SPRING 2019

MATERIALS SCIENCE AND ENGINEERING

UNIVERSITY OF WISCONSIN-MADISON

THINK GLOBALLY:

MS&E MAKES ITS MARK AROUND THE WORLD

CHAIR'S MESSAGE

Hello from Madison!

As you page through this newsletter, the spring semester is on the way toward wrapping up and we couldn't be more excited to share some of the accomplishments that our faculty, students and alumni have made during the 2018-2019 academic year. In a few short weeks, at spring commencement, we will welcome 64 newly minted MS&E alumni to the family, as 40 students will graduate with bachelor's degrees, 16 will receive master's degrees and 8 will complete their PhDs. Please join us in congratulating our graduates!

Our students are the heart and soul of MS&E, and we're proud to boast about how they have been making their marks around the world with their research and service to society. Be sure to read about PhD students Tayfun Soysal, who won an award for exceptional teaching, and Samuel Marks, who has spent the past year working on the synchrotron X-ray source at Argonne National Laboratory on a fellowship program from the U.S. Department of Energy.

After graduation, our students go on to do great things as alumni, too. From volunteering with the Peace Corps to being elected president of ASM International, MS&E Badgers always remember their Madison roots, and you can read about some of their experiences in the pages of this newsletter.

The past few months have also seen a fresh face join MS&E, as well as new titles for some of our familiar faculty. Professor Xudong Wang was named the energy and sustainability leader for the Grainger Institute for Engineering. Please join me in congratulating Xudong!

Additionally, we recently welcomed a new assistant professor to the department, Dawei Feng, who began his appointment in January. You can read more about Dawei's background and his plans for his future in our MS&E department inside this issue.

Dawei will soon be joined by additional new hires—we've been busily interviewing candidates for several open faculty positions all spring. Look for announcements of our new hires in upcoming newsletters.

Wishing everyone a wonderful spring.

ON, WISCONSIN!

Susan E. Babcock
Professor and Department Chair
chair@mse.wisc.edu • (608) 262-1862

Faculty news awards and honors

The American Association for the Advancement of Science has elected Chang-Beom Eom as an AAAS fellow. Eom, the Raymond R. Holton Chair Professor in Engineering and Theodore H. Geballe Professor, was cited for pioneering contributions to the heteroepitaxy of complex oxide films, including the development of 90-degree off-axis sputtering, conducting oxides and strain-engineering to enable oxide electronics.

Additionally, Clarivate Analytics recognized Eom as one of the top 1-percent most-cited researchers in 2018. His cross-disciplinary research has accumulated almost 25,000 citations on Google Scholar.

Professor Paul Evans was named a Vilas Distinguished Associate in recognition of his ongoing innovative research program. Evans' research runs the gamut from quantum dots to ferroelectric materials, and his publications have accumulated almost 2,600 citations on Google Scholar.

Dane Morgan, the Harvey D. Spangler Professor, received the 2019 Harvey Spangler Award for Technology Enhanced Instruction from the College of Engineering in recognition of his ongoing commitment to undergraduate research and education through the Informatics Skunkworks. The award honors faculty who use technology to enhance the learning experience for students. Additionally, the UW-Madison Office of the Provost recognized Morgan with a 2019 Award for Mentoring Undergraduates in Research, Scholarly and Creative Activities.

In recognition of his outstanding contributions to the practices of metallurgy, and materials science and technology, the Minerals, Metals & Materials Society honored Dan Thoma, an MS&E professor and director of the Grainger Institute for Engineering, with the prestigious TMS 2019 fellow award. One of only eight 2019 fellows, Thoma is a world-renowned expert in 3D printing of metals, digital manufacturing, alloy design and advanced materials.

Professor Xudong Wang was named the energy and sustainability lead for the Grainger Institute of Engineering. Wang is a world expert on energy harvesting materials, and he brings passion and ambition for scaling up laboratory concepts to real-world applications by establishing partnerships with industry.

FOCUS ON NEW FACULTY

DAWEI FENG MAKES UNCONVENTIONAL COMBINATIONS TO CREATE TOMORROW'S ADVANCED MATERIALS

Sometimes, combining two things that don't normally go together makes for something better than its individual parts.

Think of oil and vinegar. Though normally the two don't mix, extra virgin olive oil whisked up with a splash of balsamic becomes a delicious salad dressing.

In the realm of conventional materials science, metals and organic molecules usually don't mix, or rarely mix at the bulk level as composites But when combined in the molecular and atomic level, metals and organics can create new solid state compounds with a vast array of properties that could be useful in applications ranging from advanced electronics to medicine.

Those combinations are called metal-organic frameworks, and Dawei Feng, a new assistant professor, aims to harness their properties to push the limits of conventional materials.

"We don't limit ourselves to specific applications," says Feng. "We are seeking opportunities. Wherever we see opportunities where metal-organic frameworks can do better than conventional materials, we go deeper."

One reason metal-organic frameworks are such versatile materials is that they usually consist, at a molecular level, of a regularly repeating network structure with wide-open channels. Those pores can trap specific compounds, act as a sieve or serve as miniature chemical reaction chambers.

Most of the applications for metal organic frameworks take advantage of their porous structures, and their physical properties as bulk solid state materials largely remain unexplored. Feng aims to bring some of those promising uses for the materials to light with his research at UW-Madison.

Feng learned to synthesize metal-organic frameworks during his PhD at Texas A&M University. There he helped develop materials that could scavenge antibiotics and explosives from water, absorbents for natural gas storage, as well as frameworks that could speed up some of the chemical reactions that occur in living cells.

During Feng's postdoctoral work at Stanford University, he made a conductive metal-organic framework with record high performance as an electrode material in a electrochemical energy storage device called a pseudocapacitor. It's an advance that could lead to ultrafast-charging and discharging energy storage devices.

Metal-organic frameworks, as their name suggests, consist of metal atoms like copper or nickel or zirconium networked with organic molecules, which are the carbon-containing compounds that make up all life on earth. The metal components lend the materials electronic and magnetic properties, whereas the organic molecules provide structure, stability and customizability while also bridging the gaps between metallic atoms to facilitate interactions.

"We don't limit ourselves to specific applications. We are seeking opportunities. Wherever we see opportunities where metal-organic frameworks can do better than conventional materials, we go deeper."

Because the periodic table contains 91 metal elements, and there are untold thousands of different organic compounds, a dizzying array of possible combinations opens up.

By strategically selecting metals and organics, Feng tunes the frameworks he creates for a variety of uses. He likens the synthesis of metal organic frameworks to a construction project.

"It's kind of like building a house for molecules and atoms," says Feng. "You can put different pieces together and imagine what furniture you want to have in the house, and you put things together step by step, and eventually decorate the house with different functionalities as desired."

At UW-Madison, Feng plans to delve deeper into the physical properties of metal-organic frameworks, including ion conductivity and electronic properties. In addition to furthering his work on energy storage, Feng sees promise in using the materials to find new semiconductors for advanced electronic devices.

"In theory, if we can choose the right metal and the right organic molecules we could build up to thousands of completely new semiconductors or ion conductors," says Feng. "The possibilities are huge, but there needs to be a big synthetic effort."

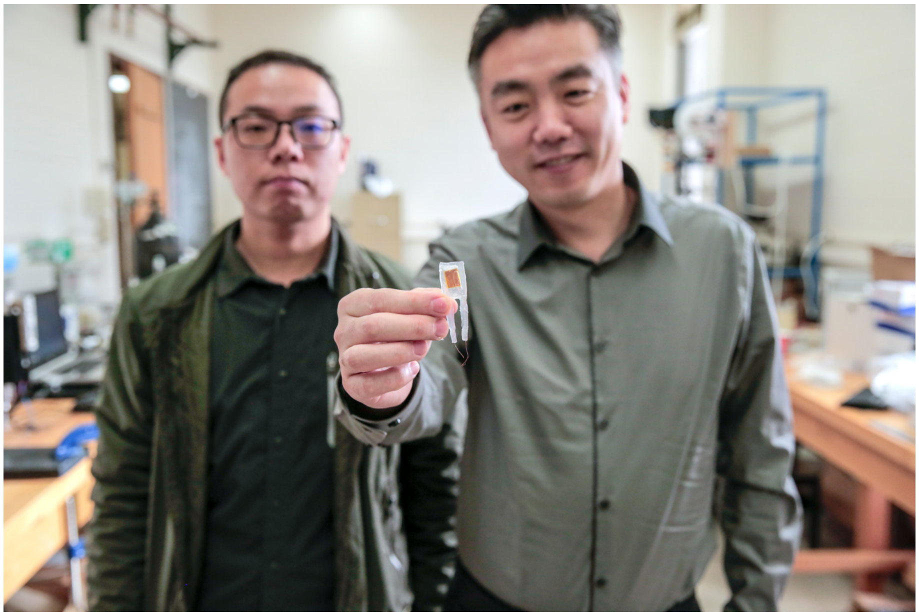
Feng's focus is not limited to developing new ion conductors and electronic materials—he's committed to synthesizing new frameworks and following the most promising properties to their logical applications.

He also has begun discussing collaborations with his colleagues, including Chang-beom Eom, the Raymond R. Holton Chair Professor and Theodore H. Geballe.

The collegial environment at UW-Madison was a major factor in Feng's decision to join the MS&E faculty.

"The people surrounding you are the most important thing in your environment," he says.

WHAT'S THE BUZZ?
NANOGENERATING MATERIALS FOR 21ST-CENTURY MEDICINE



"I don't think the cost will be much more than a regular bandage. The device in itself is very simple and convenient to fabricate."

Professor Xudong Wang (above right) is a world leader in wearable and implantable capacitive electricity-generating devices. Recently, his group leveraged that expertise to create two promising new technologies to address major challenges for human health.

Better bandages

A new, low-cost wound dressing could dramatically speed up healing in a surprising way by harnessing the energy generated from a patient's own natural body motions to apply gentle electrical pulses at the site of an injury.

In rodent tests, the dressings slashed healing times from roughly two weeks (for untreated injuries) to a mere three days.

"We were surprised to see such a fast recovery rate," says Professor Xudong Wang. "We suspected that the devices would produce some effect, but the magnitude was much more than we expected."

The new dressings consist of small electrodes for the injury site that are linked to a band holding energy-harvesting units called nanogenerators, which are looped around a wearer's torso. The natural expansion and contraction of the wearer's ribcage during breathing powers the nanogenerators, which deliver low-intensity electric pulses.

And because the nanogenerators consist of relatively common materials, price won't be an issue: "I don't think the cost will be much more than a regular bandage," says Wang. "The device in itself is very simple and convenient to fabricate."

Read more: www.engr.wisc.edu/not-shock-better-bandage-promotes-powerful-healing/

Battling the bulge

More than 700 million adults and children worldwide are obese, according to a 2017 study that called the growing number and weight-related health problems a "rising pandemic."

New battery-free, easily implantable weight-loss devices could offer a promising new weapon for overcoming obesity.

In laboratory testing, the devices helped rats shed almost 40 percent of their body weight.

Measuring less than 1 centimeter across, or about a third of the area of a U.S. penny, the tiny devices—which are safe for use in the body and implantable via a minimally invasive procedure—generate gentle electric pulses from the stomach's natural churning motions and deliver them to the vagus nerve, which links the brain and the stomach.

That gentle stimulation dupes the brain into thinking that the stomach is full after only a few nibbles of food.

"It's automatically responsive to our body function, producing stimulation when needed," says Wang. "Our body knows best."

He and his collaborators patented the weight-loss device through the Wisconsin Alumni Research Foundation and are moving forward with testing in larger animal models. If successful, they hope to progress toward human trials.

Read more: www.engr.wisc.edu/implantable-device-aids-weight-loss/

WOOD RESEARCH BRANCHES OUT

Nobody can accuse MS&E graduate students of failing to see the forest for the trees.

In fact, two alumnae (who now work for the U.S. Forest Service) recently earned national notice for their research on wood.

Nayomi Plaza-Rodriguez, who finished her PhD in fall 2017, received the 2018 Forest Products Society Wood Award for her paper, "Small angle neutron scattering as a tool to understand moisture-durability in adhesive infiltrated wood cell walls." The award recognizes timely research that has the potential to be helpful to the forest products industry, and only two papers earn distinction each year.

Plaza-Rodriguez won first place because the tool she described could aid in the development of treatments to make wood products more durable and moisture-resistant. It's an important problem, because wet wood swells and changes shape, which can cause glues to fail.

The first-place prize earned Plaza-Rodriguez $1,000, a plaque, and complimentary conference registration to the Forest Products Society International Convention, June 26-29, 2019, in Atlanta, Georgia, where she will present her research as a poster in a technical forum.

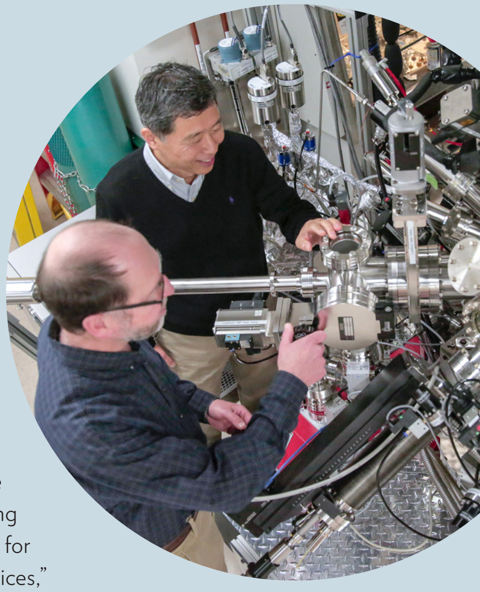
While Plaza-Rodriguez's work focuses on the harmful effects of water on wood, moisture is far from the only force that can destroy forest products. In fact, water's opposite, fire, can be just as damaging.

And fire research was a hot topic at the 2018 World Conference on Timber Engineering, where Laura Hasburgh, who graduated with her doctoral degree in 2018, won the grand prize in the Young Scientist Award.

Hasburgh developed a testing procedure to evaluate how wood contributes to safety and property damage during a full-scale compartment fire, which is a crucial question as cross-laminated timber becomes increasingly popular as a construction material for mid-rise and high-rise residential buildings.

The researchers constructed five full-scale models of two-story apartments and ignited each test structure. While the apartments burned, they collected data on air temperatures, smoke, and toxic gasses—important hazards for firefighters battling a blaze or residents escaping an inferno. The results could help inform future building codes for wood-built residences.

Hasburgh and Plaza-Rodriguez were both advised by Professor Donald Stone during their graduate studies.



SWITCHING IDENTITIES

Revolutionary insulator-like material also conducts electricity

UW-Madison researchers have made a material that can transition from an electricity-transmitting metal to a non-conducting insulating material without changing its atomic structure.

"This is quite an exciting discovery," says Professor Chang-Beom Eom. "We've found a new method of electronic switching."

The new material could lay the groundwork for ultrafast electronic devices

In their research, Eom and his collaborators answered a fundamental question that has bothered scientists for years: Can the electronic and structural transition be decoupled when a material switches from insulating to metallic?

They used a material called vanadium dioxide, which is a metal when it's heated and an insulator when it's at room temperature. At high temperatures, the atoms that make up vanadium dioxide are arranged in a regularly repeating pattern called the rutile phase. When vanadium dioxide cools down to become an insulator, its atoms adopt a different pattern, namely, a conformation known as "monoclinic."

No naturally occurring substances conduct electricity when their atoms are in the monoclinic conformation. And it takes time for the atoms to rearrange when a material reaches the insulator-to-metal transition temperature.

The researchers created two thin layers of vanadium dioxide—one with a slightly lower transition temperature than the other—sandwiched on top of each other, with a sharp interface between.

When they heated the thin vanadium dioxide sandwich, one layer made the structural switch to become a metal. Atoms in the other layer remained locked into the insulating monoclinic phase. Surprisingly, however, that part of the material conducted electricity.

Most importantly, the material remained stable and retained its unique characteristics for extended periods of time.

"We were able to stabilize it, making it useful for real devices," says Eom.

Key to their approach was the dual-layer, sandwich structure. Each layer was so thin that the interface between the two materials dominated how the entire stack behaved. It's a notion that Eom and colleagues plan to pursue further.

"Designing interfaces could open up new materials," says Eom.

The Wisconsin Alumni Research Foundation is assisting the researchers with patent filing.

Read more: www.engr.wisc.edu/switching-identities-revolutionary-insulator-like-material-also-conducts-electricity/

GRADUATE STUDENT MAKES HIS MARK AT ARGONNE NATIONAL LABORATORY

Six months into a year-long DOE fellowship at Argonne National Laboratory, PhD student Samuel Marks' research took an unexpected turn.

At Argonne, Marks has been developing new microscopes to understand how the electronic properties of a material relate to its atomic structure.

While developing new instrumentation to simultaneously image atomic structure and electronic properties in so-called correlated materials, Marks and colleagues discovered they could use the instrument to actually drive a transformation in what they were measuring.

And that means they now have a new way to manipulate a material while they measure the changes in real time. It's an advance that will be useful for probing fundamental physical processes on the nanoscale in advanced electronic materials.

The new instrumentation is a type of scanning probe microscope that detects subtle changes in the electric field between a probe tip and the sample to measure the carrier density near the sample's surface. When coupled with X-ray nanodiffraction, a new technique emerges that provides researchers an unprecedented opportunity to simultaneously image a material's crystal structure with its functional properties. "We didn't know the material would respond in that way," says Marks, whose PhD advisor is Professor Paul Evans

That startling result took Marks' research in a different direction than he had anticipated.

Yet Marks' ability to roll with the punches is part of what motivated him to pursue a PhD in the first place.

"I've always been a 'yes' person," says Marks, "Whenever I start a new project, the more I learn, the more I want to keep going and discover an interesting material or find new properties."

Read more: www.engr.wisc.edu/saying-yes-helps-mse-graduate-student-make-mark-argonne-national-laboratory/

GRAB THEIR INTEREST: INSTRUCTOR WINS TEACHING AWARD

Tayfun Soysal knows the secret to keeping his students captivated even as he teaches complicated materials science concepts.

"The first five minutes is very important," says Soysal, a PhD student and teaching assistant. "I get the students' attention in the first five minutes to keep them interested for the whole class time."

Soysal's students in the freshman-level lecture and lab course MS&E 260, *Materials Experience* appreciated his teaching style so much that they nominated him for a honored instructor award from UW Housing in fall 2018.

He's the first teaching assistant from the MS&E department to receive the honor.

"I've always loved teaching and the appreciation from the students and the department is really motivating for me," says Soysal.

Originally from Turkey, Soysal always knew he had a knack for two things—teaching and science. In fact, at the beginning of his undergraduate education—which, in the Turkish system, encouraged students to specialize early based on aptitude testing—Soysal was offered a choice between selecting education or engineering for his major.

Opting to pursue engineering, Soysal excelled during his college years at Istanbul University, eventually receiving a scholarship from the Turkish government to support his graduate studies abroad.

As a senior PhD student, Soysal has a lot on his plate. In addition to his role as an

instructor, he conducts research under Professor Sindo Kou, and during fall 2018, he was preparing two manuscripts for publication on top of his teaching duties.

Still, despite the hours of effort for preparation and time in the classroom away from his lab, teaching the course was not only personally rewarding, it was a boon for Sosyal's research, in the long run.

"Teaching helps me relax, change direction and focus on something else," he says. "When I return to my research, I come back with a fresh mind."

ALUM ELECTED PRESIDENT OF MATERIALS SOCIETY

David Ulrich Furrer (BSMetE '86 MSMetE '88) was elected president of the world's largest association for materials engineers and scientists, ASM International, for the 2018-2019 term.

Originally from Wisconsin, and a proud Badger always, Furrer worked under Professor John Perepezko during his time on campus. He credits Perepezko's mentorship for his lifelong fascination with materials.

Upon completing his master's degree, Furrer pursued a doctorate in engineering at Ulm University in Baden-Württemberg, Germany. There, he researched microstructural evolution in superalloys.

After finishing his doctoral degree, Furrer took a position at Pratt & Whitney in West Palm Beach, Florida, but he found the tropical weather far too sultry for his tastes. He returned to his home state, settling in Cudahy, Wisconsin, to work on aerospace alloys at the Laddish Company, which is now known as ATI Forged Products. That position led to an opportunity to work for Rolls-Royce, where he spent several years before returning to Pratt & Whitney as senior fellow discipline lead for materials and processes engineering.

Furrer has served on several university and industry advisory boards and has taught materials and manufacturing courses to mechanical engineering students as an adjunct assistant professor at the Milwaukee School of Engineering.

As ASM president, Furrer plans to build on the society's initiatives for education, the computational and digital materials environment, diversity and inclusion, and international activities.

And, his early-career interest in microstructure has persisted to this day, now intersecting with one of his hobbies. An avid photographer, Furrer captures striking metallographic images for display on his walls (in addition to more conventional subjects such as landscapes, aircrafts, cityscapes and the moon).

PEACE CORPS MATERIAL: ALUMNI IN SERVICE ABROAD

Our students often seek out interesting places to work after they graduate. Some go further afield than most, however: They sign up for stints in the Peace Corps after they receive their diplomas.

In recent years, several MS&E alumni have taken their talents overseas. It's a natural fit, really, as a UW-Madison engineering education provides the necessary problem-solving and leadership skills for grads to excel.

"Engineering students, in many ways, have some of the most important skillsets to take with them into the Peace Corps," says Kate Schachter, the UW-Madison Campus Peace Corps Recruiter.

And it's a win-win situation, because Peace Corps service can become a springboard to pursue their passions.

That was the case for Adam Brewer (MS '12), who spent three years in Ghana teaching math and physics to high schoolers.

Back home now, Brewer is currently completing coursework for his high school teaching certification while working at Madison-based healthcare software company Epic Systems.

"I knew that the Peace Corps was one way I could share my love of science and math and working with kids, without a specific background in education," says Brewer.

Teaching is a common assignment for engineers in the Peace Corps. Scott "Scooter" Groux (BS '18) took his classroom savvy to rural Namibia shortly after graduation. There he's been teaching computer skills and math.

Engineers also frequently put their skills to use outside of the classroom. Peace Corps volunteers are trained and encouraged to engage with communities to initiate service projects to address local needs.

"There are a lot of opportunities," says Schachter. "Whether volunteers are installing solar arrays or water systems, setting up processes is what engineering students are great at."

Engineering students also excel at making the best of challenging situations, as Todd King (PhD '96) found out during his service in rural Nepal. The paved streets of Madison were a far cry from the remote village of Sablaku in the foothills of the Himalayas in Nepal's Taplajung district, where it was an eight-hour hike to the nearest road, but King's time on campus prepared him well.

"The rigors of going through grad school in an engineering program were a good crucible for toughening me up for future challenges," says King. "UW-Madison helped me learn to take advantage of a growth situation."

King now works at NASA's Goddard Space Flight Center.

At NASA—where the stakes are literally sky-high—King's experience in the Peace Corps helps him stay grounded.

"The pace of life in Nepal is much slower, which helped me learn how to appreciate quiet time," says King. "I try to use that lesson and consciously carve out space to reflect when things are chaotic so I can return to my work refreshed and more effective."

Read more: www.engr.wisc.edu/peace-corps-material-alumni-service-abroad/

ACCELERATED MASTER'S PROGRAMS

An engineering master's degree from UW-Madison gives you the credentials to get ahead. Find a program that fits your goals and lifestyle.

- 21 flexible online & accelerated programs
- Degrees in multiple engineering disciplines
- World-renowned faculty
- Individual attention
- Innovative partners
- Dedicated fellow students
- Rigorous courses that address real-world problems
- Ideas, inspiration and tools to apply immediately on the job

Earn the recognition you deserve, and prepare yourself today to meet tomorrow's engineering challenges.
advanceyourcareer.wisc.edu/engineering

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

www.engr.wisc.edu/mse

Department of Materials Science & Engineering
1509 University Avenue, Madison, WI 53706

MADISON WISCONSIN

Nonprofit Org.
U.S. Postage
PAID
Madison, WI
Permit No. 658

CAPTIVATING IMAGES EARN AWARDS

Junior Johnathon Brehm received honorable mentions in two categories for his visually arresting microscope images in the International Metallographic Society photo contest. Using light microscopy, Brehm captured a striking shot of metallic microstructure rendered in coolly luminescent blues and grays as well as a black and white image of wrought iron slag. Brehm captured the images during his co-op work at Scott Forge during winter 2018. He expects to graduate from UW-Madison in December 2020 with a specialization in metals.

Jonathon Brehm's award-winning microscopic images.

SUPPORT MS&E

ENGINEERING
FORWARD

Valerie Chesnik
(608) 308-5226
Valerie.Chesnik@supportuw.org
allwaysforward.org/giveto/mse

SHOW YOUR SUPPORT

store.engr.wisc.edu