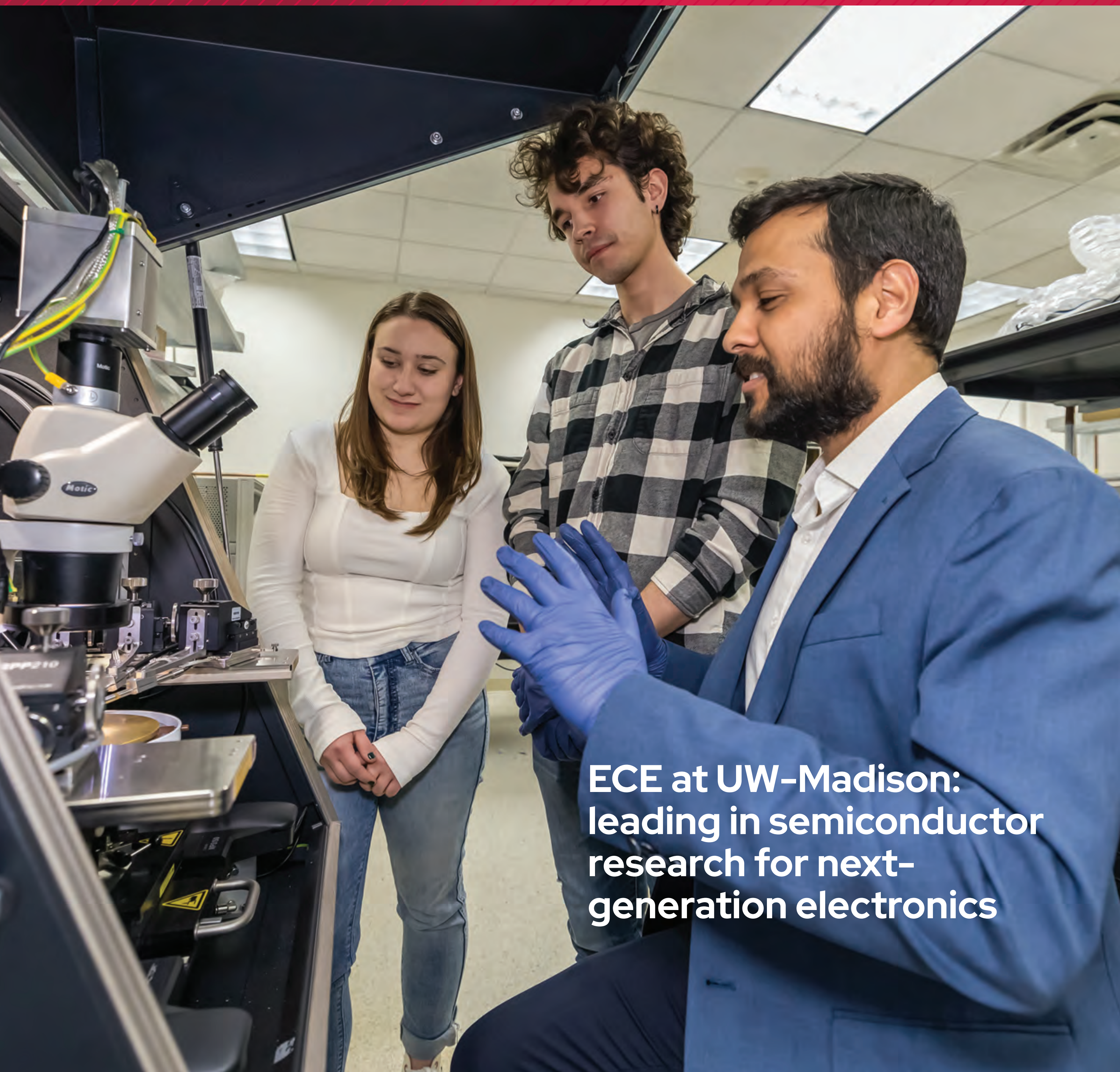
College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

SPRING 2024 NEWSLETTER

DEPARTMENT OF
ELECTRICAL AND COMPUTER ENGINEERING



ECE at UW–Madison: leading in semiconductor research for next-generation electronics

Dear alumni and friends,

I hope this letter finds you well. It is with great pleasure that I share some exciting developments taking place within the Department of Electrical and Computer Engineering (ECE) and across our UW-Madison campus.

As you may have heard, our university has embarked on a transformative journey with the launch of the Wisconsin RISE (Research, Innovation and Scholarly Excellence) initiative this spring. This initiative represents a robust commitment to advancing research and innovation in areas of global importance, starting with artificial intelligence (AI).

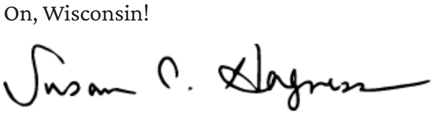
Our department is poised to play a pivotal role in the Wisconsin RISE-AI initiative. Even before the announcement of RISE-AI, ECE has been attracting top faculty and students across the diverse field of autonomous systems–one of the themes of our 2020-2025 strategic hiring plan. Several new machine learning/artificial intelligence (ML/AI) faculty have joined our department over the past couple of years, and they are already making their mark in this rapidly advancing field.

With funding from a 2023 National Science Foundation CAREER award, Assistant Professor Ramya Korlakai Vinayak is building algorithms to identify the diversity hiding in datasets in order to help preference and metric learning algorithms work better for diverse populations. Assistant Professor Kangwook Lee, a 2024 NSF CAREER Award recipient, recently received a $600,000 research grant from FuriosaAI, an AI chipmaker, to advance transformer models, a type of deep learning architecture. Our newest faculty in ML/AI, Assistant Professors Pedro Morgado and Grigoris Chrysos, are leading research initiatives at the intersection of ML and computer vision; for example, Morgado is developing methods to teach AI to understand unlabeled visual and audio information and Chrysos is enhancing the capabilities of deep neural networks in image recognition.

Bold research, educational excellence and impactful service are three of the four pillars of our department's vision. The fourth is effective technology transfer. Over the last five years, our faculty have averaged 37 invention disclosures and 22 U.S. issued patents annually through the Wisconsin Alumni Research Foundation. ECE faculty and students have an impressive track record of launching successful startup companies. Recent highlights include Assistant Professors Shubhra Pasayat and Chirag Gupta co-founding Ingantec to commercialize brighter red microLEDs; Professor Zongfu Yu co-founding FlexCompute to provide cloud-based, hardware-accelerated electromagnetic simulation tools; Professor Emeritus David Anderson co-founding Type One Energy to commercialize stellarator-based fusion energy technology; and Professor Dan Ludois co-founding C-Motive to commercialize sustainable high-efficiency electrostatic motors, just to name a few. All to say that, as we pursue discovery and innovation through our research, we are making an impact through not only our scholarship but also our entrepreneurship.

Our alumni are integral to our success. Your continued engagement is invaluable as we strive to shape the future of our department. I invite you to stay connected with us, whether through attending town hall events, engaging with our current students in myriad ways or simply keeping abreast of our latest developments. Thank you for your continued support, and as always, I look forward to the exciting journey ahead.

On, Wisconsin!



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ECE at Wisconsin: Committed to ethics and diversity in engineering

On the cover: Undergraduate researchers Casandra Mangiulli (left) and Jon Vigen (center) discuss ultrawide-bandgap semiconductors with Assistant Professor Chirag Gupta. Photo: Joel Hallberg.

Students enrolled in ECE 453, *Embedded Microprocessor System Design*, finished the Fall 2023 semester strong by presenting their Capstone Design projects at an Open House on December 11th. Devendra Kachole demonstrates the Racing Simulator. Unlike many racing games that use keyboards and controllers, the Racing Simulator incorporates a steering wheel, pedals, stick shift gears and haptic sensations, such as vibrations, to most closely simulate a real driving experience.

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We always enjoy learning what our alumni are up to after they graduate. Do you have news or an update to share with us? We'd love to hear it! Contact us at office@ece.wisc.edu.

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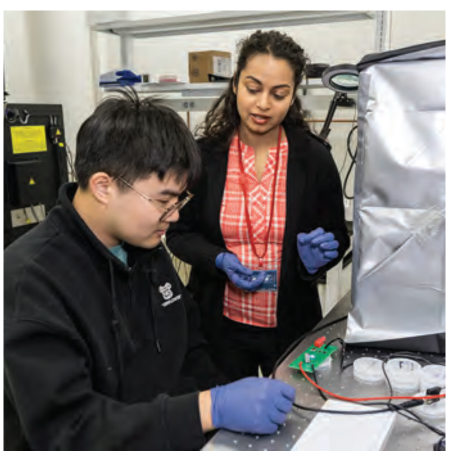
NSF CAREER AWARD RECIPIENT

Shubhra Pasayat is shedding a new light on UV LEDs

Ultraviolet (UV) light, a powerful type of radiation invisible to the naked eye, has been used for decades to detect counterfeit money; investigate crime scenes; cure coatings, inks and other industrial materials; study DNA; and light up black-light posters. For years, toxic, bulky, energy-inefficient mercury-based lamps were used to produce UV light, but in the last few decades, small, biosafe, solid-state LEDs have replaced that technology, getting better and more efficient over time.

But when it comes to one stretch of the UV spectrum—the region between 280 and 365 nanometers known as UVB—technical hurdles mean the LEDs aren't quite as good. That's why Assistant Professor Shubhra Pasayat will use a National Science Foundation CAREER award to design and fabricate new types of UVB LEDs for use in water and medical facility sterilization, vertical agriculture, food safety and other potential applications.



Assistant Professor Shubhra Pasayat (standing) and graduate student Jiahao Chen explore new types of light emitting diodes. Photo: Joel Hallberg.

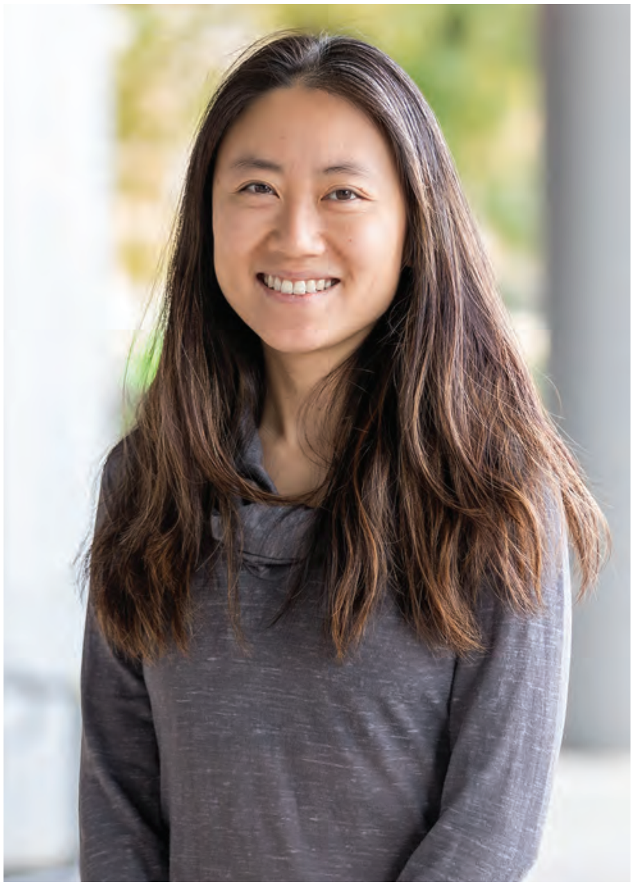
LEDs are actually semiconductors that release light when voltage passes through them. The wavelength of light produced depends on the semiconductor material the LED is made from and how it is oriented. When it comes to UV LEDs, versions of gallium nitride materials produce LEDs in the UVA range, while aluminum nitride makes UVC LEDs possible. These materials are grown in extremely thin layers on top of a substrate, like sapphire, which has a similar crystalline lattice structure at the atomic level. The more the lattices between the semiconductor and substrate match, the more efficient the LED.

Currently, however, there is no known substrate with a lattice matching the crystal semiconductors needed to produce efficient UVB LEDs. But Pasayat believes she has found a workaround. "What I'm proposing is to use a new class of material called porous nitrides which can reduce some of this lattice mismatch," she says. "Because the material is flexible, I can deposit aluminum or gallium nitride, but stretch the spongy material underneath them and get rid of this problem."

Pasayat says that the best commercially available UVB LEDs currently have an average efficiency of around 5%. In this project, she says she plans to improve that efficiency tenfold.

Pasayat is working with an industry partner to make sure her work is addressing real needs. "We always try to make sure our devices can readily get into the technology commercialization cycle," she says. "I'm working with a partner to first assess the societal impact of the solution I'm proposing. And based on those assessments we'll try to gauge interest in wavelengths that are more important for certain applications, whether it is medical or food industries."

Key to the project is a new state-of-the-art aluminum nitride reactor the College of Engineering will bring online in Pasayat's lab later in spring 2024. An existing state-of-the-art gallium nitride reactor is the materials growth workhorse for a current Office of Naval Research grant led by Pasayat and an NSF ASCENT grant co-led by Pasayat. Read more about the latter project later in this newsletter.



NSF CAREER AWARD RECIPIENT

Jennifer Choy is creating quantum-based navigation systems

One of the wonders of the late 20th century was the launch of the Global Positioning System, a constellation of 24 satellites that allows anyone with a GPS receiver to find their position on the surface of the earth. Super-accurate atomic clocks aboard the satellites have also made the system critical for synchronizing communications, the power grid, computer networks and hundreds of other applications.

But GPS is not foolproof; its signal is low-power, meaning it doesn't always work in rough terrain, and the satellites are vulnerable to all sorts of disruptions.

That's why Assistant Professor Jennifer Choy is using a National Science Foundation CAREER award to develop small, robust quantum sensors that could supplement or supplant GPS and help guide autonomous vehicles and people working in Earth's most rugged environments.

"The whole theme of the project is to develop solid-state quantum technologies to potentially help with the next generation of navigation and timekeeping-based needs," she says. "That involves developing navigational sensors in a small and reliable fashion that don't require getting signals from GPS."

Currently, the most cutting-edge quantum sensors measure the properties of atoms. While they are great at keeping time and detecting acceleration and rotation, the hardware needed to contain and measure these atoms—which are typically cooled and trapped in a vacuum chamber—is large, complex, and challenging to miniaturize and integrate. Choy believes that by creating solid-state, or semiconductor-based, versions of these quantum sensors that don't rely on cold atoms, she can make sensors small and rugged enough to work in real-world situations.

She will use "color centers," a special type of defect in diamond crystals that mimics trapped atoms and ions, to develop magnetic navigation sensors and quantum gyroscopes. She also plans to explore similar defects in silicon-based materials for developing quantum clocks which can provide accurate timing and be integrated on a computer chip.

As part of the outreach element of the project, Choy also plans to design new undergraduate courses on quantum sensing and create quantum education content for high-school students, such as student research projects through collaboration with high-school teachers and low-cost activity kits for teaching quantum and optical science.

This is not Choy's only recent award. She is also the principal investigator on a $2M NSF Quantum Sensing Challenges for Transformational Advances in Quantum Systems grant to study and miniaturize cold atom sensors, and the principal investigator on a $1.5M U.S. Department of Energy-funded project with Nuclear Energy and Engineering Physics Assistant Professor Benedikt Geiger to develop an all-optical quantum technique for plasma diagnostics in fusion experiments.

Assistant Professor Jennifer Choy is working to create solid-state quantum technologies to improve navigation and time-keeping. Photo: Sabrina Wu.

NSF CAREER AWARD RECIPIENT

Ying Wang is crafting new memory using 2D ferroelectricity

Emerging technologies—including artificial intelligence, big data analytics and edge computing—need new generations of electronics to reach their full potential. In particular, these fields need the development of small, super-fast, energy-efficient memory devices that can manage massive amounts of data.

Assistant Professor Ying Wang has proposed to develop next generation memory devices using 2D materials that exhibit a property known as sliding ferroelectricity using her National Science Foundation CAREER award.

2D materials are extremely thin crystalline materials, usually just several atoms thick. By stacking these materials together, it is possible to generate novel electrical properties. One of these properties is called sliding ferroelectricity, where the relative positioning of atomic flakes can slide, transferring charges that flip polarization. This polarization flipping process occurs with remarkable speed and efficiency, making ferroelectric materials ideal for data recording and processing.

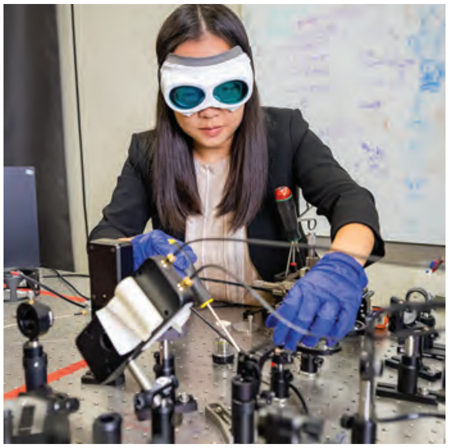
In her project, Wang plans to comprehensively study sliding ferroelectricity to understand and control the phenomenon. The ultimate goal is to create prototype memory devices, such as ferroelectric tunnelling junctions, from atomically thin 2D sheets of boron nitride and transition metal dichalcogenides. Those materials exhibit sliding ferroelectricity when stacked at slightly offset angles.

Wang says creating the devices is easier said than done. "Developing a device from these crystals is complex, requiring not only delicate fabrication but also a comprehensive understanding of the mechanisms at play," she explains. "For instance, the robustness of this new ferroelectric order in memory device geometry is yet to be determined. We will study the sliding ferroelectricity under various electrical and mechanical boundary conditions. With that new knowledge, we can optimize the memory performance accordingly."

If Wang is able to create and optimize these devices, it will be possible to integrate them into various systems that use memory.

In fact, she says if the project is successful, boron nitride-based ferroelectric memory might become feasible sooner rather than later. "Boron nitride is already accessible at the wafer scale," she says. "It's stable at ambient temperatures and can sustain extreme environments like high temperatures. It's very compatible with semiconductor manufacturing techniques."

In fall 2023, Wang also received a Department of Energy early career research program award. In that project, she is exploring a class of quantum materials called layered type-II Weyl semimetals that has strong interactions with radio frequency waves. Wang is studying the fundamental science behind these materials, which in the future may enable devices that can harvest energy from WiFi signals.



By studying a phenomenon called sliding ferroelectricity, Assistant Professor Ying Wang hopes to create next-generation memory devices. Photo: Joel Hallberg.

Data ethics course teaches undergrads how to reduce bias in AI

Large language models (LLMs) like ChatGPT and other forms of artificial intelligence are quickly reshaping the world; they're also raising concerns about privacy, bias and accuracy.

Engineering undergraduates are learning how to remedy, or at least understand, these issues in ECE/ISYE 570: *Ethics for Data Engineers*, the capstone course for the undergraduate certificate in engineering data analytics. The course is designed and led by ECE Assistant Professor Kangwook Lee, who has a background in large language models and trustworthy machine learning.

For the type of ethics considered in this course, students don't contemplate Plato or debate philosophy. Instead, they delve into equations and program codes to learn how engineers can ensure the ethical use of data for machine learning and artificial intelligence. "Besides accuracy, engineers should pay attention to whether the models are biased, whether they compromise data privacy, and whether they are going to behave reliably as designed at test time," Lee says.

In the final third of the course, students are expected to create their own large language model and implement algorithms to improve fairness, data privacy and reliability. They may develop algorithms that remedy these issues at the level of data, training algorithms or models and see how their choices affect the way the LLMs work.

The AI and machine learning spaces are developing rapidly, and Lee says the point of the class is valuable, even if the details change over time. "Probably the technical details of what they learn here might be less relevant in 10 years," he says. "But the fact that they have to keep paying attention to different dimensions of machine learning to ensure ethical use of data—that's going to hold true indefinitely."

Assistant Professor Kangwook Lee (center) discusses strategies for limiting bias and preserving privacy in machine learning models. Photo: Joel Hallberg.

NSF CAREER AWARD RECIPIENT

Our 4th NSF CAREER Award recipient this spring, Assistant Professor Kangwook Lee, is developing a framework for adapting pre-trained machine learning models for new applications. His research will be featured in our next newsletter.

Inspired by grand challenges, undergrad Simar Tathgir seeks to create positive change

Sophomore Simar Tathgir has crammed more into her first two years of school than some students do their entire college careers. She is a computer engineering and computer sciences double major, a tutor with the campus Center for Academic Excellence, and a research assistant in two laboratories. She was also part of the first class of the National Academy of Engineering's Grand Challenges Scholars Program at UW-Madison, a program that trains student engineers to think about and address the grand challenges facing society this century. We caught up with Tathgir between classes and research to learn more about her journey so far.

You work in two labs; tell us about your research!

For the last year I've been working with G. Nike Gnanateja, an assistant professor in communication sciences and disorders. We're working on an interdisciplinary project in audiology on how the brain encodes acoustic and linguistic speech features. My job is to implement machine learning into hearing aids to make them better. I also recently started another research program in the [engineering] Connected and Autonomous Transportation Systems Laboratory. We're going to learn how to use machine learning to make self-driving cars more safe and efficient.

Why did you join the Grand Challenges Scholars Program?

I kind of got into engineering because of sustainability. I led a project in my high school, creating a solar power plan for our community. Ultimately, it didn't get implemented, but I realized that engineering is a pathway to creating positive change.

What did you learn in the program?

We had weekly discussions and worked through hypothetical solutions to real world problems. We also engaged in interactive sessions with different professors and attended webinars and seminars suggested by our supervisor.

From all our new knowledge from these different seminars we tried to narrow down our perspective on sustainability. It was based a lot on reflections, and that's really great. It teaches you to question the orthodox or conventional aspects in science. There were a lot of things I heard in the seminars, and I would be like, no, maybe there's a better way to do this.

In underwater localization class, design students aim for new technology

When ECE senior Joe Berg was deciding which classes to take for the fall 2023 semester, one offering caught his eye: ECE 455, a capstone design course for undergraduates focused on developing a navigation system for autonomous underwater vehicles.

The hands-on class, designed by ECE Assistant Teaching Professor Nathan Strachen, is not about fiddling around with remote control submarines. Its goal is for students to work on a real-world problem with huge implications: finding a way to use low-frequency magnetic fields for real-time underwater positioning, or localization.

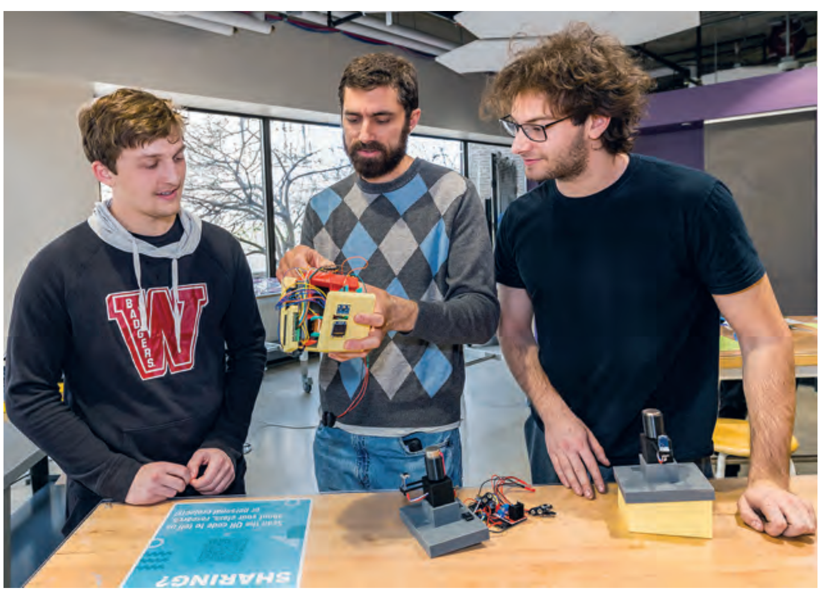
Currently, only a handful of studies have explored this, so a consistent solution could have a big impact for submarines and autonomous underwater vehicles, which usually have to surface and use GPS to find their location in the ocean.

In his class, Strachen challenged the students to create devices using low-frequency magnetic fields that could pinpoint an underwater target, a novel technology. The three teams all designed devices using spinning magnets, each taking a very different approach. One built smaller beacons powered by tiny quad copter motors while another made beacons out of huge spinning magnets. Another team fabricated its magnetic coils on a printed circuit board, instead of winding wire hundreds of times by hand. “I thought that was pretty cool and creative,” says Strachen.

The teams eventually tested their systems at a campus swimming pool. While no team was 100% successful in locating the target dropped in the pool, Strachen says they all learned to identify the problems with their approaches.

Berg says his team managed to locate the target within 2 meters and believes the group could have worked out the kinks in another few months. He says he’s glad for the experience of working on the project, which challenged his problem-solving abilities and required many of the skills he’s developed over four years at UW-Madison. “The class required some circuit design, electrodynamics and mechanical engineering, and lots of 3D printing,” he says. “I think it brought everything together.”

Strachen plans to offer the class again in fall 2024 and is also preparing to start a RoboSub student club.



Joe Berg (left), Assistant Teaching Professor Nathan Strachen (center) and Max Kulick discuss a low frequency magnetic beacon the students built to locate an underwater target. Photo: Joel Hallberg.

Computationally designed nanoparticle cuts building A/C costs

Zongfu Yu

About 10% of all the electricity produced in the world is used for air conditioning, a number set to triple by 2050. Cutting down the cooling by even a tiny amount could have a huge impact on sustainability. That’s why a new microporous glass coating designed by Professor Zongfu Yu and colleagues at the University of Maryland could make a big impact on energy use by keeping buildings cool in the first place.

When painted on a building, the coating, made from particles of aluminum oxide and glass, is able to withstand exposure to water, ultraviolet radiation, dirt, fire and temperatures up to 1,000 degrees Celsius. It is also able to reduce the building’s interior temperature by more than 6 degrees Fahrenheit, limiting the carbon emissions of an average mid-rise apartment building by about 10%.

To help develop the coating, Yu used an optical simulation software tool, based on the finite difference time domain method (FDTD) and developed by his spinoff company Flexcompute, to model the coating and optimize the particle size to ensure its reflective and radiative properties. “Modeling this kind of random media is extremely computationally expensive,” he says. “This project was enabled by the use of massive computing power.”

A spinoff company called CeraCool is currently testing new commercial iterations of the coating.

Gupta and Pasayat add new energy and resources to power semiconductor research

Assistant Professors Chirag Gupta and Shubhra Pasayat are experts in wide- and ultrawide-bandgap semiconductors and devices for power electronics. Photo: Joel Hallberg.

Semiconductor chips aren't just the "brains" of our computers and smartphones. A different variety of chip, called power semiconductors, transforms, routes and manages the energy that powers our gadgets and is equally as important. Making them faster and more efficient is just as critical to enabling next-generation technologies as improving processor speed.

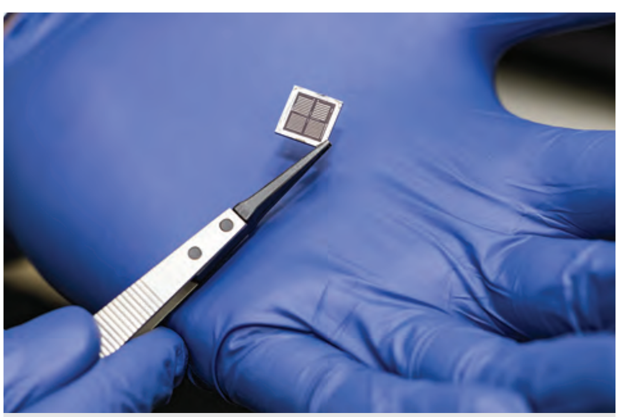
That's what power semiconductor experts Chirag Gupta and Shubhra Pasayat, both ECE assistant professors, aim to do. With $1.5 million in support from the National Science Foundation ASCENT program and $3 million from the Advanced Research Projects Agency–Energy's ULTRAFAST program, they are researching new materials, device designs and circuits that will take electric cars, the power grid and manufacturing to another level.

What, exactly, do power semiconductors do?

Gupta: I like to call microprocessors digital chips, which pack the largest possible amount of transistors, sometimes billions, onto the smallest node. In parallel, analog chips, or power semiconductors, perform different functions. Sometimes they only have one huge transistor. They help convert electricity from one form to another, like converting AC to DC, stepping voltage up or down, or routing or regulating power. And these devices are actually everywhere.

What's the maturity level of this technology?

Gupta: Until the late 1990s, silicon was the only semiconductor whose chips were commercialized for power electronics. But then, new semiconductors—gallium nitride and silicon carbide—came onto market. These are called wide-bandgap semiconductors, and can convert energy five times more efficiently than silicon and can handle higher voltages. People have already commercialized those, and they are used in fast electric vehicle chargers and phone chargers. They have reached the mass volume market.



New types of ultrawide-bandgap semiconductors, including aluminum gallium nitride and gallium nitride, will improve the efficiency of electronics. Photo: Joel Hallberg.

Pasyat: So, while we are pushing the material limits of gallium nitride, our lab is also going into what's called the ultra-wide-bandgap regime. These materials are even more efficient.

They include aluminum gallium nitride and aluminum nitride. We are also looking at diamond. So, these are all identified next-generation ultrawide-bandgap material systems. No one knows which one is going to win at this point. It's quite exciting, because then there is a lot of work that needs to be done.

Can you explain your new projects?

Gupta: For the NSF ASCENT grant, which we received through an interdisciplinary collaboration with ECE Associate Professor Dan Ludois, we are working on a relatively novel class of transistors called bidirectional transistors. These are useful in the power grid and electric cars. In our project, we want to develop ultrawide-bandgap transistors using aluminum gallium nitride and gallium nitride. Shubhra will develop the materials, I'll work on the transistors, and Dan will integrate the fabricated transistors in a circuit.

The goal of the ULTRAFAST project is to use aluminum gallium nitride and aluminum nitride transistors in electric grids to give them super-fast response times. Because if the grid can respond quickly to faults, it would help a lot with the challenges of integrating renewable resources. We are using a novel strategy to make the transistors switch fast without producing electromagnetic interference, or noise, which can damage the grid.

Power players: ECE alums are pioneers in electrifying aviation

Electric cars and trucks are slowly but surely finding their way onto roads across the world. But when it comes to air travel, electric aviation still has a ways to go. That's because current electric motors and battery technology don't come close to matching the power and energy density of old-fashioned, highly polluting combustion jet engines.

But Denver, Colorado-based startup company H3X is moving the world one step closer to electrifying the skies with new lightweight, power-dense electric motors with enough oomph to get a large aircraft like a 737 off the ground. The designs earned its three co-founders, all College of Engineering alums, a spot on the Forbes 2024 30 Under 30 list in the manufacturing and industry category.

The trio includes CEO Jason Sylvestre (BSEE '18, MSEE '19), CTO Max Liben (BSME '18, MSEE '20) and president Erik Maciolek (BSME '18). Over the past three years, H3X has received more than $9 million in investment, including backing from aviation superpower Lockheed Martin in early 2023.

The three engineers met at UW-Madison as part of the Formula SAE team, with Sylvestre and Liben eventually earning master's degrees in ECE through the Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC). During that time, they came up with their plans to start a company using state-of-the-art materials and designs to create a new class of motor.

In 2020, they were accepted into the prestigious Silicon Valley tech incubator Y Combinator, and the three began working on H3X full time, establishing an office in the greater Denver area. Three years later, and their motors are now starting to be delivered to customers.

Sylvestre says there are three areas of innovation that make the H3X motors unique, including the use of novel materials and manufacturing techniques as well as a design that co-packages the motor and inverter.

The result is a family of motors H3X calls HPDM, including 33- and 250-kilowatt versions currently being tested by customers. A 250-kilowatt version and 1.5-megawatt version, powerful enough for aircraft, should be ready for testing this year. The motors also have applications in large-scale marine, industrial and defense applications.

Sylvestre say that the company is still deeply connected with UW-Madison and has recruited many of its 23 employees from the Formula SAE team and WEMPEC. "We love UW-Madison; it really set us up well for what we're doing," he says. "It's just a great university with great programs and great students. It lets them be both hands-on as well as entrepreneurial."

H3X co-founders (left to right), Eric Maciolek, Jason Sylvestre and Max Liben. Submitted photo.

Riki Banerjee promoted to CTO of Synchron

Riki Banerjee (BSEE '00) was named chief technology officer for Synchron, a company specializing in endovascular brain-computer interfaces (BCI) focused on creating technology to restore motor function for individuals with severe paralysis. "Synchron has developed an elegant new way to deliver a neuroprosthesis device to the brain that avoids many of the barriers of more invasive BCI approaches," Banerjee said in a statement. "I'm excited to lead the R&D and product team at this pivotal time of growth to advance this innovative neurotechnology to patients." Banerjee has been with the company since September 2021 and was a 2022 College of Engineering Early Career Award recipient. After earning her BS in ECE from UW-Madison, she received her MSEE and PhD degrees from the University of Minnesota.

An electrifying discovery may help doctors deliver more effective gene therapies

In an effort to improve delivery of costly medical treatments, Philip Dunham Reed Professor Susan Hagness and Keith and Jane Morgan Nosbusch Professor Emeritus John Booske, along with their PhD student Yizhou Yao, have developed a stimulating method for making the human body more receptive to certain gene therapies.

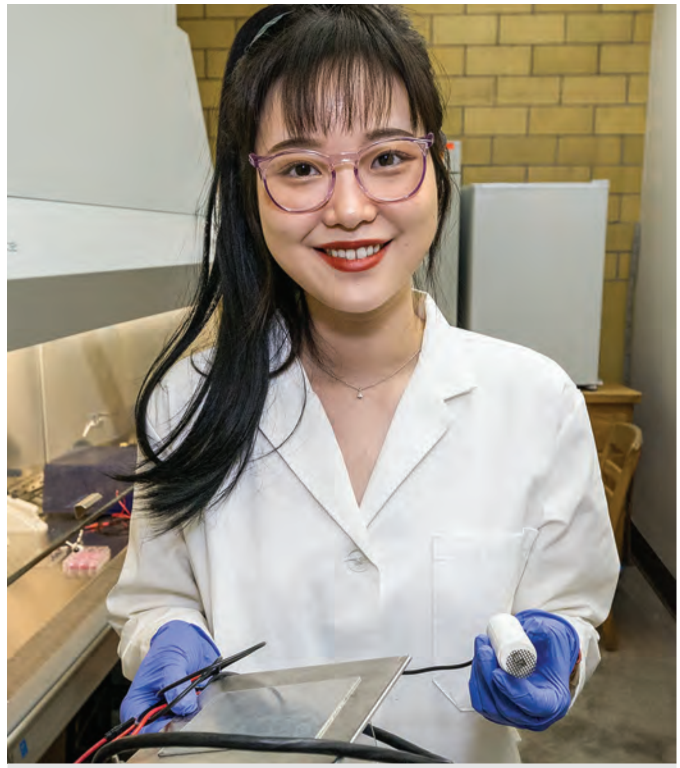
The researchers exposed liver cells to short electric pulses—and those gentle zaps caused the liver cells to take in more than 40 times the amount of gene therapy material compared to cells that were not exposed to pulsed electric fields. The method could help reduce the dosage needed for these groundbreaking treatments, making them much safer and more affordable. The research appears in the journal *PLOS One*.

The project began almost a decade ago with Hans Sollinger, a world-renowned transplant surgeon at UW-Madison. He had developed a gene therapy treatment for Type 1 diabetes, an autoimmune disease that attacks the pancreas, the organ that produces insulin.

In his treatment, the genetic code, or DNA, for insulin production is delivered into liver cells using an adreno-associated virus (AAV) that assists in transporting the therapeutic genes across the cellular membrane. This genetic code can then take up residence in liver cells, producing insulin without being attacked by the immune system in the pancreas.

While Sollinger had proof of concept that the therapy worked, he believed the future of the treatment hinged on delivery. Research has shown that exposing cells to electric fields can often increase the ability of molecules to move through the cell membrane into the interior of a cell. That's why he turned to Hagness and Booske, who have studied the impact of electric field pulse exposure on human cells.

In their study, PhD student Yizhou Yao used human hepatoma cells, a model system for studying the liver, exposing batches of the cells to various concentrations of the AAV gene therapy virus particles, each containing a fluorescent green protein. She used a pair of electrodes to deliver an 80-millisecond electric pulse to each sample. When she examined the cells 48 hours later, she found the samples that had received the zap accumulated 40 times the amount of glowing green protein than those that weren't.



PhD student Yizhou Yao found that applying electric pulses to liver cells improved delivery of gene therapy treatments. Photo: Joel Hallberg.

Sollinger passed away in May 2023, but the team says his legacy will live on through the ongoing research on this project and the work of other groups. The electrical engineering researchers are pursuing next steps with external funding and are optimistic that ultimately the technique will translate into clinical trials.

ECE research highlights

A multidisciplinary team led by Assistant Professor Akhilesh Jaiswal recently designed a computer chip based on the human retina that could improve the safety and performance of autonomous cars, drones and robots. The chip is able to detect and process certain movements instantaneously, similar to the way the retina can process information before the information reaches the brain. The research appears in the journal *Frontiers in Neuroscience.*

By adding a metallic "metasurface" to the material vanadium oxide, Jack St. Clair Kilby and Antoine-Bascom Associate Professor Mikhail Kats and his students created a new optoelectronic device that can be used as an optical switch, optical limiter and one-way window for light. The research appears in the journal *Nature Photonics.*

Associate Professor Line Roald received a UW-Madison Vilas Faculty Early Career Investigator Award. The award will support her work developing mathematical and software tools to model and optimize energy system operations, including modeling risks to the power grid form uncertain events like wildfires.

Faculty news and awards

Associate Professor Kassem Fawaz is a 2024 UW-Madison Vilas Associates Competition awardee. The honor from the Office of the Vice Chancellor for Research recognizes new and ongoing research of the highest quality and significance.

Assistant Professor Chu Ma is a 3M Non-tenured Faculty Award recipient. The award recognizes outstanding young faculty, nominated by 3M researchers, for their early-career achievements in research, experience and academic leadership.

Assistant Professor Shubhra Pasayat was selected as the recipient of the 2024 Harold M. Manasevit Young Investigator Award for her significant and innovative contributions in long wavelength nitride emitters, UVA lasers, and RF and power electronics material development. The award is sponsored by the American Association of Crystal Growth and will be presented at the 21st International Conference on Metalorganic Vapor Epitaxy in May.

Assistant Professor Haihan Sun was named a 2024 IEEE Antennas and Propagation Society (AP-S) Young Professional Ambassador. In this role, Sun and other ambassadors will elevate engagement in the field of antennas and propagation by delivering talks on specific topics.

Professor Giri Venkataramanan was named an IEEE Fellow. Venkataramanan, who is also director of the Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC), was recognized for contributions to the control of energy resources in microgrids.

Professor Amy Wendt, UW-Madison associate vice chancellor for research in the physical sciences, received the 2024 WEPAN University Change Agent Award for her work promoting a culture of inclusion and the success of women in engineering both through the Women in Science & Engineering Leadership Institute and through all the work she has done through governance at UW-Madison. Wendt also received a 2024 EDGE in Tech Athena Award in the Academic Leadership Category from the University of California and CITRIS and the Banatao Institute.


Professor Zongfu Yu and Associate Professor Mikhail Kats were named to the Clarivate Web of Science Highly Cited researchers list. Only 1 in 1,000 of the of the world's scientists appear on the list. The pair have been named to the Highly Cited list a combined 10 times over the past six years for their pioneering work in optics and photonics.

Highlights of new grants

Professor Nader Behdad and Professor Emeritus John Booske received a $1.3M grant from the Office of Naval Research to develop affordable phased-array antenna systems.

Professor Azadeh Davoodi received a $600K National Science Foundation grant to use machine learning techniques to provide feedback to predict problems within the chip design cycle. Chip technology advancements have made the design process more complex, and the project could provide understanding into the causes of a predicted design failure.

Assistant Professor Akhilesh Jaiswal is leading a $1.35M National Science Foundation-funded, multi-university, cross-disciplinary effort to create chips inspired by human brain performance. They will look specifically at the hippocampus, a brain region that can learn, recall experiences and build knowledge on the fly.

Assistant Professor Chu Ma and Associate Professor Mikhail Kats have received awards from the Defense University Research Instrumentation Program. The program provides strategic investments to buy important scientific equipment to develop new research capabilities. Ma will acquire a high-frame-rate optical imaging system for observing tissue dynamics under transient electromagnetic energy exposure; Kats will acquire interferometry equipment for research in high-power optical materials and devices.

Associate Professor Umit Ogras is the primary investigator on a new $1M+ Defense Advanced Research Projects Agency PROWESS program award that will develop high-throughput, streaming-data edge processors to analyze signal environments that change in the order of nanoseconds.

Lei Zhou, an assistant professor in ECE and mechanical engineering, received two National Science Foundation grants. One is to develop next-generation safe and dexterous robotic hands. The second is to develop a machine capable of layering ultrathin 2D materials like graphene to create new optoelectronic, electronic and quantum devices.

Student News

PhD student Chih-Chun Chang received the highly competitive MIT/Amazon Graph Challenge Innovation Award. Chang, a student of Assistant Professor Tsung-Wei Huang, won for his research, "uSAP: An ultra-fast stochastic graph partitioner."

Senior Cassie Mangiulli received the IEEE Power and Energy Society (PES) Scholarship Plus Initiative Award, which is based on GPA and distinctive extracurricular activities.

Zhewen Pan, a PhD student, took first place in the ACM SIGMICRO student research competition, held in conjunction with the ACM/IEEE International Symposium on Microarchitecture.

PhD student Maitreyee Marathe won one of four top research awards at the 2023 Energy Data Analytics Symposium. Marathe took 2nd place and was the audience choice winner for her project, "Optimal home energy management for prepaid electricity customers."

PhD student David Skrovanek and Associate Professor Dan Ludois were selected to advance to stage II of the U.S. Department of Energy's Innovating Distributed Embedded Energy Prize. The competition is designed to advance the development of ocean wave energy technology.

Associate Professor Dan Ludois and PhD student Shiying Wang received the Best Oral Presentation Paper in Emerging Technology award for IEEE ECCE. They used a balloon to test their theory that a single-wire earth return power transfer is possible at high frequencies.

Two ECE students earned honors from the 2024 National Science Foundation Graduate Research Fellowship Program. Computer engineering undergraduate student Eric Dubberstein received the Fellowship award and ECE PhD student Gwynne Symons Buxton was awarded an Honorable Mention.

In memorium

Professor Emeritus J. Leon Shohet passed away Feb. 28, 2024. He was a member of the ECE faculty for more than 50 years, focusing on the science and applications of plasmas, including plasma-aided manufacturing, controlled fusion and biophysics. He was instrumental in bringing the first stellarator fusion device to campus, laying the groundwork for fusion research in the College of Engineering. He was also director of the Engineering Research Center for Plasma-Aided Manufacturing. Shohet received a number of honors during his career, including election as a fellow at the American Physical Society and the IEEE.

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Excitement is building

Our engineering campus will soon be home to the largest and one of the most advanced buildings at UW-Madison. With formal approval of state funding for a new 395,000-square-foot building, we're continuing our growth initiative.

The seven-story building will span parts of the existing Engineering Mall and the space currently occupied by 1410 Engineering Drive (which will be demolished), and feature refreshed green space and indoor and outdoor gathering spaces.

The $347 million facility, funded through $150 million in private giving and $197 million from the state of Wisconsin, will be a catalyst for research while allowing the college to educate many more exceptional students.

Explore more, follow along with the building's progress, and support the project at engineering.wisc.edu/new-building.

All images by Continuum Smithgroup. Artist's concepts of the new building.