College of Engineering
University of California, Berkeley
Fall 2023
Volume 24

Materially better
Innovating next-gen batteries

Decoding speech with AI
Breakthrough brain implant

Berkeley ENGINEER

Nuclear power renaissance

Reinventing energy systems via molten salt technologies

Pioneering a flexible online degree

Our academic year kicked off with the exciting debut of the Master of Advanced Study in Engineering (MAS-E), our newest professional master's degree program at Berkeley Engineering. This fully online program, developed in partnership with online learning platform Coursera, is offered with busy professionals as well as recent science or engineering graduates in mind, meeting an important educational need in the tech sector.

A key feature of the program is that the curriculum comprises one-unit courses spread across five interdisciplinary themes, allowing students a high degree of customization. Students can choose to enroll part- or full-time (at least two semesters must include a minimum of four units each). It's a level of flexibility that helps students keep pace with the dizzying speed of innovation. The explosive growth of generative AI in just the last year exemplifies just how quickly the technology landscape can change.

Our newest master's degree program meets an important educational need in the tech sector.

This MAS-E degree has been many years in the planning. A primary goal was to make a world-class Berkeley Engineering education accessible to a greater diversity of students and working professionals. We recognize that not everyone is able to give up their jobs to earn an advanced degree as a full-time student in an on-campus program. A 2023 online education trends report found that balancing education with existing commitments was a leading motivator for enrolling in an online program for 42% of respondents.

The global pandemic accelerated our efforts to bring the MAS-E program online; we saw firsthand the role remote education can play in students' lives, and we learned more about delivering a great educational experience for those who are unable to attend classes in person.

As one would expect from a high-caliber Berkeley Engineering program, the courses are taught by the same renowned faculty who provide in-person instruction.

Applications opened in September for enrollments beginning next summer. I look forward to welcoming the inaugural class of MAS-E students in 2024!

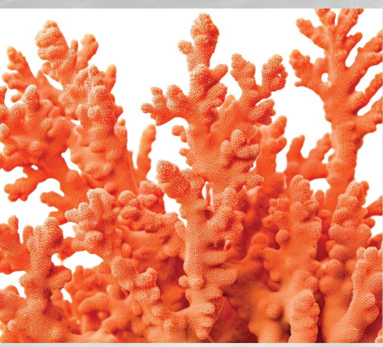
Fiat Lux!

DEAN AND ROY W. CARLSON PROFESSOR OF ENGINEERING

Dean Tsu-Jae King Liu greets aerospace engineering student Nihal Gulati and his family at this year's Alumni and Parents Weekend at Homecoming.

Adam Lau

in this issue



MORE >

> COVER: **ATOMIC PARTICLE 3D ILLUSTRATION**

DEAN
Tsu-Jae King Liu

ASSISTANT DEAN, MARKETING & COMMUNICATIONS
Sarah Yang

MANAGING EDITOR
Julianna Fleming

ASSOCIATE EDITOR, ART & PHOTOGRAPHY
Adam Lau

DESIGN
Alissar Rayes

CONTRIBUTORS
Marni Ellery
Caitlin Kelley
William Schulz
Jessica Scully
Alan Toth

WEB MAGAZINE
Steve McConnell

Berkeley Engineer is published twice yearly to showcase the excellence of Berkeley Engineering faculty, alumni and students.

Published by: UC Berkeley College of Engineering, Office of Marketing & Communications, 201 McLaughlin Hall #1704, Berkeley, CA 94720-1704, website: engineering.berkeley.edu/magazine

Reach editors: berkeleyengineer@berkeley.edu

Change of address? Send to: engineerupdates@berkeley.edu **or submit at:** engineering.berkeley.edu/update

Donate online: engineering.berkeley.edu/give, **or mail to:** Berkeley Engineering Fund, 308 McLaughlin Hall #1722, Berkeley, CA 94720-1722, phone: 510-642-2487

Accessible web versions of this and previous magazines are available at **https://engineering.berkeley.edu/magazine**

FACILITIES

Engineering Center groundbreaking

Amid cheers from hundreds of people, Berkeley Engineering celebrated the groundbreaking of its new Engineering Center in April. The event marked a key milestone toward creating a nexus for student collaboration, innovation and entrepreneurship on campus.

At the ceremony, Chancellor **Carol Christ** said the new building, slated for completion in early 2025, will prepare students for an increasingly interconnected, fast-paced world through its emphasis on inclusivity, community and cross-disciplinary engagement.

"We need to provide intellectual and actual physical space for engineers to become entrepreneurs, for climate scientists to partner with public health experts, and for computer scientists to work with legal scholars," she said. "This will be a place of possibility where, each year, thousands of engineering students and their peers from across the campus will converge, hear diverse perspectives, and skills will be melded, multiplied and brought to bear on the biggest challenges of our day."

The modern, glass-encased building, designed by architectural firm Skidmore, Owings and Merrill, will feature indoor and outdoor areas specially designed to facilitate group study, club meetings and team projects, as well as to centralize entrepreneurship activities and events.

During the event, Dean **Tsu-Jae King Liu** reflected on the impact this new space will have on Berkeley Engineering's student body, which has grown significantly since the Bechtel Engineering Center was built 43 years ago. She said the Engineering Center's collaborative environment will prove "transformative" for students by driving innovation and fostering connections across disciplines.

"Here on this site, students will learn, collaborate and innovate — whether it's to design, build and launch high-powered rockets or to advance the forefront of 3D bioprinting for applications in reconstructive medicine," she said. "Magic happens when people from different backgrounds with diverse perspectives are given space and support to interact with each other day to day, year to year."

"I have no doubt that the next planet-changing, economy-boosting, era-defining technology leader will emerge from this building, armed with a Berkeley Engineering degree and fueled by ideas seeded here in collaboration with fellow students and faculty across the campus."

— **CHARLES GIANCARLO** (M.S.'80 EECS), Berkeley Engineering Advisory Board member

Adam Lau

COMPUTER SCIENCE

Plug-and-play

Courtesy the researchers

Just a few years ago, Berkeley engineers showed us how they could easily turn images into a 3D navigable scene using a technology called Neural Radiance Fields, or NeRF. Now, another team has created a development framework to help speed up NeRF projects and make this technology more accessible to others.

Led by **Angjoo Kanazawa,** assistant professor of electrical engineering and computer sciences, the researchers have developed Nerfstudio, a Python framework that provides plug-and-play components for implementing NeRF-based methods, making it easier to collaborate and incorporate NeRF into projects.

"Advancements in NeRF have contributed to its growing popularity and use in applications such as computer vision, robotics, visual effects and gaming. But support for development has been lagging," said Kanazawa. "The Nerfstudio framework is intended to simplify the development of custom NeRF methods, the processing of real-world data and interacting with reconstructions."

This new framework is already helping engineers that employ interactive computer graphics in their work, specifically those creating 3D reconstructions in real-world settings. This includes roboticists who use NeRF for manipulation, motion planning, simulation and mapping, as well as gaming studios and news outlets that use interactive graphics to tell stories.

Since the introduction of NeRF, researchers worldwide have been working to improve the core technology. But this work is often performed by groups using proprietary repositories, making it difficult to share contributions with the larger NeRF community. Nerfstudio addresses this by providing a modular framework that "consolidates these research innovations." In addition, it makes the associated code and data publicly available through open-source licensing.

Presently, 20 Berkeley engineers are actively contributing to Nerfstudio and helping to maintain it. And as many as 100 people outside the university have contributed to the core code since its launch in October 2022.

ENVIRONMENT

Sequestering carbon

Current carbon removal methods are proving to be inadequate and costly. But Berkeley researchers have a novel proposal: growing biomass crops to capture carbon from the air, then burying the harvested vegetation in engineered dry environmental chambers. This unique approach, called agro-sequestration, keeps the buried biomass dry to suppress microbial activity and stave off decomposition, enabling stable sequestration of all the biomass carbon.

"We're claiming that proper engineering can solve 100% of the climate crisis, at manageable cost," said **Eli Yablonovitch,** professor of electrical engineering and computer sciences. "If implemented on a global scale, this carbon-negative sequestration method has the potential to remove current annual carbon dioxide emissions — as well as historical emissions from the atmosphere."

Ensuring the stability of the buried biomass is a challenge. While these storage environments are devoid of oxygen, anaerobic microorganisms can survive and cause the biomass to decompose into carbon dioxide and methane, rendering sequestration approaches carbon-neutral, at best. But living cells must be able to transfer water-solubilized nutrients and water-solubilized waste across their cell walls to survive. According to co-author **Harry Deckman,** decreasing the water activity — similar to relative humidity — below 60% stops these metabolic processes, which has been shown in research from both the U.S. Food and Drug Administration and NASA.

This approach, unlike prior efforts toward carbon neutrality, seeks not net carbon neutrality, but net carbon dioxide removal. According to the researchers' analysis, for every metric tonne of dry biomass, it would be possible to sequester approximately 2 tonnes of carbon dioxide.

Agro-sequestration is also extremely cost effective. Together, the agriculture and sequestration costs total $60 per tonne of captured carbon dioxide, in comparison to some direct air capture and carbon dioxide gas sequestration strategies, which can equal or exceed more than $600 per tonne.

PUBLIC HEALTH

Curbing antibiotic resistance

Antibiotic resistance is a leading cause of death in low- to middle-income countries and a major public health concern. However, there has been little evidence on the potential for water and sanitation access to reduce antibiotic resistance in humans. But a new study led by **Amy Pickering,** assistant professor of civil and environmental engineering, found that increasing access to clean water and flush toilets could be an effective way to curb antibiotic resistance.

For their study, the researchers turned to "metagenomic data," which is genetic sequence data from all material in a sample. Specifically, they looked at human fecal metagenomes, tagged by geospatial location, from the National Center for Biotechnology Information's Sequence Read Archive. They linked this data with household survey datasets — also geo-referenced — that reported access to drinking water sources and sanitation facility types. One advantage of this approach is that human fecal samples are more representative than using sewage, as a large proportion of households in low-income settings are not connected to sewage systems.

Pickering and colleagues identified 1,589 human fecal metagenomes from 26 countries. The mean abundance of antibiotic resistance genes (ARGs) was highest in Africa, compared with Europe, North America and the Western Pacific; and second highest in Southeast Asia, compared with Europe and North America.

"Increased access to improved water and sanitation was associated with lower ARG abundance, and the association was stronger in urban than in rural areas," the researchers wrote in the study. Improved sanitation alone was associated with a greater decrease than improved drinking water alone, "but the greatest decrease was observed with access to both."

Moreover, controlling antibiotic drug consumption is likely insufficient to stop the spread of antibiotic resistance, said Pickering. "Community environmental transmission should be given greater attention."

GRADUATE EDUCATION

New online master's degree

Berkeley Engineering has launched a new multidisciplinary, professional degree program, the Master of Advanced Study in Engineering (MAS-E), for professionals seeking "knowledge upgrades" in STEM fields. The fully online program, developed and offered in partnership with Coursera, is designed to help engineers keep pace with the speed of innovation and evolve their skills in a world driven by technological change — often while holding down a full-time job.

The MAS-E curriculum comprises one-semester-unit courses that draw content from Berkeley Engineering's top-ranked engineering programs, providing academic rigor with flexibility. Taught by Berkeley faculty, the lectures will be pre-recorded and available anytime to students for asynchronous and self-paced study. Students may enroll in the program full-time or part-time and have up to four years to complete the degree requirements. Applications for the program opened this fall.

According to **Tarek Zohdi,** associate dean for research and faculty director of the MAS-E degree program, the new program reflects the growing interdisciplinary nature of modern engineering — and the evolving need for engineering leaders with the latest, state-of-the-art technological expertise.

"The MAS-E degree is uniquely designed to help engineers expand their knowledge and skill sets, and step into leadership roles in which they successfully direct projects and organizations in global environments that cross disciplinary boundaries," he said.

BIO-PRESERVATION

A cool way to save coral

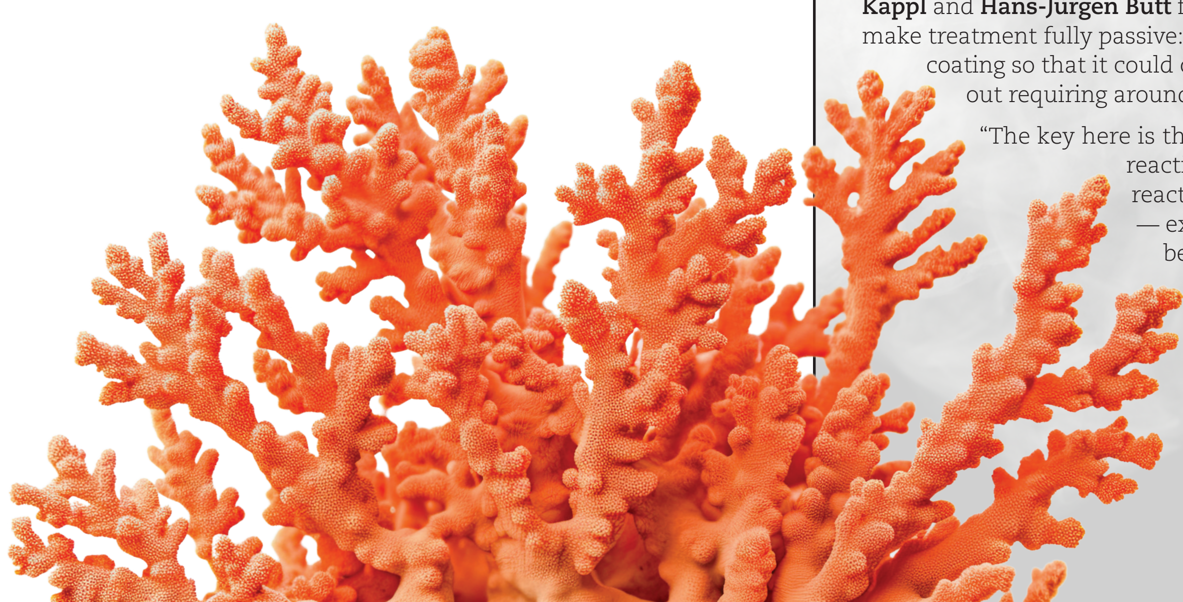
Coral is in crisis. Recent models estimate that 95% or more of the world's coral could die by the mid-2030s due to climate change. But a new, rapid approach to coral preservation could help stem the tide. Technology discovered by **Boris Rubinsky,** Professor of the Graduate School at the Department of Mechanical Engineering and professor emeritus of bioengineering, has been used to develop the first successful technique for cryopreserving and reviving entire coral fragments.

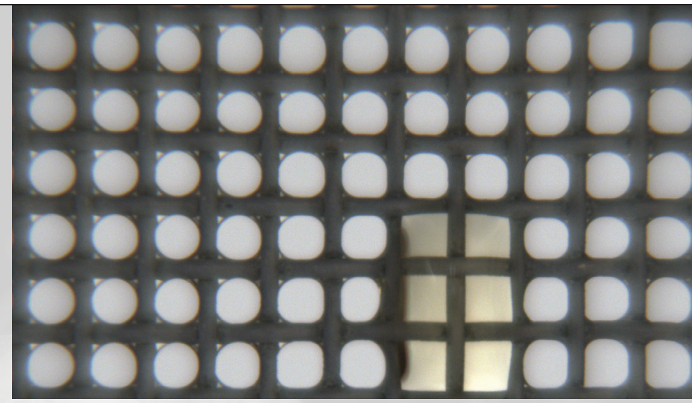
Past approaches to coral cryopreservation relied on freezing coral sperm and larvae, which could only be collected during sporadic spawning events and did not always withstand the stress of being frozen and thawed. In this latest work, researchers set out to cryopreserve and revive entire fragments of coral. Such large masses of tissue are far more complex to cryopreserve, leading researchers to employ isochoric vitrification, a cryotechnology pioneered by Rubinsky.

Rubinsky had previously discovered that maintaining constant volume, or isochoric, could vastly improve the cryopreservation of biomaterials, including transplant organs. Isochoric vitrification combines supercooling with extreme pressure to achieve cryopreservation without harmful ice crystals forming in the tissue. As a result, the coral polyps are preserved in a glass-like state that avoids damage to their delicate cells.

Mary Hagedorn and **E. Michael Henley,** research scientists at Smithsonian's National Zoo and Conservation Biology Institute, successfully tested the isochoric vitrification technique using fragments of finger coral (Porites compressa). They placed the coral inside rigid aluminum chambers, then immersed the chambers in liquid nitrogen. Once vitrification was complete, researchers thawed the chambers and transferred the coral to seawater to recover. The revived corals proved to be in good health, with an oxygen consumption rate comparable to corals that were never cooled.

The Berkeley researchers say that future possibilities for isochoric cryopreservation technology go well beyond marine life. "The range of applications is huge and is relevant to every field involving biomaterials," Rubinsky said, noting that **Brooke Chang** (B.S.'22, M.S.'23 MSE), **Antony Consiglio** (M.S.'20, Ph.D.'23 ME) and **Matt Powell-Palm** (Ph.D.'20 ME) were key contributors to this research.





Courtesy the researchers

WATER

In a fog

Fog harvesting offers regions devoid of lakes and rivers another source for freshwater, but in urban centers, where water is often scarce, there is the added challenge of air pollution. Now, researchers have developed a simple way to simultaneously collect water from fog and remove harmful contaminants, an advancement that could help provide millions of people worldwide with access to safe drinking water.

The researchers demonstrated how a nanoengineered steel mesh with a special solar-powered coating can collect water droplets from fog, then treat the water to make it safe for drinking. The coating, a polymer consisting of titanium dioxide nanoparticles, has the unique ability to stay reactive once exposed to sunlight and remove pollution, rain or shine, around the clock. This fully passive, hybrid approach to collecting and treating water is "a first in its field," according to **Thomas Schutzius,** assistant professor of mechanical engineering.

To remove these contaminants from the captured fog water droplets, the researchers looked to polymer coatings. Lead author **Ritwick Ghosh,** a scientist from the Max Planck Institute for Polymer Research (MPIP) and visiting researcher at ETH Zurich, had previously discovered that it was possible to treat, to a limited degree, contaminated fog by using mesh coatings containing photocatalytically active metal oxide nanoparticles such as titanium dioxide. Such coatings become reactive when exposed to sunlight and cause pollution molecules in fog droplets to decompose into harmless agents, making the collected water safe to drink. But these coatings required active and continuous ultraviolet lamp illumination to do the job.

In this latest study, Schutzius and Ghosh, working with **Michael Kappl** and **Hans-Jürgen Butt** from MPIP, took the next step to make treatment fully passive: They optimized the nanoparticle coating so that it could continue treating the water without requiring around-the-clock exposure to UV light.

"The key here is that we can make the surface reactive when it's sunny, and it stays reactive even when it's foggy or cloudy — exhibiting almost a capacitive-like behavior," said Schutzius, describing the reactive coating's ability to store charge, much like a battery, making it possible to effectively treat water regardless of weather conditions and time of day.

Put into words

Speech neuroprostheses may offer a way to communicate for people who are unable to speak due to paralysis or disease, but fast, high-performance decoding has not yet been demonstrated. Now, transformative work by researchers at UCSF and Berkeley Engineering shows that more natural speech decoding is possible using the latest advances in artificial intelligence.

Led by UCSF neurosurgeon **Edward Chang,** the researchers developed an implantable AI-powered device that, for the first time, translates brain signals into synthesized speech and facial expressions. As a result, a woman who lost the ability to speak due to a stroke was able to speak in her own voice and convey emotion using a digital avatar.

Berkeley Engineering graduate students **Kaylo Littlejohn, Sean Metzger** and **Alex Silva** were co-lead authors of the study, and **Gopala Anumanchipalli,** assistant professor of electrical engineering and computer sciences, was a co-author.

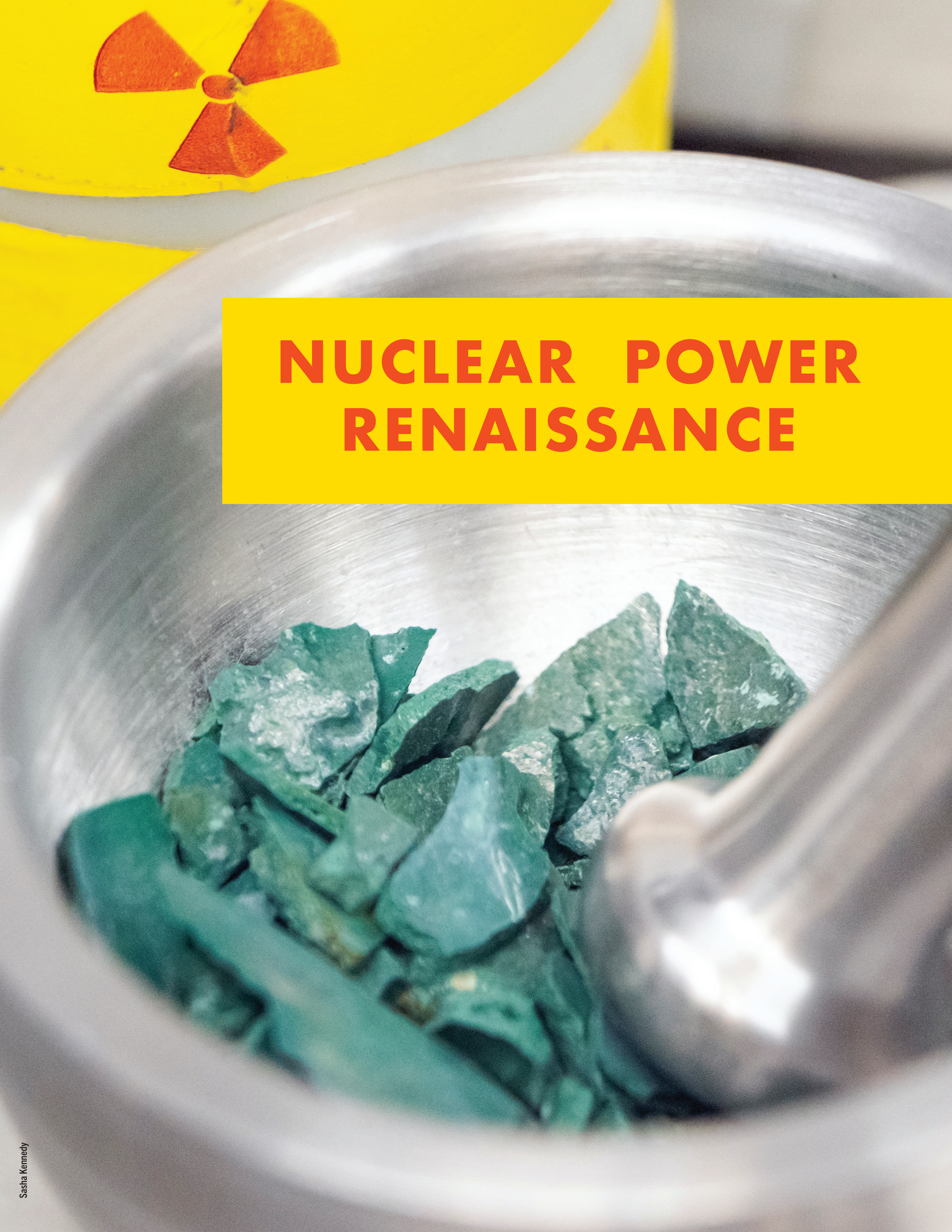
"Because people with paralysis can't speak, we don't have what they're trying to say as a ground truth to map to. So we incorporated a machine-learning optimization technique called CTC loss, which allowed us to map brain signals to discrete units, without the need for 'ground truth' audio," said Littlejohn.

"We also were able to personalize the participant's voice by using a video recording of her making a speech at her wedding from about 20 years ago. We kind of fine-tuned the discrete codes to her voice," said Anumanchipalli. "Once we had this paired alignment that we had simulated, we used the sequence alignment method, the CTC loss."

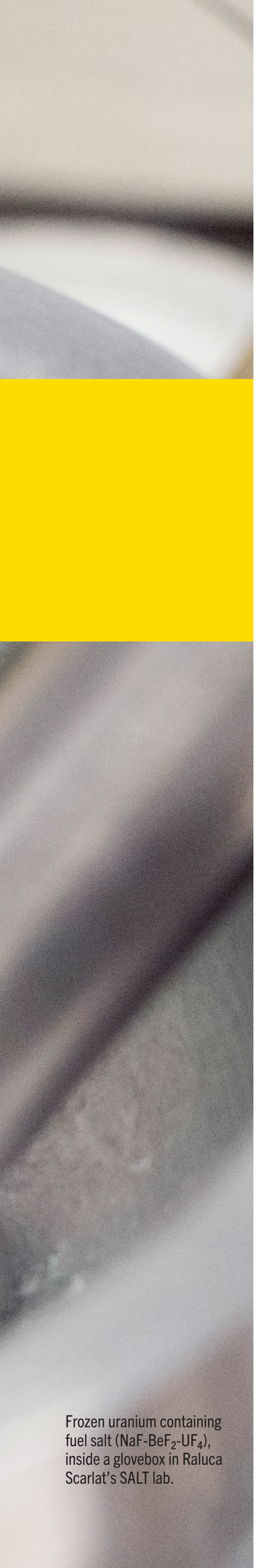
STORY BY MARNI ELLERY, PHOTO BY NOAH BERGER

See video at **engineering.berkeley.edu/magazine.**

NUCLEAR POWER RENAISSANCE



Sasha Kennedy



Frozen uranium containing fuel salt ($NaF\text{-}BeF_2\text{-}UF_4$), inside a glovebox in Raluca Scarlat's SALT lab.

Reinventing energy systems via molten salt technologies

STORY BY ALAN TOTH

A retro wonder gleaming white in the sun, propelled by six rear-facing rotors and four jet engines affixed to the longest wings ever produced for a combat aircraft, the Convair B-36 Peacemaker looks like it flew right out of a 1950s science fiction magazine.

One of these bombers, which flew over the American Southwest from 1955 to 1957, was unique. It bore the fan-like symbol for ionizing radiation on its tail. The NB-36H prototype was designed to be powered by a molten salt nuclear reactor — a lightweight alternative to a water-cooled reactor.

Nuclear-propelled aircraft like the NB-36H were intended to fly for weeks or months without stopping, landing only when the crew ran short of food and supplies. So what happened? Why weren't the skies filled with these fantastical aircraft?

"The problem was that nuclear-powered airplanes are absolutely crazy," says Per F. Peterson, the William S. Floyd and Jean McCallum Floyd Chair in Nuclear Engineering. "The program was canceled, but the large thermal power to low-weight ratio in molten salt reactors is the reason that they remain interesting today."

Because of numerous concerns, including possible radioactive contamination in the event of a crash, the idea of nuclear-powered aircraft never took off. But nuclear submarines, using water as coolant, completely replaced their combustion-powered predecessors. Civilian reactors were built on the success of submarine systems, and as a result, most nuclear reactors today are cooled with water.

While most water-cooled reactors can safely and reliably generate carbon-free electricity for decades, they do present numerous challenges in terms of upfront cost and efficiency. Molten salt reactors, like those first designed for nuclear-powered aircraft, address many of the inherent challenges with water-cooled reactors. The high-temperature reaction of such reactors could potentially generate much more energy than water-cooled reactors, hastening efforts to phase out fossil fuels.

Now, at the Department of Nuclear Engineering, multiple researchers, including Peterson, are working to revisit and reinvent molten salt technologies, paving the way for advanced nuclear energy systems that are safer, more efficient and cost-effective — and may be a key for realizing a carbon-free future.

SMALLER, SAFER REACTORS

In the basement of Etcheverry Hall, there's a two-inch-thick steel door that looks like it might belong on a bank vault. These days, the door is mostly left open, but for two decades it was the portal between the university and the Berkeley Research Reactor, used mainly for training. In 1966, the reactor first achieved a steady-state of nuclear fission.

Fission occurs when the nucleus of an atom absorbs a neutron and breaks apart, transforming itself into lighter elements. Radioactive elements like uranium naturally release neutrons, and a nuclear reactor harnesses that process. Concentrated radioactive elements interact with neutrons, splitting themselves apart, shooting more neutrons around and splitting more atoms. This self-sustaining chain reaction releases immense amounts of energy in the form of radiation and heat. The heat is transferred to water that propels steam turbines that generate electricity.

The reactor in Etcheverry Hall is long gone, but the gymnasium-sized room now houses experiments designed to test cooling and control systems for molten salt reactors. Peterson demonstrated one of these experiments in August. The Compact Integral Effects Test (CIET) is a 30-foot-tall steel tower packed with twisting pipes. The apparatus uses heat transfer oil to model the circulation of molten salt coolant between a reactor core and its heat exchange system. CIET is contributing extensively to the development of passive safety systems for nuclear reactors. After a fission reaction is shut down, such systems allow for the removal of residual heat caused by radioactive decay of fission products without any electrical power — one of the main safety features of molten salt reactors.

The first molten salt reactor tested at Oak Ridge National Laboratory in the 1950s was small enough to fit in an airplane, and the new designs being developed today are not much larger. Conventional water-cooled reactors are comparatively immense — the energy-generating portion of the Diablo Canyon Power Plant in San Luis Obispo County occupies approximately 12 acres, and containment of feedwater is not the only reason why. The core temperature in this type of reactor is usually kept at some 300 degrees Celsius, which requires 140 atmospheres of pressure to keep the water liquid. This need to pressurize the coolant means that the reactor must be built with robust, thick-walled materials, increasing both size and cost. Molten salts don't require pressurization because they boil at much higher temperatures.

In conventional reactors, water coolant can boil away in an accident, potentially causing the nuclear fuel to meltdown and damage the reactor. Because the boiling point of molten salts are higher than the operational temperature of the reactor, meltdowns are extremely unlikely. Even in the event of an accident, the molten salt would continue to remove heat without any need for electrical power to cycle the coolant — a requirement in conventional reactors.

Adam Lau

Professor Per Peterson holds a single fuel pebble, which can produce enough electricity to power a Tesla Model 3 for 44,000 miles.

"Molten salts, because they can't boil away, are intrinsically appealing, which is why they're emerging as one of the most important technologies in the field of nuclear energy," says Peterson.

THE BIG PRIZE: EFFICIENCY

To fully grasp the potential benefits of molten salts, one has to visit the labs of the SALT Research Group. Raluca O. Scarlat, assistant professor of nuclear engineering, is the principal investigator for the group's many molten salt studies. Scarlat's lab is filled with transparent gloveboxes filled with argon gas. Inside these gloveboxes, Scarlat works with many types of molten salts, including FLiBe, a mixture of beryllium and lithium fluoride. Her team aims to understand exactly how this variety of salt might be altered by exposure to a nuclear reactor core. On the same day that Peterson demonstrated the CIET test, researchers in the SALT lab were investigating how much tritium (a byproduct of fission) beryllium fluoride could absorb.

Salts are ionic compounds, meaning that they contain elements that have lost electrons and other elements that have gained electrons, resulting in a substance that carries no net electric charge. Ionic compounds are very complex and very stable. They can absorb a large range of radioactive elements. This changes considerations around nuclear waste, especially if the radioactive fuel is dissolved into the molten salt. Waste products could be electrochemically separated from the molten salts, reducing waste volumes and conditioning the waste for geologic disposal. Waste might not even be the proper term for some of these byproducts, as many are useful for other applications — like tritium, which is a fuel for fusion reactors.

Salts can also absorb a lot of heat. FLiBe remains liquid between approximately 460 degrees and 1460 degrees Celsius. The higher operating temperature of molten salt coolant means more steam generation and more electricity, greatly increasing the efficiency of the reactor, and for Scarlat, efficiency is the big prize.

"If we filled the Campanile with coal and burned it to create electricity, a corresponding volume of uranium fuel would be the size of a tennis ball," says Scarlat. "Having hope that we can decarbonize and decrease some of the geopolitical issues that come from fossil fuel exploration is very exciting."

"FINDING GOOD COMPROMISES"

Thermal efficiency refers to the amount of useful energy produced by a system as compared with the heat put into it. A combustion engine achieves about 20% thermal efficiency. A conventional water-cooled nuclear reactor generally achieves about 32%. According to Massimiliano Fratoni, Xenel Distinguished Associate Professor in the Department of Nuclear Engineering, a high-temperature, molten salt reactor might achieve 45% thermal efficiency.

So, with all the potential benefits of molten salt reactors, why weren't they widely adopted years ago? According to Peter Hosemann, Professor and Ernest S. Kuh Chair in Engineering,

"Molten salts, because they can't boil away, are intrinsically appealing, which is why they're emerging as one of the most important technologies in the field of nuclear energy."

> "Having hope that we can decarbonize and decrease some of the geopolitical issues that come from fossil fuel exploration is very exciting."

there's a significant challenge inherent in molten salt reactors: identifying materials that can withstand contact with the salt.

Anyone who's driven regularly in a region with icy roads has probably seen trucks and cars with ragged holes eaten in the metal around the wheel wells. Salt spread on roads to melt ice is highly corrosive to metal. A small amount of moisture in the salt coolant of a nuclear reactor could cause similar corrosion, and when combined with extreme heat and high radiation, getting the salt's chemistry right is even more critical.

Hosemann, a materials scientist, uses electron microscopes to magnify metal samples by about a million times. The samples have been corroded and or irradiated, and Hosemann studies how such damage alters their structures and properties. These experiments may help reactor designers estimate how much corrosion to expect every year in a molten salt reactor housing. Hosemann says molten salt reactors present special engineering challenges because the salt coolant freezes well above room-temperatures, meaning that repairs must either be done at high temperatures, or the coolant must first be drained.

Commercially successful molten salt reactors then will have to be very reliable, and that won't be simple. For example, molten salt reactors with liquid fuel may be appealing in terms of waste management, but they also add impurities into the salt that make it more corrosive. Liquid fuel designs will need to be more robust to counter corrosion, resulting in higher costs, and the radioactive coolant presents further maintenance challenges.

"Good engineering is always a process of finding good compromises. Even the molten salt reactor, as beautiful as it is, has to make compromises," says Hosemann.

Peterson thinks the compromise is in making molten salt reactors modular. He was the principal investigator on the Department of Energy-funded Integrated Research Project that conducted molten salt reactor experiments from 2012 to 2018. His research was spun off into Kairos Power, which he co-founded with Berkeley Engineering alums Edward Blandford (Ph.D.'10 NE) and Mike Laufer (Ph.D.'13 NE), and where Peterson serves as Chief Nuclear Officer. The U.S. Nuclear Regulatory Commission just completed a review of Kairos Power's application for a demonstration reactor, Hermes, as a proof of concept. Peterson says that high-temperature parts of Kairos Power's reactors would likely last for 15 to 25 years before they'd need to be replaced, and because the replacement parts will be lighter than those of conventional reactors, they'll consume fewer resources.

"As soon as you're forced to make these high-temperature components replaceable, you're systematically able to improve them. You're building improvements, replacing the old parts and testing the new ones, iteratively getting better and better," says Peterson.

Adam Lau

Assistant professor Raluca Scarlat uses a glovebox in her Etcheverry Hall lab.

LOWERING ENERGY COSTS

California is committed to reaching net zero carbon emissions by 2045. It's tempting to assume that this goal can be reached with renewables alone, but electricity demand doesn't follow peak energy generating times for renewables. Natural gas power surges in the evenings as renewable energy wanes. Even optimistic studies on swift renewable energy adoption in California still assume that some 10% of energy requirements won't be achieved with renewables and storage alone. Considering the increasing risks to infrastructure in California from wildfires and intensifying storms, it's likely that non-renewable energy sources will still be needed to meet the state's energy needs.

Engineers in the Department of Nuclear Engineering expect that nuclear reactors will make more sense than natural gas for future non-renewable energy needs because they produce carbon-free energy at a lower cost. In 2022, the price of natural gas in the United States fluctuated from around $2 to $9 per million BTUs. Peterson notes that energy from nuclear fuel currently costs about 50 cents per million BTUs. If new reactors can be designed with high intrinsic safety and lower construction and operating costs, nuclear energy might be even more affordable.

Even if molten salt reactors do not end up replacing natural gas, Hosemann says the research will still prove valuable. He points to other large-scale scientific and engineering endeavors like fusion reactors, which in 60 years of development have never been used commercially but have led to other breakthroughs.

"Do I think we'll have fusion-generated power in our homes in the next five years? Absolutely not. But it's still valuable because it drives development of superconductors, plasmas and our understanding of materials in extreme environments, which today get used in MRI systems and semiconductor manufacturing," says Hosemann. "Who knows what we'll find as we study molten salt reactors?" BE

MATERIALLY BETTER

Innovating the next generation of batteries

STORY BY JESSICA SCULLY | PHOTOS BY ADAM LAU

Professor Gerbrand Ceder inside Berkeley Lab's fully automated A-Lab, which uses AI and robotics to synthesize new materials 24/7 without human intervention.

For Gerbrand Ceder, professor of materials science and engineering and senior faculty scientist at Berkeley Lab, time is of the essence. A leader in energy storage research, he brings urgency to his life's work in developing the essential materials for a battery-powered future.

"My whole career, I've always been guided by trying to do things more rapidly," he says. "If we're going to solve the different problems we're facing in the energy transition, we have to do this research faster."

Over decades of investigation, this push for swift results has brought forth critical technologies that make batteries more efficient, sustainable and safe. In the 1990s, his work led to more rapid charging for lithium-ion batteries. In the early 2000s, he brought quantum mechanics research to materials development, ushering in advances in machine learning. The next decade, Ceder and his team found less expensive, high-energy lithium alternatives to lithium-ion batteries.

Today, his research is, quite literally, entering a new space: a lab that automates synthesizing materials that have been designed computationally, dramatically speeding up a typically slow and laborious process. The lab is developing new energy storage

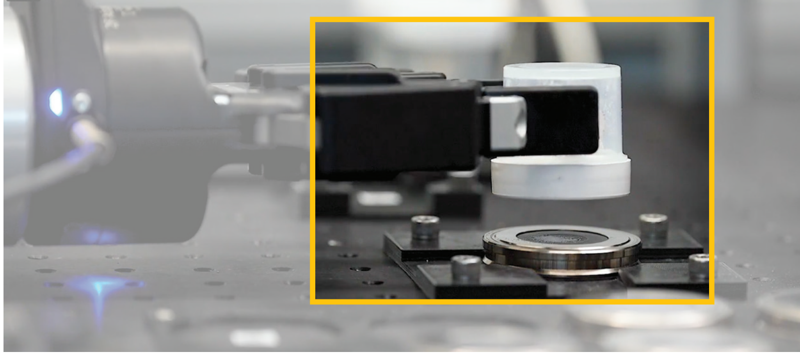
materials two orders of magnitude faster than had been achieved previously and allows researchers to evaluate small variations in materials, processing conditions and precursor chemicals.

According to Ceder, not only is this a potential game-changer for battery research, but this new approach may mark the biggest innovation in materials research in the last 70 years. The lab, he says, "is a beta-test for a new way of doing science by using automation, artificial intelligence and machine learning to the fullest extent to accelerate the pace at which science can be done."

High-throughput computing

In the late 1990s, Ceder's group was one of the first to apply what was then called "first-principles modeling" to battery materials. The approach had been used in physics research, but Ceder, then at MIT, wanted to use it to solve technologically relevant problems. He picked lithium-ion battery materials, then a relatively new technology that had been commercially available for less than a decade. It was a lucky choice. His group moved the field forward through discoveries on lithium-ion battery fundamentals, including the diffusion mechanisms for lithium ions through cathodes.

That discovery led to Ceder's group designing and demonstrating the highest rate of lithium-ion transport then seen, enabling faster battery recharging. "There was some skepticism around that at the time, but it has really withstood the test of time," says Mark Asta, professor of materials science and engineering.



Materials science research has long focused on developing new materials with properties fit for specific uses. In the late 1990s, researchers were performing computations to understand these properties material by material. Ceder had another idea.

"If you can compute something once, why not 10,000 times?" he says. The result was high-throughput computing: the automated characterization at the atomic and subatomic levels of known and new materials and their properties. Teamed with data mining, it continues to power research in battery materials in Ceder's group. It has also had an enormous impact on materials science research more broadly.

In the early 2000s, Ceder and his team were using the technique in-house. They were contacted by the White House Office of Science and Technology Policy to turn the approach into a nationwide project. That effort, called the Materials Genome Project, helped lead to the Materials Genome Initiative in 2011, a multi-agency federal project to cut in half the time needed to get from discovery to deployment of advanced materials and to dramatically cut costs.

The Materials Project "is probably the most successful outcome on the computational side," of the initiative, Ceder says. The project, which was founded at Berkeley Lab in the same year by Kristin Persson, professor of materials science and engineering, included Ceder's group as one of the core partners. For over a decade, it has provided an invaluable resource to the global materials science community: open access to computed information on nearly 155,000 known and predicted materials and tools for designing new materials.

Both high-throughput computing and computer modeling for lithium-ion research had important follow-on effects. Jeff Neaton, professor of physics and the associate laboratory director for energy sciences at Berkeley Lab, says that Ceder's calculations of lithium-ion battery materials built confidence in the experimental research community and in industry that computation could be used to accurately predict materials performance.

And high-throughput computing gave the materials science community orders of magnitude more data, Asta says. That allowed the community to generate large enough datasets to "start to understand how those tools of machine learning and AI could impact the process of materials discovery."

Supporting sustainability

The lithium-ion batteries common in electric vehicles (EVs) and consumer electronics use cathodes made from a class of materials including nickel, manganese and cobalt. Because cobalt is expensive and mined in locations with unethical standards, many manufacturers have reduced cobalt content, replacing it with nickel. But nickel, while less scarce than cobalt, remains expensive and is also mined in countries with less than rigorous environmental standards, Ceder says.

Conventional lithium-ion batteries have an orderly atomic-layered structure of cathode elements. Lithium ions move through defined pathways and line up along these layers. But in 2014, Ceder's group found that batteries could hold more lithium with a disordered atomic cathode structure. The structure they've developed is called DRX for disordered rocksalts with excess lithium. More lithium stored equals more energy stored, and with DRX, nearly any metal could be used to replace nickel or cobalt. But that metal needs to be cheap and abundant.

"You'd need multiple millions of tons per year, and that starts to seriously filter what you can use," Ceder says.

Ceder's group picked titanium and manganese. In 2018, the Department of Energy (DOE) funded a "deep dive" for the group to study remaining issues. With these successfully resolved, the DOE then funded Berkeley Lab to lead a consortium of national labs to study technical issues for scale up, including making materials in larger quantities and modifying other battery components for compatibility. If this research is successful, industry will likely take over, says Ceder, who is co-leading the consortium with Berkeley Lab scientist Guoying Chen.

Manganese and titanium are highly abundant and very cheap — less than a dollar per kilogram — while nickel is about $25 a kilogram, and cobalt fluctuates from $30 to $60 a kilogram, Ceder says. DRX technology could therefore mean much cheaper EVs with longer ranges.

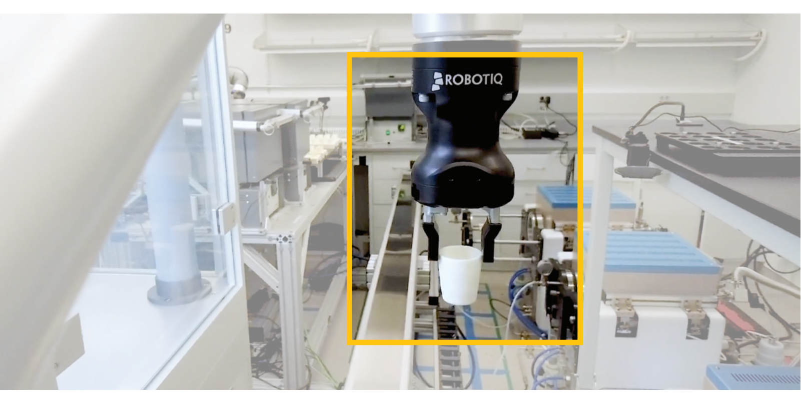
"It's almost like you're cutting the price of the car in half, because the cost of the battery is a very large chunk of the cost of the EV. And if you can have cheaper materials, you can make driving range go up because driving range is in large part an issue of cost," Ceder says.

Safer and more stable

In addition to improving lithium-ion technology, Ceder is studying battery options beyond it.

One problem with lithium-ion batteries is their flammability: if a battery is punctured or overheats, the liquid electrolytes between the anode and the cathode can catch fire.

Ceder's group is working to replace liquid electrolytes with solid ion conductors to create solid-state batteries, which would be much safer. Researchers are exploring whether lithium metal anodes in solid-state batteries give them a higher energy density profile, but Ceder cautions that's not proven. Challenges to solid-state batteries include designing a solid material that allows for rapid transport of lithium ions and is also stable.



Ceder's been joined by chemical engineering professor Bryan McCloskey on one approach: solid-state lithium-air batteries.

Lithium air is an alternative chemistry to lithium ion that intentionally reacts lithium with oxygen. Since oxygen is a very strong oxidizing agent and lithium a strong reducing agent, in theory the combination could produce a great deal of energy. But the chemistry has been plagued by interfacial instabilities, largely due to the liquid electrolyte. Fixing these instabilities is a subject of McCloskey's research. Replacing liquid electrolytes with solid-state ion conductors could solve the problem, McCloskey says, and that's the goal of his and Ceder's current research. The two are joined in the project by Mary Scott, assistant professor of materials science and engineering.

But Ceder's work in the field is much broader than just lithium-air batteries, McCloskey notes. "He's looking at a variety of different classes of solid-state ion conductors, using both computational and experimental methods," he says.

Relieving the bottleneck

Ceder's career-long goal to speed research has found further fulfillment through Berkeley's Lab's A-Lab. The idea for the lab came about seven years ago through brainstorming at a regular retreat Ceder's group holds. Computational materials design had evolved well enough to allow researchers to design most of what they needed, Ceder says. But the bottleneck came in trying to actually make these materials.

"We had all these great ideas for new materials," he says. "And then you send a student in the lab to make a completely new compound. If you're lucky, in two weeks, they have it. If you're not, six months later, they're still slogging at it, and they have no signs of life."

After tossing around ideas, robotic, machine-learning-driven synthesis was proposed. After "a lot of iteration in our minds," construction on the lab started two years ago, Ceder says.

The result, A-Lab, has been operating since February. The lab, a set of furnaces and other equipment, robots and software, works without human involvement to synthesize new materials. It takes input commands for computer-designed compounds, then gets to work. The first five attempts are what Ceder calls "literature inspired." The lab tries to create materials — using factors like precursors, temperature for firing and firing time — from machine learning and communication with the Materials Project's literature knowledge and databases.

If it can't develop a compound after those five attempts, the lab starts a cycle to actively learn from its mistakes, Ceder says. This includes using techniques like X-ray diffraction to understand what it has made. X-ray diffraction results look like a spectrum "with a lot of peaks and wiggles," he says. Through machine learning, A-Lab can interpret that data and decide on a next step to try.

On a first extensive test of A-Lab, Ceder's group gave it 56 completely novel compounds from across the periodic table that had been computationally predicted but never been made — and 17 days to make them. A-Lab successfully made 70% of the materials.

"I'm not sure anybody's ever done a statistical analysis, but if I had to guess, my own lab's success rate would probably be like 30% or 35% maybe," Ceder says.

Work continues on fine-tuning the lab's mechanics, Ceder says, but he's pleased by how well its higher-level knowledge interfaces function. A lab of robots working is cool, he says.

"But for us, what's even cooler is what's under the hood, which is basically all the software and trying to make robots do logical things or scientifically reasonable things."

A-Lab puts the team at the second of three steps Ceder thinks are needed to more rapidly develop new battery materials. The third would be testing materials A-Lab makes for use in batteries with another autonomous lab.

"We know how to do that," Ceder says. "That's just a question of money and time. Then you would have the loop complete."

Sculptor Dana King poses with the newly unveiled bust of electrical engineering professor Joseph Gier, the first tenured Black professor in the entire UC system.

Unearthing a legacy

The legacy of **Joseph Thomas Gier,** the first-ever tenured Black professor at the University of California, was lost to time — until 2018.

Maggie Crowley, newly retired communications coordinator of the Department of Electrical Engineering and Computer Sciences (EECS), was "utterly dumbfounded" when she stumbled upon the professor's 1961 obituary online.

"I found almost nothing about him online," she said in a speech at a recent ceremony honoring Gier. "The Bancroft Library only had one small box containing three of his papers. No photo, no description of his career, no mention of his race."

That is, until she unearthed Gier's personnel folder in a file drawer in the back of the Cory Hall basement. Containing the "holy grail" — a photograph of the late professor — this chance discovery jumpstarted an archival project.

Soon enough, the Berkeley EECS team filled in many blanks of the professor's life.

Gier (B.S.'33, M.S.'40 ME) shined as a Golden Bear, and he's the earliest known Black student to earn a B.S. in ME from Berkeley. Initially hired as a half-time lecturer in 1946, he was promoted to associate professor of electrical engineering in 1952. According to the archival project, he was said to be an extraordinary teacher with a "friendly and unassuming manner."

He faced many challenges while working as a Black man at a white-dominated institution. Crowley noted that the esteemed professor couldn't present his papers at conferences in certain parts of the country.

That didn't stop Gier from earning his reputation as a world authority on thermal and luminous radiation. He co-invented and patented several instruments with **Robert Dunkle,** professor of mechanical engineering. His devices were used to test solar energy in the earliest days of space exploration.

Speaking of solar energy, he also led the campus charge in communicating its importance as a renewable resource. In 1954, he said "this generation would be negligent in its duty to posterity if research in the utilization of solar energy were not quickly accelerated."

The EECS archival project is a labor of love that culminated in a bronze statue, unveiled in September by artist **Dana King.** Situated in the Blum Hall courtyard, the statue honors Joseph Gier's work and enduring influence. "My hope is that this statue will serve as a kind of wedge to keep this door to Berkeley's forgotten histories from ever fully closing again," Crowley said.

STORY BY CAITLIN KELLEY | PHOTO BY ADAM LAU

Forbes has named **Alice Agogino** (M.S.'78 ME), mechanical engineering professor emeritus, to its "50 Over 50" list in the innovation category for her work as the co-founder and CEO of Squishy Robotics. **Elizabeth Hausler** (M.S.'98, Ph.D.'02 CEE), founder and CEO of Build Change, was also named to the list in the impact category.

Electrical engineering and computer sciences professor **Venkat Anantharam** (Ph.D.'86 EECS) has won the 2023 IEEE Information Theory Society Paper Award, along with former postdoctoral fellow **Cheuk-Ting Li,** now an assistant professor at the Chinese University of Hong Kong.

Alper Atamturk, professor of industrial engineering and operations research, has been honored with the Farkas Prize by the INFORMS Optimization Society. The award recognizes a mid-career researcher for outstanding contributions to the field of optimization over the course of their career.

Eight Berkeley Engineering graduate students were selected as Siebel Scholars, a program that awards grants of $35,000 to select students based on their academic achievement and leadership: **Cindy Ayala, Arjun Bhorkar, Ruiming Cao, Sita Srinivasan Chandrasekaran, Cameron Tadashi Kato, Andre Lai, Sandeep Mukherjee** and **Anish Muthali.**

Thomas Azwell, director of the Sutardja Center for Entrepreneurship and Technology's Disaster Lab, was awarded the 2023 Chancellor's Award for Public Service in faculty-community engaged teaching for his work with underserved communities in the Bay Area.

Christopher Barry (B.S.'82 IEOR) has retired after 33 years at FedEx. During the first half of his career, he planned, designed and implemented facilities, operations and flights to support the FedEx Express network; he then worked as a supply chain consultant to FedEx's larger customers.

Dimitri Bevc (M.S.'89 MSE) was appointed a Chevron Fellow, the corporation's highest technical recognition, for his significant contributions to the fields of geophysics and seismic imaging.

Elizabeth Cantwell (M.S.'83, Ph.D.'92 ME) is the new president of Utah State University. Previously, she was the senior vice president for research and innovation and a professor of aerospace engineering at the University of Arizona.

Materials science and engineering professor **Gerbrand Ceder** has won the William Hume-Rothery Award from the Minerals, Metals & Materials Society in recognition of his contributions to the science of alloys.

Joshua Chen (B.S.'17 BioE) recently completed his Ph.D. at Rice University and was selected as a 2023 Schmidt Science Fellow. Working out of the Shapiro Lab at the California Institute of Technology, he will push the boundaries for wireless control of cell function and biology, aiming to treat diseases such as neurodegeneration.

Iain Clark (Ph.D.'14 CEE), assistant professor of bioengineering, was selected as an innovation investigator by the Arc Institute. He was awarded $1 million to pursue "curiosity-driven" research. His lab is currently focused on understanding how HIV evades the immune system and elucidating cellular interactions that control neurologic diseases.

Marie desJardins (Ph.D.'92 CS) was elected as a 2022 Fellow of the American Association for the Advancement of Science. After serving as inaugural dean of the College of Organizational, Computational, and Information Sciences at Simmons University from 2018–22, she retired last year and is currently serving on several boards.

Alexei Efros (M.S.'99, Ph.D.'03 CS), professor of electrical engineering and computer sciences, has won the Thomas S. Huang Memorial Prize by IEEE Transactions on Pattern Analysis and Machine Intelligence. The prize recognizes exemplary research, teaching, mentoring and service to the computer vision community.

Bioengineering professor **Daniel Fletcher** was honored with the 2023 Carol D. Soc Distinguished Graduate Student Mentoring Award.

Ashok Gadgil, professor of civil and environmental engineering, was named the winner of R&D Magazine's Leader of the Year Award for "creating technological innovations for safe drinking water, clean air, sustainable energy and reduced infant mortality, profoundly benefiting the health and dignity of low-resource communities."

Three faculty members have been selected for the Bakar Fellows Spark Awards: associate professor **Sanjam Garg** and professor **Ronald Fearing** from the Department of Electrical Engineering and Computer Sciences, and professor **Phillip Messersmith** from the Department of Bioengineering and the Department of Materials Science and Engineering.

Allen Goldstein, professor of civil and environmental engineering and of environmental science and policy and management, has received the California Air Resources Board's Haagen-Smit Clean Air Award, which recognizes individuals who have contributed substantially to improving air quality or addressing climate change.

Electrical engineering and computer sciences professor **Shafi Goldwasser** (M.S.'81, Ph.D.'84 EECS) has been elected as a foreign fellow of the Royal Society, the United Kingdom's national academy of sciences and the oldest science academy in continuous existence.

Michael Gollner, associate professor of mechanical engineering, is the recipient of the International Association of Wildland Fire's 2023 Early Career Award in Fire Science, which recognizes a promising early-career professional who has demonstrated outstanding ability in any field of wildland fire science.

Grace Gu, assistant professor of mechanical engineering, has been selected as the inaugural recipient of the Lawrence Livermore National Laboratory Early Career UC Faculty Initiative. She will receive up to $1 million in funding over five years to support a research project that seeks to advance AI-driven manufacturing for metal-ceramic composite structures.

Computer science professor **Venkatesan Guruswami** has won the 2023 Guggenheim Fellowship for his research proposal on mathematical computer science titled, "Mathematical Structure and Efficient Algorithms: The Polymorphic Gateway."

Computer science professor **Joseph Hellerstein** (M.S.'92 EECS) was awarded the 2023 SIGMOD Edgar F. Codd Innovations Award for "innovative contributions in extensible query processing, interactive data analytics, and declarative approaches to networking and distributed computing."

NASA astronaut **Warren "Woody" Hoburg** (M.S.'11, Ph.D.'13 EECS) has completed his six-month mission with the Crew-6 astronauts at the International Space Station National Laboratory. "Every day on station is unique and different," he said. "We could be doing anything from spending all day in a glovebox doing science experiments to doing science on ourselves, it's all incredible."

Electrical engineering and computer sciences professor emeritus **Ruzena Bajcsy** was awarded the Berkeley Citation, the university's highest honor. The citation is awarded to distinguished individuals whose contributions to UC Berkeley go beyond the call of duty and whose achievements exceed the standards of excellence in their fields. Bajcsy, whose career spans over 50 years, has conducted seminal research in the areas of human-centered computer control, cognitive science, robotics, computerized radiological/medical image processing and computer vision. The founding director of CITRIS, she is a member of the National Academy of Engineering as well as the National Academy of Medicine.

PHOTO BY NOAH BERGER

Susan Hou (B.S.'94 CE), deputy bureau manager for the San Francisco Public Utilities Commission, has received the American Society of Civil Engineering's Outstanding Projects and Leadership Award for "innovation and excellence in construction of civil engineering projects and programs." In 2017, she also received Top 25 Newsmaker Award from the Engineering News Record.

William Ibbs (Ph.D.'80 CE), professor emeritus of civil and environmental engineering, was elected as an American Society of Civil Engineers Fellow in honor of his significant contributions, including service on the California High Speed Rail Oversight Committee.

Electrical engineering and computer sciences professor **Kurt Keutzer** has received a Design Automation Conference Most Influential Paper Award for his 1987 paper, "Dagon: Technology Binding and Local Optimization by DAG Matching."

Kevin Kiyoi (B.S.'96 CE), a math and science teacher at Amador Valley High School, was named Pleasanton Unified School District's 2023 Teacher of the Year. He is the lead teacher for the school's career technology pathway, a member of the district's equity committee and has spearheaded numerous outreach efforts to introduce computer science to underrepresented students.

Paul Krueger (B.S.'97 ME) is the new dean of the College of Engineering at the University of North Texas. Previously, he was a mechanical engineering professor at Southern Methodist University.

Sam Kumar (B.S.'17, M.S.'20, Ph.D.'23 EECS) will join the UCLA engineering faculty as an assistant professor in July 2024. His research interests lie in system security and networked systems.

Ann Lee-Karlon (B.S.'89 BioE), CEO and president of EpiBiologics, and **Sonita Lontoh** (B.S.'99 IEOR), board director for SunRun and TrueBlue Inc. and Sway Ventures advisor, have been named to the San Francisco Business Times' 2023 list of "Most Influential Women in Bay Area Business."

Electrical engineering and computer sciences professor **Michael Lustig** and Stanford radiology professor **Shreyas Vasanawala** have won the Society for Pediatric Radiology Pioneer Award "for their collaborative work in ushering in a new era of cardiovascular and body MR innovations designed for the pediatric patient, bringing us closer to a dedicated pediatric MR scanner system."

Materials science and bioengineering professor **Phillip Messersmith** and materials science professor **Kristin Persson** have been named 2023 Fellows by the Materials Research Society. Persson has also won the Cyril Stanley Smith Award from the Minerals, Metals & Materials Society for outstanding contributions to the science and/or technology of materials structure.

Randy McCourt (M.S.'79 CE) was recognized by the Institute of Transportation Engineers as an Honorary Member, the organization's highest recognition of outstanding professional achievements.

The American Concrete Institute has named civil and environmental engineering professor **Jack Moehle** as an honorary member.

Jelani Nelson, professor of electrical engineering and computer sciences, has received the 2023 ACM-SIGACT Distinguished Service Award for his "outstanding contributions to broadening participation in computer science, and in theoretical computer science in particular."

Civil and environmental engineering professor **Claudia Ostertag** (Ph.D.'85 MSE) received the Scientist Medal Award from the International Association of Advanced Materials in recognition of her contributions to composites engineering and applications.

Inioluwa Deborah Raji (Ph.D.'26 CS) and **Stuart Russell,** professor of electrical engineering and computer sciences, were named to Time magazine's list of "100 Most Influential People in AI."

Gireeja Ranade (M.S.'09, Ph.D.'14 EECS), **Yakun Sophia Shao** and **Grigory Tikhomirov** — all assistant professors of electrical engineering and computer sciences — and **Hannah Stuart,** assistant professor of mechanical engineering, have been recognized with Faculty Early Career Development (CAREER) awards from the National Science Foundation.

Rhonda Righter (Ph.D.'86 IEOR), professor of industrial engineering and operations research, has been elected as a 2023 Fellow of the Institute of Operations Research and Management Science. **Maged Dessouky** (Ph.D.'92 IEOR), professor and chair of the Department of Industrial and Systems Engineering at the University of Southern California, was also elected.

J. David Rogers (M.S.'79, Ph.D.'82 CE), professor of geological engineering at the Missouri University of Science and Technology, was awarded the Civil Engineering History and Heritage Award from the American Society of Civil Engineers (ASCE) in recognition of his 30 years as a recognized expert on the history of dam failures, significant publications on civil engineering history topics and his many ASCE conference presentations.

Boris Rubinsky, Professor of the Graduate School at the Department of Mechanical Engineering and professor emeritus of bioengineering, has won the H.R. Lissner Medal from the American Society of Mechanical Engineers.

Electrical engineering and computer sciences professor **Stuart Russell** has won the AAAI Allen Newell Award from the Association for Computing Machinery, which is given to individuals who have made significant contributions to the field of artificial intelligence.

Emilia Sánchez (B.S.'06 CE) has been appointed the director of engineering for the Port of Oakland. She is the first woman and the first Latina to serve in this leadership position at the port. Previously, she spent over a decade at Bay Area Rapid Transit (BART), where she served in various positions.

Alane Suhr, assistant professor of electrical engineering and computer sciences, has received an honorable mention for the ACM Doctoral Dissertation Award for making "transformative contributions in several areas of natural language processing."

Kirk Tramble (B.S.'93 EECS) is the new president of the California Alumni Association's board of directors. A technology consultant, he is also the president emeritus of UC Berkeley's Black Engineering and Science Alumni Club.

Industrial engineering and operations research assistant professor **Rajan Udwani** has been awarded a Google Research Scholar Award in recognition of his proposal on algorithms and optimization.

Marlene Watson (M.S.'92 CEE) has won the 2023 Ely S. Parker Award, the highest professional honor conferred by the American Indian Science and Engineering Society. She is currently a civil engineer with the U.S. Department of the Interior Bureau of Indian Affairs.

Clancy Wilmott, assistant professor of geography and faculty member of the Berkeley Center for New Media, received a Graduate Assembly Faculty Mentoring Award.

The Committee of Presidents of Statistical Societies has selected **Bin Yu,** professor of electrical engineering and computer sciences and of statistics, for the 2023 Distinguished Achievement Award and Lectureship.

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

The greening of jeans

Plastics, batteries and household cleaning supplies are just a few of the consumer goods that researchers are striving to make more eco-friendly. Now, thanks to Berkeley Engineering alum **Tammy Hsu** (Ph.D.'19 BioE), we can soon add another item: bluejeans.

Indigo is the primary dye used in the manufacture of denim jeans, with over a billion pairs sold worldwide each year. But the current way indigo is created for commercial use relies on chemicals, such as formaldehyde and cyanide, that are toxic to the environment.

Applying the engineering know-how she gained at Berkeley, Hsu set out to produce a more sustainable version of indigo using microbes. In 2019, she co-founded Huue, a company that uses biotechnology to produce environmentally friendly dyes for industry.

Hsu's interest in environmentally friendly processes and sustainable dyes blossomed while working in the lab of **John Dueber,** associate professor of bioengineering. "There were a lot of interesting projects floating around in their nascent state," she said. "One of them was: how do we make the indigo precursor that's made in plants? How do we introduce that enzyme into microbes, then have the microbes produce it repeatably at large scale, at high purity?"

Soon, denim companies were inquiring about their work. "Different denim brands were starting to call my adviser and say, 'I hear you have this new way of making indigo dye,'" she said. "Currently, there's no good sustainable alternative. So brands were on the lookout for new technologies; the interest from the market was always apparent."

Hsu began to think about starting a business based on her engineered microbe technology. She had grown up in Silicon Valley, "surrounded by a spirit of entrepreneurship," so a startup seemed like the next logical step to bring the product to fruition.

Hsu discovered that she could explore her engineering aspirations while tapping into campus resources to help lay the foundation for her future business, including the Bakar Innovations Fellows program. "My PI [principal investigator], for example, was part of the Bakar Faculty Fellows program, which supports faculty interested in entrepreneurship and getting their ideas out into the world. And there's a grad student branch of the program, the Bakar Innovation Fellows, that I participated in."

Hsu also took a few courses at the Haas School of Business to learn what's involved in forming a startup. She then kicked her business idea into high gear by participating in multiple accelerator programs, including the Bakar BioEnginuity Hub's QB3 program, and applied for a grant from the National Science Foundation. Hsu later teamed up with future Huue co-founder and CEO **Michelle Zhu,** with whom she joined IndieBio, a venture capital-backed incubator program.

It's been 4 1/2 years since Hsu and Zhu founded Huue, which now has 16 employees, with the majority of the team focused on research and development. And creating sustainable indigo dye is only the first step for the company. Hsu, head of research at Huue, has begun investigating ways other textile dyes could be made using her company's microbe technology.

As she looks ahead, Hsu believes that Berkeley played a vital role in getting her where she is today. "Berkeley allowed me to realize my potential, both as an engineer and as an entrepreneur," she said.

STORY BY MARNI ELLERY | PHOTO COURTESY HUUE

Jerry Angelides (B.S.'47 ME) died in June at the age of 100. A veteran of the U.S. Army Air Corps, he worked for the Office of the State Architect and for the city of Sacramento.

Ramon Belshe (M.S.'71 CE) died in March at the age of 91. During his career, he worked for the Federal Aviation Agency, and later, as a technician and engineering manager.

Vladislav Ako Bevc (B.S.'57, M.S.'58, Ph.D.'61 EECS) died in May 2022 at the age of 90. A professor at the Naval Post-Graduate School in Monterey, he also worked for Hughes Aircraft, Aerospace Corp., Lawrence Livermore National Laboratory and the California State Public Utilities Commission.

Mark Butler (B.S.'78 ME) died in January at the age of 66. He earned a master's degree in mechanical engineering from Johns Hopkins University and had a 40-year career at Northrop Grumman as an engineering manager.

Scott Campbell (Ph.D.'94 CE) died in January at the age of 60. A faculty member at the American University of Armenia and The Ohio State University, he was also vice president at the National Ready Mixed Concrete Association.

William Colter (M.S.'70 CE) died in June at the age of 79. The founder of Dynamic Ventilation, he also worked for the U.S. Federal Highway Administration and Sprinchorn & Co.

Laurence DeCuir (B.S.'48 EECS) died in April at the age of 100. He contributed to the Manhattan Project in the Army Air Corps. After graduating, he worked in communications and aerospace, with major contributions to satellite tracking.

Paul Dennig Jr. (B.S.'21, MEng '22 ME) died in May at the age of 24. As a student, he worked on a variety of research projects, including the development of predictive control schemes for robots.

John Duckett (B.S.'56 IEOR) died in August at the age of 94. An Air Force veteran, he invented the QuickChange Movable Barrier, which is used today on many of the world's busiest roadways and bridges.

Beverley Duer (Ph.D.'62 IEOR) died in August at the age of 95. He worked at CPC International and consulted for the Department of Defense, among other positions.

Guy Embree (B.S.'44 ME) died in January at the age of 100. In the U.S. Navy, he helped to pioneer the precursor of the modern airplane flight recorder. For over 40 years, he worked as the chief operating officer of Embree Buses, Inc.

David Feather (M.S.'69, Ph.D.'72 MSE) died in June. He worked for Xerox Corp, then joined Torey Pines Research, working in product development.

William Fothergill Jr. (B.S.'49 ME) died in June at the age of 99. He served in the U.S. Navy during World War II, then had a long career with General Motors, retiring as plant engineer.

Dennis Gee (B.S.'66, M.S.'68, Ph.D.'74 CE) died in April at the age of 78. He worked as a hydraulic engineer with the Corps of Engineers for 43 years.

James Gierlich (B.S.'46 CE) died in February at the age of 97. He joined the U.S. Marines Corps Reserves, retiring at the rank of lieutenant colonel, and had his own water and wastewater engineering firm, Gierlich-Mitchell, Inc.

Hugo Hanson (B.S.'51, M.S.'69 CE) died in February at the age of 95. He first worked on water resource projects, including the Briones Dam, then worked as a geotechnical engineer.

Donald Javete (M.S.'54, Ph.D.'83 CE) died in January at the age of 93. He was the managing partner at Dames & Moore and, later, worked as a private consultant.

Alfred Kaehler (B.S.'44 ME) died in December 2022 at the age of 101. He worked on the Manhattan Project at the Berkeley Rad Lab, at Oak Ridge National Laboratory, and later, at Los Alamos National Laboratory. He also worked at SRI, Lockheed and Raychem.

Harold Knudsen (B.S.'58, M.S.'60, Ph.D.'62 EECS) died in May at the age of 86. He began his career at MIT's Lincoln Laboratory, then worked at the University of New Mexico as an electrical engineering professor.

William Langbehn (B.S.'84, MEng'86 CE) died in May at the age of 61. He was the founder of the Langbehn Geotechnical Group, working as an engineer throughout the Bay Area.

Allan Lichtenberg, professor emeritus of electrical engineering and computer sciences, died in February at the age of 92. A pioneering researcher on high-temperature plasma, nonlinear dynamics and energy utilization, he chaired the newly-formed Energy and Resources Graduate Group from 1974–78.

Adolf May, professor emeritus of civil and environmental engineering, died in August at the age of 96. A pioneer in highway transportation, he invented metering lights, setting up the first ramp meter in 1963. He was also a member of the National Academy of Engineering.

Edward McLaughlin (B.S.'55 IEOR) died in February at the age of 93. He had a long career in aerospace at Collins Radio, Celesco Industries and Brunswick Defense.

Thomas Mill (B.S.'57 CE) died in March at the age of 91. After serving in the U.S. Army, he joined the family business, Mill Construction Co., working as a general contractor.

Paul Rodgers (B.S.'52 EECS) died in March at the age of 94. A commissioned officer in the U.S. Navy, he worked for several large data system companies and as an electronics manufacturing representative.

Donald Sharman (B.S.'50 IEOR) died in February at the age of 97. In World War II, he served in the U.S. Army. Later, he ran a successful independent engineering firm.

Donald Shayler (B.S.'62 CE) died in February at the age of 84. He ran Pacific Rim, the first civil engineering office in Palm Desert, CA.

Richard Simpson (B.S.'56 EECS) died in July at the age of 93. A U.S. Navy veteran, he founded a company that specialized in naval electronics and weapon systems and was the vice president for the Rucker Company. In 1973, he became the first chairman of the Consumer Product Safety Division.

Jesse Skidmore (B.S.'02 Eng. Phys.) died in January at the age of 43. He served for 20 years in the U.S. Navy and was a captain in the U.S. Navy Reserve. He went on to work for the Department of Defense at the Pentagon and the U.S. Naval Research Laboratory.

Paul Smith (Ph.D.'71 CE) died in December 2022 at the age of 87. After working at Auburn University and NASA, he joined Lawrence Livermore National Laboratory, specializing in piping safety for nuclear power plants.

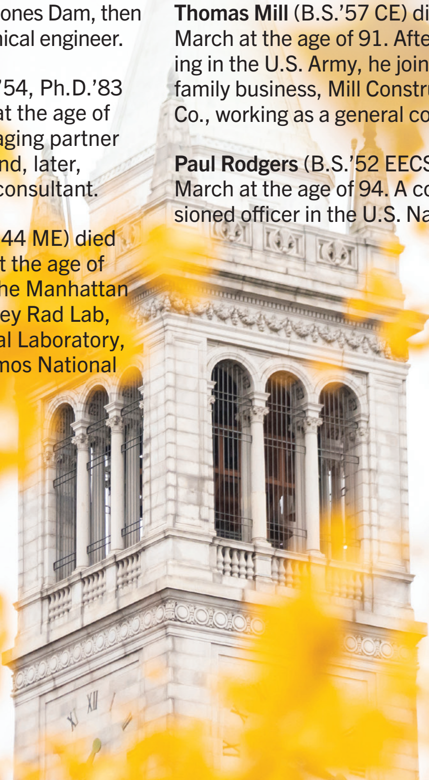
Harry Spence (B.S.'62 Metallurgy) died in March at the age of 87. He had a distinguished 40-year career in the electronics industry.

Donald Sudnikoff (B.S.'65 EECS) died in February at the age of 79. He spent over 20 years in the U.S. Navy and the Naval Reserves with the rank of commander. He also worked as an engineer for AT&T.

Fermin Viteri (B.S.'52 ME) died in February at the age of 93. He worked at Aerojet and later co-founded Clean Energy Systems.

James Willis (M.S.'56 CE) died in May. He was a structural engineer with Blaylock Willis Engineering.

Fred Womble (B.S.'45 EECS) died in February at the age of 98. He worked for Pacific Gas & Electric Co. for nearly four decades.



Adam Lau

With flexibility comes possibility

Berkeley Engineering fosters a community centered around serving the greater good and educating the next generation of scholars.

That's why we invest in top talent. To make that happen, our newest faculty receive competitive startup packages that enable them to realize their high-impact research.

Take Maya Carrasquillo, assistant professor of civil and environmental engineering. With the Huelskamp Fellowship, she quickly grew the number of student workers in the Liberatory Infrastructures Lab — and expanded the scope of her team's research from stormwater systems to broadly thinking about infrastructural justice. "It's opened up new avenues of research," she said, "and it's expanded our ability to support students that are truly amazing and share a similar vision for their research and their role as engineers."

Funding for these faculty fellowships supports our newest members as they make important discoveries and mentor students. Through your contribution, you can have a profound impact.

To learn more, visit:
engineering.berkeley.edu/give

Berkeley Engineering

ADAM LAU PHOTOS

"We're digging into projects that are trying to work alongside community partners to answer, 'How do we actually address infrastructural needs?'"

- Maya Carrasquillo, assistant professor of civil and environmental engineering

LIBERATORY INFRASTRUCTURES LAB PHOTO

BerkeleyENGINEER
University of California, Berkeley
College of Engineering
Office of Marketing & Communications
Berkeley, CA 94720-1704

ADAM LAU PHOTO

Putting students front and center

"This new project is for the future," says recent alum Christian Lander (B.S.'23 CE), a project engineer at XL Construction, the company that's building the new Engineering Center. "It's a huge blessing to build this project and know that you're not only impacting the students now but also the students 20 years from now."

Like Christian, we know that when Berkeley Engineering students collaborate, it fuels innovation and change — and hope for a better tomorrow. Slated to open in 2025, the new building will transform the student experience for generations to come. With your gift, you're helping to support a space that will equip and empower our best and brightest engineering leaders.

To learn more about supporting this project, including matching and naming opportunities, visit:
engineering.berkeley.edu/give

Berkeley
Engineering