklin-Smith.

Co-worker Tina Longerbarger, executive secretary, added: "Debbie was always so helpful. She always took the time to sit with me to go over any processes I didn't understand. I will truly miss her and wish her all the best."

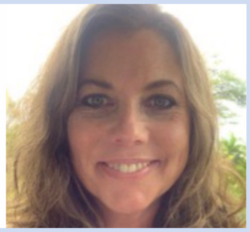
Staff honored with dept./CoE awards

MSE Staff Service Award winners for 2021 included: **Sahar Farjami** (engineering technician), **Cassandra Franklin-Smith** (HR generalist), **Amy Holihan** (finance and research manager), **Ellen Kampf** (administrative assistant), and **Keith McIntyre** (senior facilities manager).

In January, McIntrye and **Patti Vogel** (unergraduate program advisor) were recognized by the College of Engineering with a 2021 Staff Incentive Award. Initiated in 2018, the CoE Staff Incentive Awards recognize staff who consistently demonstrate the College's vision, mission and values.


Sahar Farjami


Cassandra Franklin-Smith


Amy Holihan


Ellen Kampf


Keith McIntyre


Patti Vogel

Renee Hilgendorf, Kevin Worth celebrate 25 years on MSE staff

Renee Hilgendorf and Kevin Worth (also a '96 alum) joined the MSE staff within three weeks of each other in the Fall of 1996. In honor of the 25th anniversary of their hiring, we asked them both to reflect back and share highlights of their time on staff.

Renee Hilgendorf
Graduate Program Advisor

How did you come to join the MSE staff? I began my U-M career in the Rackham Fellowships office, working there 8 years before joining MSE in 1996.

What was your work life like when you first started? It was a bit different then. Email was not a primary form of communication, so I had lots of paper forms to deal with that needed real signatures, which required face-to-face conversations, etc. If I needed to talk with a faculty or student, I would visit their office rather than emailing. I can't imagine ever working remotely back then. I also recall early on attending a workshop about a new information system where documents and information could be shared over the internet, called the "World Wide Web." It seemed like a strange concept. Now I don't know how we functioned and survived without it!

What's one of your most memorable moments? One winter morning right after the holiday break a student showed up at my office to pick up the form to take to his prelim exam that was scheduled for that morning. He was already dressed in his presentation clothes and his coat was tattered and ripped. He casually mentioned that he was hit by a car while riding his bike to campus. He said he thought he was okay and wanted to still hold his exam. When I checked in on him while he was setting up, though, it was clear to me that he was definitely not okay. He was beginning to get a headache and mixing up his words. I convinced him to get checked out at the hospital and drove him straight there. It turned out that he did indeed have a concussion, but because he was wearing a helmet that his mother had just given him for Christmas, the story has a happy ending. He was eventually rescheduled and passed his prelim after he had recovered.

What is the most rewarding part of your job? I would say it's getting to know the students on a personal level and helping them navigate the sometimes-complicated graduate school experience. It's rewarding when I can help ease their mind so they can focus on their classes and research. I have been lucky to work with such a diverse group of students from all over the world.

Kevin Worth
Senior IT Administrator

How did you come to join the MSE staff? As an undergrad I worked in the MSE/ChE mail room. My brother introduced me to John Mansfield and I started working as a lab assistant in EMAL (now (MC)2). The Internet was just starting, and I made the initial websites for EMAL and the MSE department. When I graduated, the longtime MSE facilities engineer, who had also been doing basic IT duties, retired and the department created a full-time IT position. I was hired in based on my experience in EMAL as an undergrad.

How does being an MSE major help in your job? It integrated me into the department from the beginning. Oftentimes the IT department is completely separate from the rest of the operation. Since I can speak the language, I can understand problems and goals better than a non-MSE major.

What have been some of your more memorable moments? Early on I visited Professor Emeritus Van Vlack in his home in Kalamazoo to set up a computer for him and instruct him how to get on the internet. He was incredibly nice and shared memories of his time in the department.

For a few years, I taught sections of the junior lab class and really enjoyed working with the students.

One funny moment that made me look like I had superpowers happened when the building unexpectedly lost power. I jokingly clapped my hands twice and the power immediately turned on! Everyone looked at me in disbelief.

What is the most rewarding part of your job? I enjoy working alongside cutting-edge research at the best university in the country, and value the friendships I've formed over the years with my coworkers.

Helping people when they have a really frustrating problem gives me great satisfaction….but I also like the problems that solve themselves right as I show up!

How pearls achieve nanoscale precision

"When we build something like a brick building, we can build in periodicity through careful planning and measuring and templating. Mollusks can achieve similar results on the nanoscale by using a different strategy. So we have a lot to learn from them, and that knowledge could help us make stronger, lighter materials in the future."

—**Robert Hovden**

Coaxing order from unpredictable layers, mollusks do what humans can't.

In research that could inform future high-performance nanomaterials, a team led by MSE Assistant Professor Robert Hovden's group has uncovered for the first time how mollusks build ultradurable structures with a level of symmetry that outstrips everything else in the natural world, with the exception of individual atoms.

"We humans, with all our access to technology, can't make something with a nanoscale architecture as intricate as a pearl," said Hovden. "So we can learn a lot by studying how pearls go from disordered nothingness to this remarkably symmetrical structure."

The analysis was done in collaboration with researchers at the Australian National University, Lawrence Berkeley National Laboratory, Western Norway University and Cornell University.

Published in the Proceedings of the National Academy of Sciences, the study found that a pearl's symmetry becomes more and more precise as it builds, answering centuries- old questions about how the disorder at its center becomes a sort of perfection.

Layers of nacre, the iridescent and extremely durable organic-inorganic composite that also makes up the shells of oysters and other mollusks, build on a shard of aragonite that surrounds an organic center. The layers, which make up more than 90% of a pearl's volume, become progressively thinner and more closely matched as they build outward from the center.

Perhaps the most surprising finding is that mollusks maintain the symmetry of their pearls by adjusting the thickness of each layer of nacre. If one layer is thicker, the next tends to be thinner, and vice versa. The pearl pictured in the study contains 2,615 finely matched layers of nacre, deposited over 548 days.

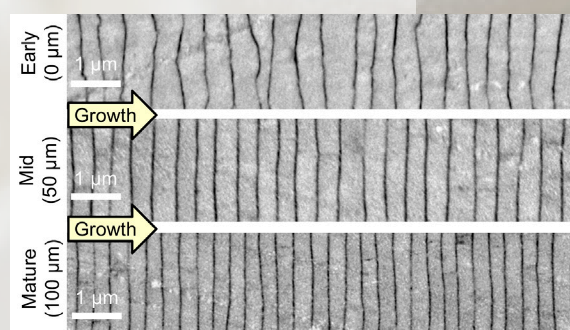
"These thin, smooth layers of nacre look a little like bed sheets, with organic matter in between," Hovden said. "There's interaction between each layer, and we hypothesize that that interaction is what enables the system to correct as it goes along."

The team also uncovered details about how the interaction between layers works. A mathematical analysis of the pearl's layers show that they follow a phenomenon known as "1/f noise," where a series of events that seem to be random are connected, with each new event influenced by the one before it. 1/f noise has been shown to govern a wide variety of natural and human-made processes including seismic activity, economic markets, electricity, physics and even classical music.

"When you roll dice, for example, every roll is completely independent and disconnected from every other roll. But 1/f noise is different in that each event is linked," Hovden said. "We can't predict it, but we can see a structure in the chaos. And within that structure are complex mechanisms that enable a pearl's thousands of layers of nacre to coalesce toward order and precision."

The team found that pearls lack true long-range order—the kind of carefully planned symmetry that keeps the hundreds of layers in brick buildings consistent. Instead, pear exhibit medium-range order, maintaining symmetry for around 20 layers at a time. This is enough to maintain consistency and durability over the thousands of layers that make up a pearl.

The team gathered their observations by studying Akoya "keshi" pearls, produced by the Pinctada imbricata fucata oyster near the Eastern shoreline of Australia. They selected these particular pearls, which measure around 50 millimeters in diameter, because they form naturally, as opposed to bead-cultured pearls, which have an artificial center. Each pearl was cut with a diamond wire saw into sections measuring three to five millimeters in diameter, then polished and examined under an electron microscope.



Electron microscopy shows how a pearl's layers of nacre become more precise as they build outward from the pearl's center.

Hovden says the study's findings could help inform next-generation materials with precisely layered nanoscale architecture.

"When we build something like a brick building, we can build in periodicity through careful planning and measuring and templating," he said. "Mollusks can achieve similar results on the nanoscale by using a different strategy. So we have a lot to learn from them, and that knowledge could help us make stronger, lighter materials in the future."

The research was conducted at U-M's Michigan Center for Materials Characterization.

Spray-on coating could make solar panels snow-resistant

A cold-weather-friendly formula developed by a team led by Anish Tuteja foils snow/ice accumulation in Alaska test.

In an advance that could dramatically improve the productivity of solar panels in cold climates, a University of Michigan-led team has demonstrated an inexpensive, clear coating that reduced snow and ice accumulation on solar panels, enabling them to generate up to 85% more energy in early testing.

The coating is made chiefly of PVC or PDMS plastic and silicon or vegetable-based oils. It can be sprayed or brushed on in cold weather and, in its current iteration, can keep shedding snow and ice for up to a year.

"Renewable energy is really taking off right now, but snow is a huge problem in northern climates," said Anish Tuteja, a professor of materials science and engineering at U-M, who led the study in collaboration with Sandia National Laboratories and the University of Alaska. "Solar panels might lose 80 or 90 percent of their generating capacity in the winter. So figuring out a way for them to continue generating energy throughout the year was an exciting challenge," he added.

While Tuteja's lab has developed a number of effective ice-shedding coatings in the past, he explains that designing a coating that can passively shed both snow and ice represents a special challenge.

"Ice is relatively dense and heavy, and our previous coatings used its own weight against it," Tuteja said. "But snow can be ten times less dense than ice, so we weren't at all certain that the tricks we use on ice would translate to snow."

U-M macromolecular science and engineering graduate researcher Abhishek Dhyani applies ice-and-snow-repellent coating to a solar panel in Fairbanks, Alaska. Credit: Laurie Burnham, Sandia National Laboratory

To find the right coating, Tuteja and his team turned to two key properties that have powered ice-shedding coatings in the past: Low interfacial toughness and low adhesion strength. Low surface adhesion is basically slipperiness. Slipperiness alone works well on small areas, but the bigger the surface, the more force is needed to slide snow and ice off it. For larger areas, you need a way to break up the adhesion entirely. This is what low interfacial toughness does—it creates cracks between the ice and the panel. These propagate along the panel, regardless of its size, breaking the ice and snow free.

The team worked to strike precisely the right balance of low surface adhesion and low interfacial toughness that would repel both ice and snow from small and large surfaces alike. They started with very rigid PVC plastic, for low interfacial toughness, and mixed in a small amount of vegetable oil that gave the PVC a low enough surface adhesion to provide the best of both worlds. They also devised a second material that works equally well using PDMS plastic and silicon-based oil.

The U-M researchers collaborated with the University of Alaska to test the material on a solar field in Fairbanks, Alaska, applying the coatings to a subset of panels that were monitored by automated cameras for a period of approximately two weeks. The tests showed that the coated panels had an average snow and ice coverage of approximately 28% over an entire winter season, in comparison to approximately 59% for the uncoated panels.

The coating was developed as part of a project led by Sandia National Laboratories, a US Department of Energy research and development lab, with funding provided by the DOE's Solar Energy Technologies Office "As the cost of solar energy has dropped and profitability has climbed, much of the growth in solar energy in recent years has been in northern states, where snow is common," said Laurie Burnham, the project's principal investigator.

"Snow-phobic coatings, if we can demonstrate their long-term efficacy, will make solar power more reliable and more affordable in snowy regions, helping accelerate our nation's transition to a more solar-dominated energy economy."

Tuteja says that, while the current iteration of the coating could be used immediately, the team plans to tweak it further with the aim of developing a coating that can last at least five years.

The paper, published in Advanced Materials Technologies, is titled "Facilitating Large-Scale Snow Shedding from In-Field Solar Arrays using Icephobic Surfaces with Low-Interfacial Toughness."

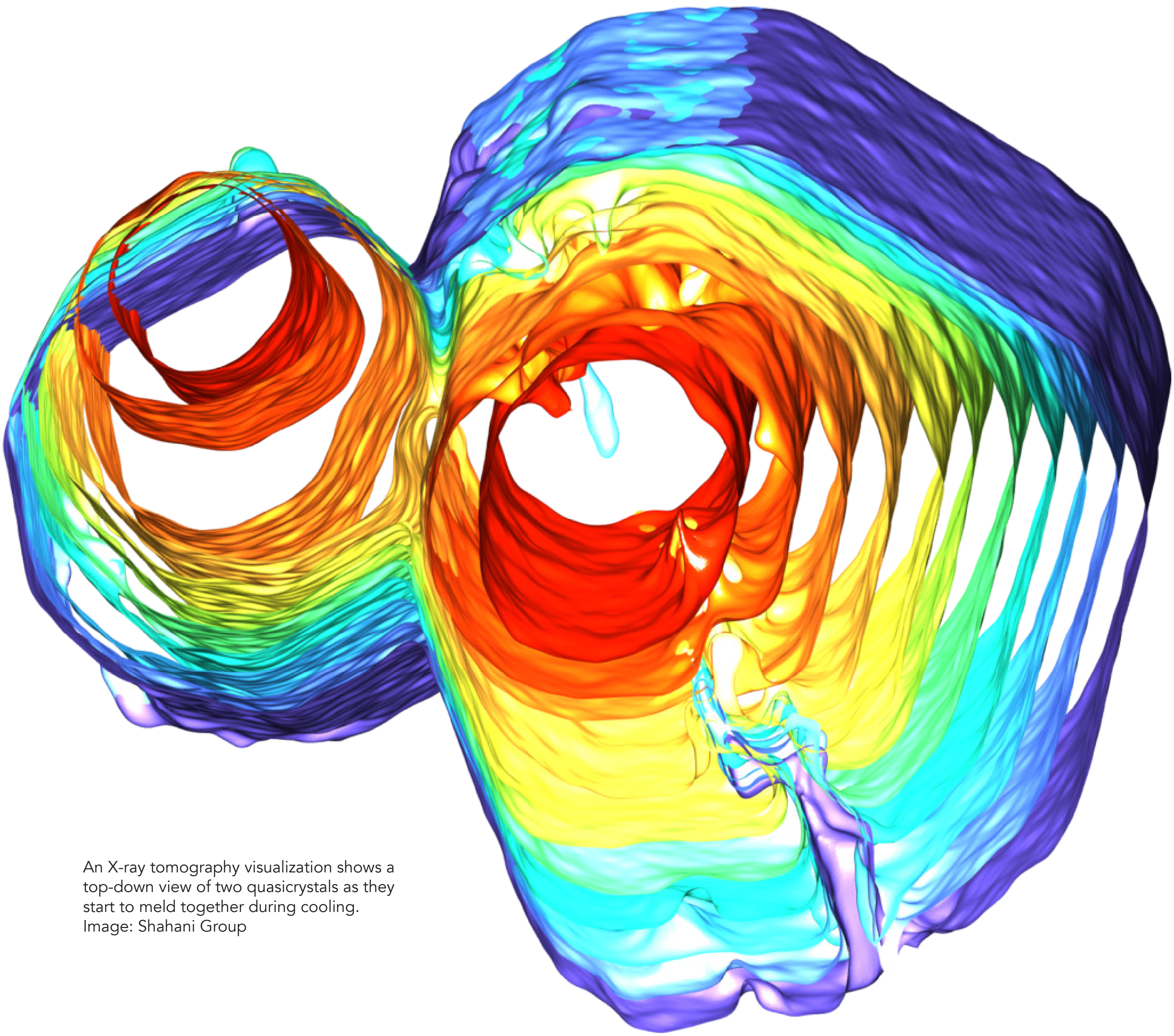
Other researchers on the project were former U-M materials science and engineering graduate researcher Abhishek Dhyani, Christopher Pike and Erin Whitney at the Alaska Center for Energy and Power at the University of Alaska and Jennifer L. Braid at the Photovoltaics and Materials Technology Department of Sandia National Laboratories.

"Snow-phobic coatings, if we can demonstrate their long-term efficacy, will make solar power more reliable and more affordable in snowy regions, helping accelerate our nation's transition to a more solar-dominated energy economy."

—Anish Tuteja

Resurrecting Quasicrystals: Findings may make an exotic material commerically

The Shahani and Glotzer groups are working together to examine how a self-healing phenomenon could reduce defects that rendered quasicrystals impractical.



An X-ray tomography visualization shows a top-down view of two quasicrystals as they start to meld together during cooling. Image: Shahani Group

A class of materials that once looked as if it might revolutionize everything from solar cells to frying pans—but fell out of favor in the early 2000s—could be poised for commercial resurrection, findings from a University of Michigan-led research team suggest.

Published in *Nature Communication*, the study demonstrates a way to make much larger quasicrystals than was possible before, without the defects that plagued past manufacturers and eventually led to the dismissal of quasicrystals by industry as an intellectual curiosity.

"One reason why Industry gave up on quasicrystals is because they're full of defects," said MSE Assistant Professor Ashwin Shahani, a corresponding author on the paper. "But we're hoping to bring quasicrystals back into the mainstream. And this work hints that it can be done."

Quasicrystals, which have the ordered structure but not the repeating patterns of ordinary crystals, can be manufactured with a range of alluring properties. They can be ultra-hard or super-slippery. They can absorb heat and light in unusual ways and exhibit exotic electrical properties, among a host of other possibilities.

But the manufacturers who first commercialized the material soon discovered a problem—tiny cracks between crystals, called grain boundaries, that invite corrosion, rendering quasicrystals susceptible to failure. Commercial development of quasicrystals has been mostly shelved ever since.

But new findings from Shahani's team show that, under certain conditions, small quasicrystals can collide and meld together, forming a single large crystal with none of the grain boundary imperfections found in groups of smaller crystals. Shahani explains that the phenomenon came as a surprise during an experiment designed to observe the formation of the material.

"It looks like the crystals are healing themselves after collision, transforming one type of defect into another type that eventually disappears altogether," he said. "It's extraordinary, given that quasicrystals lack periodicity.

The crystals start as pencil-like solids measuring a fraction of a millimeter, suspended in a molten mixture of aluminum, cobalt and nickel, which the team can observe in real-time 3D using X-ray tomography. As the mixture cools, the tiny crystals collide with each other and meld together, ultimately morphing into a single large quasicrystal that's several times larger than the constituent quasicrystals.

After observing the process at Argonne National Laboratory, the team replicated it virtually with computer simulations. By running each simulation under slightly different conditions, they were able to identify the exact conditions under which the tiny crystals will meld into larger ones. They found, for example, that the tiny pencil-like crystals must face each other within a certain range of alignment in order to collide and coalesce. The simulations were conducted in the lab of Sharon Glotzer, the John Werner Cahn Distinguished University Professor of Engineering and a corresponding author on the paper.

"It's exciting when both experiments and simulations can observe the same phenomena happening on the same length and time scales," Glotzer said. "Simulations can see details of the crystallization process that experiments can't quite see, and vice versa, so that only together can we fully understand what's happening."

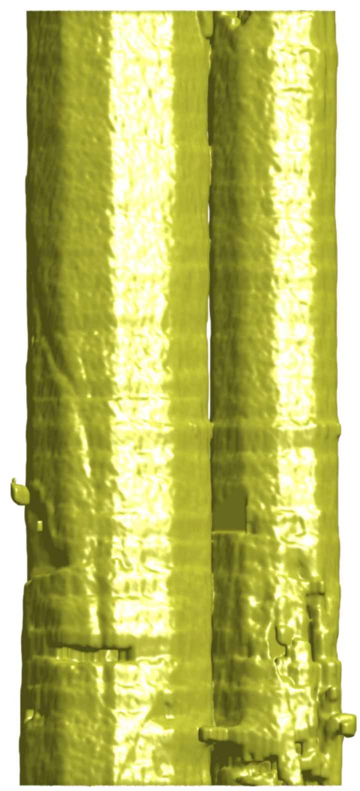
While commercialization of the technology is likely years off, the simulation data could ultimately prove useful in developing a process to efficiently produce large quasicrystals in production-scale quantities. Shahani believes that it may one day be possible to produce and process them using sintering, a well-known industrial process where materials are melded together using heat and pressure. It's a far-off goal, but Shahani says the new study opens a new avenue of research that could one day make it happen.

For now, Shahani and Glotzer are working together to understand more about quasicrystal defects, including how they form, move and evolve.

The paper is titled "Formation of a Single Quasicrystal Upon Collision of Multiple Grains." The research team also includes former MSE PhD candidate Insung Han; U-M macromolecular science and engineering PhD candidate Kelly Wang; MSE graduate research assistant Zhucong Xi; former MSE research fellow Hadi Parsamehr; Andrew Cadotte, a graduate student research assistant in the applied physics program of the U-M College of Literature, Science, and the Arts; and Brookhaven National Laboratory physicist Xiangui Xiao.

The research was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Science, Award number DE-SC0019118.

--Story by Gabe Cherry



An X-ray tomography visualization shows a side view of two quasicrystals as they begin to meld together during cooling. Image: Shahani Group

Harnessing the Hum

The property that makes fluorescent lights buzz could power a new generation of computing devices.

A new material developed in Assistant Professor John Heron's lab is at least twice as "magnetostrictive" and far less costly than other materials in its class. It holds the potential to dramatically reduce the energy consumption of the world's computing devices, and could also lead to better sensors for medical and security devices.

"Magnetostriction," which causes the buzz of fluorescent lights and electrical transformers, occurs when a material's shape and magnetic field are linked—that is, a change in shape causes a change in magnetic field. The property could be key to a new generation of computing devices called magnetoelectrics. Magnetoelectric chips could make everything from massive data centers to cell phones far more energy efficient, slashing the electricity requirements of the world's computing infrastructure.

Magnetostriction from iron and gallium

Made of a combination of iron and gallium, the material is detailed in a paper published May 12 in Nature Communication. The team is led by Heron and includes researchers from Intel; Cornell University; University of California, Berkeley; University of Wisconsin, Madison; Purdue University and elsewhere.

Magnetoelectric devices use magnetic fields instead of electricity to store the digital ones and zeroes of binary data; tiny pulses of electricity cause them to expand or contract slightly, flipping their magnetic field from positive to negative or vice versa. Because they don't require a steady stream of electricity, as today's chips do, they use a fraction of the energy.

"A key to making magnetoelectric devices work is finding materials whose electrical and magnetic properties are linked." Heron said. "And more magnetostriction means that a chip can do the same job with less energy."

Cheaper magnetoelectric devices

Most of today's magnetostrictive materials use rare-earth elements, which are too scarce and costly to be used in the quantities needed for computing devices. But Heron's team has found a way to coax high levels of magnetostriction from inexpensive iron and gallium.

Ordinarily, explains Heron, the magnetostriction of iron-gallium alloy increases as more gallium is added. But those increases level off and eventually begin to fall as the higher amounts of gallium begin to form an ordered atomic structure.

So the research team used a process called low-temperature molecular-beam epitaxy to essentially freeze atoms in place, preventing them from forming an ordered structure as more gallium was added. This way, Heron and his team were able to double the amount of gallium in the material, netting a ten-fold increase in magnetostriction compared to unmodified iron-gallium alloys.

"Low-temperature molecular-beam epitaxy is an extremely useful technique—it's a little bit like spray painting with individual atoms," Heron said. "And 'spray-painting' the material onto a surface that deforms slightly when a voltage is applied also made it easy to test its magnetostrictive properties."

Intel's MESO program

The magnetoelectic devices made in the study are several microns in size—large by computing standards. But the researchers are already working with Intel to find ways to shrink them to a more useful size that will be compatible with the company's magneto-electric spin-orbit device (or MESO) program, one goal of which is to push magnetoelectric devices into the mainstream.

"Intel is great at scaling things and at the nuts and bolts of making a technology actually work at the super-small scale of a computer chip," Heron said. "They're very invested in this project and we're meeting with them regularly to get feedback and ideas on how to ramp up this technology to make it useful in the computer chips that they call MESO."

While a device that uses the material is likely decades away, Heron's lab has already filed for patent protection through the U-M Office of Technology Transfer.

The paper is titled "*Engineering new limits to magnetostriction through metastability in iron-gallium alloys.*" The research is supported by IMRA America, the National Science Foundation (grant numbers NNCI-1542081, EEC-1160504 DMR-1719875 and DMR-1539918).

Other researchers on the paper include U-M associate professor of materials science and engineering Emmanouil Kioupakis; U-M assistant professor of materials science and engineering Robert Hovden; and U-M graduate student research assistants Peter Meisenheimer and Suk Hyun Sung. Research institutions involved in the process include and researchers at The State University of New York, Buffalo; University of Wisconsin-Madison; Purdue University; Germany's Peter Grünberg Institute; Penn State University; Lawrence Berkeley National Laboratory; and Germany's Leibniz-Institut für Kristallzüchtung.

"A key to making magnetoelectric devices work is finding materials whose electrical and magnetic properties are linked. And more magnetostriction means that a chip can do the same job with less energy."

—Assistant Professor John Heron

Accelerating the ceramic synthesis of a classic superconductor

Assistant Professor Wenhao Sun

Ceramics are found in more than just pottery—they also comprise the active materials in Li-ion batteries, superconductors, solid-oxide fuel cells and more. These advanced ceramics have complicated crystal structures and chemical compositions, and are often difficult to synthesize in the laboratory.

Published in Advanced Materials, an international team of scientists at U-M, Hokkaido University and UC Berkeley revealed new insights into how ceramic reactions proceed. These fundamental insights will guide chemists in better preparing functional materials, which is crucial for accelerating materials manufacturing and deployment.

Using the high-temperature superconductor YBa2Cu3O6+x (YBCO) as a model system, the team used advanced electron microscopy and X-ray diffraction techniques, along with state-of-the-art computational modeling, to examine how different precursors affect the formation of this classic ceramic material.

"Typically, YBCO is synthesized from BaCO3, Y2O3 and CuO, which can take upwards of 12 hours at 940°C," says Assistant Professor Wenhao Sun from the University of Michigan. "However, there is an interesting report that replacing BaCO3 with BaO2 reduces the reaction to four hours, and results in a synthesis product without impurities."

By watching this reaction in a high-temperature transmission electron microscope, the team observed a surprising liquid melt that remarkably led to YBCO formation in only 30 minutes. This observation inspired a new computational model to design ceramic reactions, which can be broadly applied to accelerate the manufacturing and development of functional materials.

> **The Sun group is leading an international team in developing a new computational model to design ceramic reactions, which can be broadly applied to accelerate the manufacturing and development of functional materials.**

Breaking down ceramic reactions

To understand why ceramic synthesis typically takes so long, the team first thought about how these reactions might look microscopically. "If we think of ceramic precursors like grains of sand, it becomes clear that three different precursors touch only at a single point," says Sun. "This means that reactions wouldn't happen between all 3 precursors at once. Instead, reactions should occur much more readily at the interfaces between two precursors at a time."

With three precursors, a reaction cannot be analyzed as A + B + C →ABC. There should be a sequence of two reactions; with the first reaction being A + B →AB, and then AB + C →ABC. The team then built a thermodynamic model to predict which pair of precursors react first.

When starting with the traditional BaCO3 precursor, the Y2O3 + CuO reaction was expected to occur first. Using powerful X-ray beams at the SPring-8 synchrotron in Japan, the experimental team confirmed this prediction, and found the Y_2O_3 + CuO reaction to be extremely slow.

When starting with the alternative BaO_2 precursor, BaO_2 + CuO was calculated to become the preferable first reaction. This prediction was confirmed by the X-ray characterization, but the successful synthesis of YBCO in only 30 minutes shocked the team. By watching the reaction in the electron microscope, the team saw the surprising formation of a liquid melt, which resolved the mystery of the fast reaction.

The unexpected role of the liquid

The conventional intuition in ceramic synthesis is that atomic diffusion is slow because the precursors are all solids. To accelerate diffusion, synthesis usually occurs at very high temperatures (greater than 700°C), and even then may take half a day or more to complete.

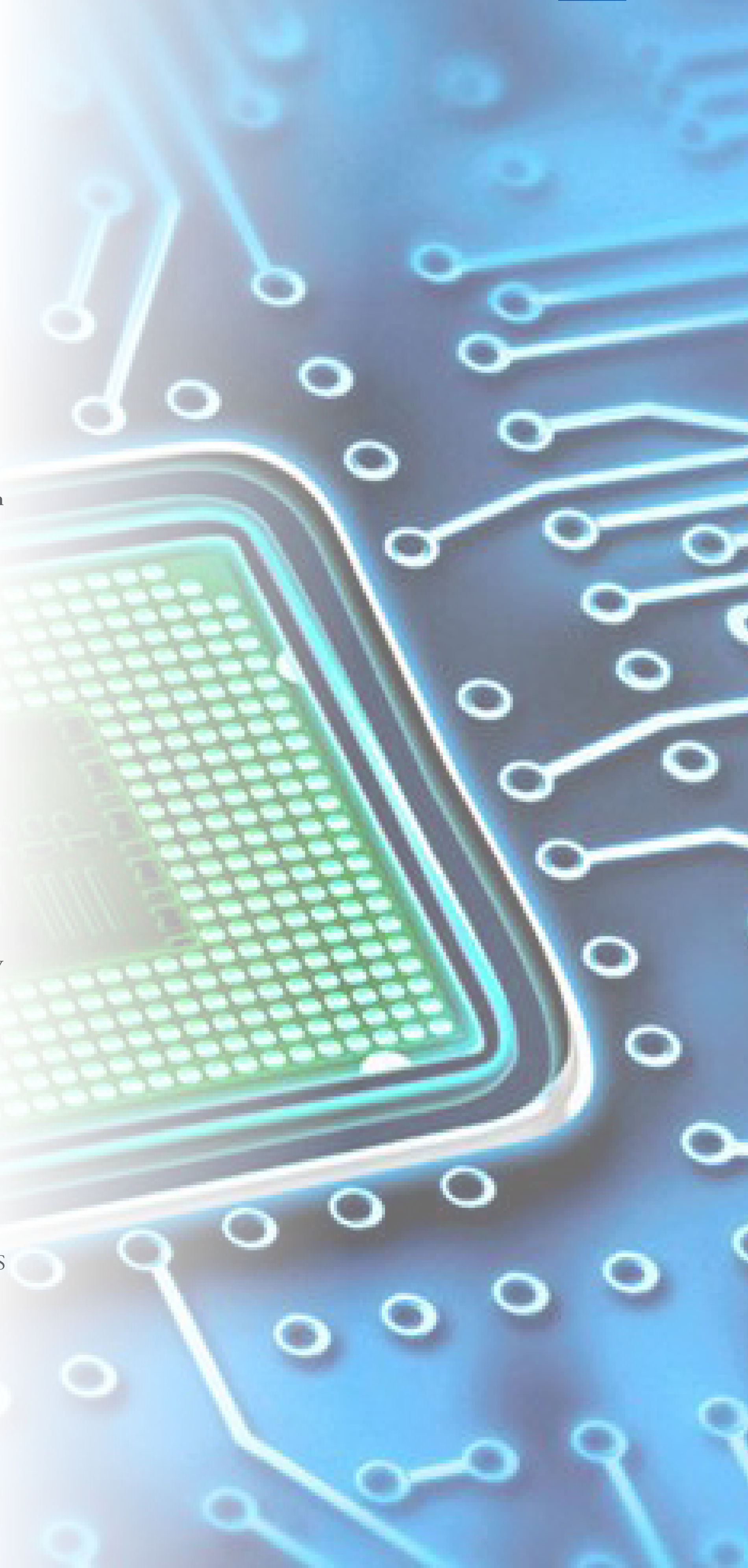
However, when starting with the BaO2 precursor, the reaction proceeded through a number of liquid phase intermediates. These liquid phases gave way to fast atomic diffusion, which provided the fast reaction kinetics for YBCO formation. “By looking at the thermodynamic phase diagram, we can anticipate which precursors can provide these low-temperature liquid melts,” says Sun. “With our new theoretical model, we can design better precursors to drive reactions through reaction pathways with favorable thermodynamics and kinetics for time- and energy-efficient reactions.”

Akira Miura, the lead experimentalist on the work, commented on the importance of the combined experimental and computational approach: “Without a model, our observations would not be generalizable to other systems,” he said. “Without the observation, it would not be possible to validate the computational model. Only together could we build new fundamental insights on the synthesis of this classic ceramic system.”

Ultimately, the team aims to continue working together to understand how materials form, and how to control chemical reactions to produce desired materials. “Computational materials predictions routinely identify new materials for safer batteries, better solar cells, stronger steels, etc. Now the crucial question is—how do we make them? Our research aims to resolve this critical synthesis bottleneck.”

Article: “Observing and modeling the sequential pairwise reactions that drive solid-state ceramic synthesis,” Advanced Materials (2021), DOI: 10.1002/adma.202100312

Funding for this work came from the Department of Energy Office of Science through an Early Career Award for Sun, and GENESIS (A Next GENeration SyntheESIS Center), a Department of Energy Frontier Research Center. The experimental work was partially supported by KAKENHI Grant Nos. JP16K21724, JP19H04682, and JP20KK0124.Advanced Materials, was done in collaboration with scientists at Sandia National Laboratories and with the group of Prof. Wei Lu, Professor of ECE and Professor of MSE (by courtesy).



Allison part of national team helping to democratize access to data with National Science Data Fabric

"Harnessing materials data in all its forms is the next big scientific opportunity for the rapid discovery and design of the new materials needed to keep pace with societal needs." —John Allison

MSE Professor John Allison is part of a national team of researchers that was recently awarded $5.6M from the National Science Foundation (NSF) to build the critical technology needed to sew-up the national computational infrastructure and to draw talent from a diversity of American to the data-driven sciences.

Through a pilot project called the National Science Data Fabric (NSDF), led by the University of Utah's Valerio Pascucci, the team will deploy the first infrastructure capable of bridging the gap between massive scientific data sources, the Internet2 network connectivity and an extensive range of high-performance computing facilities and commercial cloud resources around the nation.

In addition to Allison, Pascucci is being assisted in this mission by several co-principal investigators (PIs): San Diego Supercomputer Center (SDSC) Interim Director Frank Wurthwein, Michela Taufer at the University of Tennessee Knoxville, and Alex Szalay at Johns Hopkins University. The team will partner with NSF-funded efforts such as Fabric and Open Science Grid (OSG), and industry partners such as IBM Cloud and Google Cloud, on the project.

According to Allison, director of the U-M PRISMS Center, "Harnessing materials data in all its forms is the next big scientific opportunity for the rapid discovery and design of the new materials needed to keep pace with societal needs. We are excited to be part of the NSDF team and have our U-M Materials Commons materials data platform as an integral part of this truly transformational data infrastructure. We are particularly energized by the plans to work with minority serving institutions, like the University of Texas El Paso, to demonstrate the potential for seamless re-use of materials data in teaching and research projects."

According to Pascucci, the science and technology sector is on the cusp of tremendous discoveries and technological innovations that benefit society, and fast-paced progress requires a cyberinfrastructure enabling high-speed access to the data generated by large experimental facilities worldwide, which he notes is a key unmet challenge.

"The massive IceCube neutrino detector had to be built at the south pole, but its data is best processed at large U.S. computing facilities. The XENONnT experiment, the world's largest and most sensitive dark matter detector, has been built below the Gran Sasso mountain in Italy. Still, its data has to be quickly analyzed by scientists around the world. The Cornell High Energy Synchrotron Source (CHESS) routinely allows imaging the interior of new materials that scientists can test, analyze and perfect before turning them into technological innovations. These are just a few examples of advances in data-driven sciences that are in need for the NSDF," said Pascucci.

Taufer said that NSDF can benefit society as a whole in critical fields from environmental, health and national security concerns, to renewable energy production, and, moreover, to understanding the evolution of galaxies and the nature of dark matter.

"By placing critically located data resources at minority-serving institutions and providing training and education for a diverse workforce, the NSDF pilot will enable diverse communities to participate in cutting-edge research," said Taufer. "NSDF is partnering with the Minority Serving Cyberinfrastructure Consortium to implement a rich set of webinars, training modules, and other educational opportunities for underserved communities."

NSDF

The Battery Lab joins MMRI

The move will help drive production-level research into next-gen solid-state battery technologies.

In an effort to drive the commercialization of more affordable, higher-capacity batteries for electric vehicles and grid storage, the U-M's Battery Fabrication and Characterization Facility has joined the Michigan Materials Research Institute (MMRI).

The North Campus facility, better known simply as the Battery Lab, enables academic and industry researchers to work together to build and test batteries. It was formerly housed in the U-M Office of the Vice President for Research.

Alan Taub, the founding director of the MMRI and professor of materials science and engineering and mechanical engineering, says transitioning the lab to the MMRI, which is housed in the College of Engineering's Materials Science and Engineering department, will help position it for the major changes coming to the industry.

"The battery lab is an amazing facility that's already at the forefront of the industry's massive shift toward batteries that use new classes of materials," Taub said. "And because the MMRI is involved with materials science research across the university, I anticipate that we'll be able to catalyze new collaborations and research."

The move will help the lab scale up research on newer solid-state battery technologies like lithium metal, said lab manager Greg Less. He explains that ramping up research to the production level will require new capabilities and investments, since solid-state batteries use more reactive materials that require tighter control over production variables like humidity.

To that end, the MMRI is facilitating the installation of a $1.2 million dehumidification system in the Battery Lab, as well as other production line improvements that will enable more precise mixing of materials and streamline production of finished solid-state batteries.

The facility is supported by Ford Motor Company, the Michigan Economic Development Corporation, the College of Engineering and U-M.

Battery Lab manager Greg Less.

Left: Marisa Perez, Yumeng Bai and Kate Moo at the MMS pumpkin-carving event in October.

MMS: Enriching the student experience

"The MMS board members have worked hard to provide professional development, social, and networking activities for the undergraduate cohort, rallying to stay connected during uncertain times."
—Ashwin Shahani, MMS Advisor

Led by President Ella Leininger '22, the Michigan Materials Socity (MMS) worked hard this year to carry out its mission of supplementing the undergraduate experience with academic, professional and social opportunities. The weekly Friday luncheons, which were a hybrid of virtual and in-person events, included speakers from Accenture, BASF, Ford, GM, Nike and Nissan. Social events included a pumpkin-carving get together and Pizza & Pour event at Joyworks.

"I have been impressed with the surprisingly high level of programming over the last year, both in-person and virtual," commented MMS faculty advisor Ashwin Shahani. "The MMS board members have worked hard to provide professional development, social, and networking activities for the undergraduate cohort, rallying to stay connected during uncertain times."

In addition to Leininger, the current MMS board consists of **Kate Moo** (VP-Internal), **Carmen Giger** (VP-External), **Katie Wei** (Secretary), **Katie Martin** (Treasurer), **Marisa Perez** (Social Chair), **Jenny Chong** (Outreach Chair), **Mackenzie Darling** (Committee Representative), and **Brodie Kieras** (Committee Representative).

Ella Leininger

Kate Moo

Carmen Giger

New Van Vlack Lab worskstations allow for more engaged user experience

At the start of the Fall 2021 semester, students were greeted with an important upgrade in the Van Vlack Lab: 14 Dell Precision workstations with 43" monitors.

Instructional labs supervisor Tim Chambers commented that the new set-up "allows for more effective student collaboration/teamwork in class, wider range of modeling and simulation software, and better user experience to get students engaged and enjoying computational work."

Instructional labs supervisor Tim Chambers assists MSE360 students working on the new Dell Precision computers installed this fall in the Van Vlack Lab.

Covid cuts Bladesmithing team out of 2021 competition

One of the many pandemic-caused casualties of early 2021activities was the TMS Bladesmithing competition in March, which meant out MSE team was not able to present its American Bowie blade (pictured at left.) According to team member Grant Saxman, "Our goal was to create an American Bowie that incorporated mosaic pattern welded steel made by our team. The Bowie is a classic American blade historically used for dueling, hunting, and other outdoor tasks. We opted to do a more modernised version of the bowie to give it a sleek and fresh look while remaining reminiscent of the historical bowies."

The blade is made from their own batch of explosion mosaic steel, forged from 1084 and 15n20 mono-steel. It is furnished with a 416 SS double guard buffed to a mirror finish and a handle of stabilized amboyna burl buffed to a high finish.

The 2021-22 team, however, has been hard at work on another submission that (fingers crossed) they hope to present at the 2022 TMS Annual Meeting in early March.

Student Awards & Recognition

Nathaniel L. Field Scholarship
Kellie Chu, Deborah Reisner

Richard A. Flinn Scholarship
Kate Moo

Fontana-Leslie Scholarship Fund
Praveen Soundararajan

James W. Freeman Memorial Scholarship
Rishi Merchant, Benjamin Poole

John Grennan Scholarship
Eric Yi

Jack J. Heller Memorial Engineering Scholarship Fund
Lauren Duke

William F. Hosford Scholarship
Aaron Cooke, Dylan Edelman, Erin Parlow, Brianna Roest, Albert Tsui, Katherine Wei, Hao Zhu

Schwartzwalder Memorial Scholarship
Sarah Scheneck, Denise Schlautman

Clarence A. Siebert Memorial Scholarship
Gabriella Grey

Alfred H. White Memorial Scholarship
Rishabh Kothari, Eli Rotman

James P. Lettieri Undergraduate Award
Aidan Charmley, Leah Marks

The Brian Worth Prize
Alexandra Zimmerman

MMS Anvil Award
Kate Moo

CoE Distinguished Achievement Award
Daniel Evans

GRAD STUDENTS

In an effort to help bolster community after being remote last year, in the fall the Graduate School Council implemented a Coffee & Conversation event before each Friday seminar session.

GSC works to build community for students despite Covid challenges

Led by Geordie Lindemann in the spring and Kyle Bushick in the fall, GSC has had to be flexible and adaptive this year with ever-changing Covid protocols, but their mission has remained steadfast: provide activities and opportunities to build an inclusive, cohesive community for all graduate students.

"COVID has posed a host of challenges for graduate students, and one of the largest is finding ways to develop bonds with fellow students," commented Bushick. "In order to balance university restrictions, individual comfort level, zoom fatigue, and the weather, we've had to get creative to find ways to bring folks together."

To that end, he added, GSC has organized intramural sports teams, hosted on-campus events such as "Paint and Pot a Succulent," and facilitated happy hours and smaller potluck events off campus. GSC also initiated "Coffee & Conversation," a chance for students to meet up before the MSE890 seminar each Friday,

GSC Outreach

Over the summer, the GSC outreach team, led by Brian Iezzi and Paul Chao, developied a self-guided materials tour that explains the science behind select objects at U-M's Museum of Art (UMMA).

Using QR codes, the materials tour instantly links museum goers to information about the materials used in creating the object.

"What the object is made out of is really an important part of the piece, an inherent part of the art," Iezzi remarked. "This is a cool way to explain much more about a work by exploring the medium in more depth."

In addition to Iezzi and Chao, project team members include MSE graduate students Kyle Bushick, Joshua Cooper, Duncan Greeley, Geordie Lindemann, Leah Marks, and Alex Moy, and instructional labs supervisor Tim Chambers.

The Materials Tour at UMMA is on view at UMMA through Summer 2022. To view online: www.umich.umma/materials-tour

In addition, the outreach team conducted virtual lessons for local middle high schools on thermodynamics (May) and battery circuits (November).

DEI Mentoring Program

DEI Student Alies Ahmad Matar Abed, Veronica Caro and Taylor Repetto planned a flurry of fun mentor/mentee activities this fall, including an ice cream social, scavenger hunt. pumpkin painting party, and trip to Domino's Farms.

The goal in planning these interactive activities is to create a sense of inclusivity and belonging within the graduate student community.

Graduate students meet up after a mentor-mentee scavenger hunt in September 2021.

MSE Graduate Fellowships

Kenneth and Judy Betz Fellowship

Yujie Liu (Kioupakis)
Yanjun Lyu (Thornton)
Jinhong Min (Li)

CoE Graduate Fellowship

Avery Ansoro (Heron)
Woohyeon Baek (Sun)
Marcel Chlupsa (Shahani)
Avinara Roy (Loebel)

Rackham Engineering Award

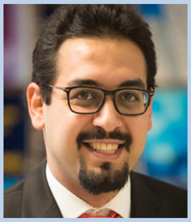
Loulou Batta
Tolu Lawal (Love)
Won Joon Suk (Sakamoto)
Amanda Wang (Kioupakis)

Frederick N. Rhines Fellowship

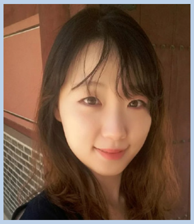
Forrest Wissuchek (Misra)

2021 Graduate Student Award Winners

Ahmad Matar Abed
(Peterson)
NSF Graduate Fellowship



Mohsen Taheri Andani
(Misra)
Towner Prize for Outstanding Research

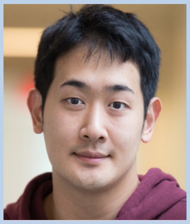


Sieun Chae
(Heron)
Rackham Predoctoral Fellowship

Paul Chao
(Shahani)
D.O.E. Graduate Research Program

Abhishek Dhyani
(Tuteja)
Towner Prize for Outstanding Research

Brian Iezzi
(Shtein)
Rackham Predoctoral Fellowship



John Kim
(Lahann)
NSF Graduate Fellowship

‘Historic’ 2021 graduation ceremony held online for first time on May 1

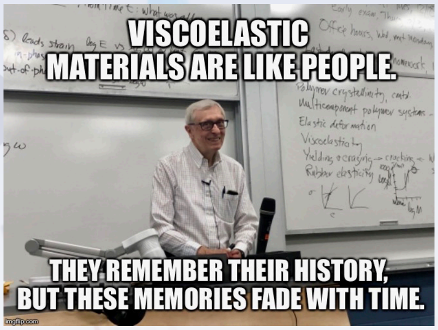
Even though students were not physically on campus in the spring, U-M decided to go ahead and hold formal graduation festivities virtually on May 1. Instead of a combined ceremony for CoE graduates and the grand mass ceremony traditionally held in the Big House, though, for the first time individual departments held their own celebrations via Zoom.

MSE festivities featured a welcome from department chair Amit Misra, a live graduation awards presentation, a video of faculty, staff and alumni wishing students well, and a student “thank you” section. The ceremony culminated in a ‘roll call,’ where undergraduate faculty advisor Steve Yalisove read each undergraduate’s name in real time and in coordination with a slideshow featuring each graduate’s photo. Master’s chair Ferdinand P. Poudeu and Ph.D. chair Manos Kioupakis read master’s and Ph.D. graduate names, respectively.

“Graduation 2021 was outstanding and historic,” said MSE Chair Amit Misra. “It was a very memorable event for all attendees.”

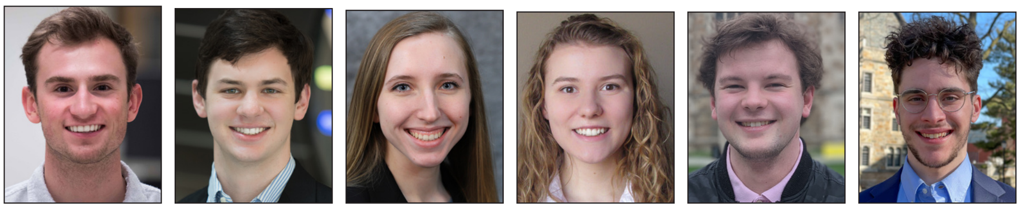
2021 Graduates’ Most Memorable MSE Moments

“I will never forget staying up past midnight many nights in a row in the Bugli with my friends trying to finish thermo & kinetics homework **—Ashton Doyle** “The last day of MSE 365 that was in person, we had all been hearing about COVID and were like ‘when is the next lecture going to be’--- I had always had the inkling it was going to be more than a brief hiatus and it was really surreal. The day the world got turned upside down **—Thomas Gabrielson** “I’ll always remember the groupme memes that always brought us together after trainwreck exams.” **—Mary Hoopes** “One of my favorite MSE-related memories was “baking cookies” in MSE 360 where we were creating sample molds. We referred to it as “baking cookies”because of the ‘ding’ sound that the machine’s timer made when the mounted sample was finished.” **—Nathan Jarski** “Interpreting my first stress-strain curve.” **—Usman Khan** “The times when everyone would convene in packed office hours are definitely memorable now that everything is online. Our openness to helping each other was really special.” **—Leah Marks** “I will always remember and love how close-knit the MSE community is. The family-feel of MSE made the large university seem a lot smaller and it gave me people who understood me and served as a major support system during my time here.” **—Kori Maxie** “I will always remember the moment when I realized that I knew everyone in my classes, and how cool it is to have found that kind of community in a major.” **—Deesha Shah** “My favorite memories in undergrad have all been with my girl friends from the MSE department. These girls have been my study buddies and my truest friends. I will always cherish our time spent together.” **—Richelle Wilson** “I will always remember all the long nights studying in the Dude and our trip to Joyworks!” **—Alex Zimmerman**



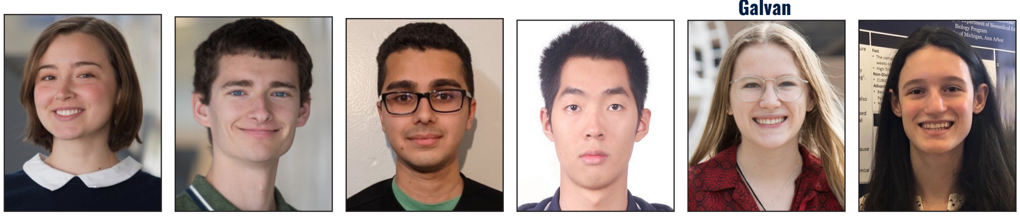
Congratulations to all our 2021 graduates!

Nicholas Arceci | Yana Beeker | Shane Boran | Cameron Cafmeyer | Aidan Charmley | Kaylynn Crawford



Jacob Dean | Charlie Donahue | Ashton Doyle | Elizabeth Eachus | Jackson Eilers | Daniel Evans

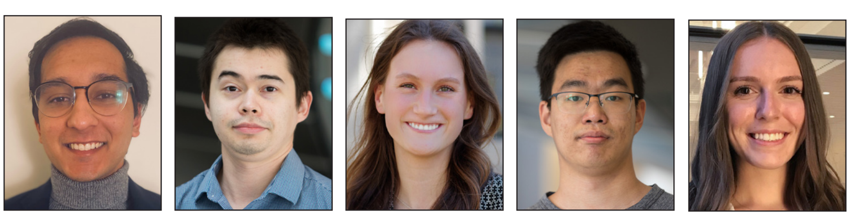
Grace Fedele | Katie Ferguson | Wesley Fermanich | Thomas B. Gabrielson | Angelica Rose Galvan | Julia Healy



Mary Hoopes | Nathan Jarski | Usman Khan | Tianle Liu | Marissa Lobbia | Leah Marks

Allison Marozza | Kori Maxie | Connor Michaelson | Karen Ni | Claire O'Donnel | Berant Perry

Jacob Pietryga | Michelle Pikulinski | Amanda Rosenkrantz | Deesha Shah | Alex Shaw | Luke Sloan



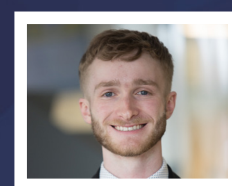
Dhruv Tatke | Johnny Wesley | Richelle Wilson | Shou Zhang | Alexandra Zimmerman

Not pictured: Viktoriya Kovalchuk, Timothy Leonard, Ross Smith, Owen Talmadge

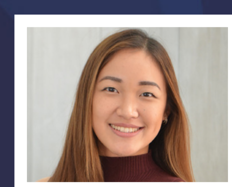
MSE 2021 Graduation Award winners

James P. Lettieri Award: Aidan Charmley & Leah Marks

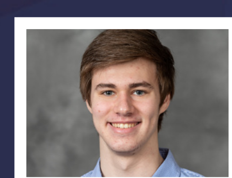
MMS Distinguished Member: Cameron Cafmeyer



MMS Anvil Award: Kate Moo '22



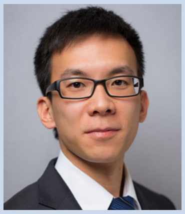
Alpha Sigma Mu Distinguished Member: Kenneth Peterson



The Brian Worth Prize: Alex Zimmerman

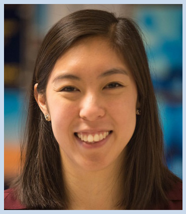
Congratulations to all our 2021 Ph.D. grads!

Winter 2021

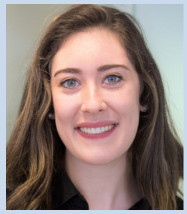


Kuan-Hung Chen
(Dasgupta/Sakamoto)
"Rational Design of Electrode Architectures for Improved Performance of Li-metal and Li-ion Batteries"

Wonjin Choi
(Kotov)
"Reconfigurable Kirigami Optics and Chiral Phonons"



Kathleen Chou
(Marquis)
"Role of Oxygen on Phase Stability, Precipitation, Deformation, and Oxidation in Pure Titanium and Beta Titanium Alloys"



Erin Evke
(Shtein)
"Kirigami-Based Approaches to the Development of Highly Tunable Mechanical, Electrical, and Optical Systems and Devices"

Christian Greenhill
(Goldman)
"Nanoscale Studies of Structural, Electronic, and Optical Characteristics in Thin Film Semiconductor Alloys and Heterostructures"

Alvaro Masias
(Sakamoto)
"Properties of Lithium Metal for Solid State Batteries"

Catherine Snyder
(Mehta/Tuteja)
"Polymer Nanoparticle Design for Ovarian Cancer Therapies"

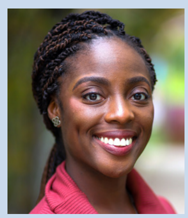
Summer 2021

Eleni Temeche
(Laine)
"Solid electrolytes to enable the assembly of all solid-state batteries"

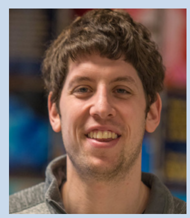
Brian Tobelmann
(Tuteja)
"Design of high-performance surfaces for controlling phase transformation"

Brandon Buchanan
(Poudeu)
"Developing New Materials for Spin-tronic, Photovoltaic, and Optoelectronic Applications"

Jun Guan
(Laine)
"Synthesis and Photophysical Properties of Silsesquiox-ane Based Molecules and Polymers"



Lydia Mensah
(Love)
"Antibiotic-Loaded Drug Delivery Platforms: Theory, Structural Evolution, and Elution Characteristics"

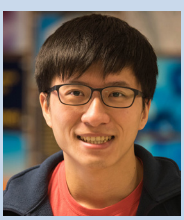


Max Powers
(Misra)
"Characterization of Hierarchical Morphol-ogies in Co-Sputter Deposited Immiscible Alloy Thin Films"

Nocona Sanders
(Kioupakis)
"First-Principles Calcu-lations on the Electronic and Optical Properties of Polar Functional Materials"

Fall 2021

Xinyu Zhang
(Laine)
"Novel Solid Electro-lytes Derived From Polymer Syntheses"



Ming-Hsun Lee
(Peterson)
"Investigation of Ohmic Contact Interfaces and Crystalline Defects for Wide-Bandgap Beta-Phase Gallium Oxide and its Alloys"

Huai-Hsun Lien
(Misra)
"Microstructural and Mechanical Studies of Interface-Dominant Materials Consisting of Nanoscale Hard/Soft Phases"

Nguyen Vu
(Heron)
"Strain engineering of perpendicular mag-netic insulators for magnetoelectronics"

Zhenjie Yao
(Allison)
"A Quantitative Investigation of Microsegregation and Phase Transformation Kinetics in Lightweight Alloys"

Ethan Sprague
(Misra)
"Characterization of Direct Metal Deposition Printed Copper-Iron Alloys"

Kelsey Steinke
(Sodano)
"Nanomaterial-based Surface Modifications for Improved Ballistic and Structural Performance of Ballistic Materials"

First PhD defenses for Hovden and Heron

"The first Ph.D. student dissertation defense is a big moment in any assistant professor's career, and any Ph.D. defense is a once in-a-lifetime milestone for the student."

—Amit Misra,
MSE Chair

Jiseok Gim & Robert Hovden

On March 10, Jiseok Gim defended his Ph.D. thesis, "Hierarchical Nanostructure of Natural Biominerals and Man-made Semiconductors."

Gim joined Hovden's group in December 2016. At the time he had little knowledge of electron microscopy, but, under Hovden's expert and patient guidance, Gim eventually mastered the skills necessary to study hierarchical structures in natural biominerals and man-made semiconductors that traverse the atomic, nano-, micro-, to macro-scale using electron microscopy. Over the course of his four years in the Hovden group, Gim produced two first-authored papers and eleven co-authored papers.
Post-graduation, Gim joined Intel (Hillsboro, Ore.) as a PTD Module & Integration Yield engineer.

"Working with Dr. Jiseok throughout his Ph.D. is one of the most productive and rewarding experiences I've had," said Hovden. "He is extremely considerate and pleasant to work alongside and brings people together within and across laboratories. I look forward to seeing Jiseok's future contributions to science and technology."

Peter Meisenheimer & John Heron

On March 24, Peter Meisenheimer defended his dissertation, "Disorder-Engineering of Ferroic Properties," officially becoming Assistant Professor John Heron's first Ph.D. student to graduate.

Meisenheimer joined the Heron lab in July 2016, after graduating from the University of Washington.

"I wanted to work with John pretty much immediately after meeting him," Meisenheimer said,

The research that Meisenheimer is proud of is finding new materials and designing devices that can mitigate heating from electronics, saving a tremendous amount of energy in the long run. To this end, his research explores the frontiers of materials synthesis to engineer new, sustainable, non-volatile devices with unprecedented performance. His research centers around discovering new ferroic states in disorder-driven materials.

This summer Meisenheimer moved to California to start a postdoc position in Berkeley.

"Working with Peter has been a blast," Heron commented. "He is intelligent and applies his creativity to his projects. I wish him the best and look forward to seeing more great work from him."

2021 Master's degrees

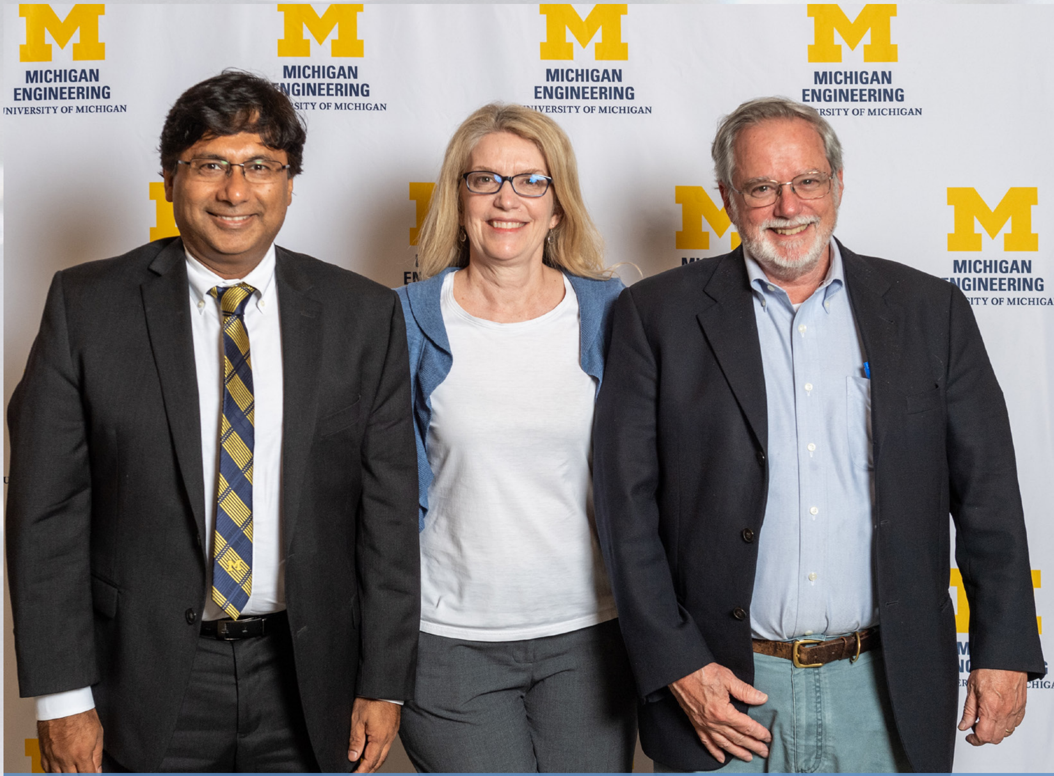
The following students earned a master's degree in 2021.

David Allen
Steel Cardoza
Ganlin Chen
Ryan Fattal
Fenghe Fu
Jiajie Li
Yu-Ho Lin
Javier Lopez-Nieto
Yu-Hung Luan
Yanjun Lyu
Brendan Miles
Mayme Philbrick
Alexander Pielack
Max Rotenberg
Keara Saud
Sujay Shah
David Speer
Mohson Taheri Andani
Leonardo Vallejo
Nicole Wang
Jiamin Wen
Keara Saud
Yuchen Wu
Chao Wu
Zhixiong Yin
Mojue Zhang
Zijing Zhang
Zenghao Zhang

Michelle Griffith (PHD '95)
2020 MSE Alumni Merit Award Recipient

After being delayed a year by the pandemic, Griffith returned to campus September 24 to officially accept her award and give a talk at a special all-department luncheon.

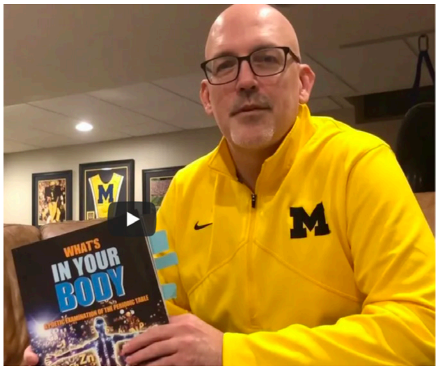
Dr. Michelle Griffith is a Senior Scientist at Sandia National Labs, a rank achieved by less than 10 percent of Sandia employees. During her distinguished career at SNL, Griffith has provided technical expertise and leadership in: materials; rapid prototyping/additive manufacturing; nuclear weapon components; satellite telescope design, manufacturing, and operation; missile defense concepts and analyses; and nuclear detonation detection and space payloads.



Above: Dr. Michelle Griffith (center) poses with Amit Misra (left) and Ph.D. advisor John Halloran.
Left: Griffith gives an overview of Sandia National Laboratories as part of her presentation to MSE faculty and students.

ALUMNI

Alums making news

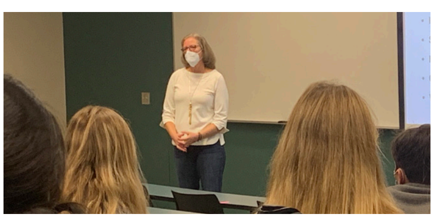


Krajewski publishes second children's book

Dr. Paul Krajewski (BSE '89, MSE '91, PHD '94), director of the Vehicle Systems Research Lab at GM, co-authored *What's in Your Car?* with Matt Topper in 2016. The book explores how the elements of the periodic table are used to make a car.

Last spring,the duo followed up with *What's in Your Body?*, this time describing how the elements of the periodic table are incorporated into the body. One Amazon review says: "From bones to bananas, prosthetics to poop, various elements contribute to build, strengthen and support our bodies. This book can be used as an entry to a deeper understanding of the periodic table and its role in human life."

Earlier this year Krajewski was featured on Michigan Story Time. You can watch him read his books at www.alumni.umich.edu/michigan-story-time/



Hall shares career advice

MSE alum and EAB member Jody Hall shared her personal career journey (which included 30 years at GM) and offered sage advice to MSE students during a Michigan Materials Society event in early November.

Weissman makes Forbes best-in-state

Proof that MSE degrees prepare people for a wide variety of successful careers, **Neil Weissman (BSE '95)** was recently named one of the Best in State Wealth Advisors by Forbes. Weissman is managing director of the Weissman Eppler Investment Group of Wells Fargo Advisors in Ann Arbor.

Maisel recieves NSF CAREER Award

Katharina Maisel (BSE '10), an assistant professor in Bioengineering at Johns Hopkins, received a 2021 NSF CAREER Award. Her interdisciplinary training combines nanotechnology, mucosal immunology, lymphatic immunology, and immunoengineering.

Gerald "Jerry" Madden

1935-2021

We were deeply saddened to learn of the passing of Jerry (Max) Madden on November 26. In addition to being an active member of the External Advisory Board, Madden was the recipient of the MSE Alumni Merit Award in 2018.

A self-described "product person," Madden worked the bulk of his career (1968-1993) in research and development with DuPont in Wilmington, Del., where he helped advance the development of Kevlar coating and oversaw the transition from dry-spinning to wet-spinning, an important step in fiber processing.

"I enjoyed every minute," said Madden of both his industry and academic accomplishments, but especially his time in Ann Arbor as a graduate student studying under Professor Van Vlack. Described by his family as "the biggest University of Michigan supporter in all of Pennsylvania," Madden was a true "Michigan Man" in every sense of the phrase.

Fellow EAB member Dr. Keith Bowman commented,"His enthusiasm was infectious and will be missed."

NEWS

PhD student Geordie Lindemann live streams a demonstration during an MSE outreach event with Detroit's Renaissance High School while fellow grad student Jonathan Goettsch looks on.

DONORS

Following is a list of our generous donors from 2016-2021, organized by giving category.

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Wilbur C. Bigelow Trust

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William F. Hosford

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(Continued on pg. 40)

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Adam and Suzanne Guise Cheslin
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Dr. Sanford Lewis
Dr. Anton Li
Dr. Yiyang Li
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Blair Marks
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Eileen and Curt Mikulski
George Mock
Marge Monnot
Patrick and Peggy Monnot
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Diann Moore
John Moore
Terri E. Moore
Alberto Morales
Carl Morin
Leslie Moser and Eric Steigenhofer
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Ian Nilsen
Rajiv Parmar
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Dr. John Piazza
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Drs. Richard and Patricia Robertson
Dennis and Lauren Stuligross
Susan Gentry Giving Fund of the Fidelity Charitable Gift Fund

Van Vlack Lecture Endowment

Dr. Robert J. Warrick

Good to be back. Graduate students Hongling Lu and Kyle Bushick share a laugh during the all-department Welcome Back picnic at Gallup Park on Sept 3.

Your gift matters!

Pouring it on. Madison Forstner '23 pours liquified aluminum into a Block M mold during the MSE Undergraduate Open House.

SUPPORT MSE

MSE is teaching and training the next generation of materials scientists whose research will make advanced materials that profoundly impact the world.

When you contribute to MSE, you impact that research and more.

In addition, this year we have Covid-related funding needs that are both immediate and coming in the near future, including:

• an emergency fund for students, who, through no fault of their own, may face personal hardships due to the pandemic and need assistance (help with living costs, food insecurity, etc.), and

• unexpected departmental/program expenses that we will incur as a result of students having to delay their graduations, requiring more resources than were originally budgeted for.

In this extraordinary time, we hope you can help our give our students the experience and tools they need to become the visionary materials leaders of tomorrow. Your gift – no matter the size - is appreciated now more than ever.

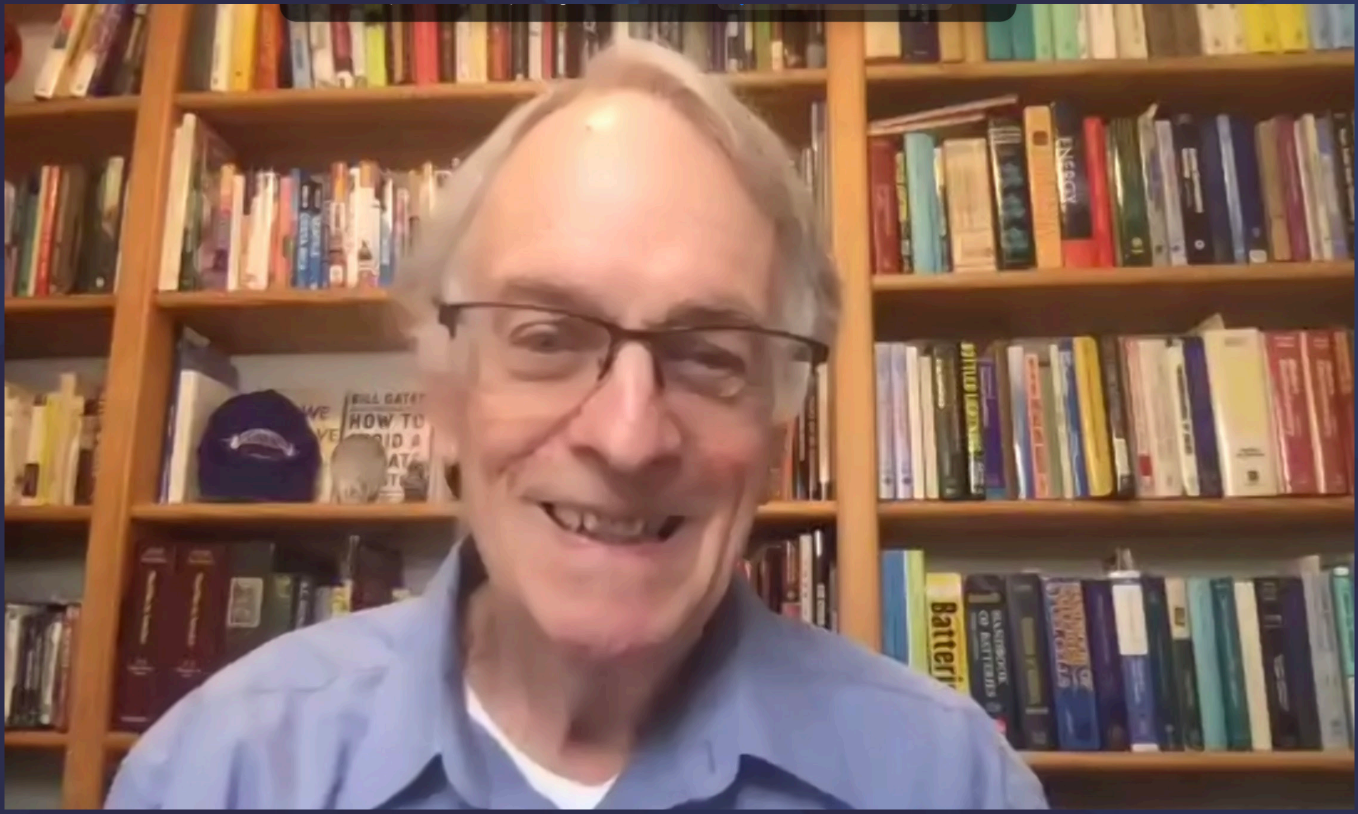
Donate today!

Go online to mse.engin.umich.edu/alumni/giving

Thank you!

COLLEGE OF ENGINEERING
MATERIALS SCIENCE & ENGINEERING
UNIVERSITY OF MICHIGAN

Van Vlack Lecture 2021...and 2022



On October 8, 2021 Nobel laureate Stanley M. Whittingham presented his Van Vlack technical lecture, “The Lithium Ion Battery - from a Dream to Readiness to Take on Climate Change” via Zoom. Whittingham is scheduled to come to campus on May 23, 2022 to give the public lecture part of the lectureship in Hill Auditorium.