DEPARTMENT OF
Electrical and Computer Engineering
UNIVERSITY OF WISCONSIN–MADISON

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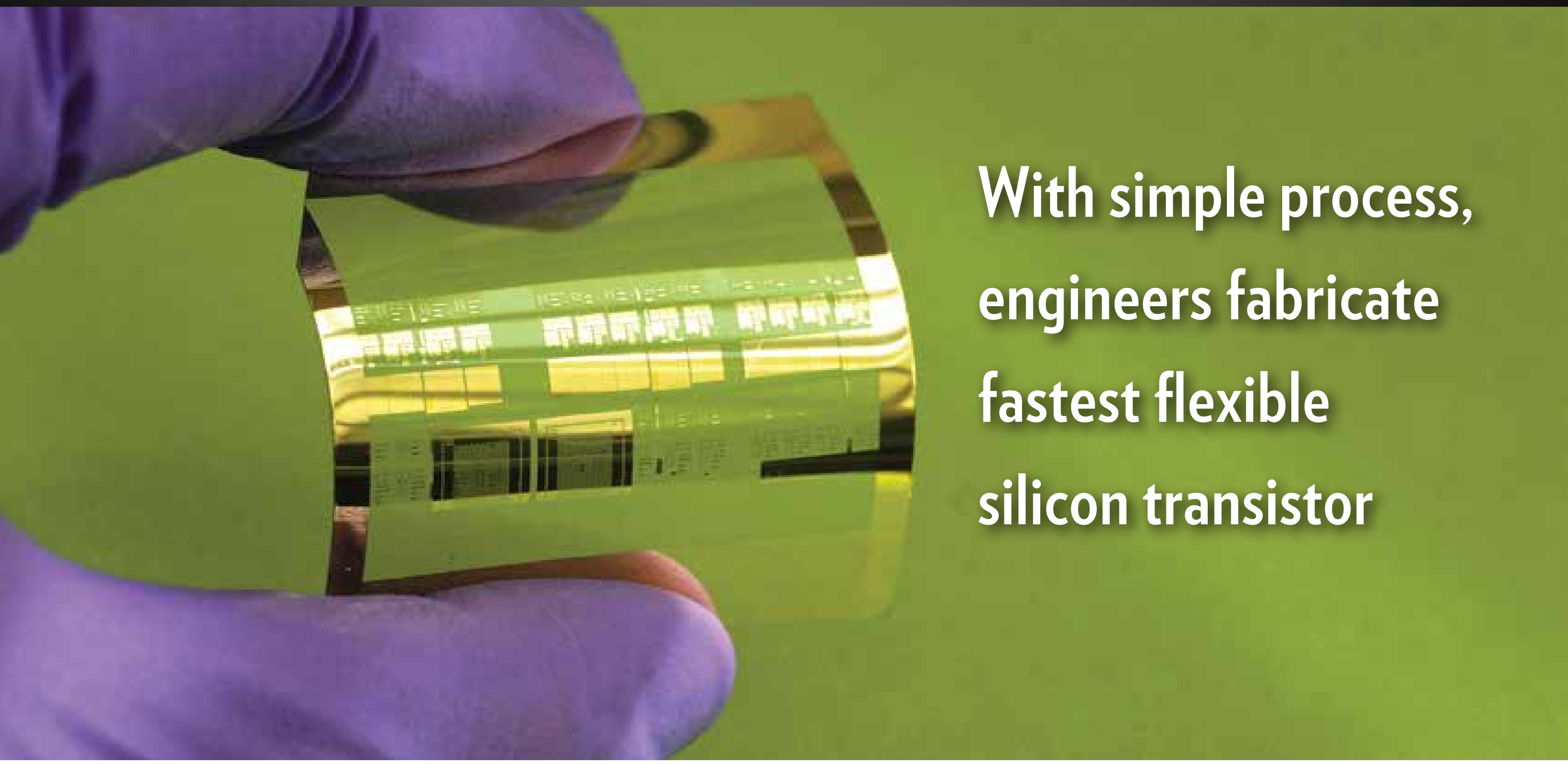
www.engr.wisc.edu/ece



With simple process, engineers fabricate fastest flexible silicon transistor

One secret to creating the world's fastest silicon-based flexible transistors: a very, very tiny knife.

Working in collaboration with colleagues around the country, UW-Madison engineers have pioneered a unique method that could allow manufacturers to easily and cheaply fabricate high-performance transistors with wireless capabilities on huge rolls of flexible plastic.

The researchers—led by Zhenqiang (Jack) Ma, the Lynn H. Matthias Professor in Engineering and Vilas Distinguished Achievement Professor in electrical and computer engineering, and research scientist Jung-Hun Seo—fabricated a transistor that operates at a record 38 gigahertz, though their simulations show it could be capable of operating at a mind-boggling 110 gigahertz. In computing, that translates to lightning-fast processor speeds.

It's also very useful in wireless applications. The transistor can transmit data or transfer power wirelessly, a capability that could unlock advances in a whole host of applications ranging from wearable electronics to sensors.

Jack Ma

The team published details of its advance April 20, 2016, in the journal *Scientific Reports*.

The researchers' nanoscale fabrication method upends conventional lithographic approaches—which use light and chemicals to pattern flexible transistors—overcoming such limitations as light diffraction, imprecision that leads to short circuits of different contacts, and the need to fabricate the circuitry in multiple passes.

Using low-temperature processes, Ma, Seo and their colleagues patterned the circuitry on their flexible transistor—single-crystalline silicon ultimately placed on a polyethylene terephthalate (more commonly known as PET) substrate—drawing on a simple, low-cost process called nanoimprint lithography.

In a method called selective doping, researchers introduce impurities into materials in precise locations to enhance their properties—in this case, electrical conductivity. But sometimes the dopant merges into areas of the material it shouldn't, causing what is known as the short channel effect. However, the UW–Madison researchers took an unconventional approach: They blanketed their single crystalline silicon with a dopant, rather than selectively doping it.

(Continued on page 7)

John Booske

As department chair, I look forward to telling you about the many fantastic things happening in our department—*your* Department of Electrical and Computer Engineering (ECE). With your support, we are making investments in our faculty, our students and our facilities so that we continue to be leaders in research and in delivering an exceptional, relevant education that provides our students the foundation for success throughout their careers.

We are recognized nationally in these areas—and one measure of that recognition is our rankings, which are high. At the graduate level, our computer engineering program is No. 13, while electrical engineering is No. 16; at the undergraduate level, we are ranked No. 13 in computer engineering and No. 14 in electrical engineering.

At the graduate level, our high rankings are related to our exceptional faculty members and their exciting research leadership. As examples, in this newsletter, you'll read about the groundbreaking work we are doing in electronic devices, optics, wireless and antennas, and other areas.

We also are known nationally as a leader in educational innovation and in active learning enabled by modern information technologies. Many of our faculty members have embraced active-learning approaches that deepen students' understanding of the material. As a testament to our department's acknowledged leadership in engineering education innovation, I was invited to organize and host a half-day workshop on blended learning at the annual meeting for the ECE Department Heads Association earlier this year (www.ecedha.org). We used online active learning activities in the workshop as a way to help department leaders learn more about *flipped classrooms* and using information technology for enhanced learning through *blended instruction*. More than 30 chairs traveled to the annual meeting early so they could attend the workshop.

In keeping with the Wisconsin Idea, we are called to widely disseminate what we've learned about effective engineering education. A better educated workforce benefits all of society. In particular, exceptionally well-educated electrical and computer engineers are *crucial* to our collective future, as we will rely on bold innovations in s*mart* electrical and computer technologies for efficient use of resources, human health, and personal and national security.

We do what we do for *you.*

So looking forward, we are dedicating the entire 2016-2017 academic year to a yearlong celebration—with you—of the amazing students, staff, and faculty who are our amazing Badger ECE family legacy.

As you may know, we're celebrating our 125th anniversary! In an effort to connect with as many of you as we can, we're hosting several events—including a distinguished lecture series and alumni receptions around the country—throughout the year. You can view the entire schedule on our anniversary website, 125.ece.wisc.edu, and be on the lookout for postcards and emails announcing events throughout the year.

Please also consider making a gift to ECE—$125, or an annual pledge of $1,250 over four years, for example—in honor of our 125th anniversary. Go to allwaysforward/giveto/ece to make a gift to our annual fund. These gifts allow us to recruit world-class faculty and improve student learning, keeping our rankings high and our brand strong for you. For example, our annual fund enables startup packages that help our new faculty members establish their laboratories and research programs. It allows us to augment scholarship amounts and invest in community-building events that integrate students into the department and build their Badger networks. It supports graduate students who assist our educational innovations, and it has allowed us to renovate classrooms for active learning that the students love and that our national peer departments look up to as models for 21st-century ECE teaching.

We continue to recruit, hire and retain the brightest, world-class faculty members and to provide our students the best possible experience we can give them. As a result, our fundraising priorities include gifts that support faculty through named professorships, faculty scholar awards, and startup funding, and gifts that support students through scholarships and fellowships. We are ever grateful for your support of our efforts!

ON, WISCONSIN!

John Booske, Chair,
Vilas Distinguished Achievement Professor,
Duane H. & Dorothy M. Bluemke Professor
jhbooske@wisc.edu • (608) 890-0804

Make plans to join us from August 2016 through May 2017 as we celebrate the department's 125th anniversary with a variety of exciting events, including lectures, alumni receptions around the country, a kickoff party, and a special anniversary celebration. *Watch for more details about how you can help us celebrate!* ***125.ece.wisc.edu***

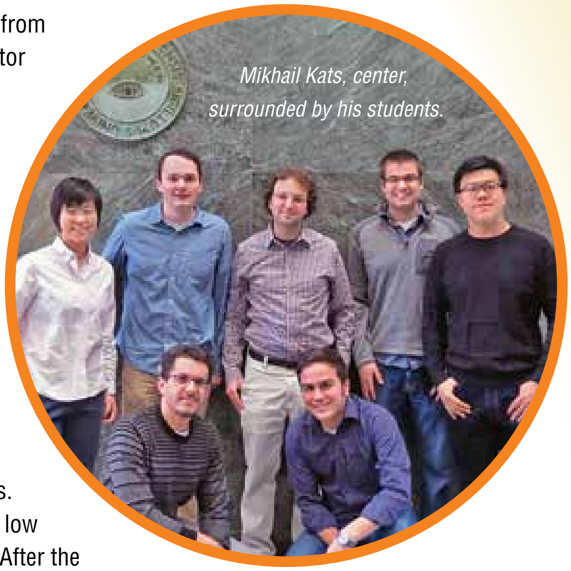
BLINDED BY THE LIGHT NO MORE:

Designing devices to protect sensitive imaging systems

For anyone involved in imaging, the future is bright. Blindingly bright, in fact.

Today's imaging technologies allow highly sensitive cameras to detect even the faintest glimmers of light. Unfortunately, however, highly sensitive pieces of optical equipment are also highly susceptible to damage: Intense light beams overwhelm devices designed to detect single photons.

Such advanced equipment needs cutting-edge protection, and a UW-Madison electrical engineer aims to develop optical "limiters" with support from the highly selective U.S. Office of Naval Research Young Investigator Program, which recognizes promising new professors for exceptionally creative research. Assistant Professor Mikhail Kats is one of 47 investigators nationwide selected to receive $510,000 over the next three years to develop innovative solutions to seemingly intractable modern problems.



Mikhail Kats, center, surrounded by his students.

Here's one problem: As artificial eyes become more perceptive, high-powered light sources penetrate more spaces around the world. Even commonplace laser pointers can fry the optics of sensitive cameras, or temporarily blind pilots flying planes.

Somewhat like eyeglass lenses that darken in sunlight, transparent devices, called optical limiters, turn opaque on demand and could prevent intense beams from blinding sensitive detectors.

"Optical limiters essentially are windows that are transparent at low powers, but become opaque at high light intensities," says Kats. "After the light goes away, they go back to normal."

Existing optical limiter technologies fall short, however, because they can switch states slowly, sometimes rely on electronics, and ultimately cannot stand up to high-powered onslaughts. Additionally, most devices on the market today absorb incoming light, which heats them up, possibly causing damage. "A significant goal of our work is to make optical limiters that transition from transparent to reflective, rather than from transparent to absorbing," says Kats.

Photos: Sam Million-Weaver

Graduate Student Chenghao Wang peers into a microscope while Mikhail Kats makes adjustments.

Devices that shine incoming beams back at the source rather than taking on energy are much less likely to become overloaded, so Kats and colleagues proposed to create alternative optical limiters that become reflective mirrors when hit with powerful pulses of energy, instead of absorptive walls.

Kats plans to use a special class of materials that have phase transitions to build the devices. These materials rapidly switch from transparent to opaque when light strikes their surfaces. Additionally, because the transition is an intrinsic property of the material itself, they do not require complex circuitry or external power sources to change from clear to cloudy.

Now Kats intends to build on their expertise creating metasurfaces and optical nanostructures with designer properties to use the materials in optical limiters that protect across multiple wavelength ranges of light. Additionally, he hopes to develop two-way versions of the devices, called optical diodes, that let light escape from a device, but prevent intense incoming beams from reaching a detector.

So far, Kats and his students have performed preliminary modeling to establish proof of concept. Their next step is to create a prototype. "We're going to make these things and blast them with lasers, in the real world, with real heat dissipation problems, and see what happens," says Kats.

Extraordinary effort merits posthumous PhD

A tragic swimming accident in 2011 left UW-Madison ECE graduate student Craig Schuff paralyzed from the neck down, but his ever-curious mind refused to get the memo.

Schuff came to the UW-Madison in 2008 to study nuclear engineering. He was well on his way toward his master's degree when, while swimming with friends on a warm May day, he dove off a pier in Lake Monona and hit his head on the bottom of the lake.

Schuff died in October from complications of his paralysis. He was only months away from wrapping up his PhD dissertation. To honor Schuff's scholarly work, which he pulled off while dealing with his new and profoundly limiting physical disability, UW-Madison awarded him a posthumous PhD in electrical and computer engineering. Schuff's parents, Mary and Rick, were presented with the degree during the May 2016 commencement ceremony. The posthumous award is a rare one: Schuff is only the second such recipient in the university's 168-year history. "He was a very energetic young man and a very hard worker," says Jerry Kulcinski, professor emeritus of engineering physics and Schuff's research advisor. "He had a genuine drive to do things, and he was always generating new ideas."

One of those new ideas led to his master's thesis: Schuff developed a method of using a pulsed neutron source to detect nuclear materials through thick metal walls. The new method could be used to counter the threat of nefarious smuggling of nuclear materials in thick-walled suitcases or shipping containers. "He was very diligent about putting that proposal together and presenting his work," says Kulcinski.

All of this was before the 2011 swimming accident. "That was very tragic. When the accident occurred, of course nobody knew what was going to happen," Kulcinski says.

At that point, Schuff had been on campus for nearly three years and had finished most of his coursework and started on his master's thesis. Kulcinski says everything was briefly up in the air as everyone waited to find out just how severe Schuff's injuries were. His parents came from Tennessee, and Schuff's mother—a teacher—took a semester off and lived with him in Madison until he was able to live relatively independently. Still, until his death, Schuff's parents and grandparents were a regular presence.

"Once he partway recovered from that initial damage we started to talk about where we were going to go next, and he said he wanted to finish his thesis," Kulcinski says.

So with the help of a generous anonymous donor, the department remodeled Schuff's lab space to be accessible for his new motorized scooter. Many other donors helped fund a special—and expensive—piece of lab equipment Schuff needed to run his experiments. The university and another donor helped fund Schuff as well. An undergraduate to be Schuff's "hands" in the lab was hired as Schuff was now paralyzed from his neck down. Between Schuff's ideas and supervision and the work of his undergraduate assistant, they were able to make progress on his thesis, and Schuff received his master's degree in 2012

Living in an apartment near the College of Engineering campus, Schuff was able to motor over to his lab in the Engineering Research Building independently most mornings when the weather allowed, Kulcinski says. His work ethic and inquisitive nature led to steady progress toward his PhD, even as Schuff navigated his disability and other health problems related to his injury. In 2013 he passed his qualifying exams and went through the prelim proposal process in 2014.

"Then he was on his way to actually running experiments with the help of an undergraduate," Kulcinski says. "He designed the experiment, he did the calculations, he plotted the graphs, he published his master's thesis and his prelim, which is pretty technical with equations, graphs, and CAD (computer-aided design) diagrams. If you didn't know that he had this disability, you'd assume he was any other student, which to me is quite remarkable."

Also remarkable, Kulcinski notes, is Schuff's attitude as he dealt with his new physical limitations. "He never let it slow him down," Kucinski says. "He had a lot of trouble with his immune system after the accident; he would be very subject to infections and all kinds of things that we would be able to handle, but his body couldn't. So sometimes he would come in and it would look like a real chore. But he came in. Quite frankly, I think that's what kept him going—he'd come in and work. The day before he died he was here, and we had a meeting. He looked good, and I remarked to one of my other colleagues, I said, 'Gee, Craig's looking good.'"

That was on October 23, 2015. On October 24, Schuff died unexpectedly, likely as a result of several factors related to his paralysis. Kulcinski says he'll remember Schuff for his perseverance, but also for his attitude.

"He had a great sense of humor," Kulcinski says. "He was always cracking jokes with the group, and he was a team player. He volunteered if we had something in the lab to do; he wasn't reticent to do anything."

Schuff was also an avid football fan, and attended most home Badger football games, motoring the short distance to Camp Randall Stadium from his apartment.

After Schuff's death, the college swiftly advocated for a posthumous PhD. Within a month of beginning the process, which needed approvals by his thesis advisors, his PhD committee, the engineering physics and electrical and computer engineering department chairs, the college, and UW-Madison Chancellor Rebecca Blank, Kulcinski says he received word that the request had been approved. "That all happened reasonably quickly—almost at light speed considering the university process," Kulcinski says.

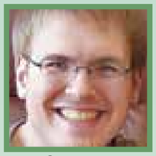
It was the final rally to recognize a student who had studied and conducted novel research while facing enormous obstacles.

Fellowship supports ECE students

The Greater Milwaukee Foundation has long recognized that an electrical engineering education opens the door to opportunities. Throughout the pioneering community trust's century-long history, the organization drew from the strength of homegrown citizens who pooled their resources to address pressing local needs, such as providing top-notch training for future engineers.

To promote economic development in the Greater Milwaukee area and strengthen communities now and for future generations, the foundation provides fellowships for undergrad or graduate students in electrical and computer engineering at UW-Madison. For more than two decades, scholars from Milwaukee, Waukesha, Washington, and Ozaukee counties have received support from the Frank Roger Bacon Memorial Fund. Students may use funds for tuition, room and board, books, fees, or equipment for coursework. In the 2015-16 academic year, the foundation awarded five fellowships to electrical and computer engineering students in recognition of their academic excellence and spirit of integrity, service effectiveness and inclusion.


Watras


Seemuth


Salman

Fellowship recipients tackle important societal problems in their research. For example, second-year PhD student Alex Watras' work on receiver localization for millimeter wave communication systems could enable next-generation 5G wireless. Watras also applies his knowledge of signal processing to assist in environmental conservation studies with researchers at the UW-Madison Trout Lake Station.

Daniel Seemuth, who defended his PhD thesis in February 2016, studied integrated circuit design under the co-mentorship of Associate Professor Katherine Morrow and Associate Professor Azadeh Davoodi.

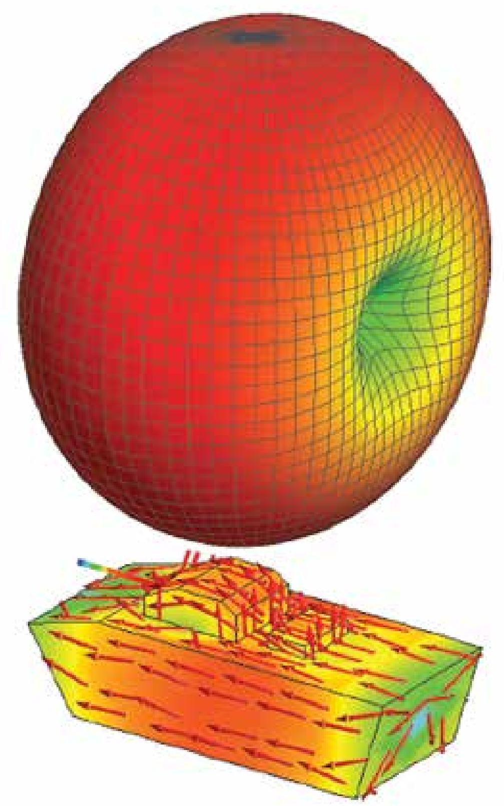
Other recipients include Jad Salman, who works under the mentorship of Assistant Professor Mikhail Kats. Another awardee, Skyler Hagen, contributed to Assistant Professor Daniel Ludois' efforts to engineer devices that power rotating electrical loads without contact. Jared Pierce also received support through the Bacon fund.

Bacon founded the American Rheostat Company, which later became Cutler-Hammer Inc., now a subsidiary of the Eaton Corporation. Since 1897, the company's electrical control devices came "universally recommended" for "giving great satisfaction to the trade," according to archival editions of American Electrician.

Four years after Bacon died in 1949, his wife, Ellen Bacon, established the Bacon Foundation to immortalize her husband's ideals. In 1978, Bacon's estate transferred $2.5 million to the Greater Milwaukee Foundation—its largest gift in history—to support scholarships for electrical engineering students at UW-Madison and Marquette University, as well as to provide general assistance to area hospitals and the United Way of Greater Milwaukee.

The ECE department received a $60,000 grant from the Frank Roger Bacon Fund in 2010, continuing a tradition of more than 20 years of support. Previous awardees have ascended to senior-level positions with Intel Corporation (George Kennedy, MS '14), and Triumph Group (Jonathan Lee, BS '09, MS '11).

AUTO ANTENNAS: Exploiting the metal in military vehicles to broadcast radio signals



Computer simulation of amphibious assault vehicle broadcasting signals.

High-frequency antennas transmit radio waves across vast distances and even over mountain ranges using very little energy, making them ideal for military communications. These devices, however, have one big problem: They need to be physically huge to operate efficiently.

Instead of adding additional bulk, UW-Madison engineers, with support from a $550,000 grant from the U.S. Office of Naval Research, are developing strategies to increase the effective sizes of antennas by turning military vehicles into transmitters—using the structures that support the antennas themselves to broadcast signals.

Troops in remote locations need to rapidly communicate by radio, without being weighed down by extraneous equipment. However, antennas' dimensions need to be at least one quarter the length of the radio waves they transmit in order to operate efficiently. High-frequency military signals use radio waves ranging from roughly a football field in length to the distance of a successful first down. Even at the smallest end, the ideal size for an antenna would be taller than an average adult. "Unsurprisingly, we don't use antennas that are that big," says Nader Behdad, an associate professor and Harvey D. Spangler Faculty Scholar. "Putting a big long antenna on top of an amphibious assault vehicle would be too high-profile."

Short antennas lighten loads at steep costs to performance. The devices are inefficient; as much as 90 percent of input power is dissipated as useless heat instead of being sent as radio signals. "The problem is that antennas that are a small fraction of the wavelength can't really communicate over long distances, and data rates cannot be as fast as they should be," says Behdad.

Increasing the size of an antenna without adding to its physical dimensions sounds impossible. However, real-world military antennas are almost always attached to other things—for example, large, metallic objects like trucks, armored transports, or amphibious assault vehicles, and Behdad realized that these structures themselves could broadcast radio signals.

"We are proposing to use the platform itself as the antenna," he says. "It's a clever way to go around the limitations set by the laws of physics. From a practical point of view, the volume of the object on the military platform is the same but we've effectively achieved a larger antenna."

Turning trucks into transmitters not only makes antennas more efficient, but also enhances communication in the field by enabling one device to send and receive multiple types of information.

Separate transmitters send Internet data, Bluetooth, and cell phone calls because each signal uses a particular bandwidth. Similarly, military vehicles sprout miniature metal forests of ungainly antennas sticking high in the sky because fundamental properties of electromagnetic waves limit the range of signals available to each device. Some scientists have speculated that a yet-undiscovered material with unusual properties could pave the way to ultrawideband antennas, but, so far, those predictions remain unsubstantiated.

"It's pretty clear that we cannot beat the laws of physics, although it's not for lack of trying," Behdad says. "With the laws of physics as they are, the only way to increase the bandwidth of ultra wideband antennas is to increase their size."

Behdad's practical approach to increase the size of antennas by using the platform they stand on as broadcasting equipment finds a loophole in the laws of physics that doesn't rely on any exotic materials. His team has already demonstrated a proof of principle using scale models of simple military platforms in the lab and computer simulations and now is focusing on developing practical applications.

Nader Behdad

UW-Madison places among top teams in SpaceX Hyperloop competition

The BadgerLoop team's innovative pod design for the SpaceX Hyperloop competition.

A team of UW-Madison engineering undergraduates won third place overall in a worldwide competition to design a pod for shuttling people on a futuristic high-speed transportation system known as the Hyperloop.

The UW-Madison BadgerLoop team competed against more than 115 student teams at the first-ever SpaceX Hyperloop pod design competition held at Texas A&M University on January 29-30, 2016. The teams came from 27 U.S. states and 20 different countries.

The Hyperloop is a conceptual rapid-transit system first proposed by SpaceX and Tesla Motors co-founder Elon Musk in 2013. It involves transporting passengers in pods traveling as fast as 760 mph in vacuum tubes above ground. With the Hyperloop, passengers could travel from Los Angeles to San Francisco in less than 30 minutes.

During the two-day competition, teams presented their designs to a panel of SpaceX, Tesla and university judges for a chance to build and test their design prototype at the world's first Hyperloop test track being built by SpaceX adjacent to its headquarters in Hawthorne, California.

The BadgerLoop team's design, which harnesses an array of magnets to levitate the pod in the Hyperloop tube, impressed the SpaceX and Tesla engineers. The team's pod design features innovative spinning wheels that have powerful magnets around the outside. These Halbach wheels help control the pod's speed. The pod will levitate and won't touch any part of the tube.

BadgerLoop is unique among the top teams because it consists primarily of engineering undergraduates, among them, about 30 from ECE, as opposed to teams like MIT that are made up of graduate students. BadgerLoop students only worked on the project in their free time rather than as part of their engineering coursework. The only teams to score higher than BadgerLoop were MIT and Delft University of Technology from the Netherlands.

Elon Musk made a cameo during the final day of the competition and gave a short talk to the rapt audience.

BadgerLoop is one of 22 student teams from the competition that will be heading to California in summer 2016 to test their actual human-scale pods on SpaceX's one-mile test track.

Regardless of whether the Hyperloop concept ever becomes a reality, the students' experiences and achievements with Badger-Loop are putting them on the fast track to bright engineering careers.

Fastest flexible silicon transistor *(Continued from front page)*

Then, they added a light-sensitive material, or photoresist layer, and used a technique called electron-beam lithography—which uses a focused beam of electrons to create shapes as narrow as 10 nanometers wide—on the photoresist to create a reusable mold of the nanoscale patterns they desired. They applied the mold to an ultrathin, very flexible silicon membrane to create a photoresist pattern. Then they finished with a dry-etching process—essentially, a nanoscale knife—that cut precise, nanometer-scale trenches in the silicon following the patterns in the mold, and added wide gates, which function as switches, atop the trenches.

With a unique, three-dimensional current-flow pattern, the high performance transistor consumes less energy and operates more efficiently. Because the researchers' method enables them to slice much narrower trenches than conventional fabrication processes can, it also could enable semiconductor manufacturers to squeeze an even greater number of transistors onto an electronic device.

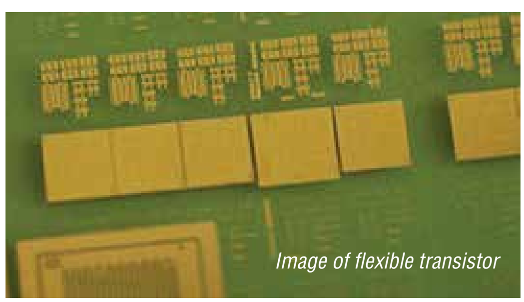
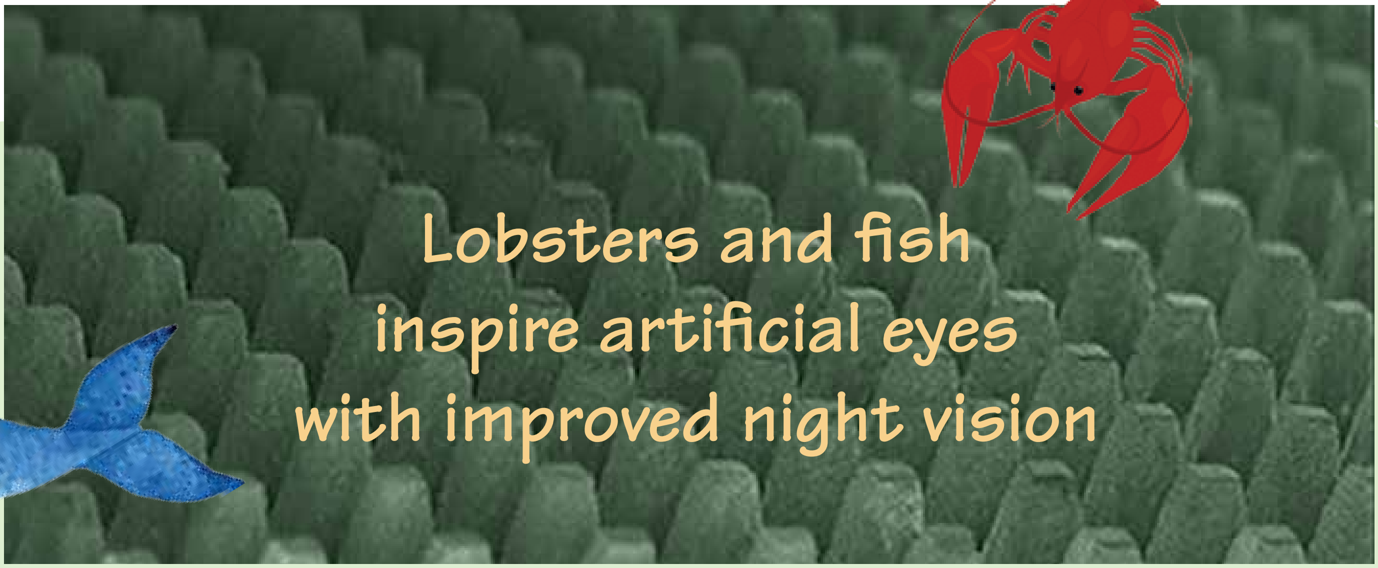


Image of flexible transistor

Ultimately, says Ma, because the mold can be reused, the method could easily scale for use in a technology called roll-to-roll processing (think of a giant, patterned rolling pin moving across sheets of plastic the size of a tabletop), and that would allow semiconductor manufacturers to repeat their pattern and mass-fabricate many devices on a roll of flexible plastic. "Nano-imprint lithography addresses future applications for flexible electronics," says Ma, whose work was supported by the Air Force Office of Scientific Research. "We don't want to make them the way the semiconductor industry does now. Our step, which is most critical for roll-to-roll printing, is ready."

Additional authors on the paper include Shaoqin (Sarah) Gong of UW–Madison, L. Jay Guo and Tao Ling of the University of Michigan, Weidong Zhou of the University of Texas at Arlington and Alice L. Ma of the University of California, Berkeley.



Lobsters and fish inspire artificial eyes with improved night vision

Hongrui Jiang

Arrays of minuscule crystal cups arranged on the artificial eye's surface collect and concentrate incoming light.

Combining the best features of a lobster and an African fish, UW-Madison engineers have created an artificial eye that can see in the dark.

Their biologically inspired approach, published March 14, 2016, in the *Proceedings of the National Academies of Sciences*, stands apart from other methods in its ability to improve the sensitivity of the imaging system through the optics rather than the sensor component.

These fishy false eyes could help search-and-rescue robots or surgical scopes make dim surroundings seem bright as day.

Amateur photographers attempting to capture the moon with their cell-phone cameras are familiar with the limitations of low-light imaging. The long exposure time required for nighttime shots causes minor shakes to add up into majorly blurry images. Yet, fuzzy photos aren't merely an annoyance—bomb-diffusing robots, laparoscopic surgeons, and planet-seeking telescopes all need to resolve fine details through almost utter darkness.

"These days, we rely more and more on visual information. Any technology that can improve or enhance image taking has great potential," says Hongrui Jiang, the Lynn H. Matthias Professor and Vilas Distinguished Achievement Professor.

Most attempts to improve night-vision tweak the "retinas" of artificial eyes so that they respond more strongly to incoming packets of light. Usually technicians try to change the materials or electronics on the imager—such as a camera's charge coupled device.

However, rather than interfering with efforts to boost sensitivity at the back-end, Jiang's group set out to increase intensity of incoming light through the front-end optics. They found inspiration for the strategy from two aquatic animals that evolved different strategies to survive and see under murky waters.

Hongrui Jiang demonstrates an imaging system.

Elephant-nosed fishes resemble river-dwelling Cyrano de Bergerac impersonators. Looking between their prominent proboscises reveals two strikingly unusual eyes, with retinas composed of thousands of tiny crystal cups instead of the smooth surfaces common to most animals. These miniature vessels collect and intensify red light, which helps the fish discern its predators.

"We were thinking: Why don't we apply this idea? Can we enhance the intensity to concentrate the light?" says Jiang.

The group emulated the fish's crystal cups by engineering thousands of miniscule parabolic mirrors, each as tall as a grain of blue spruce pollen. Jiang's team then shaped arrays of the light-collecting structures across the surface of uniform hemispherical dome. The arrangement, inspired by the superposition compound eyes of lobsters, concentrates incoming light to individual spots on the imager, further increasing intensity.

"We showed fourfold improvement in sensitivity—that makes the difference between a totally dark image you can't see and an actually meaningful image," says Jiang.

The device could easily be incorporated into existing systems to visualize a variety of vistas under low light. "It's independent of the imaging technology," says Jiang. "We're not trying to compromise among different factors. Any type of imager can use this."

Although superposition compound eyes are exquisitely sensitive, they typically suffer from less sharp vision. Increased intensity costs clarity when broad amounts of light compress down to single pixels. To recover lost resolution, Jiang's group captured numerous raw images then applied a super-resolution-processing algorithm to produce crisp, clear pictures.

Currently the group is working to refine the manufacturing process to further increase the sensitivity of the devices. With perfect precision, Jiang predicts that the artificial eyes could improve by at least an order of magnitude. "It has always been very hard to make artificial superposition compound eyes because the curvature and alignment need to be absolutely perfect." says Jiang. "Even the slightest misalignment can throw off the entire system."

The National Institutes of Health, National Science Foundation, and the UW-Madison provided support for the research.

Splinters capitalize on once-in-a-lifetime opportunity to assist ECE department

When Mike and Pat Splinter heard about the $100 million gift-matching opportunity announced by John and Tashia Morgridge to create more named professorships in the college, they knew it was an opportunity they couldn't refuse.

"We knew we'd never get an opportunity like that again," says Mike Splinter, an alumnus of electrical and computer engineering who has had a successful and influential career in the Silicon Valley microchip industry.

So the Splinters—who have already committed to a named chair gift to the department in their will—took advantage of the Morgridge Match opportunity to the benefit of the ECE department. Their gift—the most recent in more than 30 years of giving to the department—will fund a new named professorship.

Mike says he and Pat were motivated by their desire to help Wisconsin maintain its well-earned reputation for academic and research excellence. "What it gets down to for us is we want Wisconsin to continue to be competitive and be the world-class university that I got my education at," says Mike. "And to provide new students with a great education you've got to have great professors. These named professorships are a huge help for the departments in recruiting and in keeping great professors in the school."

The gift extends a long tradition of the Splinters' of giving back to the institutions that have shaped their lives, Mike says.

"Giving is a very individual kind of thing, but if you look at your life and you see what's made a difference, what were the turning points in your life, where do you put the University of Wisconsin electrical engineering department on that list?

For me, it's pretty high up on that list. Helping the University of Wisconsin is very, very high on our set of things to do and organizations we want to support going forward," says Mike. "On Wisconsin!"

Photo courtesy of Semiconductor Industry Assoc.

Gift aims to develop 'great people'

UW-Madison prepares students to become lifelong leaders for one of the lowest tuition rates among the nation's top-10 public universities, yet the cost still presents a barrier to some scholars from low-income families.

To enable access to top-quality education, the UW-Madison Great People scholarship program provided need-based financial aid to 66 engineering students through the office of financial aid in 2015. In the future, the college will be able to support even more engineering scholars, thanks to a generous gift to the fund from alumnus Vincent Chan (BS '72, MS '73, PhD '75) *(pictured)*.

"The scholarship is my way of thanking UW for the great education I received," says Chan, who currently resides in Del Mar, California, with his spouse, Pauline.

Chan applies his disciplinary expertise in fusion physics as director of theory and computational science at General Atomics in San Diego. He also serves on numerous governmental panels and advisory boards, including the American Physical Society, and the UW-Madison College of Engineering Industrial Advisory Board. He is a fellow of the American Physical Society, and in 2009 the Chinese National Office for Science and Technology Awards honored Chan at the Great Hall of the People in Beijing with the 2009 International Science and Technology Cooperation Award of the People's Republic of China for his contributions towards promoting Sino-USA magnetic fusion research collaboration.

Throughout his career, Chan has promoted strong linkage between theory and experiment, and advanced understanding of fusion energy by applying high-throughput computing to elucidate theoretical challenges in magnetized plasmas. His research has moved the fields of burning plasma and economical fusion forward, with more than 100 high-impact publications.

Chan hopes his contribution will enable future generations to similarly pursue their ambitions. His gift adds to the fund's $44 million pool of support for all UW-Madison students, enabled by an ongoing $20 million UW Foundation matching initiative, announced in 2008.

Renovated spaces position department to lead mobile systems and wireless research

A much needed facelift of laboratory and learning spaces in Engineering Hall is supporting the department's strategic effort to become an international leader in mobile systems and wireless research.

The newly renovated spaces—including a graduate research lab, offices and classroom spaces—provide professors, graduates and undergraduate researchers with secure, clean, useful and adaptable spaces to discover and test new technologies for our increasingly wireless world. They were funded by a gift from alumnus Peter Schneider, who earned his BS and PhD from the department and has since been a steadfast supporter of its goals.

"I think it's important for people who graduate from universities to support the university that helped them along in their career," says Schneider, noting that he placed no restrictions on the gift that funded the renovations other than it must somehow support the department's goals.

The renovations have transformed rooms that hadn't seen a paintbrush since the middle of the 20th century.

"There was old equipment in here from the 1940s and '50s that nobody had touched in years," says Professor Parmesh Ramanathan, referring to a space where he and Assistant Professor Xinyu Zhang now lead a graduate research group in the development of super-high-speed wireless communications technologies.

The new laboratory has a fresh coat of paint, and new carpets and furniture. But the truly important changes go beyond the cosmetic updates, and there are electrical outlets galore that make the lab a dynamic and adaptable space.

Ramanathan says the renovations—on the third floor of Engineering Hall—are a welcome improvement for students and faculty and, importantly, a significant asset for recruiting top-notch mobile systems researchers to UW-Madison.

"The department wants to be known for research in several areas, and one of those areas is mobile systems," says Ramanathan, noting that ECE has made four faculty offers this year in an effort to beef up that research area.

Top-notch facilities are a hugely important asset in recruiting and retaining top researchers, he says, noting that UW-Madison is facing tougher competition from other institutions all the time.

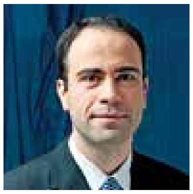
"When I took these faculty candidates to these rooms as possible places where their graduate students are likely to work, they were all very impressed," Ramanathan says. "They had been interviewing at many places and they said they don't see this kind of facility elsewhere."

The newly remodeled rooms, which were all completed during the 2015-16 academic year, join other recently renovated spaces that make UW-Madison's ECE department a particularly attractive place to teach and conduct research, Ramanathan says.

"If you combine these new labs with the remodeling of the Plexus Collaboratory and the Qualcomm design labs, it's a fantastic asset," he says.

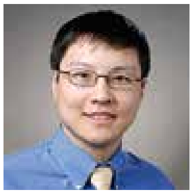
The Plexus Collaboratory and Qualcomm design lab are interactive classrooms that house multifunctional workstations for students.

Zhang and Ramanathan and their students currently are working on millimeter-wave wireless technology that has the potential to dramatically improve wireless data speeds among other applications. They're also researching the potential of LED lights for wireless signal transmission. So-called "LiFi" could transform wireless networks with the ability to send and receive wireless signals from indoor and outdoor LED lighting systems.



Associate Professor **Nader Behdad** is among four College of Engineering faculty who were named 2016 Vilas Associates by the UW-Madison Graduate School. The prestigious awards fund some of the university's highest quality research and are doled out following a competitive application process. Each Vilas Associate receives up to two years of salary support and $25,000 in flexible research funds.

Behdad is working on material folding techniques similar to origami that could create unique electromagnetic properties, eventually leading to technologies—including active camouflage skins—that offer stealth capability across radio frequency, microwave and mm-wavebands.



The American Institute for Medical & Biological Engineering (AIMBE) elected Lynn H. Matthias Professor and Vilas Distinguished Achievement Professor **Hongrui Jiang** as a fellow in recognition of his pioneering, innovative work.

Fellows in the AIMBE represent the top 2 percent of researchers in the medical and biological engineering community. The organization selects candidates for fellowship based on peer-nominations identifying outstanding leaders and innovators in the field.

This is the third professional society in as many months to recognize Jiang's cross-disciplinary research. He was also recently named a fellow of the Institute of Physics and the Royal Society of Chemistry.

Assistant Professor **Mikhail Kats**' research manipulates the optical properties of materials with nanoscale modifications. His findings shine a light on novel approaches to make materials invisible. Seeing the potential in Kats' work, *Forbes* named him as one of the 30 most promising young innovators currently working in science.

Forbes' annual 30 Under 30 list showcases top talents at the beginning of their career. Three expert judges evaluated each awardee's track record and future potential. UW-Madison researchers were heavily represented on the roster this year, with both Kats and Assistant Professor of Chemistry Trisha Andrews receiving recognition.

Kats joined UW-Madison in September of 2014. During his first few productive years as an independent researcher, he made highly visible contributions to the advanced optics field, with publications appearing in *Science, NanoLetters,* and *Applied Physics Letters*. Currently Kats advises five graduate students, and he is looking to grow his lab during the coming year.

Morrow honored with college excellence award

On Feb. 11, 2016, College of Engineering Dean Ian Robertson honored eight individuals whose service to the college and to their profession goes above and beyond. Each of these people was nominated by—and chosen by a committee of—their peers. Associate Professor Kati Morrow was among the award recipients, and earned the **Harvey Spangler Award for Technology Enhanced Instruction**.

Alumnus Harvey Spangler recognized that technology can greatly enhance the learning experience for students, making it a crucial part of the instructor's toolbox. The rapid growth of technology in teaching allows the opportunity to greatly enhance student learning.

UW-Madison has been a leader in innovative teaching in engineering. Two electrical and computer engineering courses—*Introduction to Computer Engineering* and *Digital System Fundamentals*—exemplify this constant and necessary adaptation of the classroom setting.

Through a deep commitment to blended learning, Morrow "flipped" these two courses—which are required for electrical engineering and computer sciences students—into technology-enhanced, active-learning formats.

"ECE 252 and 352 are premier examples of what can be done when good pedagogy and effective technology are paired," says Elizabeth Harris, assistant director for teaching and learning for the college.

Not only do students' grades reflect their increased understanding of the material, the students themselves rate the courses positively. "Professor Morrow's understanding of how to convey information to students is unmatched by most professors at UW," says electrical engineering undergraduate Jonathan Enz. "Students walk out of her classroom familiar with concepts they would never expect to fully understand after just one semester. Professor Morrow is the ideal instructor for this teaching award."

Cancer-therapy spinoff company joins Johnson & Johnson

On March 7, 2016, Ethicon, a medical device company within the Johnson & Johnson corporate family, announced an agreement to acquire NeuWave Medical Inc., a spinoff company founded by Professor Daniel van der Weide and Fred Lee, Jr., the Robert Turrell Professor of Imaging Science in radiology.

NeuWave manufactures minimally invasive devices that enable surgeons to precisely target and destroy tumors without causing collateral damage to the patient. Surgeons use NeuWave's technology to target tumor masses with tiny needle-shaped applicators that emit microwave power and kill cancerous cells—a treatment called thermal ablation. Since the company's establishment, tens of thousands of people around the world have been successfully treated with the NeuWave system, including more than 400 patients at UW Hospital.

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

Department of Electrical & Computer Engineering
1415 Engineering Dr.
Madison, WI 53706

Alvarados renew support for global student experiences

Longtime College of Engineering supporters Carla and Fernando Alvarado are renewing their commitment to providing unique global learning opportunities to engineering students.

Fernando, professor emeritus of electrical and computer engineering, and Carla, a research scientist emerita in the college Center for Quality and Productivity Improvement and a PhD graduate of UW-Madison's industrial engineering program, recently announced a planned estate gift to support the existing scholarship in their name.

Carla and Fernando

The Alvarado Global Experience Scholarship, established in 2006 through an endowed gift from the couple, supports engineering students studying abroad with $1,000 scholarships. The Alvarados created the scholarship fund because they saw a need for assisting students who proactively seek ways to deepen their learning and broaden their worldviews.

"Carla and I created and continue to support the Alvarado Global Experience Fund because we think that the most important thing we can do for the world is to help with education," says Fernando. "And the most important thing a well-rounded education can do is expose students to the richness and diversity of the world."

The Alvarados add that, while UW-Madison is a top-notch institution for learning, they want students to be aware of how much more there is to experience and learn about globally. "Students who are aware of today's world are likely to be better engineers and better citizens as a result of exposure to other places and cultures," Fernando says.

The scholarship fund, and the Alvarados' renewed commitment to it, is meant to support engineering students who might not otherwise have the opportunity to experience cultures and scholarly pursuits outside of Wisconsin. The Alvarados say their hope is that students who study abroad will learn that "there are also talented, creative and well-meaning people in other places, no matter their upbringing."

The Alvarados place very few restrictions on the awarded funds, and leave most of the proceeds to be spent at students' own discretion.

Betsy Burns, of the UW Foundation, says that planned gifts like the one just announced by the Alvarados are as important to the university's long-term goals as all other gifts. "Planned estate gifts are so important because they create a legacy moving forward," says Burns. "This estate gift from the Alvarados will only strengthen the engineering Global Experience Scholarship program."

Fernando says that's the aim of the Alvarados' latest gift: "We hope not only to leave a lasting legacy for engineering students in Wisconsin, but we also hope to continue to inspire others to do the same."