UNIVERSITY OF WISCONSIN–MADISON
COLLEGE OF ENGINEERING

FALL 2021 NEWSLETTER

MECHANICAL ENGINEERING

DESIGN INNOVATION

Driving new materials, manufacturing and mobility

Greetings!

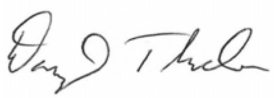
Following the challenges of '20-21, it was extra special to welcome the students fully back into our classrooms and laboratories this fall. I am pleased to report that our department remains strong and growing. We now have nearly 1100 undergraduate students in mechanical engineering which represents 20% growth from just three years ago. To accommodate this growth, we will be hiring up to four faculty this year to expand our work in data-driven design, machine learning in modeling and simulation, robotics and automation.

We did welcome two new faculty to our department in fall 2021. Katherine Fu joined us as an associate professor with expertise in CAE, design science, and design theory and methodology. Pavana Prabhakar joins the department as an assistant professor with a joint appointment in civil and environmental engineering. Pavana investigates the mechanics, design and manufacturing of composite materials for extreme environments. We are excited about the new educational and research opportunities that Kate and Pavana will provide to our students.

I would like to recognize the extensive contributions of Weideman Professor Vadim Shapiro, who retired over the summer. Vadim joined the department in 1994 as one of our first faculty in computational engineering. He taught and conducted research in computer-aided design, geometric modeling, and digital design and manufacturing. He received several awards for his creative and rigorous contributions from the NSF, ASME and the Solid Modeling Association. Within the department, he was known for his insightful perspectives, which served to challenge and motivate his colleagues and students, and we'll welcome Vadim's continued involvement as an emeritus faculty member.

I would also like to recognize some recent alumni and student accomplishments. Congratulations to Grant James (BSME '09) who along with his twin brother Ross was recently inducted into the UW Athletic Hall of Fame for a distinguished rowing career that included the 2012 Olympics. It's great to see "lifelong engineer" included in Grant's list of accomplishments. Congratulations are also due to Ana Ebrahimi for winning the university's Postdoc Excellence in Service Award and launching the Graduate Women in Mechanical Engineering program. Finally, huge thanks to Jake and Inez Bligard for their generous gift to the Department of Mechanical Engineering Fund. Visiting the Bligards and learning about Jake's lifelong passion for engineering was a personal highlight for me this past summer. Their gift will support future generations of students who share that passion for engineering.

On, Wisconsin!



Darryl Thelen
John Bollinger Chair of Mechanical Engineering & Bernard A. and Frances M. Weideman Professor
(608) 262-1902
dgthelen@wisc.edu

SUPPORT MECHANICAL ENGINEERING

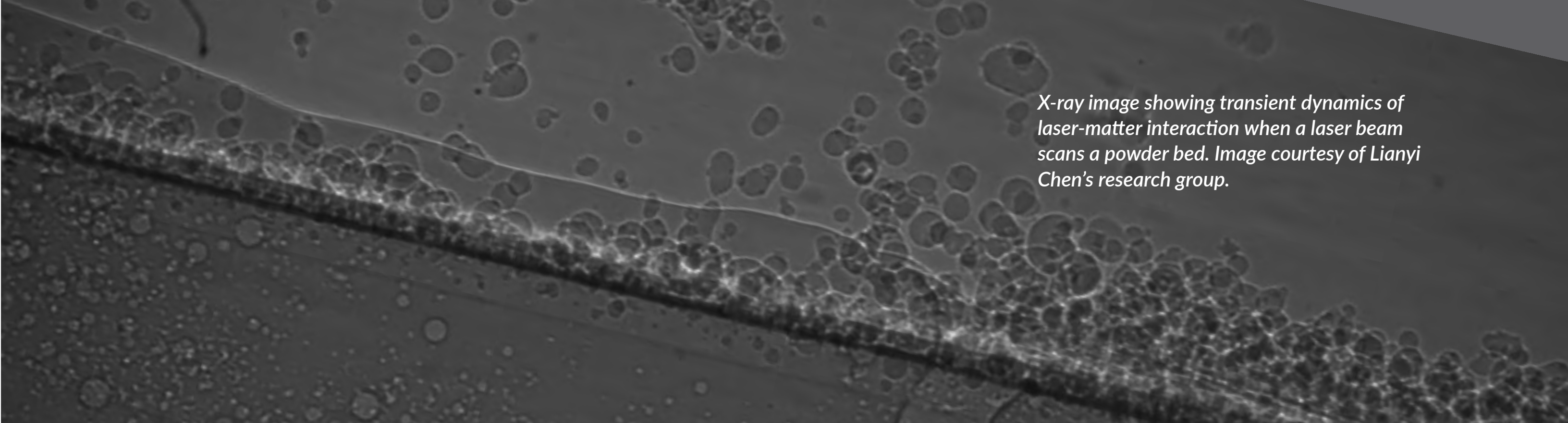
ENGINEERING
FORWARD

Brad Green
(608) 224-9823
brad.green@supportuw.org

Caroline Sullivan
(608) 572-2002
caroline.sullivan@supportuw.org

supportuw.org/giveto/me

engr.wisc.edu/me
facebook.com/UWMechEngr
twitter.com/UW_MechEngr
linkedin.com/school/uwmechengr



X-ray image showing transient dynamics of laser-matter interaction when a laser beam scans a powder bed. Image courtesy of Lianyi Chen's research group.

Unlocking the potential of metal additive manufacturing technology

Electron beam powder bed fusion is a metal additive manufacturing technology that holds immense promise with its ability to make complex metal parts that are difficult or unachievable through conventional manufacturing approaches.

This technology has a wide range of applications, from 3D-printing titanium aluminide for making jet engine turbine blades to creating personalized biomedical implants and prosthetics.

However, the dynamics of this additive manufacturing process largely remain a mystery, which has held back the development and adoption of electron beam powder bed fusion technology in industry.

"Without a better understanding of the process dynamics, we don't know what causes defects in manufactured parts," says Lianyi Chen, Charles Ringrose Assistant Professor. "So it's critical to learn more about the process in order to develop improved electron beam additive manufacturing technologies that can mitigate or eliminate defects."

Chen is leading a unique team that aims to significantly improve measurement and understanding of the electron beam powder bed fusion process. The research will enhance U.S. manufacturers' ability to use this technology to make high-quality, innovative and complex products at high volume. A two-year, $1 million grant from the National Institute of Standards and Technology (NIST) is supporting the project.

The electron beam powder bed fusion process involves using an electron beam to melt and fuse powdered metal together under a vacuum to build 3D parts layer by layer. After the electron beam melts a layer of the metal powder to the product, a new thin layer of powdered metal is rolled onto the working area of the powder bed to build the next layer of the product.

The researchers will develop a testbed for in-situ monitoring of the process dynamics beneath the surface of the powder bed and use high-speed x-ray imaging/diffraction to quantify those dynamics.

"The testbed and protocols that we're developing for this project will allow us to take in-situ measurements of process dynamics in the electron beam powder bed fusion process, generating knowledge that will significantly advance this additive manufacturing technology," Chen says.

As the electron beam interacts with the powdered material, high temperatures occur and hot vapor forms in the area above the interaction zone. Chen says it's also critical to understand the properties of the vapor, as the vaporization will affect the liquid pool, influence the absorption and change the composition of the alloy. However, the vaporization process occurs very quickly and is currently highly challenging to study.

To address this challenge, Professor Scott Sanders is harnessing various laser and optical techniques to measure the properties of the vapor, including temperature and the composition of the gas, for the first time. Sanders is a longtime faculty member in the world-renowned UW–Madison Engine Research Center, and he will draw on his engine research expertise for this project.

"At the Engine Research Center, we have been applying optics to study hot gases in the combustion process for quite a long time. So we're essentially leveraging that expertise for a different application—to study this additive manufacturing process," Sanders says.

In addition, Kevin Eliceiri, an associate professor of biomedical engineering and medical physics, and Brandon Walker, a postdoctoral research associate in Eliceiri's group in the campus-based Morgridge Institute for Research, are collaborating on the project. Walker has been developing a novel multi-source electron beam scanning system for use in metal additive manufacturing techniques for biomedical applications, and he and Eliceiri will leverage their expertise to advise the team on various applications for the technology.

Focus on new faculty

Katherine Fu, adding a human element to engineering design

Popular culture often references people who are left-brained or right brained—creating somewhat of an either-or among those who are deeply analytical and methodical in their thinking and people who are creative, free-thinking and artistic.

Meet Katherine (Kate) Fu, however, and you quickly realize you don't need to choose sides. Fu elegantly marries her love of all things science and math with her passion for art and design—a mix that how allows her to develop methods and tools that foster more effective and inspired engineering design and innovation. "I think we often overlook the human element of engineering, and being able to study it brings so much richness to our approach and practice," she says. "Design is so universal—and the way we study and formalize it allows us to apply our methods to nearly any problem, including the major challenges facing us today, like climate change, transportation and health. This far-reaching impact is exciting and motivating to me."

In August 2021, Fu joined the department as an associate professor, coming to the UW–Madison from Georgia Tech, where she served on the faculty for seven years and earned tenure. "I'm so excited about all that is happening at the university," she says. "The makerspace, collaborations across campus and with local industry partners, and being able to meet and work with students who are passionate about engineering design—to name a few."

Fu earned her bachelor's degree in mechanical engineering from Brown University, and her master's and PhD in mechanical engineering from Carnegie Mellon University. In graduate school, Fu says she learned how to study engineers and designers using techniques from cognitive science to better support innovation and creativity.

At Carnegie Mellon, through postdoctoral positions at Massachusetts Institute of Technology and Singapore University of Technology and Design, and as she began her faculty career at Georgia Tech, Fu has used cognitive science tools to help her understand and improve engineering design methods and processes. In 2019, she received an NSF CAREER Award to study the role that error management cognitive bias plays in the design process, and to identify and test ways to mitigate that bias.

At UW–Madison, she'll continue to work to help expand understanding of designers and design by applying mixed-methods approaches, paradigms and expertise, and she'll use advanced computation—including data mining, modeling and artificial intelligence—to provide information to designers to improve their design output and innovation potential.

While Fu already has earned several honors for her research, including the 2020 ASME Design Theory and Methodology Young Investigator Award, she also cares deeply about developing people, and says her approach to mentorship is rooted in compassion, flexibility, respect and trust. "It is crucial to me that my lab group has a culture of inclusivity and equity; I seek out mentees who come from diverse backgrounds, and I work to mentor them in the ways that work best for them," she says.

Read more: www.engr.wisc.edu/news/focus-on-new-faculty-katherine-fu-adding-a-human-element-to-engineering-design/

Focus on new faculty

Prabhakar brings composite materials expertise to department

Pavana Prabhakar's new position with the department will allow her to combine the best of two worlds.

Prabhakar, the Charles G. Salmon assistant professor in civil and environmental engineering, began a joint appointment in mechanical engineering in August 2021. Much of Prabhakar's work focuses on understanding the damage and failure of composite materials in multi-physics environments. While she will maintain her primary appointment in civil and environmental engineering, she says her new role in mechanical engineering will allow her to better focus on her area of expertise.

"A lot of my work is on lightweight polymer composites, and these are predominantly used in the aircraft and automotive industries," she says. "It's a natural fit to be in the Department of Mechanical Engineering. The department has a lot of connections with those industries and one of my primary motivations was to open a road toward collaborating with industry partners for my research."

Her new appointment also should make it easier to find graduate students who are more familiar with Prabhakar's research areas than students in civil engineering tend to be.

"This will really help put my work out there so people know there's polymer composite science here at UW–Madison in both the civil and mechanical engineering departments," she says.

Darryl Thelen, Bernard A. and Frances M. Weideman Professor and the John Bollinger Chair of Mechanical Engineering at UW–Madison, says Prabhakar is a valuable new member of his department.

"Pavana is a wonderful addition to our faculty," he says. "Her research spans the mechanics, design and manufacturing of composite materials for extreme environments, which are important to consider when using composites in aerospace, automotive and wind power generation systems. Her joint position with civil and environmental engineering will help strengthen ties between the departments, while also providing an interdisciplinary perspective to our students on the broad use of composites in an array of fields."

Prabhakar's new appointment will also allow her to strengthen ties with colleagues in the Polymer Engineering Center. Though she's long been affiliated with the center, Prabhakar hopes to establish closer collaborative ties with faculty, staff and students in the center to help elevate the outcomes of her research.

Read more: www.engr.wisc.edu/news/prabhakar-brings-composite-materials-expertise-to-mechanical-engineering/

Helping a lunar rover stay on the move

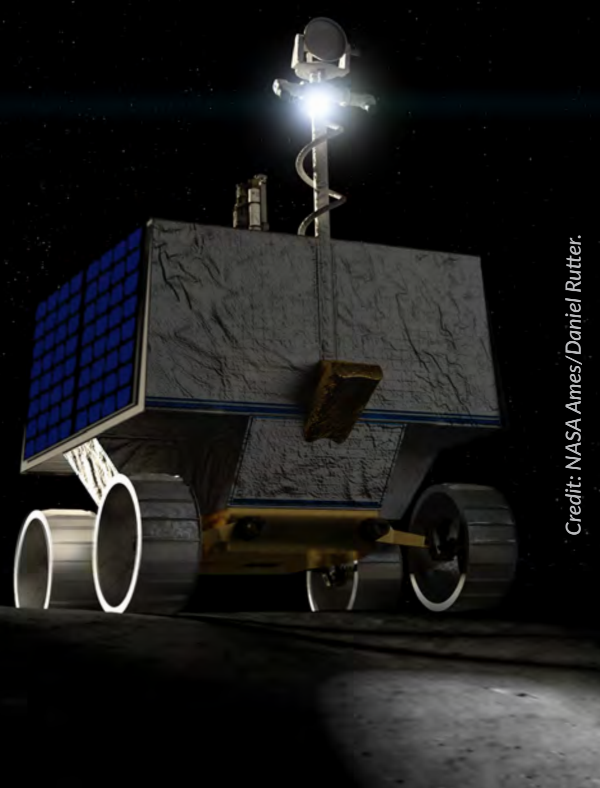
NASA is planning a 2023 mission to send the VIPER rover to the moon, where it will traverse the lunar surface as it searches for ice—and UW–Madison engineers are helping to ensure the rover is able to remain on task.

When vehicles drive across extraterrestrial surfaces, they risk getting stuck in rocky areas or in soft terrain. "NASA wants to avoid the catastrophic failure that happened when the Spirit rover got stuck in sand on Mars and was unable to free itself, ending its mission," says Dan Negrut, the Mead Witter Foundation Professor of Mechanical Engineering.

To help tackle this challenge, Negrut and his students are working on a NASA-funded project to simulate how the VIPER rover will travel on the moon's surface. They are leveraging Project Chrono, an open-source physics simulation engine developed at UW–Madison in collaboration with scientists from Italy. This software allows the researchers to model complex mechanical systems, such as full rovers operating on deformable soil.

Negrut and his team in the Simulation-Based Engineering Lab are creating comprehensive simulations that include models of the rover and its wheels, the lunar terrain, the gravitational pull and the vehicle's interaction with the soil.

Read more: www.engr.wisc.edu/news/helping-a-lunar-rover-stay-on-the-move/



Credit: NASA Ames/Daniel Rutter.

Meet the outstanding alumni we honored at Engineers' Day

Bjorn Krogh Borgen

2021 Distinguished Achievement Award recipient

Chairman, Borgen Investment Group

BSME '62, (MBA '66, Harvard)

Bjorn was born in Norway and immigrated to the United States at a young age with his family after their home and belongings were destroyed by bombing in World War II. The family settled in the town of Strum, Wisconsin. From 1975 to 1998, Borgen was the sole owner, president and chief investment officer of Founders Asset Management, the management company of the Founders Funds, which he built into one of the leading mutual fund companies specializing in growth stock investing. In 1998, he sold Founders to Mellon Bank to concentrate his efforts on Borgen Investment Group, a private asset management company, and the Borgen Family Foundation. The college honored Borgen as a leading financial manager and entrepreneur whose success has enabled him to support educational, athletic and cultural causes that have benefited people across the United States and in his home country of Norway.

Kara Byrne

2021 Early-Career Award recipient

North America Commercial leader, turbomachinery and process solutions-valves, Baker Hughes

BSME '04

Kara has more than 15 years of experience in the energy industry working in various commercial, engineering and supply chain roles. At Baker Hughes, she is responsible for leading the North America Commercial Team for the Masoneilan, Consolidated, Becker and Mooney valve product lines. And as 2021 national president elect of the Women's Energy Network (WEN), she brings educational, leadership and industry programming to all 22 chapters of the nonprofit organization. The college honored Byrne as a technical and strategic leader in energy, valves, and turbomachinery whose passion for inspiring women to enter engineering has enabled her to mentor, develop and retain future women leaders in energy industry.

Peter Holsten

2020 Distinguished Achievement Award recipient

President and managing broker, Holsten Real Estate Development Corporation

BSME '72, (MBA '75, University of Chicago)

In 1975, Peter Holsten founded Holsten Real Estate Development Corporation, which has since grown into a team of companies including real estate development, property management, construction management, and social services. These companies are linked by a mission to profitably develop affordable, mixed-income, and mixed-use housing by using creative site selection and financing; cost-efficient construction; leasing and sales strategies that are effective in the community; and comprehensive supportive services. The college honored Holsten as a mechanical engineer and humanitarian who is devoted to the principle that everyone deserves affordable, quality housing and who strives to build and maintain healthy communities.

Remembering distinguished alumnus Arthur Janes

Arthur Janes (BSME '67, BBA '67, UW–Madison), a passionate supporter of UW–Madison engineering and an accomplished entrepreneur and corporate leader, passed away on March 11, 2021.

After beginning his career as an aerospace engineer with companies that included Boeing, Lockheed Propulsion and others, he founded PDS Technology, a leader in engineering staffing for such industries as aerospace, defense, machinery, energy, technology and more.

During the 41 years he led PDS Technology, the company worked on every significant aerospace project in the United States, including defense projects for Northrop. In 2018, PDS was successfully sold to the Belgian publicly traded company, AKKA Technologies.

Janes served on the College of Engineering's advisory board, and he received the college's Distinguished Achievement Award in 2018. A generous philanthropist, Janes committed $2 million as the lead donor to endow the mechanical engineering department chair. His commitment inspired other gifts totaling $5 million to create the John Bollinger Chair of Mechanical Engineering. The endowed chair provides flexible funding that allows the department to capitalize on opportunities to enhance research efforts and enrich students' educations.

Engineering degree enables alum to pursue his passion

Darryl Thelen, John Bollinger Chair of Mechanical Engineering and Bernard A. and Frances M. Weideman Professor, with Jake and Inez Bligard in summer 2021.

Erling "Jake" Bligard's passion for engineering flourished during his time as a mechanical engineering student at UW–Madison, and his education paved the way for a highly rewarding career.

Born and raised in Minneapolis, Bligard, 95, figured he'd attend the University of Minnesota. But then the United States entered World War II, and he joined the Navy with the goal of being a pilot.

"At that time in the war, the military needed people with engineering skills and it was pushing a program called V-12, which I ended up joining, and that shifted my focus to engineering," Bligard says.

The V-12 Navy college training program aimed to generate a large number of officers to meet the demands of World War II. The program Bligard enrolled in was based at UW–Madison.

After earning his bachelor's degree in 1948, Bligard stayed at UW–Madison for his mechanical engineering master's degree, which he earned in 1949.

After the war ended, there was a large influx of veterans enrolling in universities—including UW–Madison—through the GI Bill. Many chose to study engineering, creating high demand for instructors. Based on his outstanding performance in the master's program, UW–Madison hired Bligard as an engineering instructor.

Bligard says his time at UW–Madison had a profound influence on his life. Not only did he receive training that would serve him well throughout his long career, he also met his future wife, Inez, when she was a student at UW–Madison.

"There was a Sunday afternoon dance at the student union; it was a mixer to celebrate a Wisconsin victory in football, and that's where I met Inez," Bligard recalls. "I asked her to dance, and we ended up dancing together all afternoon."

Bligard went on to work at several companies as a chief engineer, first on the East Coast and then later in the greater San Fernando Valley in California, where he and Inez raised their family.

Bligard earned several patents for his engineering work, including patents for airplane engine suspension and mounts. "Throughout my career, my expertise was in vibration control, and I focused on developing solutions to prevent equipment problems due to vibration in vehicles, mostly aircraft," he says. "There was demand for my skills, and I always enjoyed doing engineering work."

Bligard spent a significant portion of his career working at Hughes Aircraft Company in California, where he did engineering work related to cruise missile systems.

He retired at age 75. "Engineering is his passion. He just loved being an engineer, and his UW–Madison education made that possible," says Inez, who graduated from UW–Madison with a psychology degree in 1950.

To show their gratitude, the couple made a $1 million gift to the department.

"I appreciated the education I received from UW–Madison, which was valuable for starting my engineering career," Jake says. "It's a great institution, and I learned an awful lot about how to develop engineering solutions to various challenges. So, I wanted to do something for the department to give back and help it continue to deliver an outstanding educational experience."

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

www.engr.wisc.edu/me

Department of Mechanical Engineering
1513 University Ave., Room 2107
Madison, WI 53706

Powering 'air taxis' through manufacturing innovation

The future of transportation—think urban air mobility—calls for a new generation of manufacturing. Recent PhD graduate Behzad "Buzz" Rankouhi is building an audacious prototype and a company to do it.

With support from WARF Accelerator, Rankouhi wants to leverage 3D-printing technology to open up new opportunities and a new generation of electric motors with applications in aerospace and beyond.

"If you want to hop from one side of town to the other in somewhere like New York or Los Angeles, we will start to see electric vehicles—air taxis—that take off and land vertically before the end of this decade," Rankouhi says.

Rankouhi, who is the co-founder and CEO of Dastan Technologies, is working with his faculty advisor, Professor Frank Pfefferkorn, and their collaborators to develop a multi-metal additive manufacturing system that can create fully 3D-printed electric motors used in an emerging market called urban air mobility.

While existing 3D-printing technology can create components with very complex geometries and fine features, crafting those fine parts out of multiple materials at the same time is currently impossible.

"Today you can make a part out of copper, and another part out of stainless steel, and then figure out a way to assemble it. But being able to print that complex component in one shot, in one machine, is what we're working on," Pfefferkorn says.

Credit: NASA

The ability to 3D print an electric motor in its entirety in a single process offers advantages such as weight reduction. It also allows for a kind of design freedom not possible with conventional methods, such as the ability to replace traditional copper windings with more efficient 3D-printed structures.

The researchers are envisioning an additive manufacturing system that allows for concurrent 3D printing of complex parts with up to four different metals and controlled compositional gradient.

Pfefferkorn says he was attracted to the project for its boldness. "The way the U.S. funding ecosystem works, we don't often get to build machines," he says. "We generally focus more on processes. So to be working on a first-generation prototype is exciting. That's an opportunity that I haven't had previously."