College of Engineering
University of California, Berkeley
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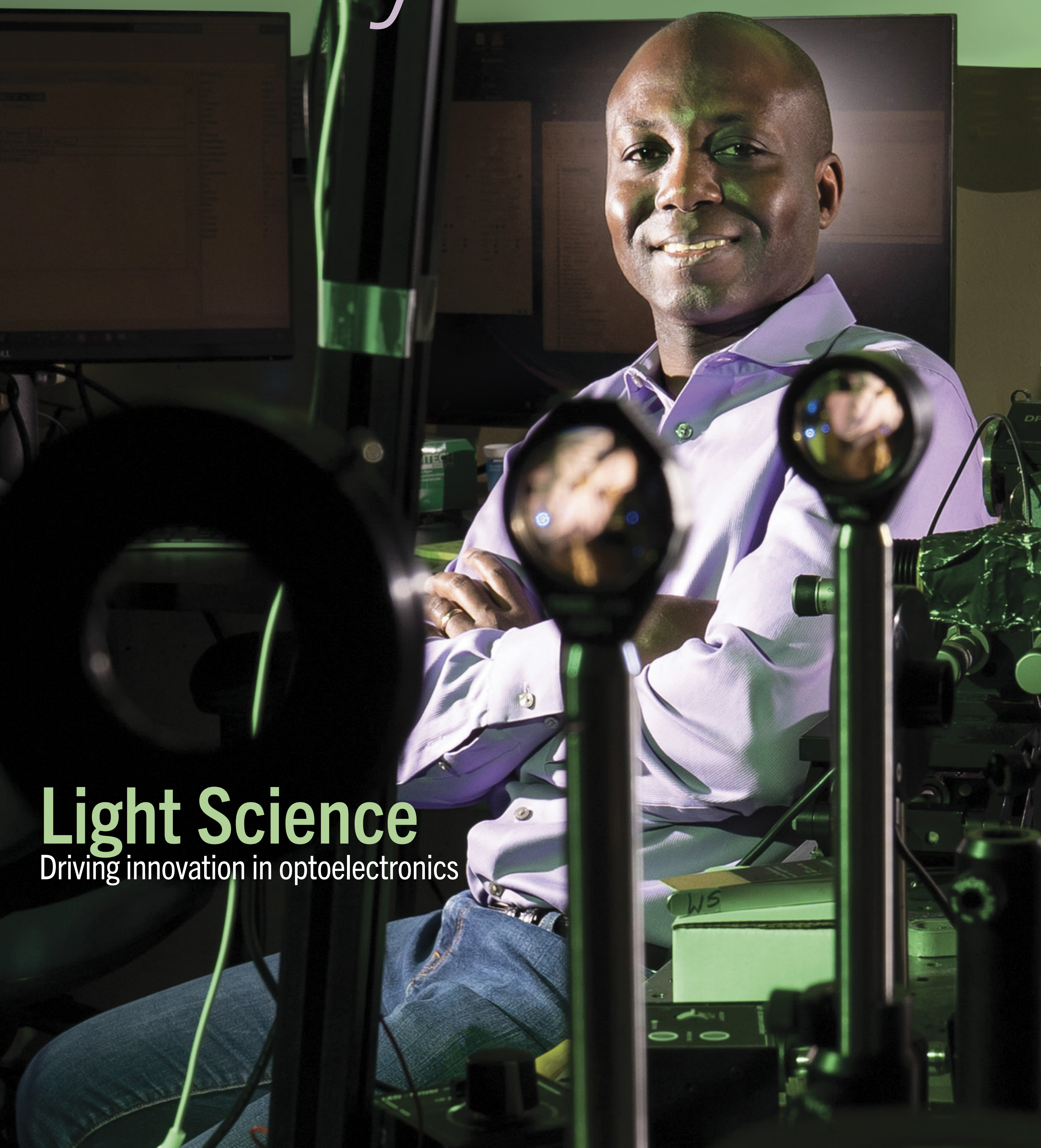
Volume 25

Cool it down
Advances in preserving biomaterials

Ready to roll
How BB-8 makes its moves

Berkeley ENGINEER



Light Science
Driving innovation in optoelectronics

Building on strength

Earlier this year, UC Berkeley celebrated the extraordinary success of its Light the Way campaign, which raised more than $7.3 billion, far exceeding the original ambitious goal of $6 billion. The fundraising total included $900 million for Berkeley Engineering in support of our research programs, faculty and students — including a new Engineering Center that is slated to open early next year.

The campaign has established a strong foundation upon which to build, as it engaged almost 18,000 unique donors over the course of 10 years. Looking ahead, the college's priorities will be to modernize and expand the capacity of our facilities for research, teaching and learning; to support new faculty hiring and graduate student fellowships; and to enhance the success and well-being of all our students.

Solutions to pressing societal challenges, such as digital authoritarianism, require innovation and collaboration across multiple disciplines. Therefore, we are continually forging new partnerships with other academic units across the campus — building on Berkeley's comprehensive excellence — to cultivate multidisciplinary competency in our future engineering leaders.

One such collaboration that I'm excited about is the Yardi Scholars Program, a scholarship program launched last fall that brings together undergraduate students in Berkeley Engineering and in the Division of Social Sciences in the College of Letters & Science. Run by the Division of Undergraduate Education, this program has an intellectual focus on the intersection of democracy, technology and social change — timely topics as we head into a consequential presidential election with concerns related to disinformation and voting security.

Our newest Berkeley Engineering graduates recently walked across the stage at commencement. I can't wait to see all they will accomplish as agents for positive change in our global society.

Fiat Lux!

—Tsu-Jae King Liu
DEAN AND ROY W. CARLSON PROFESSOR OF ENGINEERING

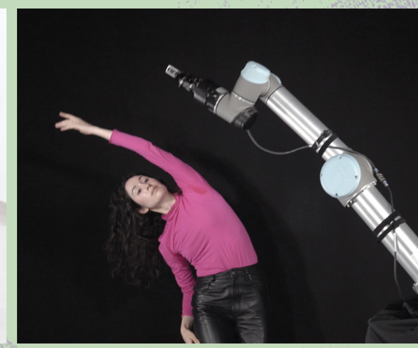
The Light the Way campaign has established a strong foundation upon which to build.

Nobel laureate Jennifer Doudna greets students after delivering this year's Ernest S. Kuh Distinguished Lecture. The UC Berkeley professor of chemistry and of molecular and cell biology spoke about what's next for CRISPR-based genome editing.

Adam Lau

in this issue

Berkeley**ENGINEER SUMMER** 2024



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> COVER: **BOUBACAR KANTÉ, PROFESSOR OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCES**
PHOTO BY **ADAM LAU**

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BIOELECTRICITY

Putting on the heat

Viruses can be useful in many applications, including vaccines, gene therapy and agriculture. Now, Berkeley researchers have found — for the first time — that viruses can generate electricity when exposed to heat, a phenomenon known as pyroelectricity. This finding may pave the way for next-generation biosensors and diagnostic tools.

"We discovered that when we apply heat to virus particles, they undergo structural changes that lead to changes in spontaneous polarization and the generation of electric potential," said bioengineering professor **Seung-Wuk Lee.**

Lee and his team first demonstrated the bioelectric potential of the engineered M13 virus more than 10 years ago. In this latest work, the researchers genetically engineered a portion of the M13 phage's protein coating, then observed and measured the virus' electric response to heat. According to Lee, their findings showed that heat denatures, or melts, the protein coating on the engineered phage, causing a difference in electrical potential.

Next, the researchers investigated the M13 phage's pyroelectric responses to other molecules. Peptides genetically tuned to be responsive to specific nonvolatile and volatile organic compounds were attached to the protein coating of the engineered pyroelectric phages. When these phages were exposed to the different solvents, they generated different pyroelectric responses depending on chemical species and their concentrations.

"Our findings showed that, depending on the chemical receptor, we could easily detect a harmless or a toxic chemical, like xylene," said Lee.

The researchers believe this work could eventually lead to handheld devices that use pyroelectricity to sense other viruses and detect new strains, and it could also shed light on how biomaterials — cells, tissues and proteins — generate electricity at a molecular level.

FACILITIES

New Berkeley Space Center

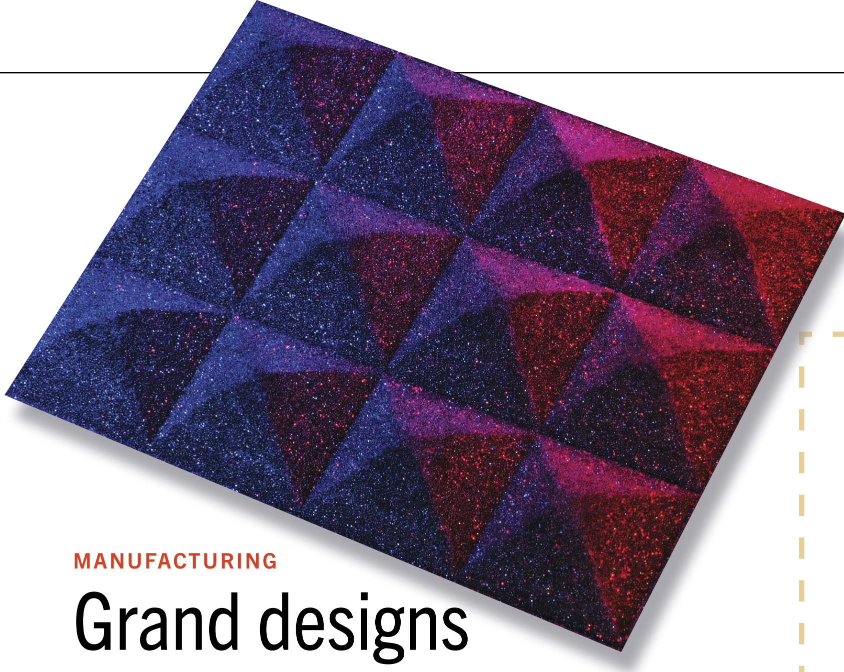
Aiming to generate futuristic innovations in aviation and space exploration, UC Berkeley is teaming up with NASA's Ames Research Center and developer SKS Partners to create the new Berkeley Space Center. The site — which will include research space for companies interested in collaborating with scientists and engineers from Berkeley and NASA — plans to accommodate up to 1.4 million square feet on 36 acres of land at Moffett Field in Mountain View, leased from NASA.

"We believe that the research and the capabilities of a major university like Berkeley could be a significant addition to the work being done at Ames," said NASA Ames Director **Eugene Tu** (B.S.'88 ME). "In a more specific way, we would like the potential of having proximity to more students at the undergraduate and graduate level. We would also like the possibility of developing potential partnerships with faculty in the future."

"The NASA mission is twofold: inspiring the next generation of explorers, and dissemination of our technologies and our research for public benefit," he added. "Collaboration between NASA and university researchers fits within that mission."

The new buildings, some of which could be ready for move-in as early as 2027, will house not only state-of-the-art research and development laboratories for companies and Berkeley researchers, but also classrooms for Berkeley students. These students will benefit from immersion in the Silicon Valley start-up culture and proximity to the nation's top scientists and engineers at Ames. Eventually, Berkeley hopes to establish housing at Moffett Field to make working at the innovation center easier for students.

"This expansion of Berkeley's physical footprint and academic reach represents a fantastic and unprecedented opportunity for our students, faculty and the public we serve," said Chancellor **Carol Christ.** "Enabling our world-class research enterprise to explore potential collaborations with NASA and the private sector will speed the translation of discoveries across a wide range of disciplines into the inventions, technologies and services that will advance the greater good."



MANUFACTURING

Grand designs

Metamaterials like sneaker midsoles and car bumpers are engineered to carry load or resist impact, but designing them to perform as expected can be an error-prone process. Now, Berkeley engineers have developed an innovative design method that leverages AI and additive manufacturing to create better-performing materials and simplify the manufacturing process.

"With our method, a user can input a desired mechanical behavior described by a curve, and this data is then fed into the machine learning code to generate a design — a process that takes only a few seconds. And once that design is 3D printed, it will replicate the desired mechanical behavior," said **Xiaoyu "Rayne" Zheng,** associate professor of materials science and engineering. "While still in its early stages, our machine learning-based design method can produce almost any type of material behavior with nearly 90% accuracy."

To create their approach, the researchers first made an integrated machine learning framework, which consists of an inverse prediction module and a forward validation module. Next, they developed a family of cubic symmetric, strut-based cells to train the machine learning model. The cells' lattice structure makes it possible to achieve almost any mechanical behavior and the corresponding stress-strain curve. The researchers then 3D printed the cells and tested them to generate training datasets.

Using their new method, Zheng and his team fabricated a shoe midsole with the energy absorption and stiffness required by runners. They also demonstrated the potential for designing structures, like car bumpers, that absorb a high amount of collision energy.

According to Zheng, protective gear, soundproofing material and more complex materials like optical film coatings — as well as those featuring band gap or shape memory effects — could also be good candidates for this design and fabrication method. Eventually, this approach may lead to the creation of materials with novel properties.

"This discovery could provide a new paradigm for product and material design," said Zheng. "One in which we are no longer limited to materials found in nature."

ROBOTICS

Ready to roll

BB-8 of Star Wars fame is known for its adorable beeps, dome-shaped head and spherical body. But fighting alongside the Resistance is just one of its many talents. As this spherical robot rolls across surfaces, it's exhibiting holonomy, a phenomenon in rigid body dynamics that Berkeley researchers think may have broad applications in real-life robotics. Now, Ph.D. student **Theresa Honein** and mechanical engineering professor **Oliver O'Reilly** have calculated all the possible changes in the orientation of a rolling sphere in a quest to better understand holonomy.

What is holonomy? "Imagine a tennis ball rolling in a closed path, on a tabletop, so that the center of the ball returns to its original location. Surprisingly, the orientation of the ball will have changed, as you'll notice by looking at the branding markings on the ball," said O'Reilly. "This same phenomenon is exhibited by BB-8. As the robot moves around a room and returns to its original location, the orientation of its spherical part will have changed, albeit camouflaged by the ingenious magnetic mechanism used to orient its head."

In the study, the researchers showed that a sphere tracing a closed path returns to its original position but not always to its original orientation. They also showed that any rotation of a sphere (in three dimensions) can be achieved by tracing rectangles in the plane — and presented dimensions of three rectangles that should be traced consecutively to obtain a desired change in orientation of the sphere.

"The surprising result was that we showed how any change in the orientation of a sphere [in three dimensions] can be achieved by tracing three interlocked rectangles on the plane," said Honein. "This finding used one of three methods for describing rotations developed by the famous mathematician Leonhard Euler in the 18th century."

Their findings may lead to new strategies for achieving more efficient navigation with spherical robots, as well as real-world applications in surveillance, environmental monitoring, and underwater and planetary exploration.

NEUROSCIENCE

So to speak

Human speech has always been an oddity within the animal kingdom. Only a handful of other animals exhibit vocalizations that approach the complexity of human speech, leaving scientists to struggle in identifying its neural and genetic underpinnings. Now, Berkeley researchers, working with scientists at Carnegie Mellon University, have identified the part of the brain in Egyptian fruit bats that controls vocalizations and found that it contains similar neural wiring and genetics to the part of the human brain that controls speech.

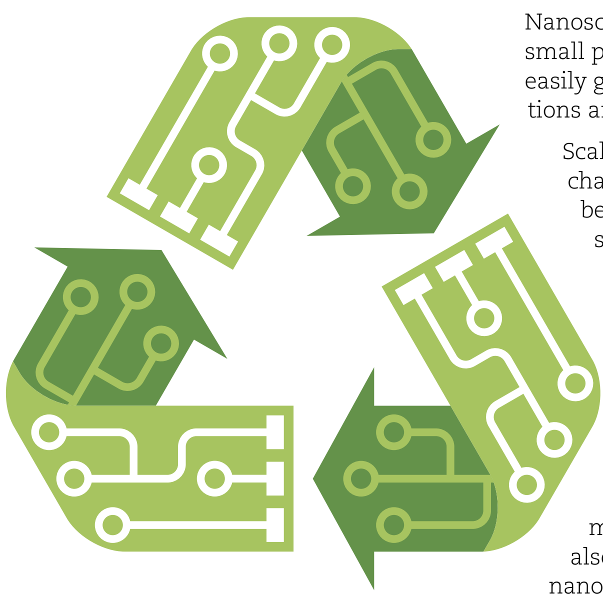
“Very few mammals are actually capable of learning the sounds that they make, which makes it very difficult to study this core aspect of humanity,” said **Michael Yartsev,** associate professor of bioengineering and of neuroscience. “We were able to identify parallels between bats and humans in the structural elements of the brain, the genetic content and even the neural circuitry that control vocal learning.”

To identify the areas of the bat brain associated with vocal learning, co-first authors **Julie E. Elie** and **Tobias Schmid** used wireless neural recording devices to “listen in” on the brains of a group of Egyptian fruit bats as they freely vocalized. The researchers then used anatomical tracers to decipher how these neurons connected with other areas of the bat’s brains. The tracing experiments highlighted a direct anatomical link between a unique part of the motor cortex and the neurons that directly control the bats’ larynx. This direct neural connection acts like a vocal “puppeteer” and could potentially give bats precise control over the pitch of their calls.

The researchers then used a machine learning approach to analyze the genetic elements in the areas of the bat brain associated with vocal production. When compared with those of 222 other mammals — both vocal learners and non-vocal learners — they identified 50 gene regulatory elements that are highly correlated among vocal learners, including humans, bats, whales and seals. The researchers say this study highlights a striking translational potential between basic research in bats and clinical research in humans, and it may have important implications for the treatment of human speech impairments, including autism.

MATERIALS

Going big with nano



Nanoscientists have just proved that good things really do come in (super) small packages. Building on decades of research, they have devised a way to easily grow nanomaterials that are both large enough for industrial applications and recyclable.

Scaling up nanomaterial synthesis into useful materials has been an ongoing challenge, as stacking nanosheets often leads to “stacking defects,” or gaps between the sheets. Now, researchers led by **Ting Xu,** professor of materials science and engineering and of chemistry, and faculty senior scientist at Berkeley Lab, have developed a nanosheet material that self-assembles, forming hundreds of nanosheets simultaneously, without gaps.

To build the nanosheets, researchers used a blend of materials known to self-assemble into small particles with alternating layers of the component materials suspended in a solvent. As the solvent evaporates, the small particles come together and spontaneously organize, coarsely templating layers, and then solidify into dense nanosheets.

The nanocomposite blend can be used to form a protective barrier on multiple surfaces, like the glass screen of an electronic device. The material also can be redissolved and recast to produce a fresh barrier coating. The nanosheets, about the width of a human hair, could radically accelerate the development of sustainable nanomaterials for electronics, energy storage, and health and safety. Such materials may significantly extend the shelf life of consumer products and keep single-use packaging and electronics out of landfills.

Q+A on solar sails

Nearly 70 years after the launch of the first satellite, we still have more questions than answers about space. But a team of Berkeley researchers, led by electrical engineering and computer sciences professor **Kristofer Pister** and mechanical engineering Ph.D. student **Alexander Alvara,** is on a mission to change this. Their idea: the Berkeley Low-cost Interplanetary Solar Sail (BLISS) project, consisting of a fleet of low-cost, autonomous spacecraft, each weighing only 10 grams and propelled by nothing more than the pressure of solar radiation. These miniaturized solar sails could visit thousands of near-Earth asteroids and comets, capturing high-resolution images and collecting samples.

Why solar sails?

AA: Solar sails use a non-consumable propulsion force. They are propelled by sunlight, similar to how a sailboat is propelled by wind. So, unlike other spacecraft, solar sails can travel around the galaxy, or, more specifically, our solar system, without having to carry any fuel or worry about refueling.

KP: The magic is that light, even though it doesn't have mass, has momentum. When light bounces off a mirror, you get a force due to that change in momentum. And on a square meter sail, that force is tiny. It's about the weight of a grain of sand, but you get it for free. And you get it for as long as you want, as long as you're sitting in space with the sunlight striking you.

What are the project's goals?

KP: Our initial goal for the BLISS project was simple: capture images of all the near-Earth asteroids, starting with the biggest ones. Roughly a thousand near-Earth asteroids are bigger than a kilometer in diameter. And we have pictures, usually fuzzy pictures, of maybe 10 of them. We were excited by the idea that you could potentially take an iPhone camera, orbit around one of these things, take a thousand high-resolution color photographs from a very close distance and then beam that information down.

Why make them small?

AA: A smaller size allows the spacecraft to be more agile. We don't have to worry about buckling of the sail, which is just one square meter. This is a huge issue with larger solar sails.

KP: Cost is another advantage to going small…if we do everything right, the cost of the solar sails will be a thousand dollars or less. We could then put thousands of these tiny spacecrafts into a little package, the size of a small satellite, and launch them into space.

What were other key design features?

KP: We're leveraging all the technology, all the miniaturization and low power consumption that goes into the design of cell phones. But there are also many other instruments that MEMS [microelectromechanical systems] has managed to miniaturize.

Our little spacecraft has roughly a 1/2 meter diameter, super-lightweight mirror — maybe the size of a card table — that is connected to the body of the spacecraft by a few carbon fiber filaments. The inchworm [motors] inch their way along those filaments, pulling on the filaments and moving the sail relative to the center of mass of the spacecraft. It turns out that's what you need to navigate — just like on a sailboat. You pull on the lines and change the attitude of the sail through the wind, and that affects direction.

AA: [For navigation], the majority of the analysis is done using something called the Lost in Space [Identification] Algorithm. The idea is that you map the stars that you can see, then compare them to the pixels of the images that you can get from your on-board cell phone camera. So we can basically use smartphones to help navigate.

What might the concept missions look like?

AA: Kris had mentioned earlier sending the solar sails to explore near-Earth asteroids. One of the other main concept missions is cometary sample retrieval, so getting microdust from comet plumes.

KP: As for the mission durations, they vary a lot. It will take us some number of months to get out of Earth's orbit, it will take us months or years to get to the asteroid or comet that we're interested in, and then the reverse of that coming back in. So, certainly months at the short end, and maybe a decade or so at the long end.

HOW DO I FIND OUT MORE? Find links to source articles and expanded coverage at **engineering.berkeley.edu/magazine.**

Bridging the Brain

In the performance piece "Breathless," a UR5e robot arm flails wildly back and forth, as dancer and roboticist **Catie Cuan** arches her full body to mimic its movements. The unnatural effect of the robot's motion becomes that much more heightened when paired with the human body. But Cuan never offers a 1:1 copy; the eight-hour piece aims to spark conversation about the relationship between artificial intelligence and the future of human labor.

So it's fitting that she gave a presentation on this collaboration with **Ken Goldberg,** professor of industrial engineering and operations research and of electrical engineering and computer sciences, in the latter's class, Beyond the Uncanny Valley: Art, AI and Robotics.

A science fiction staple, the "uncanny valley" theory posits that as robots acquire more human-like features, they become more likable — until they don't. That "valley" was charted by Japanese roboticist Masahiro Mori in 1970 to describe the frightening sensation of observing objects that are too human-like.

The course, co-led by **Lisa Wymore** — professor of theater, dance and performance studies — seeks to offer historical context to bridge the artistic and technical understanding of technological advancements in the wake of the AI explosion. The syllabus covers everything from dance to deepfakes, with plenty of insights from guests working at OpenAI, Niantic and the Department of Art.

"I was really interested in teaching students about the history of 'uncanny' that predates the 'uncanny valley,'" Goldberg said. "I would say most engineers don't know that background."

On the flip side, Goldberg also intends to provide context to humanities majors who "don't know the history of AI."

This left brain-right brain approach is seeded into the class structure. One minute, students can hear graduate student instructor **Curtis Rumrill** of the music department unpack his unsettling composition on the violent lifespan of a farmed rabbit. The next, graduate student instructor **Simeon Adebola** of the AUTOLab might explain in detail how machine learning helps robots move.

Goldberg sees this interdisciplinary format as a reflection of the zeitgeist. "These fields are starting to come together in interesting ways," he said. "That's really exciting, because it brings together viewpoints. It's intellectual diversity. Engineers think a little differently than English majors."

STORY BY CAITLIN KELLEY, PHOTO BY ADAM LAU

COOL IT

HOW GROUNDBREAKING FREEZING TECHNOLOGIES CAN PROTECT FOOD, ORGANS — AND EVEN THE PLANET

STORY BY ALAN TOTH | PHOTOS BY ADAM LAU

If you've ever made the mistake of putting certain fresh fruits or vegetables in the freezer, then you're already familiar with the effects of freezing on biological tissue. Banana skins turn black and slimy. Whole oranges leak and deflate. Lettuce comes out limp and soggy. The cause of all this spoilage? Ice crystallization.

Fruits and vegetables, like all biological systems, are mostly water, and when that water freezes, the resultant ice crystals pierce and shred cell membranes like tiny knives. This same thing happens with most of the biological materials that we'd like to preserve — from genetic samples to transplant organs.

DOWN

"If you want to keep something forever, you need to store it at cryogenic temperatures, but ice kills biological tissues. So, how do we get cryogenic temperatures without the ice?" asks Boris Rubinsky, Professor of the Graduate School at the Department of Mechanical Engineering and professor emeritus of bioengineering.

The answer, he has found, lies in a peculiar property of water. Most matter condenses when it solidifies, but water expands, which had Rubinsky and his team wondering: could crystallization be prevented by restricting the expansion of water as it cools? Now, the process that they have devised and refined — known as isochoric preservation — is being used to save corals from extinction, preserve foods and even extend the viability of organ transplants.

Rubinsky first theorized isochoric freezing in 2005, when he proposed a system designed to cool liquid far beyond its freezing point while preventing crystallization. There are chemicals used to prevent crystallization called cryoprotectants, but they're extremely toxic and limit the use cases in biological preservation. Rubinsky aimed to achieve the same outcome with thermodynamics alone. The key was confinement. If enclosed in a robust, air-tight container, water has no room to expand as it freezes.

But achieving isochoric freezing in practice proved more difficult. Matt Powell-Palm (Ph.D.'20 ME), now an assistant professor of mechanical engineering at Texas A&M University, was a Berkeley graduate student in 2019 when he began working with Rubinsky.

Powell-Palm recalls that when he and Rubinsky designed the first isochoric chambers, they struggled to achieve isochoric freezing. In one early experiment, Powell-Palm dipped an isochoric chamber into a cooling bath over and over, but the sample inside just wouldn't freeze. In a moment of frustration, he hit the chamber with a hammer, hoping the vibration might initiate a state change. An idea struck him.

"I thought, what if this bug is actually a feature of some other technique?" Powell-Palm says.

That other technique turned out to be isochoric supercooling, a whole new type of isochoric preservation. Over years of research, Rubinsky and Powell-Palm eventually identified three different varieties of isochoric preservation: isochoric vitrification, isochoric freezing and isochoric supercooling.

As Powell-Palm describes it, these types of isochoric preservation are all low-tech, high-science endeavors. The devices the team developed are little more than fancy metal jars. The only thing that's special about them is that they're designed to anticipate thermodynamic scenarios that might emerge inside. Each is dependent on temperature and cooling speed, and each has different applications, all of which are now being pursued by researchers at Rubinsky's Bio-Thermal Laboratory.

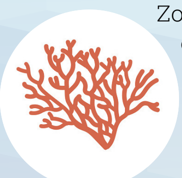
ISOCHORIC VITRIFICATION

Preserving threatened species

Vitrification refers to the transformation of a substance into glass. Biological samples can be vitrified when cooled very quickly to temperatures around -200 degrees Celsius, suspending all biomolecular processes. According to Powell-Palm, so long as temperature is maintained, there is virtually no limit to the duration for which a vitrified sample could be stored. This makes it particularly appealing for preserving genetic samples from threatened species.

Brooke Chang (B.S.'22, M.S.'23 MSE), a visiting scholar in the Bio-Thermal Laboratory and Director of Vitrification Research at BioChoric Inc., joined Rubinsky's coral preservation research team in 2021. Currently studying best practices for preserving coral fragments, Chang was drawn to the project by the challenge of solving basic science questions in the service of conservation, like the design of the isochoric chambers.

On a recent morning, Chang visited the Bio-Thermal Laboratory to demonstrate the design of the chamber used to preserve coral samples. It's just a rectangular jar with two small holes at the top that cause water to be squeezed out of the chamber when a threaded lid is screwed in — all air must be removed because ice forms easily where air and water meet. The jars are composed of an aluminum alloy (aluminum 7075) that combines strength with high thermal conductivity.



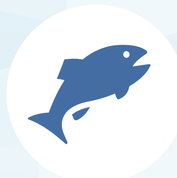
Chang currently works with the Smithsonian's National Zoo and Conservation Biology Institute to vitrify coral samples for preservation and test their revivability. Because of the rapid cooling, the samples are infused with cryoprotectant chemicals, which must be flushed and replaced with water if the coral is revived. Chang recently visited the Hawaii Institute of Marine Biology and worked with marine biologists there to find gentler ways of rehydrating the samples. They haven't yet seen any growth in revived corals, but the samples appear healthy.

"It's great to see things through the eyes of the marine biologists, because they have a completely different perspective. We see the project as engineers, and so we would never notice the kinds of things that they notice," says Chang.

ISOCHORIC FREEZING

Better food storage

While coral can survive inundation with cryoprotectants, those chemicals are completely toxic to humans and can't be used in food preservation. But the relatively slower cooling speeds and warmer temperatures of isochoric freezing make the process ideal for preserving food.



In isochoric freezing, water begins to crystallize around the edges of the chamber, but the expanding ice causes increased pressure that inhibits its own growth. A state of equilibrium is reached in which part of the water is ice, but most is still liquid, even when it reaches temperatures well below the freezing point — around -20 degrees Celsius. If the complicating factor in isochoric vitrification is cooling speed, in isochoric freezing, it's pressure. Alan Lenon Maida, a graduate student researcher in the Bio-Thermal Laboratory, says that pressure can deliver unexpected benefits in food preservation.

The pressure generated by isochoric freezing can range anywhere from 0 to 220 megapascals — double the pressure of the deepest part of the ocean. The team discovered that high pressures can kill bacteria. Though freezing temperatures alone will suspend the growth of bacteria, once thawed the bacteria can bounce back, causing foodborne illness and faster spoilage of the food.

"We're looking for the sweet spot where pressure is high enough to kill bacteria but low enough to preserve quality," said Maida.

A recent study conducted by the lab found that higher pressures were associated with limited preservation time. When frozen at pressures of 75 megapascals, milk could only be stored for five weeks before some of the proteins were altered. Maida said that the ideal pressure would likely turn out to be somewhere between 65 and 75 megapascals.

Commercial applications may not be far off. Rubinsky has spun off a private enterprise, BioChoric Inc., that has licensed Berkeley's patent of isochoric freezing technology to sell commercial units. Some of these were recently sold to the government of Iceland for the purpose of exploring the long-term preservation of fish. The company also has received a $25 million dollar grant from NASA to develop new methods of preserving food for space travel.

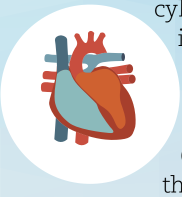
The benefits of utilizing isochoric freezing in food storage could have an even greater impact here on earth. A study conducted by Rubinsky's lab in 2021 found that freezing foods under isochoric conditions might reduce global energy use by as much as 6.49 billion kilowatt hours per year — the resultant decrease in carbon emissions would be equivalent to removing a million cars from the road.

ISOCHORIC SUPERCOOLING

Extending organ transplant viability

In 2021, some 9,000 liver transplants were performed in the United States, and there are more people who need liver transplants than donor livers. According to the Health Resources and Services Administration, of the over 100,000 people waiting for donor livers, 17 die each day for want of one. Liver transplants are further complicated by the need to perform the surgery within 9 to 12 hours of the donor's death.

Through isochoric supercooling, the Bio-Thermal Laboratory hopes to double that transplantation window. Tony Consiglio (M.S.'20, Ph.D.'23 ME), a postdoctoral scholar at the lab, recently demonstrated the isochoric liver preservation chamber. At the heart of the device is a cylindrical aluminum vessel surrounded by cooling units. The device cools the material inside the chamber to -5 degrees Celsius.



A conventional liver transplant is packed in ice and transported at temperatures between 0 and 5 degrees Celsius. Consiglio explains that the colder the storage temperature, the longer an organ can be preserved. If cryoprotectants could be added to the saline mixture that is currently used in the isochoric chamber, they might be able to preserve organs at colder temperatures for longer periods.

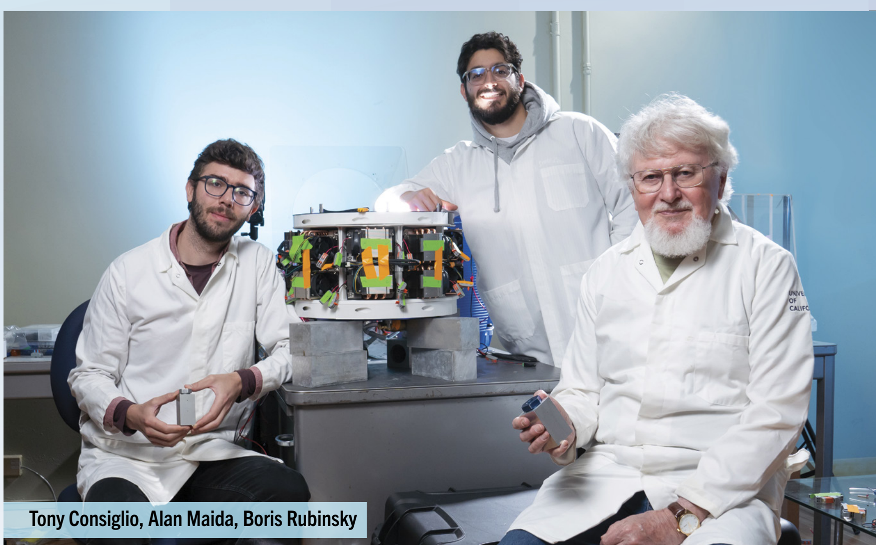
"One of the major challenges that people are trying to solve is how to make these cryoprotectant chemicals less toxic to the organs. If you could do that, you could reduce the temperature even further," says Consiglio.

In a previous study, the team found that they could preserve pig livers at -2 degrees Celsius for as much as 48 hours before tissue changes became apparent. Moving forward, they're partnering with the Department of Surgery at UCSF to test the viability of the technology in human livers. They'll preserve livers donated for scientific research for a period of 24 hours. Once removed from storage, the livers will be evaluated for signs of tissue damage by UCSF gastrointestinal surgeon Tammy T. Chang.

Isochoric supercooling will be more expensive than current organ preservation methods, which involve packing the organs with ice in coolers. But it will likely be much less expensive than other advanced alternatives like normothermic perfusion — machines designed to keep transplant organs alive by flushing them with blood-like solutions and mimicking in-body conditions. The team believes that their isochoric supercooling method will provide a good middle-ground between cost and storage time.

Rubinsky says that such discoveries are possible because of the interdisciplinary nature of his lab. Though isochoric preservation may be low-tech, achieving it requires a thorough understanding of thermodynamics, mechanics and bioengineering. The pursuit of basic science, often yielding simple, elegant solutions, is to Rubinsky's mind, a beautiful process — and he gives a great deal of credit to the undergraduates who've come to his lab and helped advance his research.

"The quality of undergraduates at Berkeley makes all the difference," says Rubinsky. "They're driven by science, they're willing to pursue new ideas, and they're very good." BE



Tony Consiglio, Alan Maida, Boris Rubinsky

"If you want to keep something forever, you need to store it at cryogenic temperatures, but ice kills biological tissues. So, how do we get cryogenic temperatures without the ice?"

Brooke Chang

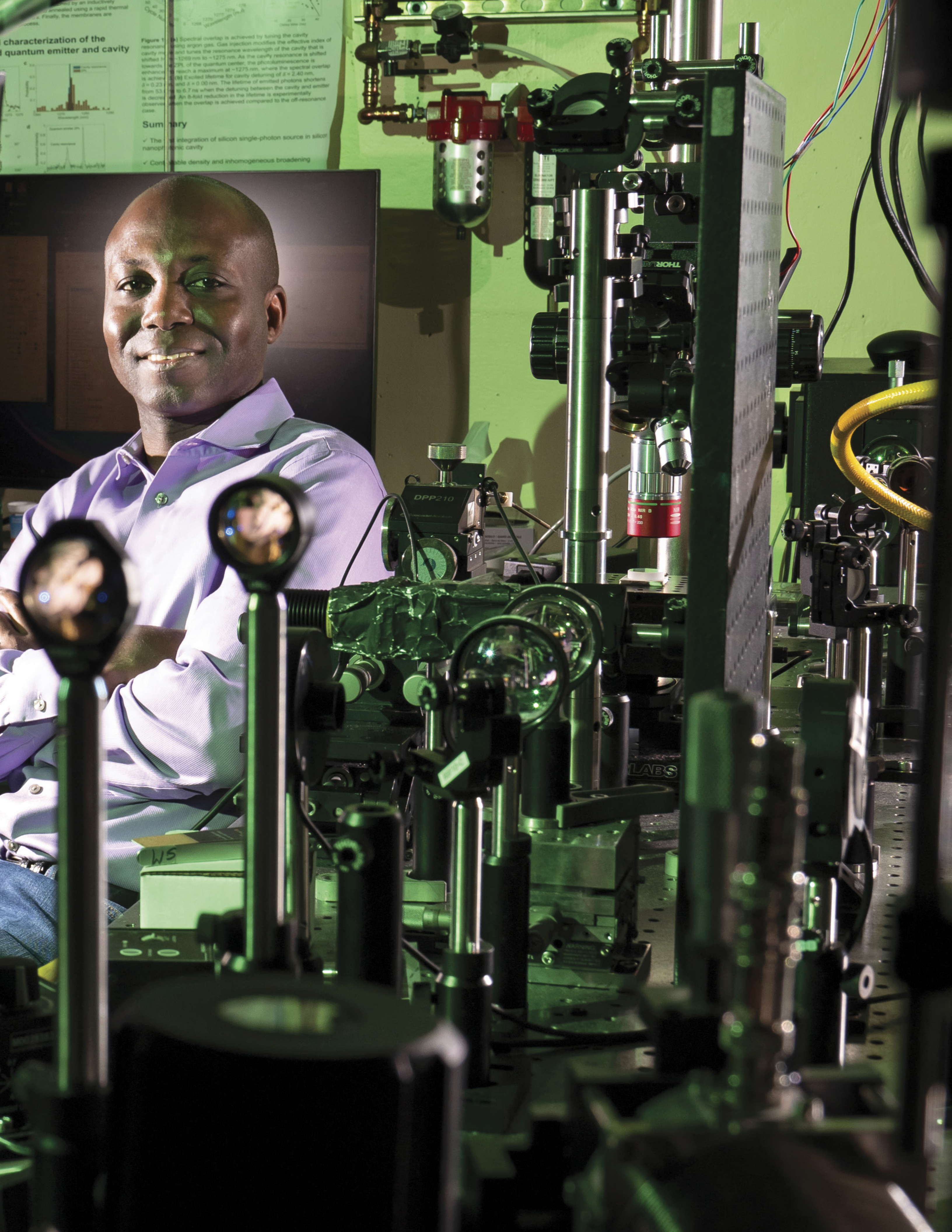
LIGHT SCIENCE

BOUBACAR KANTÉ TAKES ON TOUGH CHALLENGES TO DRIVE INNOVATION IN OPTOELECTRONICS

STORY BY WILLIAM SCHULZ | PHOTO BY ADAM LAU

The ability to commandeer light is both an ancient dream of humanity and a science and engineering challenge that has never been more relevant.

Harnessing light to transfer more information at higher speed has become increasingly critical as data centers reach the limits of copper-wire connections. To solve the perils of climate change, researchers are looking to lasers that can deliver an enormous shot of power, triggering fusion reactions for clean energy. Lasers are also needed in manufacturing, to see processes inside the human body, for wrangling quantum phenomena for a variety of practical applications — and much more.


characterization of the
quantum emitter and cavity
DPP210
THORLABS

Many potential applications of lasers have remained locked or unwieldy for the past 60 years due to fundamental limitations of the technology. But now, that has begun to change, thanks to researchers like Boubacar Kanté, the Chenming Hu Professor of Electrical Engineering and Computer Sciences.

Tackling tough challenges comes second nature to Kanté. Among his many achievements from the seemingly impossible category, he is perhaps best known for work developing a new type of semiconductor laser — the Berkeley Surface Emitting Laser (BerkSEL).

When first announced in 2022 in a landmark paper, BerkSEL technology resolved a decades-long challenge in wave-physics: The ability to emit a single mode of light while scaling up in size and power. The new type of laser means that increases in size do not have to result in a loss of coherence, which is light of a single wavelength being beamed out in one direction.

Coherence is what enables lasers to be more powerful and to cover longer distances, making them suitable for a range of applications. Researchers typically use external mechanisms, such as a waveguide, to amplify laser beams and circumvent loss of coherence.

But using another medium to amplify laser light takes up a lot of space, Kanté says. By eliminating the need for external help, the BerkSEL can be smaller, thus increasing the efficiency of computer chips and other components in a range of consumer and industrial applications that rely on lasers.

"Researchers have been trying since the 1960s to build a single-mode laser that can be scaled up in size and power," says Kanté. "Now, we have met the challenge, demonstrating both of these qualities in a laser. This will likely stand as one of the most important papers published by my group."

Rushin Contractor (Ph.D.'23 EECS), one of Kanté's former graduate researchers who now works with him on commercial development of the BerkSEL, recalls the early days when they first began research on the new laser.

Kanté "assigned me to look at some possible ideas — what were some developments in physics discovered five or 10 years ago but never really applied for anything? Then I found that maybe there's a certain combination of electromagnetic fields that can give rise to these [BerkSEL-like] effects," Contractor says. "But I was also asking the question, what if we make this into a realistic device? Will it work?"

It did. And now, experts say the BerkSEL will lead to more powerful and efficient lasers for industrial materials processing; communication networks; military applications; small, unmanned spacecraft propulsion; and semiconductor lasers for carbon-free fusion energy. Moreover, the new strategy may also provide insights for longstanding problems in basic physics research.

"YOU HAVE TO CHOOSE WELL"

The BerkSEL and Kanté's other research successes are part of his personal journey, one that spans cultures and continents. He says he has been interested in science since his childhood in Gabon, where his family moved shortly after his birth in Mali. His father, a high school science teacher, provided early inspiration; Kanté's young life was steeped in learning and the values of discipline and hard work.

Following undergraduate studies in science in France, Kanté says, he began to zero-in on the problems he found interesting and wanted to tackle.

"At first you're interested in everything," he says of the challenges. "But then you realize you can't do them all. You have to choose well in order to contribute to science and engineering."

For Kanté, those contributions began in earnest with a 2009 paper reporting a nonmagnetic metamaterial cloak at microwave frequencies. He co-authored the paper as part of his doctoral studies at the University of Paris Saclay.

Cloaking, or the ability to render objects invisible, is an ancient human dream, Kanté explains. The rise of metamaterials — engineered materials with unique electromagnetic properties offering extreme control over optical fields — has awakened new efforts to create invisibility cloaks that would have numerous applications, especially related to national security.

Kanté and his coauthors created an invisibility cloak in free space that had the biggest concealed region reported at the time. They did so with split ring resonators, devices embedded in a silicone matrix operating at microwave frequencies and based on electric rather than magnetic response. The nonmagnetic approach was key, allowing for the scaling of the cloak from microwave to optical regions of the spectrum.

MORE THAN A MATHEMATICAL CURIOSITY

Following his doctoral studies, Kanté's first faculty position took him to UC San Diego, where his research interests evolved from the microwave and radar parts of the spectrum to optics. He would go on to demonstrate the world's first topological laser based on the quantum Hall effect for light, and his interest in wave physics — in particular, a concept in quantum mechanics called bound states in the continuum (BICs) — began a series of pathbreaking discoveries in light science.

For many years, Kanté explains, BICs were regarded as little more than a mathematical curiosity. In time, however, researchers came to understand BICs as a wave phenomenon that could exist outside the purely theoretical realm of quantum mechanics. These bound states were shown to occur in many different fields of wave physics, including acoustics, microwaves and nanophotonics.

What attracted the attention of researchers like Kanté is that BIC waves remain perfectly confined, or bound, in open systems. They will not escape like other waves in an open system. Being able to confine laser light in this way would be highly advantageous. The ability to elicit lasing action from a BIC, however, remained elusive.

But then, in 2017, Kanté led a team that reported room temperature lasing action from an optically pumped BIC.

The BIC laser Kanté developed is made of a thin semiconductor membrane consisting of indium, gallium, arsenic and phosphorus. The membrane is structured as an array of nanosized cylinders suspended in air. The cylinders are interconnected by a network of supporting bridges, which provide mechanical stability to the device. By powering the membrane with a high frequency laser beam, Kanté and coworkers induced the BIC system to emit its own lower-frequency laser beam at telecommunication frequency.

A larger quantum number means light can expand its vocabulary

The technology, he says, could revolutionize the development of surface lasers, making them more compact and energy-efficient for applications in communications, computing, sensing and more. The new BIC lasers could also be developed as high-power lasers for industrial and defense applications.

A WIDE RANGE OF INTERESTS

Since Kanté's arrival at Berkeley in 2019, his research interests have included areas of wave-matter interaction, from microwave to optical wavelengths, and related fields such as antennas, nanophotonics, novel materials and quantum optics.

Continuing his interest in topological lasers, Kanté's group, in 2021, demonstrated the emission of discrete twisting laser beams from antennas made up of concentric rings, roughly equal to the diameter of a human hair, and placed on silicon chips.

The work is based on the orbital angular momentum (OAM) of light, a property that has attracted the interest of researchers because it offers exponentially greater capacity for data transmission. One way to think about OAM, Kanté says, is to compare it to the vortex of a tornado.

By applying a magnetic field perpendicular to the ring microstructure, Kanté's team generated three OAM laser beams traveling in circular orbits above the surface of a chip. The laser beams had as many as 276 twists of light — referred to as their quantum number — in one wavelength, around an axis.

A larger quantum number means light can expand its "vocabulary," Kante says. His group has demonstrated the capability at telecommunication wavelengths, but it could also be adapted to other frequency bands. And though his team created just three lasers, multiplying the data-rate capacity by three, he says there is no limit to the possible number of beams and data capacity.

Kanté's work in topological lasers is just one example of his wide range of scientific interests. Students from a variety of backgrounds in science have become aware of his research group, and it is a draw for those looking for the cutting edge.

"He's definitely a very hands-on group leader," says electrical engineering and computer sciences doctoral student Emma Scott Martin, who works on designing photonic crystal lasers. "He's always [wanting to know] what everyone is up to. Especially as a new student who doesn't have as much experience, that's definitely a positive thing."

ADVANCING QUANTUM OPTICS

Indeed, when he presents his work at scientific meetings, or just in conversation, Kanté's passion for work in the laboratory is obvious. At one recent meeting, he gave a whirlwind presentation of his group's work in semiconductor lasers, including his breakthroughs in confining light in nanocavities. Just last year, his group demonstrated the first on-demand quantum light source using silicon — the material upon which millions of tiny electronic devices are manufactured each day, and the most "scalable" optoelectronic material known. Among the exciting potential applications is a source of photons for a quantum internet.

A quantum internet at scale, Kanté explains, would require not only a bright and efficient quantum light source but also photons that can propagate in existing optical fibers without being absorbed. No light source available today can meet that high bar.

The on-demand silicon quantum light source developed by the Kanté Lab is the first experimental work demonstrating integration of a single silicon atomic emissive center, known as the G center, directly in a silicon nanophotonic cavity. For the first time, his team embedded an atomic defect in silicon the size of an atom (1 angstrom) in a silicon photonic cavity (1 micron) with the size of less than one-tenth of a human hair.

The cavity forces the atom to be brighter, and it emits photons at a faster rate, Kanté says. "Those are necessary ingredients for scalable quantum light sources for the future [quantum] internet."

Manufacturing of the single-photon emitters involves a controlled fabrication sequence, starting with a commercial-grade silicon wafer that is carbon implanted. The implantation is followed by lithography, etching and thermal annealing — all standard processes available in today's semiconductor foundries. Kanté says his team has overcome some of the key challenges, but improvements are needed, and many questions are yet to be answered.

A 2023 study on this work was led, in part, by Walid Redjem, who joined Kanté's group in 2020 as a postdoctoral researcher after completing his Ph.D. in quantum optics. At first, Redjem wondered how he would fit in with the rest of the lab, as Kanté's research up to that point aligned more with classical optics. But he says Kanté's solution was simple: Redjem was to start a new area (of quantum optics) in his group.

"He is always trying to explore, always ready to try new things," Redjem, now at State University of New York at Albany, says of Kanté. "He doesn't want to sit in one place.

"It wasn't easy every day," Redjem continues. "But in the end, I have learned a lot [from Kanté] about how to think about science, how to work with the best people, always trying to be impactful, trying to push the limits."

Kanté says, "I tell people the problems I want to solve, and while I may not have the entire solution, I can tell you why I think the problems can be solved." He says at Berkeley he has found the support and the students with capabilities "for all of this to come together for discovery." BE

Rebecca Abergel, associate professor of nuclear engineering and of chemistry; **Boubacar Kanté,** professor of electrical engineering and computer sciences; and **Jay Keasling,** professor of bioengineering and of chemical and biomolecular engineering, have been awarded the 2024 Bakar Prize, which is designed to give a boost to campus innovators as they translate their discoveries into real-world solutions.

Clarivate has included nine Berkeley Engineering faculty members on its list of "Highly Cited Researchers" for 2023: bioengineering: **Paul Adams** and **Jay Keasling;** electrical engineering and computer sciences: **Ali Javey;** materials science and engineering: **Jill Banfield, Gerbrand Ceder** (Ph.D.'91 MSE), **Kristin Persson, Ramamoorthy Ramesh** (Ph.D.'87 MSE) and **Junqiao Wu** (Ph.D.'02 AS&T); materials science and engineering/mechanical engineering: **Robert Ritchie.**

Gopala Krishna Anumanchipalli and **Grigory Tikhomirov,** assistant professors of electrical engineering and computer sciences; Derfogail Delcassian, assistant professor of bioengineering; and **Amy Pickering** (M.S.'04 CEE), assistant professor of civil and environmental engineering, have been selected as 2023 Hellman Fellows.

Alexandre Bayen, professor of electrical engineering and computer sciences and of civil and environmental engineering, has been appointed the director of CITRIS.

Colleen Bronner (M.S.'06 CEE) has been honored with UC Davis' 2023 Women & Philanthropy Impact Award. She is an associate professor of civil and environmental engineering and vice chair of undergraduate studies at the College of Engineering at UC Davis.

Electrical engineering and computer sciences professor emeritus **Constance Chang-Hasnain** (M.S.'84, Ph.D.'87 EECS) has won the IEEE Nick Holonyak Jr. Medal for Semiconductor Optoelectronic Technologies.

Alvin Cheung, associate professor of electrical engineering and computer sciences, has won the 2023 Very Large Data Bases Early Career Research Contribution Award.

Electrical engineering and computer sciences assistant professor **Natacha Crooks** has won the IEEE Technical Committee on Data Engineering Rising Star Award "for contributions to distributed data management, and its applications to blockchain technology, security and cloud computing."

Civil and environmental engineering assistant professor **Maria Laura Delle Monache** has received the 2023 IEEE ITSS Young Researcher/Engineer Award "for contributions to modeling, control and large-scale testing of intelligent transportation systems."

Andrea Goldsmith (B.S.'86, M.S.'91, Ph.D.'94 EECS), dean of Princeton University's School of Engineering and Applied Science, has been named to the National Inventors Hall of Fame for her pioneering work in wireless communications and information theory.

UC Berkeley's Graduate Division announced the recipients of this year's mentoring awards, including **Allen Goldstein,** professor of civil and environmental engineering and of environmental science, policy and management; **Kara Nelson,** professor of civil and environmental engineering; **Lisa Yan** (B.S.'13 EECS), assistant professor of electrical engineering and computer sciences; and **Myoungseok Kim** and **Federico Mora Rocha,** electrical engineering and computer sciences Ph.D. students.

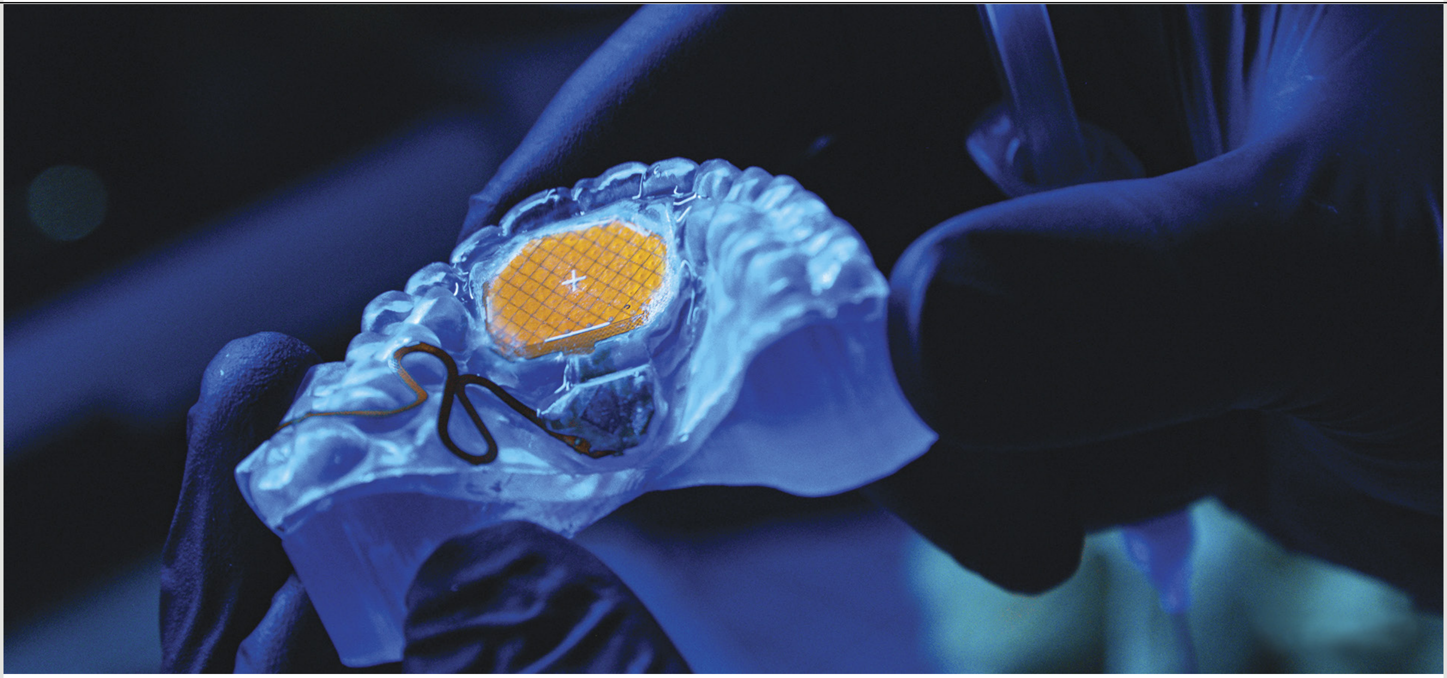
Julia Griswold (M.S.'10, Ph.D.'13 CEE) is the new director of UC Berkeley's Safe Transportation Research and Education Center, a partnership between the Institute of Transportation Studies and the School of Public Health focusing on transportation, bicycle and pedestrian safety.

Grace Gu, assistant professor of mechanical engineering, was honored with the Orr Early Career Award at the 2023 ASME International Mechanical Engineering Congress and Exposition.

Giulia Guidi (Ph.D.'22 CS), assistant professor of computer science at Cornell University and an affiliate researcher at Berkeley Lab, has been honored with an Early Career Prize from the Society for Industrial and Applied Mathematics Activity Group on Supercomputing for her work in applying high-performance computing to computational genomics.

Last October, President **Joe Biden** presented **Ashok Gadgil,** professor of the graduate school at the Department of Civil and Environmental Engineering, with the National Medal of Technology and Innovation, the nation's highest honor for technological achievement. Known as a "humanitarian inventor," Gadgil has worked for decades to create low-cost, robust solutions to some of the world's most challenging problems. His work, including safe drinking water technologies and fuel-efficient cookstoves, has proved transformative for low-resource communities, helping more than 100 million people across four continents.

PHOTO COURTESY OF THE WHITE HOUSE



A new paradigm

Designing devices for people with disabilities demands more than engineering know-how; it requires a desire to understand the different ways we all interact with the world. For **Corten Singer** (B.A.'17 CS, B.A.'17 CogSci, M.S.'18 EECS), nothing is more fulfilling than developing assistive technologies that impact everyday lives.

Now, he's poised to do just that. With fellow alum **Tomás Vega** (B.A.'17 CS, B.A.'17 CogSci), Singer has co-founded Augmental, an assistive technologies company that has developed a unique tongue-controlled touchpad, MouthPad^.

MouthPad^ transforms the concept of the computer mouse or trackpad into a Bluetooth-enabled device that rests like a retainer on the roof of one's mouth. By sliding or pressing their tongue, or even creating reverse pressure in their mouth with a "sip" gesture, MouthPad^ users can direct their cursor to perform standard operations like click, click-and-drag and right click. The device also features a pressure sensor and a motion sensor, so that head movement and other gestures can be used for input.

"This is to enable more universal access to the control of one's personal devices — computer, smartphone, tablet," said Singer. "Such access doesn't depend on using the hand-based paradigm, which has pretty much dominated computer interaction for decades."

It was at Berkeley, while spending time with friends who were part of the Berkeley Disabled Students' Program, that Singer took a deep dive into assistive technology. He and some classmates, including Vega, hacked an automatic door-opening motor. Their custom-made app allowed a sensor to detect when a user flexes or squeezes their hand muscles, triggering the door open command.

Later, as part of his embedded and cyber physical systems class, EECS 149, Singer built a self-driving, obstacle-avoiding wheelchair. "This work was foundational to the internship I later did at Microsoft — in which I designed gaze-based wheelchair navigation interfaces for people with ALS and other neurodegenerative diseases — and, ultimately, my master's project," said Singer.

As a master's degree student, Singer worked with **Björn Hartmann,** associate professor of electrical engineering and computer sciences. The CITRIS Invention Lab played a key role during this time, not only providing a community, but also cutting-edge resources and around-the-clock access for superusers like Singer.

Still, Singer never envisioned becoming an entrepreneur. But that changed after a call from Vega, who proposed designing an interface system for people with spinal cord injuries. The idea was to use the tongue, what Singer and Vega like to call "the eleventh finger" because of its incredible dexterity and ability to move around with precision and ease of control.

"This was in the realm of assistive technology, which I love, but it even spoke to this future in which we kind of change the paradigm of human-device interaction for everyone, even people without mobility issues," he said.

Since founding Augmental, Singer and Vega have been featured on the Forbes' "30 Under 30" list, won the Innovation Grand Prix at the 2023 Cannes Lions International Festival of Creativity and were named the grand prize winner at this year's Consumer Technology Association Foundation's Pitch Competition.

As for Singer, he remains passionate about assistive technologies and human-centered design. "My time at Berkeley and working on MouthPad^ have taught me how important it is to iterate the design process based on feedback from real users," he said. "It's the best way to ensure that I don't just design a cool engineering solution, but something that is truly useful to people."

STORY BY MARNI ELLERY | PHOTO COURTESY OF AUGMENTAL

Dan Gutierrez (M.S.'17 CEE), resident officer in charge of construction at Norfolk Naval Shipyard, has received the Military Engineer of the Year Award from the Naval Facilities Engineering Systems Command Atlantic for his exceptional contributions to naval engineering.

John Randolph Haag (B.S.'75 ME/NE) has been appointed president and CEO of Neutrex Inc., the manufacturer of Purgex-brand purging compounds used to remove contamination and colorants from plastic molding machinery. Previously, he was general counsel of Neutrex and a California litigation attorney handling business, technology and other disputes.

Assistant professors of electrical engineering and computer sciences **Nika Haghtalab, Preeya Khanna** (Ph.D.'17 BioE) and **Sophia Shao** have been named 2024 Sloan Research Fellows. Additionally, Haghtalab and **Jacob Steinhardt,** assistant professor of computer science and of statistics, have been named Schmidt Sciences' AI2050 Early Career Fellows.

Deirdre Hanford (M.S.'85 EECS) has been named the first chief executive officer for Natcast, the new entity created to operate the CHIPS for America National Semiconductor Technology Center.

Electrical engineering and computer sciences associate professor **Björn Hartmann** has been elected to the Special Interest Group in Computer-Human Interaction Academy, an honorary group of individuals who have made contributions to shaping the field of human-computer interaction.

Bioengineering professor **Amy Herr** has won the 2023 Microsystems & Nanoengineering/Springer Nature Test of Time Award, which recognizes research presented at MicroTAS within the last 10-15 years that is still impacting research in microfluidics.

Professor emeritus of electrical engineering and computer sciences **Chenming Hu** (M.S.'70, Ph.D.'73 EECS), former chief technology officer at Taiwan Semiconductor Manufacturing Company, has been awarded the Taiwan Presidential Science Prize.

Rachel Huang (B.S.'17 MSE), **Drew Lilley** (Ph.D.'23 ME), **Connor Tsuchida** (Ph.D.'23 BioE) and **Ivana Vasic** (Ph.D.'22 BioE) were named to Forbes' "30 Under 30" list. Huang, a postdoctoral researcher at the University of Texas at Austin, developed a non-flammable electrolyte for lithium batteries. Lilley is the founder and CEO of Calion Technologies, where he is working to commercialize his doctoral research on ionocaloric heating and cooling. Tsuchida's research formed the basis for Azalea Therapeutics, a CRISPR delivery startup. Vasic is the founder of Vitra Labs, which is developing therapies to make in vitro fertilization safer and more accessible.

David Jaber (M.S.'95 CEE) is teaching the course "Carbon Management and Business Strategy" at UC Berkeley Extension.

Ari Juels (Ph.D.'96 EECS) published "The Oracle," a crypto thriller novel, in February. He is a computer science professor at Cornell University, as well as the co-director for the Initiative for CryptoCurrencies and Contracts.

Dean **Tsu-Jae King Liu** has won the IEEE Founders Medal "for leadership in the advancement and commercialization of nanometer semiconductor technologies and the promotion of microelectronics workforce development."

Simge Küçükyavuz (M.S.'00, Ph.D.'04 IEOR), chair and professor of industrial engineering and management sciences at Northwestern University, has been named a 2023 INFORMS Fellow.

Wilbur Lam (Ph.D.'08 BioE), professor of pediatrics and biomedical engineering at Emory University and Georgia Tech, has been named a member of the National Academy of Medicine.

Electrical engineering and computer sciences professor emeritus **Kam-Yin Lau** has won the IEEE/RSE James Clerk Maxwell Medal "for spearheading high-speed semiconductor lasers and RF-over-Fiber Systems, enabling today's wireline and wireless broadband access."

Kristin Persson, professor of materials science and engineering, has been elected as a foreign member of the Royal Swedish Academy of Sciences in its 2024 Class for Chemistry. The academy, consisting of approximately 480 Swedish and 175 foreign members, has awarded the Nobel Prizes in physics and chemistry since 1901.

"It is truly an honor for me to be recognized by the oldest academy of my home country," said Persson. "The goal of the Royal Swedish Academy of Sciences resonates strongly with me, as I have focused my career on the realization, adoption and democratization of large-scale, computed materials data, for the benefit of engineers and scientists worldwide."

PHOTO BY CHRISTOPHER KUMAI

Monique Lebrun (M.S.'03 CEE) has been named the director of the Port of Long Beach's program management division.

Paul Lee (M.S.'16 CEE) is one of the civil engineers featured in the American Society of Civil Engineers' second IMAX film, "Cities of the Future: Reimagining Our World." He is currently an energy policy analyst at the Los Angeles Mayor's Office of Sustainability, where he leads work on renewable energy, greenhouse gas monitoring and air quality.

Xiaoye Sherry Li (Ph.D.'96 EECS) has been elected vice president-at-large of the Society of Industrial and Applied Mathematics. She is currently a senior scientist at Berkeley Lab, where she is the lead developer of the SuperLU package, a widely used sparse direct solver.

Linsey Marr (Ph.D.'02 CEE) has been named a winner of the MacArthur Fellowship — often referred to as the "genius grant" — for her research on the transmission of airborne illnesses and effective public health interventions.

Jack Moehle, professor of the graduate school at the Department of Civil and Environmental Engineering, was elected to the National Academy of Construction for his work as an influential researcher, author and academician.

Ren Ng, associate professor of electrical engineering and computer sciences, has been elected as a 2024 Optica Fellow.

Electrical engineering and computer sciences professors **Ali Niknejad** (M.S.'97, Ph.D.'00 EECS), **Borivoje Nikolic** and **Kris Pister** (M.S.'89, Ph.D.'92 EECS) have won the IEEE SSCS Innovative Education Award for their pioneering efforts in creating an integrated circuit tapeout course. The instructors took a cohort of largely undergraduate students from the design phase of a chip to its manufacture in one semester.

Mario Noble (B.S.'98 MSE/ME) is now the chief operating officer and head of portfolio operations at Red Ball Holding Corporation. He also serves on the board of directors of Ma'alaea Kai Enterprises.

Civil and environmental engineering assistant professor **Eyitayo Opabola** has received the 2023 Shah Family Innovation Prize from the Earthquake Engineering Research Institute

Mary Ann Piette (M.S.'88 ME) has been appointed associate laboratory director of Berkeley Lab's Energy Technologies Area.

Daryll Pines (B.S.'86 ME), president of the University of Maryland, has been selected as the DC Cal Alumni Club's 2024 Distinguished Alumni Honoree.

Patricia Quaye (MDevEng '22) has founded SHE 4 Change, an organization that uses sustainable fashion design to empower women in Africa by paying seamstresses fairly and expanding their market reach.

Industrial engineering and operations research professor **Rhonda Righter** (M.S.'82, Ph.D.'86 IEOR) has been named a 2023 INFORMS Fellow. The honor is one of the most prestigious in the operations research profession.

Robert Ritchie, professor of materials science and engineering and of mechanical engineering, has been elected as a foreign fellow of the Academy of Athens.

Time magazine's list of "200 Best Inventions of 2023" included innovations from two alums. Cala kIQ, a wearable device that assists people with essential tremor and Parkinson's Disease, was developed by Cala Health, founded by **Kate Rosenbluth** (Ph.D.'09 BioE). Proven 40 OS, a fertilizer using naturally occurring microbes to reduce emissions and pollution while producing higher crop yields, was developed by Pivot Bio, founded by **Karsten Temme** (Ph.D.'11 BioE).

Aluna, founded by **Charvi Shetty** (B.S.'12 BioE), has been named a Tech for Global Good Laureate, one of four ventures recognized for using technology to significantly advance health equity and improve lives. Aluna makes hardware and software that helps people with breathing problems.

Joaquin Siques (M.S.'98 CEE) has been selected as the new transportation director for the City of Pasadena, where he has played a critical role in implementing dozens of projects and programs for the past 20 years.

Kenichi Soga, professor of civil and environmental engineering, has been selected by the British Geotechnical Association to deliver the next Rankine Lecture, one of the most prestigious lectures in geotechnics. The lecture will be held at Imperial College London in March 2025.

Electrical engineering and computer sciences professor **Claire Tomlin** (Ph.D.'98 EECS) has won the IEEE Mildred Dresselhaus Medal "for foundational work in the design and verification of cyber-physical systems with applications to safety in autonomous systems."

Civil and environmental engineering professor **Iris Tommelein** was honored with the American Society of Civil Engineers' Construction Management Award for her "groundbreaking research in lean construction and leadership in teaching and advancing state-of-the-art construction management practices worldwide." She is the first woman to receive this recognition since it was instituted in 1973.

Julea Vlassakis (Ph.D.'18 BioE), assistant professor of bioengineering at Rice University, has received a 2023 National Institutes of Health Director's New Innovator Award.

Amy Wendt (M.S.'85, Ph.D.'88 EECS) has won the 2024 EDGE in Tech Athena Award for Academic Leadership from CITRIS. Wendt is co-director of the Women in Science and Engineering Leadership Institute and is the associate vice chancellor for research in the physical sciences at the University of Wisconsin-Madison.

Three professors elected to NAE

Three Berkeley Engineering professors have been elected to the National Academy of Engineering (NAE): **Arpad Horvath,** professor of civil and environmental engineering, for research on the environmental life cycle assessment of infrastructure systems; **Ravi Prasher,** adjunct professor of mechanical engineering, for development of thermal management technologies for microelectronics; and **Ion Stoica,** professor of electrical engineering and computer sciences, for developing networked systems for large-scale data processing, analytics and machine learning.

This year's roster of new NAE members also includes **Glenn Bell** (M.S.'75 CE), **Wonyong "Andy" Choi** (B.S.'97 ME), **Juan Carlos De La Llera** (M.S.'90, Ph.D.'94 CE), **Tejal Desai** (Ph.D.'98 BioE), **James Gebhardt** (M.S.'79, Ph.D.'83 MSE), **Ashraf Habibullah** (M.S.'70 CE), **George Pappas** (Ph.D.'98 EECS), **Jonathan Paul Stewart** (B.S.'90, M.S.'92, Ph.D.'96 CE) and **Dawn Tilbury** (M.S.'92, Ph.D.'94 EECS).

STORY BY CAITLIN KELLEY | PHOTOS BY ADAM LAU, MARILYN SARGENT AND NOAH BERGER

SEND YOUR CLASS NOTES to **berkeleyengineer@berkeley.edu,** submit at **engineering.berkeley.edu/update** or mail to:
Berkeley Engineer magazine, 201 McLaughlin Hall #1704, Berkeley, CA 94720-1704

Adnan Al-Saffar (M.S.'61 CE, Ph.D.'64 CE) died in February at the age of 87. He had an extensive career as a chief hydraulic engineer at Bechtel and was instrumental in establishing ASCE's Environmental & Water Resources Institute.

Robert Bellue (B.S.'58 CE) died in November at the age of 93. A U.S. Army veteran, he helped design canals in the Bakersfield area and was chief engineer for the Kern County Water Agency for 27 years.

Robert Boehm (Ph.D.'68 ME) died in October at the age of 83. His research advanced our understanding of heat transfer and renewable energy. A distinguished emeritus professor of mechanical engineering at University of Nevada, Las Vegas, he also founded and served as the director of the Center for Energy Research.

Robert Brodersen, professor emeritus of electrical engineering and computer sciences, died in February at the age of 78. A leader in the areas of RF and digital wireless communication design, he was a founding member of the Berkeley Wireless Research Center. Among his many honors, he was elected to the National Academy of Engineering. He also was a mentor and beloved teacher to many.

Chin-Liang Chang (Ph.D.'67 EECS) died in September at the age of 86. He remained focused on artificial intelligence throughout his academic and professional career and later authored several books on the subject. Prior to founding Nicesoft Corporation, he worked at the National Institutes of Health, IBM and Lockheed-Martin.

Robert Clawson (B.S.'50 CE) died in September at the age of 97. A veteran of the U.S. Air Force, he worked at the California Department of Water Resources for over 50 years.

Gilles Corcos, professor emeritus of mechanical engineering, died in September at the age of 97. Trained as a Free French Air Force pilot during World War II, he had a long academic career. He later co-founded the NGO Agua Para La Vida to deliver water projects in Nicaragua and served as chairman for DiCon Fiberoptics.

Andrea Glerum (B.S.'97 CE) died in December at the age of 60. A civil engineer specializing in transportation, they worked for multiple Bay Area engineering firms before retiring from the San Francisco Municipal Transportation Agency.

Michael Jordan (B.S.'56 CE, M.S.'61 CE) died in September at the age of 88. A veteran of the U.S. Navy Civil Engineer Corps, he founded Liftech Consultants Inc. and was one of the world's pioneer designers of the first ship-to-shore container crane.

Christopher Kinzel (M.S.'66 CE) died in December. During his 64 years in the field of traffic engineering, he co-founded TJKM Transportation Consultants and mentored numerous engineers and planners.

Clyde Lee (Ph.D.'62 CE) died in October at the age of 94. A U.S. Army veteran, he was a professor emeritus in the Department of Civil Engineering at the University of Texas at Austin, where he had a 40-year career. His research included pioneering work in highway weigh-in-motion systems.

Larry Lewis (B.S.'62 CE) died in January at the age of 84. He served with the U.S. Coast and Geodetic Survey and had a long career as a structural engineer.

Newell Dee Lewis (B.S.'63 CE) died in October at the age of 83. He worked as an engineer for the city of Sacramento for over 31 years.

Wayne Lichtenberger, assistant professor of electrical engineering, died in October at the age of 90. A pioneer in computing research, he led the DARPA-funded Project Genie, which produced the first commercially successful time-sharing system. He also had a career in private industry, working for Hewlett-Packard, Ungermann-Bass, Cisco Systems and XKL.

Donald Machen (B.S.'59 EECS, M.S.'64 EECS) died in December at the age of 87. A veteran of the U.S. Naval Reserve, he developed accelerator control systems at Berkeley Lab and Los Alamos National Laboratory, where he had a long career. He also developed the first computer-control system used at CERN.

James Mitchell, professor emeritus of civil and environmental engineering, died in December at the age of 93. He held the Edward G. Cahill and John R. Cahill Chair in the Department of Civil and Environmental Engineering, authored more than 375 publications and was most known for the geotechnical reference Fundamentals of Soil Behavior. His many honors include being elected to the National Academy of Engineering and the National Academy of Sciences.

William Mueller (B.S.'50 EECS; M.S.'53, Ph.D.'58 IEOR) died in January. He had a long career in corporate management at Hughes Aircraft Company.

Andrew Rudd (M.S.'72, Ph.D.'78 IEOR; MBA'76) passed away in April at the age of 74. He was the founder, CEO and chair of Barra Inc. as well as Advisor Software Inc. He was also a professor of finance and operations research at Cornell University, as well as the chair of the Rudd Family Foundation, which established Berkeley's Big Ideas program, the V&A Café and the Rudd Family Foundation Chair in Safe Water and Sanitation, among other contributions.

James Skilling (B.S.'53 EECS) died in October at the age of 92. A veteran of the U.S. Navy, he worked many years at GenRad Inc. as an electrical engineer and served as a technical advisor to the U.S. Department of Commerce. He later taught computer science and statistics at the University of Maine.

Shirish Trivedi (M.S.'67 EECS) died in September at the age of 81. He had a long career at IBM as a computer engineer.

Roger Troxell (B.S.'51 CE, MEng '55 CE) died in September at the age of 95. An officer in the Army Corps of Engineers, he spent most of his career at Oakland-based Kaiser Engineers, where he managed projects in the U.S. and abroad.

Theodore Van Duzer (Ph.D.'60 EECS), professor emeritus of electrical engineering and computer sciences, died in October at the age of 95. A former radio technician in the U.S. Navy, he spent more than 50 years on the faculty at Berkeley. He authored multiple books and was the founding editor of IEEE Transactions on Applied Superconductivity. He also was inducted into the National Academy of Engineering.

Jack Welch (M.S.'58, Ph.D.'60 EngSci), professor emeritus of electrical engineering and computer sciences and of astronomy, died in March at the age of 90. A pioneer in molecular radio astronomy, his research led to discoveries in star formation and helped launch the field of astrochemistry. He served four decades on the faculty at Berkeley and was a founding member of the SETI Institute, where he played a pivotal role in the creation of the Allen Telescope Array. He was a member of the National Academy of Sciences.

Wilbur Wenger (M.S.'77 CE) died in January at the age of 79. He had a long career as an engineer in the oil and gas industry.

Niklaus Wirth (Ph.D.'63 EECS) died in January at the age of 89. An ACM Turing Award winner, he was renowned for the creation of several programming languages, including Pascal, and for the adage "Wirth's Law," which states that software tends to slow down more rapidly than hardware speeds up.

James Woodfill (B.S.'61 Metallurgy, M.S.'66 MSE) died in September at the age of 84. He worked for 32 years at Bechtel as a mechanical engineer.

Keegan Houser

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