FACULTY AWARDS

AT THE FRONTIER OF RESEARCH

Materials and chemistry professor **Craig Hawker,** and **Rachel Segalman**, chair of the Chemical Engineering Department, were among the 129 new members elected to the National Academy of Engineering (NAE) for 2021. Election to the academy is among the highest professional distinctions accorded to an engineer.

With particular interests in energy, efficiency, sustainability, and materials and interfaces, Segalman focuses her research on controlling self-assembly, structure, and properties of functional polymers. Structural control over soft matter at microscopic length scales is an essential tool to optimize properties for applications ranging from solar and thermal energy to biomaterials. Her work paves the way for the development of sophisticated materials for such energy applications as photovoltaics, fuel cells, and thermoelectrics. Segalman, the Edward Noble Kramer Chair in Materials, was recognized "for contributions to semiconducting block polymers, polymeric ionic liquids, and hybrid thermoelectric materials."

"The perception is that this is an individual honor, but I see it as a recognition for the university and the wonderful people whom I've been able to work with for decades," said Segalman, a recipient of multiple honors throughout her career, including election as a fellow of the American Academy of Arts and Sciences (AAAS) and the American Physical Society (APS). "I also believe our selection is a testament to UCSB's collaborative culture, for creating an environment that allows scientists and students to be inspired together and pursue research in new directions."

Hawker's research activities are focused on synthetic polymer chemistry, integrating cross-disciplinary studies to develop nanostructured materials having unique physical and mechanical properties for applications in biomaterials and energy research. Hawker, the Alan and Ruth Heeger Chair in Interdisciplinary Science and the Peter J. Clarke Chair for the Director of the NanoSystems Institute (CNSI), who also serves as director of the Dow Materials Institute, was cited for "contributions to polymer chemistry through synthetic organic chemistry concepts and the advancement of molecular engineering principles."

Rachel Segalman

Craig Hawker

"I am thrilled by this honor, especially when I think about all of the people over the years who made this happen, including **Ed Kramer**, who was Rachel's graduate advisor at UCSB and a huge reason why I joined the faculty at UCSB," said Hawker, who is also an elected fellow of the Royal Society, the National Academy of Inventors, and the American Academy of Arts and Sciences. "Our election reflects the university's status as a leader in materials and polymer science. It also shows UCSB's unique collaborative culture, in which great science and engineering are built on a tradition of working across boundaries. The sum is certainly greater than any individual research success."

Hawker's groundbreaking work has formed the basis for more than eighty U.S. patents and ten start-up companies. A number of these companies have developed drugs to improve the quality of life for people who suffer from chronic kidney disease (CKD). Hawker received the American Chemical Society's 2021 Kathryn C. Hach Award for Entrepreneurial Success in recognition of his "innovative leadership in creating, developing, and commercializing revolutionary polymer-based therapeutics and personal-care products through multiple successful start-up companies."

The newly elected class will be inducted during the NAE's annual meeting, to be held in this coming October.

A sampling of honors received by College of Engineering faculty from April 2020 – April 2021: **Chris Bates (MAT):** Camille Dreyfus Teacher-Scholar Award, *Camille and Henry Dreyfus Foundation* * **Matt Beane (TM):** Best Paper Award, *Organizational Communication Information Systems* * **Irene Beyerlein (MAT/ME):** Elected Fellow, *Materials Research Society* * **John Bowers (ECE/MAT):** Highly Cited Researchers List, *Web of Science* * **Michael Chabinyc (MAT):** Elected Fellow, *American Association for the Advancement of Science* * **Phillip Christopher (ChE):** Young Investigator Award, *American Institute of Chemical Engineers' Division of Catalysis and Reaction Engineering* * **Xi Dai (MAT):** Highly Cited Researchers List, *Web of Science* * **Yufei Ding (CS):** Early CAREER Award, *National Science Foundation* * **Michael Doherty** (ChE): John M. Prausnitz Institute Lecture, *American Institute of Chemical Engineers* * **Emilie Dressaire (ME):** Regents' Junior Faculty Fellowship Award * **Yu Feng (CS):** Research Scholar Award,

RECOGNIZING **INNOVATION**

Nine assistant professors in the UC Santa Barbara College of Engineering have received prestigious Early CAREER awards from the National Science Foundation (NSF) since April 2020. An NSF CAREER award includes up to $500,000 in funding over five years to support the pioneering research conducted by junior faculty and to advance excellence in education.

"We are tremendously proud of the nine assistant professors for receiving this highly esteemed award," said **Rod Alferness**, dean of the College of Engineering. "They are shining examples of the high-quality junior faculty we have in the College of Engineering, whose cutting-edge research in emerging fields, ranging from quantum computing to vine robots, will push the boundaries of scientific discovery in ways that will benefit society."

Brief summaries of each recipient's research projects that led to their NSF CAREER awards are included below.

Yufei Ding
Computer Science

Ding has developed an innovative plan to improve the efficiency and accuracy of quantum applications in the next generation of quantum devices. In the project funded through her NSF Early CAREER award, Ding seeks to design state-of-the-art architecture to improve the stability of quantum computing by focusing on compilation and optimization. Compilation is the process by which a computer program takes a source code written in one program language and translates it into a second language to create an executable file or outcome. Presently, the longer a quantum algorithm runs, or compiles, the more its performance degrades because of noise or environmental disturbances, such as vibration or temperature changes. As part of the project, Ding will create a new high-level programming language to optimize algorithms and develop advanced testing and debug support.

"Our work has the potential to benefit major quantum computing applications, such as quantum chemistry, and to expand to materials, finance, and stochastic/numerical mathematics," said Ding. "The success of our agenda will enable a more complete and efficient hardware stack and support quantum applications on near-term devices."

Elliot Hawkes
Mechanical Engineering

With colleagues at Stanford University, Hawkes developed a new robot, characterized by tip extension. Called *vine robots,* referring to their similar growth-based movement from only the tip, they are well suited for navigation and exploration in cluttered environments. Hawkes received his CAREER award to design new robots by better understanding the factors that govern their movements. He is interested in two particular designs: A burrowing vine robot that would emit water or air from its tip, creating a path to enable subterranean navigation; and a medical vine robot that could be used by surgeons to safely access a point inside the body for diagnosis and therapy delivery. Because of their durability and adaptability, Hawkes says, the robots could prove transformative in numerous fields of study.

"Burrowing vine robots could help geologists to investigate soil layers, archaeologists to explore buried ruins, environmentalists to study pollution in soil, biologists to navigate underground burrows, crews to route cables under roads or buildings, and emergency personnel to locate survivors after natural disasters,"said Hawkes, whose soft robot was named one of the "Ten Robotics Technologies of the Year" by *Science Robotics* in 2019. "The medical vine robot could transform minimally invasive procedures in fields such as urology and neurology, be used during endovascular surgeries, and even grow into the lungs to revolutionize emergency tracheal intubation."

Paolo Luzzatto-Fegiz
Mechanical Engineering

Taking a three-pronged approach that includes simulations, experiments, and theory, Luzzatto-Fegiz will use his CAREER award to pursue research in the rapidly emerging area of superhydrophobic surfaces (SHS). SHS are meant to reduce the resistance that results from water or other fluids moving along a surface, like the hull of a ship. In the ship's case, the drag causes it to move more slowly than it would if the fluid friction were reduced.

One way to achieve a "slippier" hull is to coat it with an SHS, which contains tiny air pockets that separate the hull from the water. Because air is much less viscous than water, when less water comes into contact with the hull, there is less drag. But SHS often don't work as models suggest they should, and in previous research, Luzzatto-Fegiz and colleagues figured out why. The culprit is surfactant, a compound, such as soap or algae (or, in the ocean, many things), which, even in

Google * **Glenn Fredrickson (ChE):** Elected Member, *National Academy of Sciences* * **Songi Han (ChE/CHEM):** EAS Award for Outstanding Achievements in Magnetic Resonance, *Eastern Analytical Symposium* * **Craig Hawker (MAT/CHEM):** Elected Fellow, *National Academy of Engineering*; Kathryn C. Hach Award, *American Chemical Society* * **Elliot Hawkes (ME):** Early CAREER Award, *National Science Foundation*; Packard Fellow for Science and Engineering, *Packard Foundation*; Early Career Award, *NASA* * **Alan Heeger (MAT):** Highly Cited Researchers List, *Web of Science* * **Yogananda Isukapalli (ECE):** Distinguished Teaching Award, *UCSB Academic Senate** **Jonathan Klamkin (ECE):** Director's Fellowship, *Defense Advanced Research Projects Agency* * **Paolo Luzzatto-Fegiz (ME):** Early CAREER Award, *National Science Foundation* * **Igor Mezíc (ME):** J. D. Crawford Prize, *Society for Industrial and Applied Mathematics Activity Group on Dynamical Systems* * **Diba Mirza (CS):** Mentoring Award for Undergraduate Research, *National Center for Women &*

trace amounts, can reduce surface tension along the hull and diminish the SHS's drag-reducing effect. In this new project, Luzzatto-Fegiz and colleagues at the University of Cambridge and the University of Manchester will study the precise impact of surfactants on SHS in order to identify practical mitigation strategies to unlock their drag-reducing potential for real-world applications. They will then take a multidisciplinary approach to adjusting the geometry of surface particles to address the macroscopic effect of the coating and the microscopic chemical effects of surfactants.

"Most people who looked at this problem did so from more of a classical mechanical engineering perspective, so they didn't know anything about surfactants or contaminants until we started this work," said Luzzatto-Fegiz, who hopes the research will lead to SHS that have the optimal texture and microscopic particles of the correct geometry to make ships more slippery.

Galan Moody
Electrical and Computer Engineering

The key to the speed of quantum computers lies in qubits, the basic units of information that can exist in multiple states, a phenomenon that provides far more processing power than the binary bits of classical computers. Qubits, however, are easily affected by environmental disturbance, referred to as *noise*, such as temperature fluctuations and vibrations. Most qubits also need to be cooled to absolute zero (-273 degrees Celsius) to be usable. One potential way around those obstacles being explored by UCSB researchers involves integrated photonics, a field in which on-campus researchers have established themselves as world leaders. Integrated photonics refers to the design and fabrication of photonic devices in which all of the components, from lasers to optical interconnects, are contained on one chip. Moody, an assistant professor of electrical and computer engineering, will work to develop a quantum photonics platform that allows for chip-scale quantum information processing with light. He plans to replace the silicon waveguides that direct light around a photonic chip with the III-V semiconductor alloy aluminum gallium arsenide (AlGaAs).

"We expect several new important capabilities and better performance than we get from silicon, including more efficient quantum light sources, a reduced need for laser power to pump the sources, better electrical efficiency, and significantly less optical loss in order to preserve the photon's quantum state," said Moody, who also received the Defense University Research Instrumentation Program (DURIP) award from the Department of Defense (see page 22) to build the instrumentation needed to test the quantum photonic chips his group will design and fabricate as part of the CAREER award.

Angela Pitenis
Materials

Numerous soft biomedical devices, such as silicone implants and contact lenses, are placed in direct contact with living cells and tissues. They are designed to adjust their form or appearance, or to improve their function through interactions with tissues and cells. However, soft implant surfaces may induce inflammation by unintentionally increasing friction when the outer surface of the device slides against living cells and tissues. Pitenis, an assistant professor in the Materials Department, received a CAREER award to study the dynamics of fragile interfaces, with a long-term goal of creating low-friction interfaces for soft biomedical devices. The project is guided by her hypothesis that sliding surfaces in nature reduce friction through a delicate balance of fracturing and rapidly rehealing crosslinks between macromolecules in aqueous solutions.

"This work responds to the critical need to develop biocompatible surface engineering approaches involving lubricious gels on implants to improve interactions during frictional sliding motions against cells and tissues," said Pitenis. "Our approach may prove transformative for several engineering challenges in healthcare."

Alban Sauret
Mechanical Engineering

Sauret, an assistant professor in mechanical engineering, works to further the knowledge of multiphase flows involved in environmental science, industrial applications, and sustainable processes. A particular focus of his research involves understanding the complex dynamics at play when applying liquid coatings to a surface, such as by dipping a probe or a sheet of material into a captured liquid. Particles are commonly suspended in the liquid, whether deposited directly or sprayed to improve the coating's performance. However, the processes are often challenging and poorly controlled, which leads to product rejection and waste. In his project, Sauret is investigating interfacial dynamics in the presence of particles.

"The dynamics of the system, in which the thickness of a

Information Technology * **Galan Moody (ECE):** Early CAREER Award, *National Science Foundation* * **Shuji Nakamura (ECE/MAT):** Queen Elizabeth Prize for Engineering, *QEPrize Foundation* * **Michelle O'Malley (ChE):** Early Career Award, *American Institute of Chemical Engineers, Division of Food, Pharmaceutical and Bioengineering* * **Sumita Pennathur (ME):** Fellow, *American Institute for Medical and Biological Engineering* * **Linda Petzold (ME/CS):** Fellow, *American Institute for Medical and Biological Engineering*; Elected Member, *National Academy of Sciences* * **Angela Pintenis (MAT):** Early CAREER Award, *National Science Foundation* * **Beth Pruitt (ME):** Fellow, *Biomedical Engineering Society* * **Alban Sauret (ME):** Early CAREER Award, *National Science Foundation* * **Rachel Segalman (ChE/MAT)**: Elected Member, National Academy of Engineering * **Timothy Sherwood (CS):** Award for Inclusion Research, *Google*; Outstanding Graduate Mentor Award, *UCSB Academic Senate* * **Misha Sra (CS):** Research Scholar Award, *Google*; Best Dissertation liquid film reflects the size of the particle, challenges our understanding, because the surface gives rise to capillary effects that affect the system," said Sauret, referencing the ability of a liquid to flow in narrow spaces without external forces like gravity. "Because of the great complexity of multiphase flows, it is impossible to represent the phenomena numerically. We hope to develop new approaches to describe how particles affect the overall process."

William Wang
Computer Science

As we rely more on natural language processing to help us navigate our world, it's more important than ever that these artificial intelligence (AI) models — used increasingly in applications such as caption generation for the visually impaired — remain accurate and truthful. However, in the many iterations required for a model to learn how to describe or predict what a scene depicts, elements can creep in that cause errors in data-to-text translation or object hallucinations, in which the caption contains an object or an action that doesn't exist in the image. Wang, an assistant professor of computer science, received a CAREER award to create more robust deep learning-based natural language generation models. In his project, he will investigate the complex relationship between uncertainty and faithfulness, two important and sometimes opposing elements in the realm of deep learning.

"We believe that the AI model has to maintain a certain level of uncertainty in order to explore difference solutions, but it also has to be balanced and constrained at the same time," said Wang, the Duncan and Suzanne Mellichamp Professor of Artificial Intelligence and Designs and director of UCSB's Center for Responsible Machine Learning. "The current research in machine learning and AI primarily focuses on independently and identically distributed data — each image is independent of one another. But how can we work with AI agents to enable dynamic decision making? This would be very practical for building AI agents that can interact more effectively with humans in the real world."

Yu-Xiang Wang
Computer Science

In Wang's CAREER project, he will take an innovative approach to maximizing the potential impact of artificial intelligence and big data technologies. Wang, the Eugene Aas Chair in Computer Science, seeks to advance the theory and applications of differential privacy (DP), a mathematical definition of privacy that provides provable guarantees against identifications of individuals in a dataset, while still allowing the dataset, as a whole, to be useful. Wang plans to use numerical algorithms and computations to automate some of the complex mathematical derivations, and to provide new algorithms that publish comprehensive, private data-dependent reports to address existing challenges related to the design and analysis of DP.

"The combination of computing and math is especially powerful, because computing will allow for the practical implementation of mathematical equations that are precise but not simple, rather than resorting to simple approximations," said Wang, whose group is collaborating to apply DP to clinical research studies and the collection of person-generated health data. "DP is at a pivotal moment, transitioning from a theoretical construct into a practical technology. Our research paves the way for DP to be used and deployed in a wider array of applications."

Yangying Zhu
Mechanical Engineering

Zhu will study phase change, or the process by which matter transitions from one state (solid, liquid, or gas) to another. A phase change takes place because of heat transfer, the exchange of thermal energy between physical systems. The mechanical engineering assistant professor says that understanding phase change and heat transfer at the microscale will unlock secrets that can lead to next-generation technologies and increased energy efficiency at the very large scale. She has proposed a project to develop a temperature-measurement technique that can directly probe the three-phase region, something that has been very difficult to realize before. The three-phase region refers to the location where liquid, vapor, and solid meet during the phase change, such as the base of a bubble on a solid surface during boiling.

"The data from this experiment will help us to better understand phase-change processes and identify factors that limit efficient heat transfer," said Zhu, who plans to apply her findings to the transmission of respiratory diseases from the perspective of heat and mass transfer. Further, she says, "The insights gained through this work will potentially lead to highly effective and improved phase-change devices that can enable energy savings and reduce freshwater withdrawals for power plants, provide energy-efficient thermally driven desalination, effective heat dissipation for high-power-density electronic devices, and more energy-efficient thermal control of buildings."

Zhu is also lead investigator on a project with mechanical engineering professor **Paolo Luzzatto-Fegiz** and **Javier Read de Alaniz** to study phase changes aboard the International Space Station two years from now. (See article on page 18.)

Award, *Institute of Electrical and Electronics Engineering, Visualization and Graphics Technical Committee* * **Ryan Stowers (ME):** Young Investigator Award, *Cells Tissues Organs* Journal; Regents' Junior Faculty Fellowship Award * **Megan Valentine (ME):** Fellow, *American Institute for Medical and Biological Engineering* * **Anton Van der Ven (MAT):** William Hume-Rothery Award, *The Minerals, Metals & Materials Society* * **Chris Van de Walle (MAT):** Highly Cited Researchers List, *Web of Science Group* * **William Wang (CS):** Early CAREER Award, *National Science Foundation*; AI's 10 to Watch, *Institute of Electrical and Electronics Engineers, Intelligent Systems* Journal * **Yu-Xiang Wang (CS):** Early CAREER Award, *National Science Foundation*; Research Scholar Award, *Google* * **Enoch Yeung (ME):** Young Investigator Award, *U.S. Army Research Office* * **Yangying Zhu (ME)**: Early CAREER Award, *National Science Foundation;* Regents' Junior Faculty Fellowship Award * **Frank Zok (MAT):** Outstanding Graduate Mentor Award, *UCSB Academic Senate*

ROYAL RECOGNITION

Shuji Nakamura, a professor of materials and electrical and computer engineering at UC Santa Barbara, was one of five recipients of the 2021 Queen Elizabeth Prize for Engineering, or QEPrize. The winners are all pioneers in the field of light-emitting diodes, or LED lighting. Nakamura began developing LED technology while a researcher in Japan in the 1980s and won a Nobel Prize in Physics for his work in 2014.

"I am so honored to receive the Queen Elizabeth Prize for my contributions to solid-state lighting, which provides tremendous benefits for humanity by providing energy-efficient lighting and displays," said Nakamura, the Cree Endowed Chair in Solid State Lighting and Displays.

The prestigious QEPrize comes with one million pounds and is awarded every two years by the Queen Elizabeth Prize for Engineering Foundation. The QEPrize celebrates engineering's visionaries, encouraging them to extend the boundaries of what is possible across all disciplines and applications. In its statement announcing the prize, the Queen Elizabeth Prize for Engineering Foundation said that the development of LED lighting "forms the basis of all solid-state lighting and technology." The winners, the foundation said, are being recognized "not only for the global impact of LED and solid-state lighting but also for the tremendous contribution the technology has made, and will continue to make, to reducing energy consumption and addressing climate change."

With his flawless gallium nitride (GaN) crystals, Nakamura not only developed the bright-blue LED, but also helped pave the way for the white LED, a technology that has revolutionized lighting and displays, which have been the main force behind a huge reduction in energy consumed by lighting. The U.S. Department of Energy estimates that by 2030 our energy consumption for lighting will have decreased by more than forty percent, equivalent to the output of more than fifty power plants.

SCIENTIFIC ACHIEVEMENT

Linda Petzold

Glenn Fredrickson

Two professors in the UC Santa Barbara College of Engineering, **Linda Petzold** and **Glenn Fredrickson**, were elected to the National Academy of Sciences in recognition of their distinguished and continuing achievements in original research. Membership in the NAS is one of the highest honors given to a scientist or engineer in the United States. This year, the Class of 2021 includes 150 people, including 30 international members.

Petzold, the Mehrabian Endowed Chair in the College of Engineering and Distinguished Professor of Mechanical Engineering and Computer Science, was honored by the NAS for her contributions to theoretical numerical analysis. A member of the prestigious National Academy of Engineering (NAE), she is also an elected fellow of the American Institute for Medical and Biological Engineering (AIMBE), the Society for Industrial and Applied Mathematics (SIAM), the Association for Computing Machinery (ACM), and the American Association for the Advancement of Science (AAAS).

"I am deeply honored that my work has been recognized by my colleagues in the NAS," said Petzold. "Up to this point, my work has been recognized mostly for its contributions to computer science and engineering. It is gratifying to be recognized for my contributions in mathematics and the sciences."

Petzold's breakthrough 1982 paper "Differential-Algebraic Equations (DAEs) are not ODEs [ordinary differential equations]" opened up a new subfield in computational mathematics, and her public-domain software DASSL has enabled the simulation of countless systems in engineering and science. Her LSODA software has been used extensively and remains in widespread use, particularly in the chemical and pharmaceutical industries. Current collaborations range from biology (jet lag and cell polarization), to medicine (trauma and chronic pain), to ecology (ant behavior), to neuroscience (learning, neuronal networks, and migraines).

Fredrickson, the Mitsubishi Chemical Corporation Chair in Functional Materials, was honored by the NAS for his contributions to soft-matter theory. He pioneered computational field theory techniques that revolutionized the study of soft materials and complex fluids, most notably in self-assembling polymers and block copolymers. Known as field-theoretic simulations (FTS), his techniques are important not only to molecular thermodynamics, but also for their engineering impact on directed self-assembly, an important technology for manufacturing semiconductor devices.

"Election to the NAS is the highest recognition for scientists in the U.S., so I am thrilled and humbled that my research has been honored in this manner," said Fredrickson, who was previously elected a member of the NAE, and is a fellow of the American Institute of Chemical Engineers (AIChE), the American Academy of Arts and Sciences, the American Physical Society, and the AAAS. "While my applied research has been previously honored by election to the NAE and awards from the AIChE, it is extremely satisfying to be recognized for my fundamental accomplishments by peers in the scientific community."