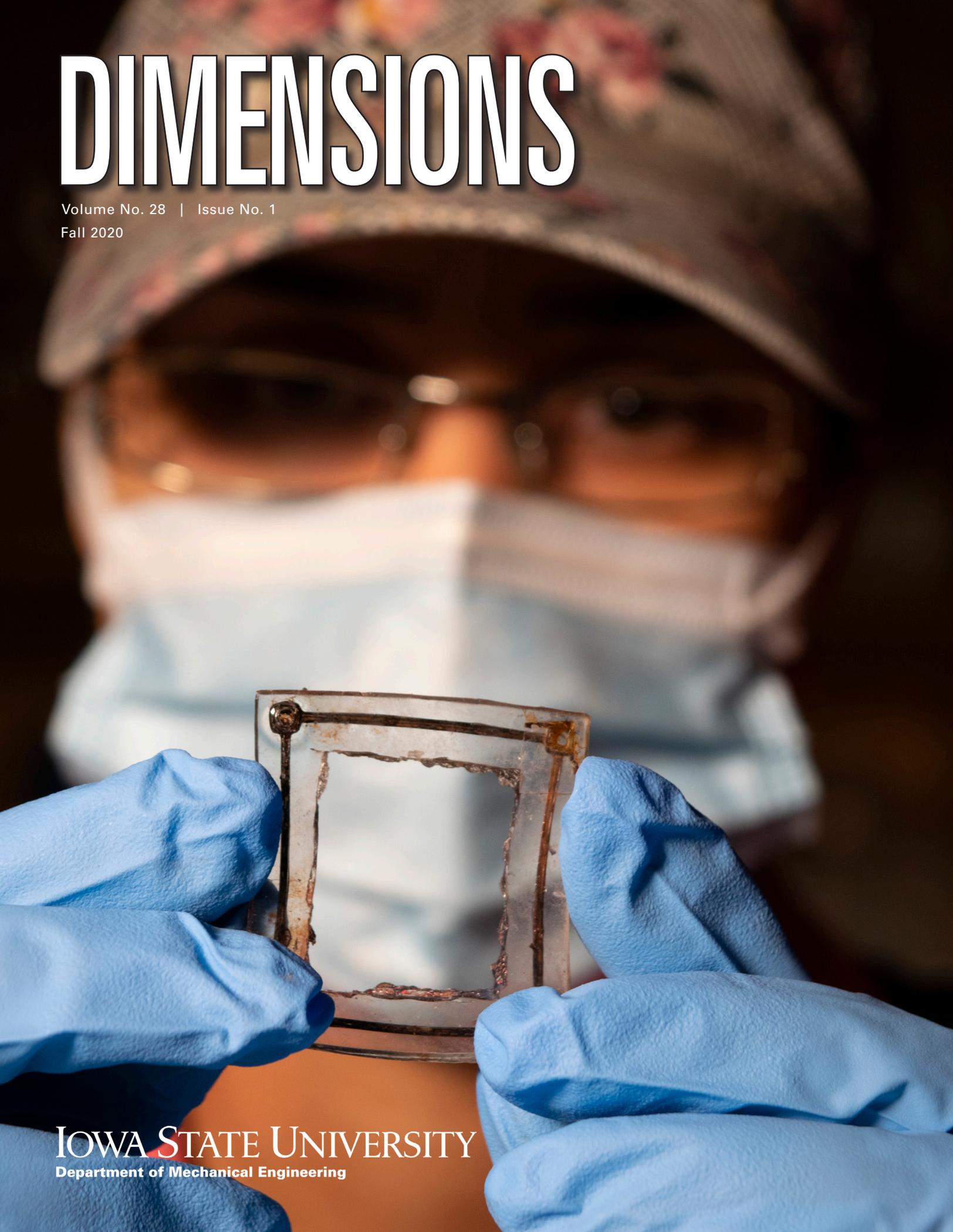


DIMENSIONS

A close-up photograph of a person wearing a white lab coat, safety glasses, and a white face mask. They are holding a rectangular metal component with a central square hole and some internal structure. The person's hands are wearing blue nitrile gloves. The background is dark and out of focus.

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IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Letter From the Chair

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On the cover

Soheila Shabaniverki, a Ph.D. candidate in mechanical engineering, examines a ferrofluid-infused polydimethylsiloxane (PDMS) actuator. The ferrofluid actuator was developed as part of a joint research project between Jaime J. Juárez, assistant professor of mechanical engineering, and Juan Ren, William and Virginia Binger Assistant Professor in Mechanical Engineering. Their research looked at using 3D printing to create channels filled with ferrofluid inside PDMS. This allows the PDMS structure to serve as a magnetically sensitive actuator. Their findings were recently accepted for publication in *3D Printing and Additive Manufacturing*.

Front cover photo by Nick Fetty

Back cover photo by Caroline Hayes

Dear alumni and friends,

While we may be doing this differently this year, I am pleased to tell you that all of our education and research programs are still marching forward.

Some highlights in this issue include:

An overview of the efforts the department is taking to ensure the safety and wellbeing of our students while also maintaining the high-quality of engineering education for which Iowa State University is known,

ME student Katie Lyon interned with Tesla over the summer, and she hopes to use this experience to engineer cars of the future when she completes her studies at Iowa State,

ME student Kathryn Hining has been named the ME Outstanding Senior for Fall 2020. Not only is she accomplished in the classroom but she also participates in intramural sports and enjoys listening to the Beatles in her free time,

ME student Sebastien Mueller, with the help of folks in the Boyd Lab, has designed a unique bicycle that he has dubbed “the Dahu,”

ME professor Shankar Subramaniam is involved with a research project that uses computer simulations to improve clean energy generation,

ME associate professor Travis Sippel has teamed up with researchers at the University of Iowa on a Department of Defense-funded project which examines energetic materials,

A pair of Cyclone brothers, one of whom is an ME alum, have launched their own company: Jensen Applied Sciences. The duo, who also happen to be movie buffs, were inspired by Batman’s ingenuity,

ME alum Sarah Walter’s career has taken her everywhere from Canada to Germany after she left Ames,

ME alum Tina Akinyi wants to make college more accessible for students from disenfranchised backgrounds.

This semester has been a challenge because of COVID-19, but we have applied our problem solving skills to create a safe environment in our classrooms and laboratories. I hope you will enjoy reading about some of the efforts of our department and alums, to combat this deadly outbreak. I am extremely proud of the hard work of our students, faculty and staff as they have transitioned to learning, teaching and working in new ways, including in-person, virtual or a mix of the two.

Our alumni are vital to the growth and success of mechanical engineering and industry in the U.S. and abroad. I enjoy hearing about your accomplishments and encourage you to reach out and share your story. I can be contacted at mealumni@iastate.edu.

Regards,



Caroline Hayes
Mechanical Engineering Department Chair
Lynn Gleason Professor of Interdisciplinary Engineering



Department Honors

Students

Lusi A, Graduate Student

Research Excellence Award, Presented by ISU Graduate College

Jessica Brown, Graduate Student

1st place in the graduate research poster competition at the TCS 2020 conference

Ava Depping, Undergraduate Student

Spring 2021 undergraduate merit scholarship, presented by Iowa Space Grant Consortium

Parinaz Hafezisefat, Graduate Student

Teaching Excellence Award, Presented by ISU Graduate College

Kathryn Hining, Undergraduate Student

Fall 2020 Outstanding Senior, Presented by ISU College of Engineering

Sai Katamreddy, Graduate Student

Teaching Excellence Award, Presented by ISU Graduate College

Lionel Ouedraogo, Graduate Student

2020 Educational Foundation Scholarship Award, Presented by the International Society of Automation

Kshama Parate, Graduate Student

Research Excellence Award, Presented by ISU Graduate College

Roy Pillers, Graduate Student

Named the 2020 FED Prof. Kirti Ghia Scholar

Faculty and Staff

Mark Bryden, Professor

ISU Alumni Association Faculty-Staff Inspiration Award

Jim Heise, Professor of Practice

Advanced to Professor of Practice

Ming-Chen Hsu, Associate Professor

Early Achievement in Research Award, Awarded by ISU College of Engineering

Aliza MacKenzie, Academic Adviser

Early Achievement in Advising Award, Awarded by ISU College of Engineering

Reza Montazami, Associate Professor

Named Fellow of the Royal Society of Chemistry; Award of Excellence from the ISU Student Government (for development and use of Online Educational Resources-OER)

Cary Pint, Charles Schafer (Battelle) Chair in Engineering

Global Top 100 Visionary in Education from Global Forum for Education and Learning; R&D 100 Award in the Materials/Mechanical category by R&D World Magazine (for SkyNano LLC); Named Charles Schafer (Battelle) Chair in Engineering by ISU College of Engineering

Soumik Sarkar, Associate Professor

Named Walter W. Wilson Faculty Fellow in Engineering by ISU College of Engineering

ME graduate student earns 2020 Educational Foundation Scholarship Award

Lionel Ouedraogo, mechanical engineering graduate student, earned the 2020 Educational Foundation Scholarship Award.

"It is with great honor and joy that I received this award. It showed me that all the effort and time I put in the work I do pays. Receiving this award meant that between all the candidates that applied to this award my contributions to the automation, instrumentation, and systems field stood out and made a great impact," Ouedraogo said.

The scholarship is awarded by the International Society of Automation (ISA) for a student's outstanding

potential to contribute to the automation, instrumentation and systems field.

The scholarship helps fund Ouedraogo's tuition and related expenses for research and other initiatives. Additionally, students are granted a one-year complimentary student membership to ISA.

Currently, Ouedraogo is working as a graduate student in the Nicole Hashemi lab to improve an organ-on-a-chip system developed in their lab. Hashemi is an associate professor of mechanical engineering.

Ouedraogo said, "I am developing a new sensor that will help quantify and qualify the exchanges that take place between

a mother and her fetus in the placenta and how the cells react to these changes and I am also working on automating the data collection system that we have in place for the chip."



**Contributed by Martha Haas/
Engineering College Relations**

Driven by a passion to engineer vehicles of the future

From fuel-efficient snowmobile engines to the electric motors in the Tesla Model Y, mechanical engineering student Katie Lyon has a passion for environmentally friendly vehicles.

Lyon grew up in Burnsville, Minnesota and as a child loved playing with Legos, Lincoln Logs and other toys that allowed her to combine her creativity with her analytic skills. She further developed her interest in STEM in high school and said she was intrigued by the possibility of using science and math principles to solve complex problems.

For college, Lyon knew she wanted to attend a large university that would provide many opportunities both inside and outside of engineering.

“I wanted to meet people from all different majors and backgrounds while also being able to tailor my engineering experience to my passions,” she said.

She chose mechanical engineering (ME) as her major because at the time she was not sure what industry she would pursue, so she felt ME provided her some career flexibility while also allowing her to pursue her passion of working on “things that move.” When she got to Iowa State, she continued to pursue this passion through her involvement in the SAE Clean Snowmobile Challenge. She and her teammates are tasked with taking an existing snowmobile engine and modifying it to make it more fuel-efficient.

“Clean Snowmobile does a fantastic job of marrying two of my largest engineering interests – the automotive industry and clean energy solutions – and has really allowed me to get a taste of what working in those industries might entail,” said Lyon.

This experience with Clean Snowmobile really paid off when she landed a spot as a Manufacturing Equipment Engineering Intern at Tesla’s Fremont factory for the summer of 2020. She and her team were responsible for ensuring the Model Y General Assembly line was running as efficiently, consistently and safely as possible. The team was responsible for finding areas of improvement, designing solutions, implementing the final products and other tasks as they came about.



Lyon

“She has always been extremely helpful and supportive throughout my time here and inspires me to be as passionate and deliberate of a person and engineer as her,” Lyon said.

In her free time, Lyon enjoys spending time outdoors, particularly going on walks and hikes. She also enjoys cooking and baking, and is currently obsessed with French macarons. Music is also an important part of her life and she enjoys playing both the piano and the cello.

Lyon plans to complete her studies in May 2022 and hopes to pursue a career in either the automotive or renewable energy industries after graduation. More specifically, she said she would love to work on the design of new vehicles, solar technology or biorenewable fuels. She said that passion is what has driven her in her professional life, so she encourages others to find the passion that drives them.

“I would encourage people to pursue opportunities they are passionate about even if they believe they might not be qualified enough for the job. I felt under-qualified for my position, and perhaps was, but the passion and determination I have for the industries allowed me to stand out amongst other applicants and really grow in the role I was given,” she said.

Lyon said she has taken concepts and principles from the ME curriculum and applied it to her work at Tesla. Specifically, she has used statics, physics and materials engineering to ensure a design would be able to withstand the forces to which it would be subjected. Additionally, she said her knowledge of 3D modeling using SolidWorks, which she learned in her freshman engineering design course, was helpful during her internship.

Paola Pittoni, an ME associate professor of teaching who taught Lyon’s freshmen engineering design course, has been one of Lyon’s strongest mentors during her time at Iowa State, and also one of the first female engineering faculty members she has studied under.

Kathryn Hining: Outstanding senior in mechanical engineering

Major: Mechanical engineering

Hometown: Quincy, Illinois

Clubs and Activities: Iowa State Club Volleyball Team, various intramural sports

Awards and Honors: Dean's List, First-Year Honors Mentor Grant, highest 2% of engineering freshman, National Merit Special Scholarship, Return to Iowa – Generations Scholarship, Meier Family Endowed Scholarship, John P. Keller Endowed Scholarship in Mechanical Engineering, Raymond A. and Kathryn A. Engel Fund in Mechanical Engineering, William and Emily Haines Memorial Scholarship, Award for Competitive Excellence

Kathryn Hining's musical taste earned her the nickname "Beatles Girl," her sports skills have earned 14 intramural championship t-shirts and a fifth in the nation place with Iowa State's club volleyball team – all while earning top honors studying mechanical engineering at Iowa State.

Hining hails from Quincy, Illinois and is a third-generation Cyclone. Both her parents and grandfather studied engineering at Iowa State.

"At first I was like, 'I want to go somewhere new, I want to be different,'" Hining said. "I didn't want to do exactly what my parents did. And I visited campus and I was like, 'alright, never mind.' I loved it and my parents were super excited."



Hining considers balancing the demands of mechanical engineering while also creating lasting memories and friendships her greatest accomplishment throughout her four years at Iowa State.

Maintaining a busy schedule and staying on top of her studies wouldn't have been possible if not for the people Hining met and relationships she's formed over the course of her time in Ames.

Forming study groups was crucial for Hining while in mechanical engineering, to be able to work together and bounce ideas off of one another. Her biggest piece of advice for freshmen and underclassmen within engineering is to "find your people."

"Find true friends, find people that are going to help you when you're struggling, find people that are hopefully smarter than you," Hining said. "I try to study with people that are better than I am at that subject, you don't want to be the one that's dragging all your friends along, you want to find people that can build you up and make you stronger and I think that's why I did well at Iowa State, because I was lucky enough to find those people pretty early and I've had them all four years."

Having a role model such as teaching professor of mechanical engineering, Gloria Starns, was pivotal for Hining, a fellow female in the STEM field. So much so, that Hining would prematurely scour course catalogs to ensure she was placed in Starns courses for the semester.

"She's just so pro-lady engineers, that I just loved her," Hining said. "She's uniting the women left and right. She was the first professor that I had felt comfortable talking to that I knew, knew my name, knew that if I had a problem that had nothing to do with school, that I could talk to her."

When Hining isn't blasting Beatles music outside Curtiss Hall or doing homework, she can usually be found outdoors, participating in any activity where she can show off her athleticism, or doing things that help her mind decompress after a long day of staring at a screen.

Post-graduation, Hining is going to work for Hoss and Brown Engineers, a consulting firm in Kansas City. Her first project is going to be visiting the Pentagon, right away after graduating.

Contributed by Sierra Hoeger/Engineering College Relations

"Find your people"

Read about another effort that aims to connect ME students: me.iastate.edu/like-me-article

Creating a safe environment for in-person mechanical engineering classes



Lauren Perdue (left) and Jacob Bevirt work on their laptops during ME 270: Introduction to Mechanical Engineering Design on Sept. 24, 2020.

When Iowa State University was given the go-ahead to open up for fall classes, faculty, staff and student technicians in the mechanical engineering department quickly made every effort to prepare lesson plans, classrooms, labs and other spaces to be as safe as possible so students can get the hands-on engineering education Iowa State is known for while also taking the necessary steps to reduce the spread of COVID-19.

Much of this effort has been coordinated by mechanical engineering (ME) department chair Caroline Hayes. Hayes, who also serves as the Lynn Gleason Professor of Interdisciplinary Engineering, said that all of the “unknowns” early on made planning for the fall exceedingly difficult.

“Back in March, when we first started planning for fall semester in a COVID world, we didn’t know yet whether we would be teaching online or in-person,” said Hayes. “The virus was so new that scientists did not know how it would behave, or how one can best guard against it.”

In May the uncertainty continued as disruptions in supply chains left Hayes questioning if they would even have access to disinfectants, hand sanitizer, personal

protective equipment (PPE) and other gear that has become essential during the COVID-19 era.

“It was really scary to think that we might have to start the semester in-person without those things. We were considering making both hand sanitizer and masks if we could not get them through the normal channels,” said Hayes.

Though the department did procure the necessary supplies, it was also involved in its own efforts to produce PPE using both traditional means as well as 3D printing. Hayes even drove to Iowa City twice to hand deliver boxes of face shields to the University of Iowa Hospitals and Clinics and other health care organizations.

“The sports rivalry side of things is fun, but in times like these it’s important for us to come together,” Hayes said.

The virus has drastically changed the way courses are delivered and the way that classrooms and labs are set up. Hayes said that masks, physical distancing and good ventilation were the three key necessities they kept in mind for designing safe in-person instruction. Of these three, the need for physical

distancing in teaching spaces has had the largest repercussions.

“It jointly impacts the physical layout of teaching spaces, and the way in which each class is structured,” said Hayes. “In order to give students adequate space for physical distancing, you need bigger teaching spaces. Unfortunately, for laboratories requiring special equipment which is wired or plumbed into a specific room, you can’t easily move it to a bigger room without major construction – assuming we even had a bigger room.”

Instead, personnel in the department have thought of new ways of effectively using the existing space. For example, by temporarily removing half the lab stations to make space, and then scheduling half the students to gather data on any given day. In another model, half the students on a lab team come in person while the other half connect with their teammates remotely. Then they switch for the next lab session.

Sebastien Feve, associate teaching professor of mechanical engineering, has made adaptations to his sections of M E 270: Intro to Mechanical Engineering design this semester. Part of these adaptations included activities such as team quizzes (in-person) and early assignment work check-ins (in-person and remote hybrid). Students have even had to adapt the way in which they communicate, with more emphasis on web calls and email.

“The learning curve for this new style of communication was steep at first but I’m proud to see everyone has been coming along nicely since the start of the semester,” said Feve.

Sandy Sayer, program coordinator for ME and a member of the department’s safety committee, led her team of teaching lab coordinators and student techs in making adaptations to the teaching spaces to ensure safety. It required constant, summer-long collaboration

between her team and the instructors to ensure the new set-up would support instruction, and vice versa.

“What I hear most from students is that they are happy to be here,” said Sayer. “The students that I am around are careful to wear their masks and physically distance because they want to continue to have hands-on opportunities on campus.”

The final challenge, and perhaps the most difficult of all, was to provide preferred solutions that could meet the students’ varied needs. Some students preferred in-person instruction, while others, including those already managing serious health challenges, felt safer continuing remotely until the virus subsides.

“We needed to serve all of our students. You can’t simply deliver all classes in-person or all classes on-line and still meet the needs of the students. They need options,” she said.

Department personnel now look ahead to the spring semester, though many uncertainties remain. Hayes and others in the department will continue to monitor the situation and will do everything possible to provide a top-notch engineering education while taking the necessary precautions to lessen the spread of COVID-19.

“It’s a work in progress, but I am proud of the efforts from everyone,” said Hayes. “We are still learning and watching carefully to see how spring goes. So far, fall semester has gone surprisingly smoothly. But continued success of in-person learning in the COVID-19 era depends on the whole community, faculty, staff and students, continuing to be very careful, and very proactive, both on campus and also in their personal lives.”

Evan Christianson works on his laptop during ME 270: Introduction to Mechanical Engineering Design on Sept. 24, 2020.



Iowa State alum turns passion project into a reality with the help of Boyd Lab

When Sebastien Mueller ('19 mech engr) was young, his dad told a story about his quest to "save the Dahu," a goat whose legs are shorter on one side than the other, making it so Dahus can only walk in circles around their mountain homes.

The story was the inspiration behind the name for the bicycle Mueller crafted in Boyd Lab. Mueller hopes that with his bicycle, riders will never want to leave the mountain and continue going in circles around it.

Dahus are fictional, but what are engineers if not makers of reality from what was once just imagined?

Education + Passion = Bikes

Growing up in Santa Cruz, California, Mueller was surrounded by bikes. He had worked at a bicycle shop in high school and envisioned a future with them.

"Since I was in college and doing mechanical engineering, I wanted to try and kind of put it together, my education and something I enjoyed doing," Mueller said.

After learning of the Boyd Lab and meeting with Craig Severson, supervisor of the lab, Mueller was itching to get started on a project.

"We discussed it and we were both excited," Mueller said. "Overall it was just a way to kind of blend more things I'm passionate about and my education."

Born from Boyd

The Boyd Lab, located in Hoover Hall at Iowa State, provides students with the resources needed to complete hands-on engineering projects. Tools such as power tools, hand tools, woodworking equipment, milling and turning equipment, metal-working equipment, welders and a plasma cutter are all available for use.

Never having used tools like this before, Mueller relied on help from Severson and Josh DeLarm, another lab supervisor, as well as problem-solving skills to craft the bicycle.

"I went from never having done anything like this to designing and building all the fixtures and working with Craig to see what geometry would work the best,"



ME student Sebastien Mueller (right) and ME teaching lab coordinator Craig Severson pose with Mueller's Dahu bicycle.

Mueller said. "It definitely wouldn't have happened without the resources Iowa State let us use."

Throughout the duration of this project, Mueller also learned about and got hands-on experience with the manufacturing process.

Specialized Skills

While on a road trip to Santa Cruz with his brother, Mueller got to visit Specialized, a bicycle manufacturing company known for creating the first production mountain bike. Specialized had also donated parts to help Mueller complete Dahu.

Right now Mueller works in the auto industry but plans to work in engineering bicycles in the future.

"I really used skills that I developed in my education and my mechanical engineering degree to be able to make this," Mueller said.

Contributed by Sierra Hoeger/Engineering College Relations

"Sebastien designed a custom frame, selected the appropriate material, made custom jigs and fixtures, operated various machining equipment, and became proficient at TIG welding a challenging bicycle frame. The frame was designed with a slacker geometry for better stability and higher speeds."

~Craig Severson, Boyd Lab Supervisor

Student hopes NASA internship will propel her to career in aeronautic or automotive industry

From New Jersey to Australia to Michigan to California and back to Ames, Sara Mayne has done a lot during her short time as a mechanical engineering student at Iowa State University.

Mayne grew up in South New Jersey, east of Philadelphia. She was attracted to STEM at an early age because of her parents, Gigi and Joseph, who both work as programmers that studied computer science at Penn State University. She was also influenced by her oldest sister, Kristina, who studied civil engineering at Penn State.

However, Mayne bucked the family trend of attending Penn State, and instead opted to pursue her studies at Iowa State. She remembers visiting Iowa State's campus on an uncharacteristically warm February day – temperatures were in the 60s as she recalls – and she immediately fell in love with the picturesque campus and all that it had to offer.

"I wanted that big school feel and that big college town community, like my parents and sister had at Penn State," said Mayne. "I loved the hands-on Boyd Lab inside Hoover Hall and also the fact that they have a high-level football team. It just seemed like I'd really fit in here."

Again deviating slightly from her parents and sister, Sara Mayne decided to study mechanical engineering (ME). She said her decision was influenced by her time on the FIRST robotics team in high school. She liked designing and building the mechanical components for the robots and felt that ME was her best path to continue to develop these interests.

Classes such as M E 170: Engineering Graphics and Introductory Design and M E 270: Intro to Mechanical Engineering Design further cemented her interest in the design and fabrication processes. She said that she liked M E 170 because it allowed her to design a project using the SOLIDWORKS software. During this process, she discovered that she could combine her analytical skills with her creative side. She actually took the project that she designed for this course and presented it during the spring 2018 Engineering Pitch Off contest and was ultimately named runner-up.

"Then for M E 270 we're solving a real world problem and manufacturing it ourselves. That helped me work through the entire process of designing and building and modifying things," she said.

Just as these two courses have contributed positively to her professional development, she cites two ME faculty members as being just as impactful: Paola Pittoni, associate teaching professor; and Gloria Starns, teaching professor.

"I was in Dr. Starns's office hours like every day last semester for our dynamics class. She gave me interview advice and was just a really awesome professor," said Mayne. "Dr. Pittoni was my M E 170

professor and is also the faculty adviser for SAE Supermileage. She even wrote me a letter of recommendation for the internship I ended up getting with NASA."

During the spring 2020 semester, Mayne served as an aeromechanics intern at NASA's Ames Research Center in Mountain View, Calif. She worked on three main projects during her three and a half month stint.

The first project utilized the structural analysis skills she developed in the ME curriculum back in Ames. She also relied on the SOLIDWORKS software that she has been trained on at Iowa State. These were used to validate the structural analysis of a future Mars helicopter.

The second project she said was similar to her M E 270 course. For this, she designed and tested the locking and actuating arms for a six-blade Mars helicopter. This project was unfortunately cut short when the COVID-19 pandemic forced NASA to close down most of its research park.

However, she was able to complete the internship and for her final weeks she relocated to Arizona and worked remotely from her aunt's home. For this third project, she did a trade study on the folding legs of a Mars helicopter to optimize the use of space in the aeroshell for its journey to Mars.

In addition to the NASA internship, she completed an internship with Nexteer Automotive in Saginaw, Mich. During the summer of 2019. Back on campus, she is a member of Alpha Sigma Kappa, a social sorority for "Women in Technical Studies" and the Society of Women Engineers (SWE) student group.

Mayne plans to complete her B.S. in ME in fall 2021. After graduation, she wants to go on for a master's degree and after that, hopes to work in either the aeronautical or automotive fields for an employer like NASA, SpaceX or Tesla.

"I want to work for one of those places that's really pushing the envelope in terms of technological innovation," she said.



Using computer simulations to improve clean energy generation



Shankar Subramaniam, professor of mechanical engineering (left), and Jiazhong Zhou, Ph.D. student in mechanical engineering, pose in front of the high performance computing (HPC) supercluster known as Nova, located inside the Durham Data Center on the Iowa State University campus.

As the damaging effects of climate change become more apparent, researchers are studying ways to generate energy with minimal impact on the environment. Computer simulations could be the key to making this process more efficient.

Shankar Subramaniam, a professor of mechanical engineering at Iowa State University (ISU), is the principal investigator (PI) on a project titled “Advances in closure modeling for turbulent flows with finite-sized particles informed by massive simulations on heterogeneous architectures.” The National Science Foundation’s (NSF) Computation and Data-enabled Science and Engineering (CDS&E) program has provided more than a quarter of a million dollars to Iowa State University for this three-year study. The total award amount for the project to all three institutions is \$678,526, of which \$262,072 comes to ISU.

The research team will use highly accurate simulations of turbulent particle-laden flow developed previously by Subramaniam and his colleagues combined with a super-fast algorithm for turbulent flow developed by P.K. Yeung, a co-PI on the project and a professor of aerospace engineering at Georgia Tech University (GT). Yeung has performed the world’s largest turbulent flow simulation, but without particles.

The group will also utilize another super-fast algorithm for particles developed by Jesse Capecelatro, the project’s other co-PI and an assistant professor of mechanical engineering at the University of Michigan (UM), to perform first-of-its-kind simulations of the largest turbulent particle-laden turbulent flow with this level of accuracy and fidelity. This project builds upon past work Subramaniam has done with Capecelatro. The duo are currently involved with another NSF project examining heat transfer in particle-laden flows.

The research team will also utilize the NGA code developed by Capecelatro, which is capable of taking the information obtained by the simulations of the largest turbulent particle-laden turbulent flow performed with the ISU-GT-UM code and computing the flow inside a commercial reactor. Though Subramaniam acknowledges these particular simulations are not part of his current project, the research performed in this regard will open the door to future studies in this field.

As the PI on this project, Subramaniam is responsible for coordinating team meetings between the researchers at the three universities and also for keeping the project on track. Prior to COVID-19, the researchers had planned to collaborate in-person during annual conferences and through visits to partner institutions, however they’ve had to adapt their plan during the project’s first year. The group is hopeful that in-person interactions will be more feasible a year from now. Despite the changes to the original plan, Subramaniam said that inter-university projects like this have many benefits, particularly for graduate students involved.

“I find that graduate students learn a lot about collaborative teamwork and the need to deliver on deadline in collaborative research projects,” said Subramaniam. “Also, it makes our ME graduate students far more professionally networked and enhances their chances of job placement upon graduation.”

For his contributions to the project, Subramaniam will bring in mechanical engineering concepts such as lift and drag, which are covered in his ME 335: Fluid Flow course. He will also utilize heat transfer from flow over a particle, as covered in his ME 436: Heat Transfer class. Lastly, he’ll bring in past flow collections of particles in what researchers call a particle-laden suspension from his ME 632: Multiphase Flow course.

“These fundamental concepts apply directly to this project, but we learn a lot of new things about the collective motion of these particles, how they cluster and how that affects the drag they experience and the heat transfer characteristics of the suspension,” he said.

One potential application from this project could be the ability to simulate commercial scale reactors with a level of accuracy and predictive capability that was previously unimaginable. This could build upon another project in which Subramaniam is collaborating with ME associate professors Alberto Passalacqua and Mark-Mba Wright and Anson Marston Distinguished Professor in Engineering Robert C. Brown, which applies computational tools for the simulation of entire fluidized bed reactors.

Subramaniam is now focused on assembling a team of student researchers for his part of the ISU-GT-UM collaboration.

“We’re excited to be working on this project. I am looking forward to recruiting some really motivated students who have serious computing skills to work on these advanced algorithms in high performance computing architectures,” Subramaniam said.

Iowa State U, U of Iowa team up on energetic materials research project

Even though the Cyclones and Hawkeyes often duke it out on the field, court and mat, researchers from the two universities have come together to collaborate on a Department of Defense-funded project.

The project, titled “3D-Printed, Hierarchical Polymer-Bonded Energetic Composites with Electromagnetically Switchable Porosity,” is being led by principal investigator (PI) Xuan “Sean” Song, assistant professor in industrial and systems engineering at the University of Iowa (UI). Co-PIs on the project include Travis Sippel, associate professor of mechanical engineering (ME) at Iowa State University (ISU) and H.S. “Uday” Udaykumar professor of ME at UI. The team will build upon research first developed by Mitat Birkan and the Air Force Office of Scientific Research’s (AFOSR) Space Propulsion and Power branch.

The goal of the current research project is to create safer energetic materials that are less prone to accidental ignition. These accidental ignitions can occur when materials are being transported or otherwise handled and can have devastating consequences, including human casualties, when accidents occur.

“This project aims to develop intrinsically safe energetic materials resistant to accidental ignition by, for example, impact, drop, etcetera, whose sensitivity can be switched in an on-command manner through dynamic control of their structural properties,” Sippel said.

Sippel and student researchers in his lab will focus on enabling the sensitivity of an energetic material to be switched, electromagnetically, from an insensitive to ignition-sensitive state. Electromagnetic energy is an attractive means through which to interact with energetic materials, as many energetic materials are relatively transparent to microwave fields, according to Sippel.

Sippel and his group have recently developed a technique to wrap nanoscale thermites in graphene coatings, giving the thermite the property of microwave ignitability.

“By placing these graphene wrapped particles inside an energetic, we can achieve localized microwave heating and reaction of the graphene coated thermites,” said Sippel. “The chemical composition of the thermite, and replacing the thermite with other energetic materials can allow us to tune the resulting reaction to produce either high gas release, high temperature, or both.”

The project will also rely on the specific expertise of the UI researchers. Song will 3D print energetic materials containing the microwave sensitive energetics developed by Sippel and his team at ISU.

“This project will be one of the first to use 3D print to enable dynamic control of the energetic material’s energy release,” said Sippel. “The 3D printing technique Dr. Song’s group plans to use has never been used to print an energetic material and may offer advantages over techniques that have been used thus far.”

Udaykumar has developed a simulation framework for modeling the shock/compression wave initiation with energetic materials. His simulations have demonstrated, over several years, the ability to predict detonation properties of actual energetic material microstructures, including the effects of damage.

“Dr. Udaykumar’s involvement in the project will help the team understand how microwave-induced damage will affect energetic material sensitivity,” said Sippel. “The project will combine the unique strengths of Iowa and Iowa State in 3D print, energetic material simulation and energetic materials with goals of achieving a number of firsts and enabling the dynamic control of an energetic material’s sensitivity to ignition.”

Sippel and Udaykumar first connected in 2016 while attending a seminar sponsored by Iowa State’s Center for Multiphase Flow Research and Education (CoMFRE). At the time Sippel’s lab did not have the capability to perform detonation research. Through a project supported by the Defense Threat Reduction Agency, Sippel and ISU ME assistant professor James Michael, developed facilities capable of performing energetic materials detonation research.

“The facility we have developed is unique, only a few institutions in the country possess the capability to study detonation at the scale required by this project,” Sippel said.

Work on this project began in August 2020, and funding will continue through July 2023. Funding for this project was made possible because of Martin Schmidt and AFOSR’s Dynamic Materials and Interactions branch. This project is part of a bigger \$3.6 million effort funded by the Department of Defense.



Sippel

Opposites attract: Cyclone engineers team up to improve battery reliability and safety

Energy storage reliability and safety could be improved on everything from electric vehicles to wind turbines because of a research project involving an interdisciplinary team of Iowa State University engineers.

Chao Hu, assistant professor of mechanical engineering (ME), is the principal investigator (PI) on a project titled “Physics-Based Probabilistic Prognostics for Battery Health Management.” Simon Laflamme, Waldo W. Wegner Professor in Civil Engineering, and Shan Hu, associate professor of mechanical engineering, are co-PI’s on the nearly \$400,000 effort funded by National Science Foundation’s (NSF) Division of Electrical, Communications and Cyber Systems.

The objective of this project is to create a physics-based probabilistic prognostics platform for lithium-ion (Li-ion) batteries, according to Chao Hu. This platform will offer new methods and tools for making a probabilistic prediction of the end-of-life of a battery cell based on rapid degradation inference from noisy voltage and current measurements.

This current effort builds, in part, upon another NSF project Chao Hu and Shan Hu (no relation) collaborated on titled “Data-Driven Dynamic Reliability Assessment of Lithium-Ion Battery Considering Degradation Mechanisms.” The aim of this project, which started in 2016 and continued through July 2020, was to create an ensemble prognostics framework through exploring multi-physics simulation and data-driven learning.

“In our previous NSF project, the data-driven approach has been proven effective in estimating lithium-ion battery’s state of health,” said Shan Hu. “However, these data-drive methods are data hungry. They need lots of data to make right estimations. In the cases where only limited data is available, knowledge about physics and chemistries underpinning a battery’s charging and discharging processes can make up for the insufficiency of data and enable us to still effectively predict the end-of-life of the battery.”

For the most recent project, Chao Hu and Shan Hu will integrate physical knowledge of battery degradation with probabilistic machine learning models to enable remaining useful life prediction.

“One potential benefit of incorporating physics is the accuracy improvement in the prediction of the long-term degradation in the early lifetime over no use of physics,” said Chao Hu. “This new capability could help accelerate the processes of battery materials design for materials scientists, and battery supplier selection for end users.”

Laflamme will lend his expertise to this project from a civil engineering perspective by extending methods and concepts from the field of structural health monitoring to the problem of battery health prognostics.

“Research discoveries on condition assessment and reliability forecast of civil structures will be extended to our research problem, with particular attention to physics-informed model enabling the formulation of efficient adaptive representation to learn and forecast battery behavior,” Laflamme said.

The team has also been collaborating with Medtronic, a medical device company based in Minneapolis, Minnesota. This collaboration will allow the project team to validate the developed models and tools using long-term cycling data acquired from commercial implantable battery cells.

“This research, if successful, will produce major advancements in extending battery life while ensuring battery safety,” said Chao Hu. “Advances in energy storage management could reduce the costs and promote the wide-scale adoption of hybrid and electric vehicles and renewable energy sources, which in turn will reduce the dependence of our nation on foreign sources of energy and also reduce harmful carbon emissions.”

Ensuring reliable and safe operation of battery energy storage systems in the power grid is crucial for renewable energy integration, according to Chao Hu. These improved battery energy storage systems can benefit industries in Iowa, such as renewable energy and agriculture.

“The deployment of these battery systems for enhancing renewable penetration of renewable energy sources, such as wind and solar into the power system has become an increasingly important issue in Iowa,” said Chao Hu. “Additionally, having reliable and safe power sources will promote the widespread deployment of electrically-driven farm equipment, thus having a positive impact on the agriculture industry.”

In addition to the faculty and industry researchers, this project will also utilize student support. The team aims to engage at least one female undergraduate student and at least two undergraduates from underrepresented groups. These undergraduate students will work closely with the graduate students and the PI’s to plan and execute the battery cycling tests. The team also aims to engage in at least one K-12 outreach program to help promote their research.

Work on this project started in June 2020 and funding will continue through May 2023.



Chao Hu



Shan Hu

Inspired by Batman and smart brewing, Cyclone brothers team up to start their own company

In *The Dark Knight* movie trilogy, Bruce Wayne (i.e. Batman without the mask) ventures into the Applied Sciences division of Wayne Enterprises. This is where he develops his unique, innovative tools for fighting crime in Gotham City. As major movie buffs and aspiring entrepreneurs, this served as the inspiration for the Jensen brothers when they were developing their own company.

“The Applied Sciences division of Wayne Enterprises is essentially just a financial cover up to hide the funding of his Batman-vigilante lifestyle, spending vast amounts of money on R&D to develop the Batmobile and his suit. We slapped our last name, Jensen, in front of Applied Sciences, and we knew immediately that it was a fitting name for our company, though our aim is a bit different than Batman’s,” Cole Jensen said with a laugh.

Cole and Dillon Jensen launched Jensen Applied Sciences (JAS) in January 2019. JAS is a cloud technology company providing smart monitoring solutions to the Midwest. The company’s main focus right now is a fleet of smart sensors for the craft brewing industry, which collect data and allow brewers to visit an online dashboard (which they call “Mission Control”) to analyze their beer data, configure alerts, and to make the brewery more efficient and automated.

The idea first came about when Dillon was working on a small side project for a neighbor-owned craft brewery in suburban Minneapolis while still in high school. Through this experience, he realized how they could collect real-world data and leverage cloud technology to brew better beer. After brainstorming some business ideas with his older brother, Cole, the duo quickly realized that these tools could also be applied outside the world of craft beer.

“Since launching JAS in 2019, the idea has grown and pivoted, but our vision has stayed the same. This means bringing the benefits of high-level technology, like IoT, cloud computing and machine learning, to local communities. Currently almost all the implementation and improvement of this technology is found in large corporations, because it has not yet funneled down to each and every street corner, but this is what we are trying to accelerate,” Dillon said.

The two brothers split up their responsibilities based on each person’s strengths and interests. Cole, who graduated with his B.S. in mechanical engineering in summer 2020, handles the hardware and engineering side of the operation. Dillon, a senior in computer science, manages the software and the



Dillon Jensen (center) and Cole Jensen (right) present their business concept to Iowa governor Kim Reynolds (left, foreground) and Iowa State University president Wendy Wintersteen (left, background) inside the rotunda of the Iowa Statehouse in 2019. Cy the Cardinal is there for moral support too!

cloud. They work together on other aspects and are always looking for ways to “innovate, validate, grow and scale.”

Cole said that much of what he learned in the core team engineering design courses (M E 170, M E 270, M E 415) has been applicable to operating the business, adding that the concepts and methods he learned in fluids and thermodynamics have also been helpful as well as the content covered in the management classes he took through Iowa State’s Ivy College of Business.

JAS is currently a part-time job for both Cole and Dillon. Dillon is a full-time student, while Cole started his career as a manufacturing engineer with Rolls-Royce in Indianapolis, Indiana after graduating from Iowa State. He interned at Rolls-Royce in summer 2019 and also completed a co-op with Mercury Marine while he was a student.

Dillon said he hopes fully to commit his time to JAS when he completes his B.S. in computer science in spring 2021.

“My main goal is to pursue JAS full time, and not have to take on any other responsibilities or jobs that would distract me from growing JAS. I believe I am going to achieve this goal, but there is still work to be done, with scaling JAS and improving our consistency in terms of landing custom solutions and selling our existing products,” Dillon said.



Engineers use supercomputers to identify more robust artificial heart valves

You're in the middle of the aorta, the body's pipeline for oxygen-rich blood, looking back toward the heart's primary pump, the left ventricle.

The ventricle muscle contracts and the aortic heart valve's three leaflets explode open and blood flows by at up to 200 centimeters a second. And what's this?

Those three leaflets are flapping in the flow – fluttering, in engineering terms. That's a problem. It could lead to leaflet tearing, calcium deposits, fatigue failure, even damage to the blood flowing by.

We have an eyewitness look, from a physically impossible point of view, thanks to computational models of the fluid-structure interactions of blood and heart valves developed by engineers at Iowa State University and The University of Texas at Austin.

The engineers used their technology to study what happens when thinner and thinner biological tissues from cows or pigs are used in transcatheter aortic valve replacement. That procedure involves collapsing an artificial valve into a catheter that is threaded through an artery to the aortic root, where it expands and secures itself in place. It makes sense to choose thin tissues when building the replacement valves – thinner tissues can be folded into smaller catheters for easier movement through the narrow tubes of the arteries.

But, in side-by-side models comparing tissue thicknesses of 100%, 75%, 50% and 25%, you can see there are problems with the two thinner options.

The engineers' findings are reported in a paper just published online by the Proceedings of the National Academy of Sciences. Corresponding authors are Ming-Chen Hsu, an associate professor of mechanical engineering at Iowa State; Thomas J.R. Hughes, professor of aerospace engineering and engineering mechanics at Texas; and Michael S. Sacks, professor of biomedical engineering at Texas. Emily L. Johnson, a doctoral student in mechanical engineering and the Wind Energy Science, Engineering and Policy program at Iowa State, is the first author.

The engineers' comparison of the performance of thinner valve tissues was supported by grants from the National Institutes of Health.

It's not easy to develop a predictive computational model of a heart valve in action, said Iowa State's Hsu, who



Hsu

has been modeling heart valves for more than five years.

There's constant contraction, pressure and flow. The valves are flexible. It's a highly dynamic system, with a lot of variables.

"We're really modeling the whole physiological system," Hsu said.

"That's why it has taken several years to correctly model the blood flows, which can change from laminar to turbulent, the heart valves, which are very thin and nonlinear, and the multiphysics coupling, which can be numerically unstable."

This kind of modeling takes supercomputing power, Hsu said. The valves in this study were simulated using computing resources at the Texas Advanced Computing Center, with each cardiac cycle taking about two days to run on 144 processing cores.

But this is a problem worth the time and effort. Any time a replacement heart valve wears out, patients face another heart procedure. That makes avoiding leaflet flutter in a replacement valve a "crucial quality criterion," the engineers wrote.

Hsu credits Emily Johnson, a doctoral student in his lab who also works on wind turbine modeling, with helping him take his lab's work further in a new direction.

"My background is in computational methods," he said. "But students suggested we should look more at the science questions, too. We're not just developing computational tools anymore."

In this case, the computer models and resulting videos make the science easy to see and understand. (As Hsu says, "I think videos are the best way to show our results.")

When thrown open by a pumping heart, the thinner leaflets buckle in the middle and flutter in the blood flow. "It's like a flag flapping," Johnson said.

She said the engineers were able to quantify the flapping and found that thinner tissues had as high as 80 times more "flutter energy" than thicker tissues.

The resulting conclusions are clear as the engineers' views of the fluid-structure interactions inside a heart valve:

"Considering the risks associated with such observed flutter phenomena, including blood damage and accelerated leaflet deterioration, this study demonstrates the potentially serious impact of introducing thinner, more flexible tissues into the cardiac system."



Johnson

Life in the fast lane: ME alum goes international

A pursuit of high-caliber experiences in engineering has led Sarah Walter on a cross-national career journey, spanning from Canada to Germany. The ME alum's passion for engineering was formed at an early age and driven by her strengths in science and math. When she turned 14, Walter began working in her father's car dealership, marking the beginning of her engineering journey.

"It was inevitable that I became interested in mechanical things as I grew up around cars and motorcycles," Walter said. "I remember my dad pushing me to go to college. He would say 'Sarah you are too smart to work in a dealership, go to school and design something that doesn't need to be fixed all the time'."

For Walter, there were a number of selling points that ultimately led her to choose Iowa State over other universities. She recalls listening to Gloria Starns, teaching professor with the Department of Mechanical Engineering presenting the ME program to prospective Iowa State students. Starns would eventually go on to be Walter's academic advisor in the ME program.

"[Gloria] wanted us all to be successful," Walter said. "I didn't get the same feeling when visiting other universities."

Once Walter officially launched her undergraduate engineering adventure, she became heavily involved in the College of Engineering while leaning on an entrepreneurial spirit.

As a founding member of Alpha Sigma Kappa sorority for women in STEM, Walter learned how to both mentor and engage with other women in the field. She was also a dedicated member of Iowa State's SAE International Baja Car Team. During her fourth and fifth year at Iowa State, Walter joined the Engineering Leadership Program sponsored by 3M.

"Developing this program and watching the students flourish taught me about real service-based leadership," Walter said. "Teaching and mentoring others to enable them to become their best has become a life passion for me."

One of Walter's favorite engineering classes was a thermodynamics course taught by William Bathie, professor emeritus with the Department of Mechanical Engineering. The experience equipped her with critical problem-solving skills and an eye for innovation she uses in her career today.

Aside from the ME program's appeal, Walter was also drawn to Iowa State given the College of Engineering's high career placement rates. Walter says the Engineering 101 orientation



Walter

course taught by Starns readied her for the professional world. One of the assignments in the course was to attend the Engineering Career Fair and speak to at least one company. Walter could not have guessed where her participation would have led her.

"I spoke to seven different companies and a few weeks later I landed a co-op with Rolls-Royce in Indianapolis," Walter said. "I have been with Rolls-Royce now for 16 years, working across industries and in many amazing places."

After graduating from Iowa State, Walter joined the company in Indianapolis as a Combustion Design Engineer. After a few years

of experience, she began working for Rolls-Royce's Director of Engineering and our Chief Scientific Officer in the United Kingdom. Eventually, Walter moved to Montreal where she served as the Assistant Chief Engineer in the Rolls-Royce Energy Business Unit.

Today, Walter works in France as the Chief Technology Officer for Aero Gearbox International, a joint venture between Rolls-Royce and Safran Transmission Systems.

"This truly is my dream job," Walter said. "I'm leading a small business, developing people and new technical challenge each day. It's a nice mix of operational management, product development and strategy."

Walter's skills have been put to the test in light of the COVID-19 pandemic. Since mid-March, France has been under a tight lockdown. Walter says her team has stayed resilient in the face of the instability and is successfully navigating new challenges.

"I am still going into the office to support my essential staff who are also working on site, although 90% of my team is working from home," Walter said. "This takes coordination and strong communication skills if you want to minimize efficiency losses."

After trekking across Canada, Germany and France over the past decade, Walter says her Iowa State engineering experience equipped her with the skills needed to succeed in her various roles.

"My education taught me how to approach a technical problem and how to be persistent even if I didn't particularly like the subject," Walter said. "Outside of the classroom I learned how to manage my time, as well as how to and how not to lead."

**Contributed by Madeline McGarry/
Engineering College Relations**

Researchers print sensors to monitor food freshness, safety

Researchers dipped their new, printed sensors into tuna broth and watched the readings.

The sensors – printed with high-resolution aerosol jet printers on a flexible polymer film and tuned to test for histamine, an allergen and indicator of spoiled fish and meat – can detect histamine down to 3.41 parts per million.

The U.S. Food and Drug Administration has set histamine guidelines of 50 parts per million in fish, making the sensors more than sensitive enough to track food freshness and safety.

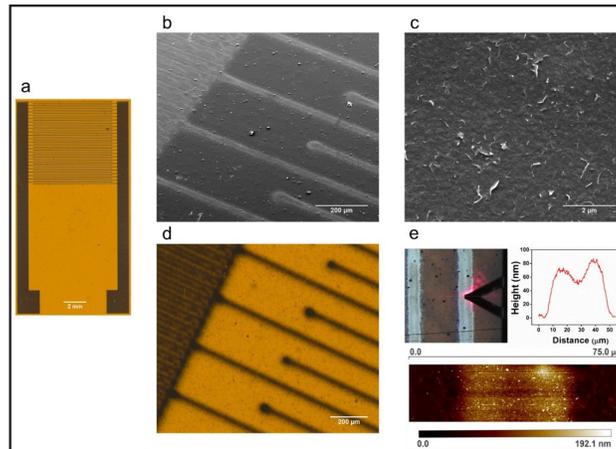
Making the sensor technology possible is graphene, a supermaterial that's a carbon honeycomb just an atom thick and known for its strength, electrical conductivity, flexibility and biocompatibility. Making graphene practical on a disposable food-safety sensor is a low-cost, aerosol-jet-printing technology that's precise enough to create the high-resolution electrodes necessary for electrochemical sensors to detect small molecules such as histamine.

"This fine resolution is important," said Jonathan Claussen, an associate professor of mechanical engineering at Iowa State University and one of the leaders of the research project. "The closer we can print these electrode fingers, in general, the higher the sensitivity of these biosensors."

Claussen and the other project leaders – Carmen Gomes, an associate professor of mechanical engineering at Iowa State; and Mark Hersam, the Walter P. Murphy Professor of Materials Science and Engineering at Northwestern University in Evanston, Illinois – have recently reported their sensor discovery in a paper published online by the journal *2D Materials*.

The National Science Foundation, the U.S. Department of Agriculture, the Air Force Research Laboratory and the National Institute of Standards and Technology have supported the project.

The paper describes how graphene electrodes were aerosol jet printed on a flexible polymer and then converted to histamine sensors by chemically binding histamine antibodies to the graphene. The antibodies specifically bind histamine molecules.



The histamine blocks electron transfer and increases electrical resistance, Gomes said. That change in resistance can be measured and recorded by the sensor.

"This histamine sensor is not only for fish," Gomes said. "Bacteria in food produce histamine. So it can be a good indicator of the shelf life of food."

The researchers believe the concept will work to detect other kinds of molecules, too.

"Beyond the histamine case study presented here, the (aerosol jet printing) and functionalization process can likely be generalized to a diverse range of sensing applications including environmental toxin detection, foodborne pathogen detection, wearable health monitoring, and health diagnostics," they wrote in their research paper.

For example, by switching the antibodies bonded to the printed sensors, they could detect salmonella bacteria, or cancers or animal diseases such as avian influenza, the researchers wrote.

Claussen, Hersam and other collaborators have demonstrated broader application of the technology by modifying the aerosol-jet-printed sensors to detect cytokines, or markers of inflammation. The sensors, as reported in a recent paper published by *ACS Applied Materials & Interfaces*, can monitor immune system function in cattle and detect deadly and contagious paratuberculosis at early stages.

Claussen, who has been working with printed graphene for years, said the sensors have another characteristic that makes them very useful: They don't cost a lot of money and can be scaled up for mass production.

"Any food sensor has to be really cheap," Gomes said. "You have to test a lot of food samples and you can't add a lot of cost."

Claussen and Gomes know something about the food industry and how it tests for food safety. Claussen is chief scientific officer and Gomes is chief research officer for NanoSpy Inc., a startup company based in the Iowa State University Research Park that sells biosensors to food processing companies.

They said the company is in the process of licensing this new histamine and cytokine sensor technology.

It, after all, is what they're looking for in a commercial sensor. "This," Claussen said, "is a cheap, scalable, biosensor platform."

Contributed by Mike Krapf/ISU News Service

Team PrISUm keeps truckin’

While COVID-19 has slowed the progress of Iowa State University’s solar car team, they are not letting it stop them completely.

Since returning to campus at the start of the semester, members of Team PrISUm have been working on their newest model. Much like anything else on campus and beyond, this contagious virus has affected the team’s operations.

“We’re keeping our team to five people at a time in the shop, all wearing masks, and unfortunately that’s just not enough people to facilitate fast work on the car,” said Michael Holm, project director for Team PrISUm.



Holm

“But, the team agrees that it’s worth it. No one wants this disease, and if moving slower on the car is the price we have to pay, then we’re willing to pay it.”

Though their pace may be slower, the team is making progress. Earlier this year, the team was on track with an assembled and painted aeroshell, designs for the electrical team’s boards were coming together, and they were even beginning to do some testing. Then the COVID-19 pandemic hit, which forced Iowa State to close down much of its normal on-campus operations for the remainder of the spring semester.

However, since the fall semester began, Holm said the team has found a new drive. In the first three weeks of the term, they made several electrical boards and began testing them, and they also assembled the car’s suspension, all while maintaining proper physical distancing.

Holm, a junior in mechanical engineering, added that the team is like a family, so it has been challenging for them to not be all together. The team is an eclectic mix of aerospace, electrical, materials, mechanical, software and other engineering majors as well as folks from business and even interior design.

Rachel Eckert, a junior in materials engineering, said she was reluctant to join the team her freshman year because she wasn’t sure how much she’d be able to develop as an aspiring materials engineer. She quickly found out that there was a need for someone with her skill set on the team.

“I wanted to get involved in something that would give me experience relevant to my future career, challenge me, and introduce me to highly motivated people. Solar car met all the criteria,” she said.

In addition to developing her technical engineering abilities, she said PrISUm has also allowed her to develop other soft skills like communication and leadership, which are key to being an effective engineer. Though not the first, Eckert is one of the few females throughout the team’s history to serve as an assistant project director. Her responsibilities in this position include overseeing administrative duties, developing partnerships with sponsors and procuring necessary supplies.

Even though she’s now one of the team leaders, Eckert still enjoys working alongside the underclassmen and new team members to contribute to the manufacturing operations in the shop.

Through this she feels that she has a better understanding of the happenings on all of PrISUm’s sub-teams. She also feels that it helps to develop a good team culture, something she hopes to influence to continue fostering inclusivity of females on the team.

“To young women and girls who have an interest in the STEM field, take initiative. Jump at the chance to take on projects you’re interested in, even if they scare you, because you’ll learn from them,” she said.



Eckert

The team is building its current model with the American Solar Challenge and the Formula Sun

Grand Prix in mind, and therefore the car will meet the specs for those particular competitions. Though little is known about the future of these competition because of COVID-19, the team is ready to get back on the road.

For Holm, being part of Team PrISUm has been a dream of his since he was six years old. Growing up in Ames, he first saw the team’s 8th car, Fusion, as part of a VEISHEA parade. He continued following the team as he grew older, and even watched coverage from their competition at the Bridgestone World Solar Challenge in Australia in 2017. Much like Eckert, Holm too hopes to inspire the next generation of Team PrISUm.

“Ultimately, I joined PrISUm because the team’s mission of using the car we spend several years building to convince younger students to enter STEM really speaks to me. I’ve been interested in STEM for almost my entire life, because of the team, and I’d love to do the same for another six-year-old somewhere out there,” he said.

Researchers simulate, assess damage to brain cells caused by bubbles during head trauma

Say there's a bomb attack on a military base. A few of the soldiers suffer concussions and other brain injuries. Could some of the injuries be caused by tiny bubbles that form and collapse within the skull during head trauma?

Mechanical engineering researchers at Iowa State University, with the support of grants from the Office of Naval Research, are using their expertise with the manufacture of microstructures to study and describe the damage to brain cells caused by the formation and collapse of microbubbles – a process known as cavitation.

The researchers report their findings in a paper featured on the cover of the July 2020 issue of the research journal *Global Challenges*. Lead authors are Nicole Hashemi, an Iowa State associate professor of mechanical engineering, and Alex Wrede, a former doctoral student and postdoctoral research associate in Hashemi's lab.

The researchers write that microbubbles measured in microns – that's millionths of a meter – can form in cerebral spinal fluid inside the skull during traumatic brain injuries.

The researchers wrote the "formation and dramatic collapse" of these microbubbles could be responsible for some of the damage in a brain injury.

Bubble damage may sound trivial. But bubble collapse, and the resulting shock waves, are known to damage the steel foundations of boat propellers. The researchers report that prior studies indicate the expansion and collapse of microbubbles creates forces of 0.1 to 20 megapascals, or 14.5 to 2,900 pounds per square inch.

"... So it is alarming to realize the damage that cavitation inflicts on vulnerable brain tissue," the researchers wrote.

Looking for changes in brain cells

To test and characterize the impact of cavitation inside the skull, the researchers simulated a brain by creating a 3D cell culture platform for astrocytic cells (star-shaped cells in the brain and spinal cord that are active in supporting, maintaining and repairing the central nervous system). They submerged the cell culture platform in a small tank and created microbubbles around 60 millionths of a meter in size. Some of the microbubbles adhered to the cell-laden microfiber scaffold.

Researchers turned on an ultrasonic device in the tank, collapsing the microbubbles and creating cavitation. (They also used the ultrasonic device on a control group of cells that were not exposed to cavitation.)

The researchers looked for two kinds of effects:

First, they used an inverted microscope to record any morphological changes to the cells. Second, they worked with

colleagues in Iowa State's College of Veterinary Medicine to assess whether there were genetic changes in the cells.

The researchers found cavitation caused the cells to shrink and roughened their surfaces. The cells appeared to elongate and grow when images were taken 22 and 48 hours after cavitation. Even so, the researchers found cell growth after 48 hours – in terms of surface area – was about half as much as the control cells.

The researchers also found the cells damaged by cavitation had elevated expression of genes such as TNF- α and IL-6, which are associated with inflammatory conditions such as infection with the SARS-CoV-2 virus and neurological disorders such as Parkinson's and Alzheimer's diseases.

"Taken together, these results confirm that surrounding cavitation is detrimental to astrocytic function," the researchers wrote.

Designing better helmets

Hashemi said while doctors look for treatments for the brain damage caused by cavitation, she said engineers can work to identify the places in the brain where cavitation is most likely to occur.

"A location map of cavitation occurrence can be directly used to design a helmet that dampens force and reduces the possibility of cavitation," the researchers wrote.

And while this study focuses on military helmets, Hashemi said the same ideas could be applied to helmets for football and other sports.

"This research is looking at battlefield applications, but in football there are similar impacts and shock waves," Hashemi said. "Players do get mild forms of traumatic brain injury. Players might not realize it, but the effects of cavitation injuries would be there."

Wrede, Hashemi's former graduate student who's now working as a dynamic systems modeling engineer for John Deere in Dubuque, said the project has taught him there's great need for more research and development.

"The people who have served our country and come back with injuries are really relying on research to find answers," he said. "Answers could improve quality of life for our veterans and everybody unfortunate enough to go through traumatic brain injury."



Hashemi



Wrede

Contributed by Mike Krapfl/ISU News Service

Summer research internship in additive manufacturing leads to journal paper

Persistence has paid off for a mechanical engineering student who recently published a research paper after completing a research internship at a national lab.

Xian Yeow Lee, a doctoral student in mechanical engineering (ME), spent three months during the summer of 2019 as a research intern at the Lawrence Livermore National Laboratory in California. His findings from this research were recently published the journal *Additive Manufacturing*, along with co-authors Brian Giera, Sourabh K. Saha and Soumik Sarkar, an associate professor of ME who serves as Lee's Ph.D. adviser.

"My main responsibility was to develop and apply machine learning algorithms to automate and accelerate additive manufacturing processes," Lee said. "The goal was to have a software which identifies ideal printing parameters by having the algorithm monitor which manufactured parts have defects and which parts turned out well."



Lee

Lee completed his B.S. in ME at Iowa State in 2016 and was attracted to the field because of its broad career applicability. He said he was able to take the things he has learned in the ME curriculum and apply it to his research this summer.

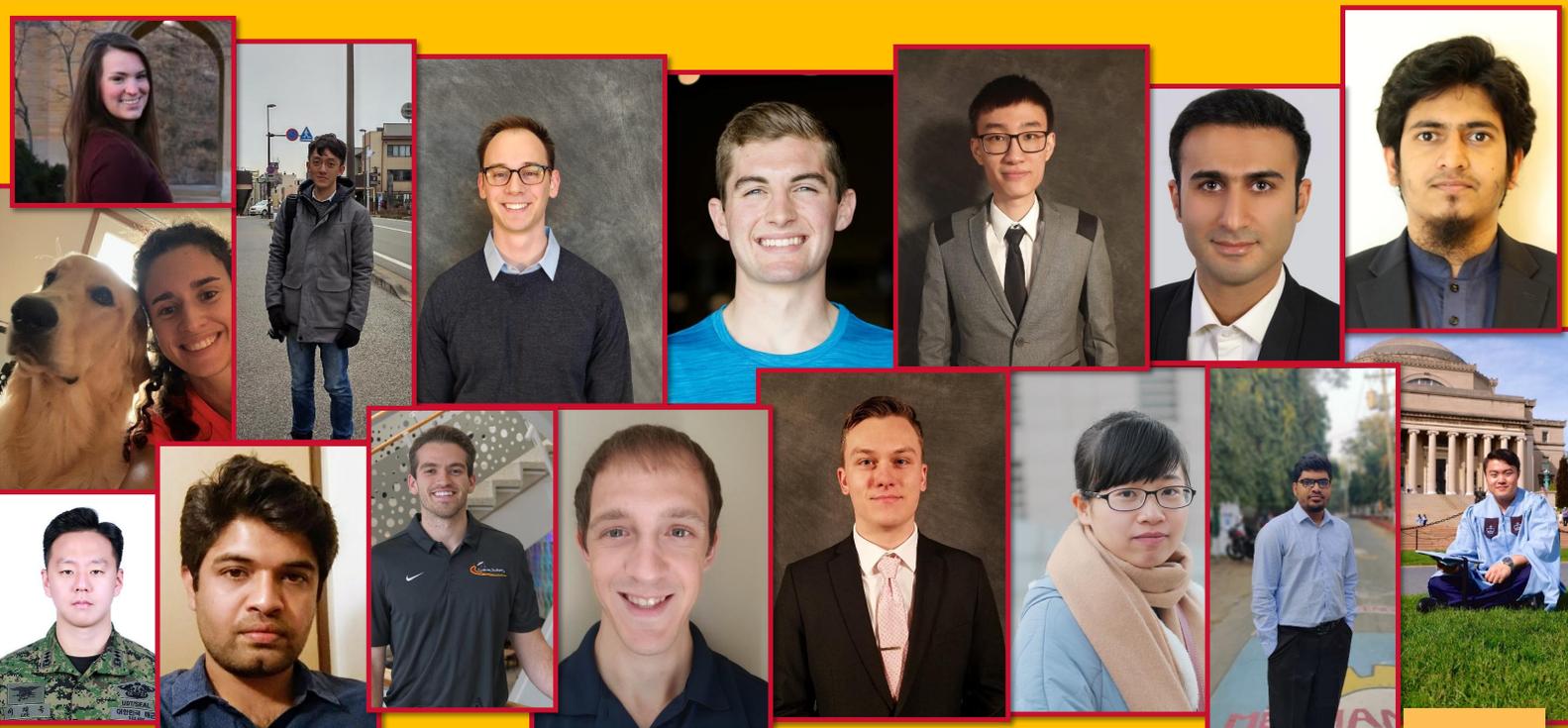
"Although my main responsibility was to implement machine learning algorithms, my undergrad classes in manufacturing and experimental

design and data collection procedures learnt in lab sessions definitely helped me understand the problem we are attempting to solve from a different perspective. This definitely facilitates and improves the cross-collaboration process," he said.

Lee plans to complete his studies in fall 2021 and hopes to pursue a career in machine learning research after graduation.

Message from the Mechanical Engineering Graduate Student Organization (MEGSO)

New graduate students had quite the adventure at Iowa State during the last two semesters affected by COVID-19. Avoiding in-person meetings made taking our class photo a little more difficult, but they still learned a lot about being new graduate students together and got their degrees off to a strong start with the MEGSO Learning Community!



ME's Pint and team receives international recognition for sustainability research

Cary L. Pint, Charles Schafer (Battelle) Chair in Engineering and an associate professor of mechanical engineering, was recently honored for groundbreaking innovations.

First, Pint and his team were designated as winners of a prestigious 2020 R & D 100 Award in the Mechanical/Materials category. This is a worldwide competition that highlights revolutionary technologies as judged by nearly 50 of the world-leading industry professionals across the globe.

Pint and his team were chosen for their work on "Transforming the Production of Carbon Nanotubes using Carbon Dioxide," where he and his team designed a technology to capture carbon dioxide either directly from air or from a stream of exhaust gas and convert the carbon dioxide into tiny carbon nanotubes that are about 1000 times smaller than a human hair, but stronger and lighter than steel.

"This award is so humbling because we started this project in the research lab with mostly fundamental questions, and now a few years later we are chosen for this prestigious award on a global stage alongside some of the biggest companies in the world," Pint said.

Among the award winners in the Mechanical/Materials category this year are companies including Toyota, Dow Chemical, and PPG, among others.

The team of researchers who developed the award-winning technology include Pint and Anna Douglas, a former Ph.D. student from Pint's research team. Together, Pint and Douglas co-founded a company, SkyNano LLC, in 2017, where Pint and Douglas remain as CTO and CEO, respectively. SkyNano then licensed the award-winning technology from Vanderbilt University, where Pint served on the faculty prior to coming to Iowa State University in January 2020.

Pint notes that the key to the viability of their technology comes from zeroing in on the energy consumption of their electrochemical technique combined with advances to realize the best quality and most valuable carbon nanotubes. Pint's team at Iowa State continues to research this area by targeting the conversion of carbon dioxide into new materials, such as diamond, and also extending this technology to sustainable agricultural processes.

In addition to the R & D 100 award, Pint was also named as a "Top 100 Visionary in Education" by the Global Forum for Education and Learning, a global organization that serves to bring together and empower the brightest minds in education around the world. Pint was evaluated for this distinction based on the overall impact and reach of his research program, but also based on his vision and efforts to combine core education and innovation in a classroom environment.

Going forward, Pint said he sees incredible opportunity at Iowa State University to combine engineering education with innovation and entrepreneurship at both the undergraduate and graduate levels.

"With the extraordinary facilities at Iowa State, combined with the best and brightest students from around the country and world – I am so excited to work toward and be part of a future where learning and doing happen together in a way that sets us apart from other institutions," he said.



Banner season for MEs on the gridiron

The Iowa State Cyclones had one of its most successful seasons in the football program's history, and part of it can be attributed to contributions from a couple impact players who happen to be mechanical engineering students.

Charlie Kolar, a redshirt junior tight end from Norman, Oklahoma, tallied 44 receptions for 591 yards (13.4-yard average per reception) and 7 touchdowns. His longest reception of the season - 44 yards - came during Iowa State's 23-20 win over then 17th-ranked Texas on Nov. 27. He compiled a total of 131 receiving yards during the contest, a career high for the 257-pounder.



Images courtesy of Iowa State Athletics Communications

Mike Rose, a junior linebacker from Brecksville, Ohio, recorded 96 tackles (54 solo), 1.5 sacks and 5 interceptions on the season. The 245-pounder was named the Big 12 Conference Defensive Player of the Week after Iowa State's 38-31 come-from-behind victory over Baylor on Nov. 7.

Both Kolar and Rose announced their plans to return for the 2021-22 season. The 2021-22 season kicks off on Sept. 4 when the Cyclones host the Panthers from the University of Northern Iowa.

Converting paper and plastic wastes into food

Mechanical engineering researchers at Iowa State University (ISU) and its partners will create a system that converts wastes generated by military expeditionary forces into food. The technology could vastly improve military logistics and may have wider application to produce food and reduce plastic wastes.

The Defense Advanced Research Projects Agency (DARPA) has awarded a Phase I cooperative agreement for \$2.7 million that could entail up to \$7.8 million over the course of the project. Partners include the University of Delaware, Sandia National Laboratories, and the American Institute of Chemical Engineering (AIChE)/RAPID Institute.

The system, dubbed Novel Oxo-degradation to Macronutrients for Austere Deployments (NOMAD), aims to convert plastic wastes into fatty alcohols and fatty acids, and paper wastes into sugars to be bioprocessed into single cell biomass rich in proteins and vitamins. Familiar examples of single cell proteins are nutritional yeast and Vegemite. NOMAD will be a fully integrated system that conforms to specific size, weight, and power requirements to enable transportation, deployment, and extraction by military expeditionary forces.

Turning paper into sugars builds on previous biomass pyrolysis research at Iowa State University, while the conversion of plastics into fatty compounds draws inspiration from the natural process of plastics degradation in the environment.

“When exposed to heat or ultraviolet light in the presence of oxygen, plastics convert to oxygenated compounds that can be consumed by microorganisms – plastics are, in fact, bio-degradable, but the process is very slow, as evidenced by the accumulation of plastic wastes in the environment,” explains Dr. Robert Brown, the project’s principal investigator, Anson Marston Distinguished Professor in Engineering and the Gary and Donna Hoover Chair in Mechanical Engineering.

“We can dramatically increase oxo-degradation of plastics to fatty compounds by raising the temperature a few hundred degrees Fahrenheit. The cooled product is used to grow yeast or bacteria into single cell proteins suitable as food,” Brown said.

Food from wastes, especially plastics, has many potential benefits. For military expeditionary forces, the technology could potentially convert every pound of packaging and similar expendable supplies into four ounces of nutritionally-balanced high-protein nourishment for soldiers. Such a system would improve the military logistics resiliency and extend military missions.

Beyond the military, the conversion of waste into food would go a long way toward solving looming problems of



Chad Peterson (left), postdoctoral researcher for the Bioeconomy Institute, collaborates with Jessica Brown, Ph.D. student in mechanical engineering, on the DARPA project inside the Biorenewables Research Laboratory.

plastic disposal and ensuring a viable global food chain. It might also be possible to extend the technology to production of chemicals currently produced from petroleum, reducing the extraction rate for this fossil resource.

NOMAD includes innovations in four processes needed to convert waste into food: release, breakdown, build-up, and recovery. For the release phase, waste streams of polyethylene terephthalate (PET), high density polyethylene (HDPE) and low density polyethylene (LDPE) plastics and paper are ground to peppercorn-sized particles and loaded into a thermal reactor. In this step, heat and oxygen break the plastics into fatty molecules and wastepaper into sugars. The team will build on ISU’s advances in autothermal pyrolysis to self-heat the reactor.

Plastics and wastepaper, however, contain virtually none of the macro-elements (phosphorous, potassium and nitrogen), micro-elements (for example, trace metals) or amino acids required for microbial growth. So, the NOMAD project will aim to harvest these nutrients from the local environment, such as local water sources and purified nitrogenous waste. A key component of our design is the use of microalgae to harvest nitrogen, a key component protein, from the air.

One of the key challenges in bioprocessing is product recovery, which is particularly problematic for troops in the field. The project avoids this problem by exploiting the natural tendency of many kinds of microorganisms to spontaneously clump and settle out from suspension at the end of the process, allowing recovery as a slurry from the bottom of the bioreactor.

Later phases of the project include development of procedures for disinfection of the equipment and integration of the various systems.

**Contributed by Bob Mills/
Bioeconomy Institute**

Recent paper advances research in the field of heat transfer



Wang

A team of researchers have developed a novel way of distinguishing the atomic and molecular level thermal non-equilibrium in nanoscale materials, which can have a significant impact in the area of heat transfer according to one Iowa State University professor.

Xinwei Wang, professor of mechanical engineering (ME) at Iowa State, was one of the authors on the paper titled “Distinguishing Optical and Acoustic Phonon Temperatures and Their Energy Coupling Factor under Photon Excitation in

nm 2D Materials,” recently published in the journal *Advanced Science*. Other authors on the paper represent various universities in China, including first author Ridong Wang (no relation to Xinwei), an associate professor at Tianjin University who graduated with his Ph.D. in ME from Iowa State in 2019 and worked in Xinwei Wang’s lab as a graduate student.

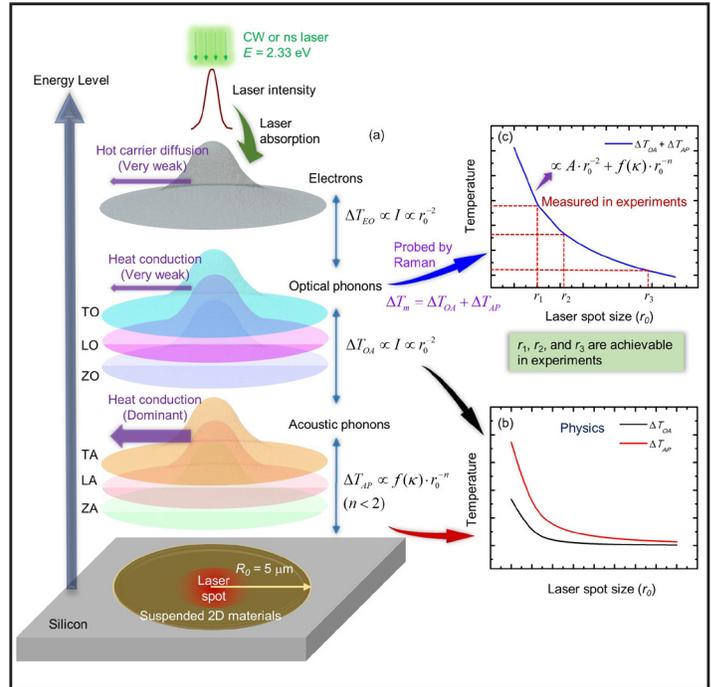
“In our work, we designed a unique and advanced technique to construct different energy transport states using continuous laser and nanosecond laser irradiation and simultaneous Raman measurement. For the first time, we distinguish the temperatures of optical phonons and acoustic phonons, and measure the intrinsic thermal conductivity of 2D materials,” Xinwei Wang said, adding that they also reported the first energy coupling coefficient between optical phonons and acoustic phonons.

The project built upon past research Xinwei Wang has conducted using Energy Transport State-resolved Raman (ET-Raman).

“This is a very promising technique that pushes the thermal probing to the nanosecond and picosecond limit,” said Wang. “It provides unprecedented accuracy and high-level measurement of interface thermal resistance, thermal conductivity, and hot carriers diffusion in 2D atomic layer materials.”

Wang applied various ME concepts and methods to this project including thermal conductivity, heat conduction, numerical modeling and thermal nonequilibrium. He conducted many of the experiments in his Micro/Nanoscale Thermal Science Laboratory on the Iowa State campus with the assistance of Hamidreza Zobeiri, a Ph.D. student in ME at Iowa State and an author on the paper.

Illustration of the cascading energy transfer process among different energy carriers in 2D materials studied in this work.

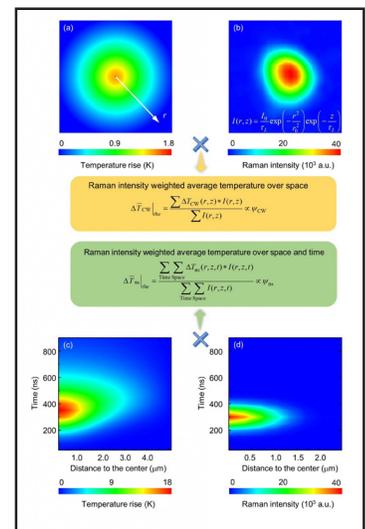


The data processing, analysis, physics interpretation and writing was done collaboratively with the other researchers. Wang said that for complicated scientific problems, such as the ones addressed in this paper, international and interdisciplinary collaborations are key to analyze the problems from different perspectives and find the best solutions.

Once further developed, Wang said the findings from this research can be applied to various industries outside of academia, some of which are particularly relevant in Iowa.

“The techniques developed in this work can be readily applied to study the dynamic chemical processes in biomass pyrolysis for biomass-to-fuel conversion. Also, the findings will find broad applications in the solar cells and semiconductor industries,” Wang said.

Support for this project provided by the National Science Foundation.



Above: Physics of the measured temperature rise in the research team’s ns ET-Raman technique used in this work.

ME alum strives to make college more accessible for disenfranchised students

As a collegian, Tina Akinyi remembers often being the only student of color in her classes and the sense of isolation she felt because of it. Now in her professional capacity, she hopes to remove that sense of isolation for future students by bringing more people of color and other disenfranchised students into higher education.

In May, Akinyi took over as the coordinator for GEAR UP (Gaining Early Awareness and Readiness for Undergraduate Programs) Iowa. The program aims to effectively prepare students entering postsecondary education, with a particular focus on low-income and first-generation college students. Akinyi's appointment is through Des Moines Area Community College (DMACC) and she mostly serves students in the Des Moines area, but her reach extends as far west as Perry.

Her duties in this position will include supporting academic skill building, monitoring GEAR UP student grades, tracking class attendance and academic progress in order to foster on-time graduation, and being a resource, advocate, mentor and role model for GEAR UP students. Prior to taking this position, Akinyi served as an academic advisor at the DMACC Urban Campus, which helped expose her to the student services side of academia.

Akinyi was born and raised in Nairobi, Kenya's capital and largest city. She describes her home country as "not only beautiful but also culturally rich." Her parents instilled in her the importance of education, specifically the STEM fields. By high school, she discovered a strong passion for chemistry and physics, and aspired to become a civil engineer.

"Being from a developing country, I wanted to be a civil engineer because I desired to contribute to the establishment of better and stronger roads, buildings and physical infrastructure," she said.

Akinyi moved to New Brighton, Minnesota to complete her high school studies at Mounds View High School and after graduation, she enrolled at Iowa State University to pursue studies in chemical engineering. She said she chose Iowa State because of its strong engineering programs, coupled with the fact that her father, Frederick Ngesa, graduated with a degree in agricultural education from ISU in the 1980s.

After completing her B.S. in chemical engineering, Akinyi stuck around Ames to pursue her M.Eng. in mechanical engineering. Despite Akinyi's interests switching from civil to chemical to mechanical engineering, her passion for helping others has remained consistent.



Akinyi

In graduate school, much of her research focused on postsecondary recruitment, matriculation, retention and graduation rates of college students. She also learned more about the struggles that students of color often face in the postsecondary environment, which allowed her to reflect on her own experience as a student of color at Iowa State.

"As I look back on my time as an undergraduate, I began to make sense of why I was often the only Black student in most of my classes," said Akinyi. "Save for a few international students, there were rarely other students of color in my classes."

It was these experiences and the knowledge that she gained through them that guided her to take the career path she is on today. Despite some of the struggles, Akinyi also remembers the good times from her college years.

As an undergraduate, she served as treasurer for her dorm floor in Wilson-Owens and was part of a group called Freshman Action Team. She also served on the social committee for the Freshman Council. In grad school, she served as president of the Mechanical Engineering Graduate Student Organization (MEGSO). She said all of these experiences taught her about leadership, decision-making, risk taking, teamwork and proactivity.

"One of my highlights in MEGSO was having a fundraiser where we raised thousands of dollars by selling merchandise. And most of these orders were from ISU ME alumni. Having that support from former students was a beautiful display of college pride and solidarity," she said.

In whatever free time she manages to find, Akinyi enjoys music, reading, trying new recipes and traveling. She credits a study abroad experience in Australia as sparking her passion for travel. Through this experience, she said she developed a stronger appreciation for culture, multi-ethnicity and diversity.

In the near term, Akinyi will continue traveling around central Iowa preparing young students of color for college. While Akinyi's background is in STEM, she acknowledges that people of color and others facing adversity need to be encouraged to pursue all career fields to ensure a more democratic society that represents all voices.

"If we can have more teachers, social workers, nurses, policymakers, college presidents, entrepreneurs, realtors, journalists, engineers, etcetera, from diverse backgrounds then we can begin to bring about the systemic change that our country desperately needs," she said.



ENGINEERING
TOMORROW,
TODAY.

*The northwest staircase inside
Black Engineering Building*