NEWS BRIEFS

ANOTHER HONOR FOR THE MAN WHO REVOLUTIONIZED LIGHTING

UC Santa Barbara engineering professor **Shuji Nakamura** was honored in Dayton, Ohio, on November 13 when he and two others were inducted into the Engineering and Science Hall of Fame. The professor of electrical and computer engineering and of materials was elected "for pioneering invention and development of the blue light emitting diode (LED), a breakthrough that made possible the energy-efficient white-light LED in global use today." The invention earned Nakamura the 2014 Nobel Prize for Physics. The other 2024 inductees were Carl Harry Knowles, inventor and developer of the first programmable barcode scanner and handheld laser scanner, and Clarence "Kelly" Johnson, a pioneer in designing jet fighter planes.

Nakamura joined others to light up Henley Hall on Dec. 4 as the Solid State Lighting and Energy Electronics Center at UCSB celebrated its 25th anniversary during the 2024 SSLEEC Annual Review Conference. Initially named the Solid State Lighting Display Center and part of the Materials Department, the center was renamed SSLEEC in 2013, expanding the goal of advancing new semiconductor-based energy-efficient lighting technologies through partnerships with key industry leaders.

The SSLEEC leadership team comprising Nakamura as director, **Steven Denbaars** (Materials; Electrical and Computer Engineering [ECE]) as co-director, **Jim Speck** (Materials), and College of Engineering dean, **Umesh Mishra** (ECE), has established a unique business model linking key industry partners with UCSB faculty and student researchers to collaborate across disciplines in addressing challenging problems in a range of important research areas.

Photograph by John Martin

Shuji Nakamura wears the medal he received as an inductee into the Hall of Fame.

Image courtesy Sphere Ent.

The surface of the Sphere in Las Vegas is covered with 1.2 million ultra-high-resolution LEDs that can display 256 million different colors.

LED UP YOUR WORLD

National LED Light Day was celebrated on October 7, as it has been since 2016. Here are a few quick facts about the tiny lights that changed the world.

1939 – Zoltán Bay and György Szigeti create and patent the first LED.
1968 – Hewlett Packard begins using LEDs in calculators, and experiments with LED colors.
1987 – LEDs are used in vehicle brake lights and signal lights, as well as in traffic lights.
2006 – UCSB professor of electrical and computer engineering **Shuji Nakamura** invents the white LED.
2012 – 49 million LED bulbs are in use in the U.S., accounting for roughly $675 million in energy savings.(The Department of Energy's current estimate is 2.3 billion LED bulbs)
2014 – Isamu Akasaki, Hiroshi Amano, and Shuji Nakamura receive the Nobel Prize in Physics for developing a blue LED.

- Today's LEDs use 90-percent less energy than incandescent lights.
- LEDs can last up to 50,000 hours, compared to a maximum of 2,000 hours for an incandescent bulb. An LED bulb installed in a newborn baby's room today will last until that child is ready for college.
- LEDs don't attract bugs.
- The famous Time Square New Year's Eve crystal ball is illuminated by 32,256 LED lights; the Eiffel Tower has 20,000. But the largest LED display in the world, by far, is the Sphere at The Venetian Resort in Las Vegas (left), with 1.2 million lights covering 580,000 square feet of the Exosphere.

NSF FUNDS PARTNERSHIPS FOR ACCESS

As part of its Partnerships for Research and Education in Materials (PREM) program, the National Science Foundation (NSF) has awarded more than $5 million to support two collaborative research efforts involving UC Santa Barbara. The programs broaden access to materials-science-focused skills and opportunities by supporting partnerships between minority-serving institutions and NSF-funded research centers and facilities at research-intensive institutions.

A new round of funding was provided for the Partnership for Research and Education in Materials Science (PREMS). Since 2006, the UCSB Materials Research Laboratory (MRL), an NSF Materials Research Science and Engineering Center (MRSEC), and Jackson State University (JSU) in Mississippi, where Black students make up thirty-seven percent of the population, have collaborated to provide summer research internships for JSU students at UCSB, allowing them to work with faculty and spend time in the university's world-class facilities.

New for this round of funding is a partnership involving the NSF Quantum Foundry at UCSB (see article on page 18), the nation's first Quantum Foundry, established in 2019 with a six-year, $25-million NSF grant aimed at developing materials and devices for quantum-information-based technologies. Now, New Mexico State University (NMSU) — one of the largest minority-serving institutions in the U.S., with more than sixty percent of its students identifying as Hispanic or Native American — has partnered with the Quantum Foundry to launch the Partnership for Research and Education on Quantum Materials and Processes (PREQ). The PREQ is aimed at broadening participation of underrepresented minority students in materials research and education by providing them with opportunities to work on next-generation quantum materials and devices.

"It will be great to partner with NMSU and share expertise and students with them, enabling us to broaden our own research impact and to reach a wider network of minority-serving institutions," said **Stephen Wilson**, a UCSB materials professor and co-director of the Quantum Foundry. "Quantum science in particular has suffered from a lack of participation from researchers from minority communities, and the PREM program helps to narrow that divide."

UCSB researchers are also involved with a third active PREM, which partners New Mexico Highlands University and the NSF-supported BioPolymers, Automated Cellular Infrastructure, Flow, and Integrated Chemistry Materials Innovation Platform (BioPACIFIC MIP). Faculty from various departments at UCSB and UC Los Angeles received a five-year, $23.7-million grant from NSF in 2020 to operate the one-of-a-kind facility dedicated to revolutionizing high-performance polymers.

"For UC Santa Barbara to have three partnerships really speaks to our commitment to broadening participation in STEM disciplines," said materials professor **Ram Seshadri,** the College of Engineering's Associate Dean for Research and director of the MRL. (See the interview with him on page 16.) "The PREMs are a testament to the spirit on campus and within the College of Engineering."

Students present their summer research projects at the conclusion of their internships provided by the Partnership for Research and Education in Materials Science Program.

DENISE MONTELL WINS SECOND NIH PIONEER AWARD

It is extremely difficult to secure a highly competitive Pioneer Award, which the National Institutes of Health issue in support of high-risk, high-reward research. Now, UC Santa Barbara's **Denise Montell**, Duggan Professor and Distinguished Professor in the Department of Molecular, Cellular and Developmental Biology at UC Santa Barbara, has received her second Pioneer Award in ten years.

The honor comes with $5.5 million over five years for her to further develop her work on innovative immune therapy. She intends to use the funds to test a new treatment her group is developing to treat cancer and other diseases, and to combat antibiotic-resistant bacteria.

"I'm extremely excited about this project, because it's one that really started with my very first graduate student, **Anne Marie Murphy** [regarding the toxicity of a hyperactive form of a particular protein found in fruit flies] when I was a brand-new assistant professor," said Montell.

"The NIH High-Risk, High-Reward Research program champions exceptionally bold and innovative science that pushes the boundaries of biomedical and behavioral research…and is poised to have a broad impact on human health," said Tara A. Schwetz, NIH Deputy Director for Program Coordination, Planning, and Strategic Initiatives.

Chancellor Henry T. Yang said of the accomplishment, "It is truly incredible that, for the second time in a decade, Professor Montell has received this prestigious award, which highlights her groundbreaking research and her unwavering dedication to advancing biomedical science."

Professor Denise Montell will receive $5.5 million in funding to pursue her groundbreaking immune therapy research.

NEWS BRIEFS

UCSB's SciTrek educational program teaches students to think critically and work as part of a team by providing first-hand scientific experiences.

FEDERAL GRANT EXPANDS UCSB SCIENCE-EDUCATION OUTREACH PROGRAM

Learning to think like a scientist involves learning to design experiments, and since 2010, a program started by UC Santa Barbara Feldwinn and biochemistry professor **Norbert Reich** has been engaging enthusiastic UCSB undergraduate volunteers to help teach those skills to K-12 students.

Now, the SciTrek program is set to expand its scope and offerings thanks to a $1 million grant from Congress spearheaded by U.S. Representative Salud Carbajal. Through SciTrek, Carbajal said, "UCSB is providing firsthand scientific experiences to our next generation, sparking interest in STEM careers and ensuring that investments we are making in cutting-edge economies like space and science have the bright young minds to carry these fields forward."

Each SciTrek module involves five to eight days of experiments on a particular topic, such as sound waves or cellular respiration. A teacher or SciTrek staff member leads the module, and undergraduate mentors work directly with small groups of students.

"They do an experiment, they collect their own data, they come up with their own ideas. They make mistakes. They fail. They do it again," Reich said. "At the end, they come up with a poster and they argue about it, just like science in a research setting.

"I'm not necessarily interested in making little scientists out of students," he adds. "I'm interested in improving their understanding of how to think deliberately and critically about problem solving."

SHELL(PHISH) GAME

Shellphish, the hacker collective that began in UC Santa Barbara's Cyber Security Group (SecLab) under the direction of computer science professors **Giovanni Vigna** and **Christopher Kruegel,** and that now includes assistant professor **Wenbo Guo** and UCSB alumni who are professors at Arizona State University and Purdue University, has qualified for the finals of the AI Cyber Challenge (AIxCC), sponsored by the Defense Advanced Research Projects Agency (DARPA) and the Advanced Research Projects Agency for Health (ARPA-H). The competition unfolded at the DEF CON 32 Hacking Conference, one of the world's largest cybersecurity conferences, which was held in Las Vegas from August 9-11.

The finals, which will include seven teams remaining from an initial field of nearly forty, will be held in August 2025. The team's remarkable achievement, earned by the performance of its cutting-edge Cyber Reasoning System (CRS), earned a $2 million cash award.

The ARTIPHISHELL AI system succeeded in the semifinal round by demonstrating exceptional capabilities in autonomously identifying, analyzing, and patching complex vulnerabilities found in real-world software, and solving a problem that no other team did.

The Shellphish hacker collective won $2 million for advancing to the DARPA AI Cyber Challenge (AIxCC) finals.

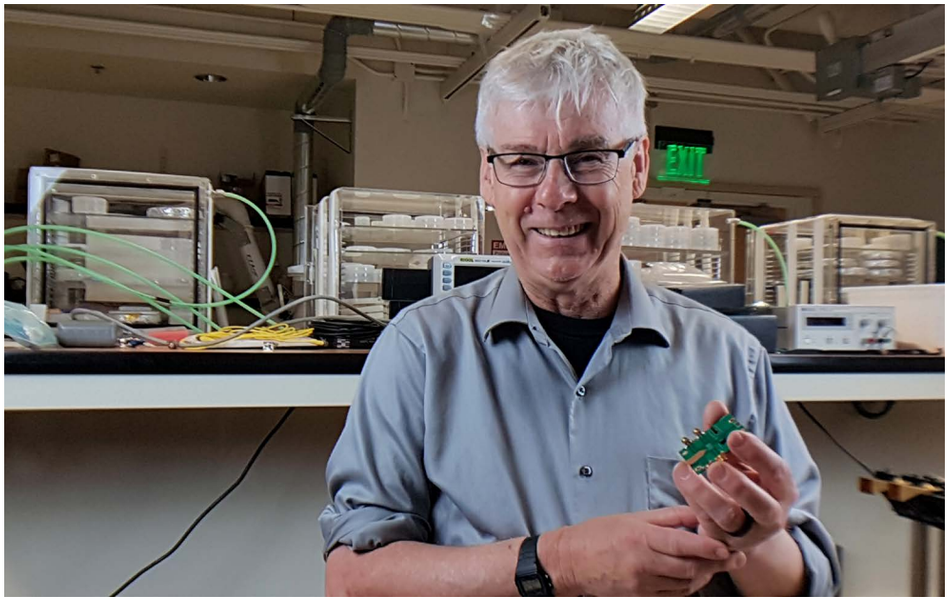
Students will gain hands-on experience inside the UC Santa Barbara NanoFabrication Facility, a state-of-the-art cleanroom with more than $60 million in equipment.

LOCAL PARTNERSHIP FOR SEMICONDUCTOR WORKFORCE TRAINING

UC Santa Barbara and Santa Barbara City College (SBCC) have joined forces to expand a National Science Foundation–funded program that provides critical workforce pathways for micro/nanotechnology and semiconductor manufacturing. The collaboration with NSF and Intel will help meet a demonstrated need in the high-tech-industry space by providing SBCC students and faculty access and training in the university's state-of-the-art NanoFabrication Facility.

"With increasing investment in semiconductor technologies in the U.S., it's really important that we also support a talented and diverse semiconductor workforce," said **Galan Moody,** an associate professor in electrical and computer engineering at UCSB and a co-PI on the proposal. "This partnership does exactly that by providing students with hands-on cleanroom training, certification, and pathways to industry jobs."

"With this new NSF-funded program we will be able to provide a pathway for the local population to enter the semiconductor industry," said UCSB NanoFab scientist **Demis D. John.** "Since 2022, NSF has already enabled SBCC students and others to get their foot in the door with our one-week cleanroom 'bootcamp,' hosted at UCSB. Over the next few years, we'll be able to expand that one-week experience into a full educational program powered by SBCC curriculum and the advanced facilities we have on campus.



UC Santa Barbara professor Mark Rodwell and collaborators are joining forces to develop next-generation semiconductor technologies.

DESIGNING NEW ARCHITECTURE FOR LIGHTNING-FAST CHIPS

Within the next decade, electronics will need to handle incredibly high data rates — up to terabits per second — to drive a range of data-intensive technologies. **Mark Rodwell,** professor in the UC Santa Barbara Electrical and Computer Engineering Department, is joining colleagues at Penn State University as part of a three-year, $2-million National Science Foundation grant to study the future of semiconductors, with an eye to making that possible.

The work will involve developing wireless communications and sensing platforms through advanced chips and packaging. The solution will require large transmitter and receiver arrays above 200 GHz, but implementing them using current semiconductor and packaging technologies presents significant thermal, electromagnetic, and mechanical challenges.

If successful, the work is expected to serve as the basis for next-generation wireless connectivity and sensors to drive the integration of digital, physical, and human worlds, thus enabling innovation across industries. In his part on the project, Rodwell will focus on developing an indium phosphide amplifier design, which is needed to generate sufficient power at such high frequencies. Together, the researchers will work to integrate the three technologies into a single device. Look for more on their progress in the future.

NEWS BRIEFS

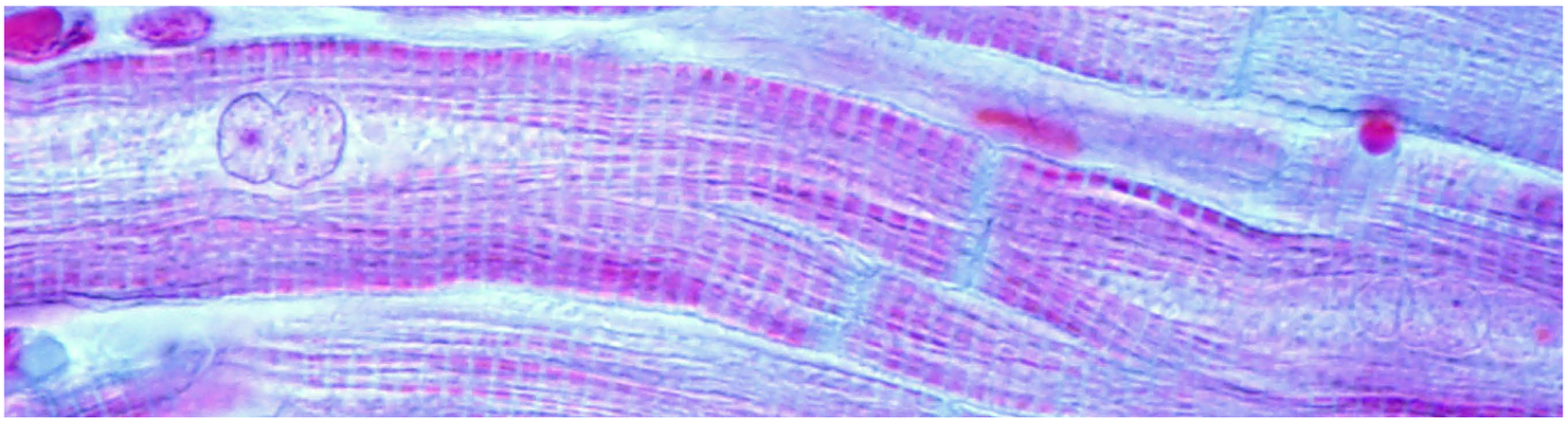
UCSB SCHOLAR EARNS AWARD GIVEN TO ONLY THREE PHD STUDENTS IN THE WORLD

The steady improvement in the performance and versatility of electronic systems is due largely to the scaling down of transistors and their derivatives, allowing for smaller, more powerful, more versatile electronics. These advancements have, however, introduced challenges, particularly in power dissipation, which directly impacts energy efficiency. As a result, electronics engineers, material scientists, and physicists worldwide are striving to address the degradation in energy efficiency of electronics caused by the continuous miniaturization and denser arrangements of components.

Among them is **Arnab Pal,** a recent UC Santa Barbara doctoral graduate in electrical and computer engineering. His doctoral research was recognized with a prestigious PhD Student Fellowship from the Institute of Electrical and Electronics Engineers (IEEE) Electron Devices Society (EDS), annually awarded to a single PhD student from the Americas and to a total of three PhD students worldwide.

Pal, who was advised by electrical and computer engineering professor **Kaustav Banerjee,** focused his doctoral research on exploring the fundamental physics of 2D materials in designing high-performance transistors and neuromorphic electronics exhibiting brain-like energy-efficiency. "As the only student from the Americas and the fourth from the Nanoelectronics Research Lab and UC Santa Barbara to earn this distinction, I am particularly grateful to Professor Banerjee," he said. "His unwavering support, invaluable insights, and inspirational guidance have been instrumental in shaping my research journey. His mentorship not only fueled my passion for discovery, but also empowered me to achieve the results that made this recognition possible."

Arnab Pal (right) and Professor Kaustav Banerjee hoist Pal's fellowship plaque.



A microscopy image showing muscle fibers of heart myocardium.

THE HEARTBEAT GOES ON

Researchers in the lab of UC Santa Barbara bioengineering professor and Bioengineering Department chair, **Beth Pruitt,** have worked with colleagues at Stanford University to develop software to enable high-throughput observations of the contractile dynamics of individual cardiomyocytes (heart cells responsible for heart expansion and contraction) derived from human induced pluripotent stem cells (hiPSC_CMs). The work appeared in the June 26 issue of the journal *Nature Communications*.

The software program, called CONTRAX, which the authors describe as a "versatile, streamlined, open-access pipeline," makes possible "quantitative tracking of the contractile dynamics of thousands of single hiPSC-CM over time," at a much-increased rate of throughput. That, in turn, makes it possible to "reveal converging maturation patterns, quantifiable drug response, and significant deficiencies in hiPSC-CMs that carry disease mutations."

CONTRAX comprises three modules that work in a complementary manner to: provide parameter-based cell identification according to user specifications; perform microscopy video of many cells in a streamlined fashion; and stitch together video images to quantify mechanical function and create a timed trace from the heartbeat in a dish, important in trying to figure out the peak force, as well as contraction and relaxation velocities.

From there, Pruitt says, "We can determine whether there are differences in response to our changing parameters we define for the different experimental treatments."

ELECTRONS IN ACTION: THE MOVIE

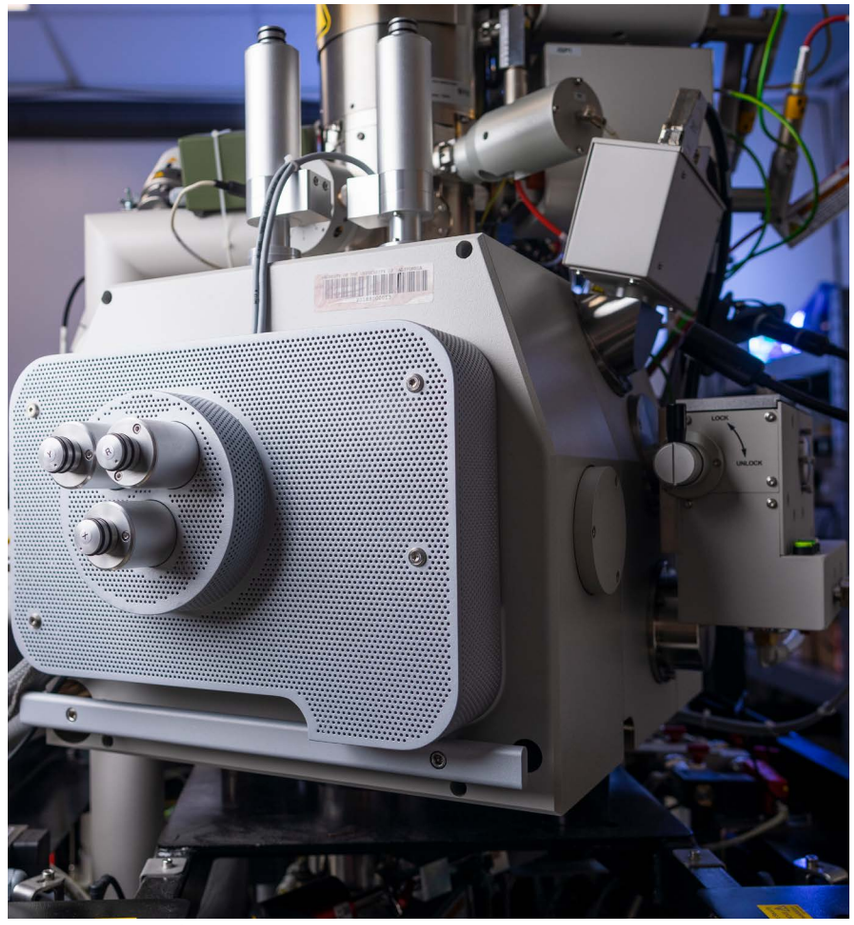
Electrons moving across the interface of different semiconductor materials drive all of our electronic devices, but no one had ever seen that process until **Bolin Liao,** an associate professor in the UC Santa Barbara Mechanical Engineering Department, used scanning ultrafast electron microscopy (SUEM) techniques developed in his lab to make a "movie" of the phenomenon.

Anyone who has used a solar cell has seen the result of *photocarriers* in action. Sunlight hits a semiconductor material, causing excited electrons to move and separate from their opposite-charged "holes," creating a current that can be harnessed to power electronic devices.

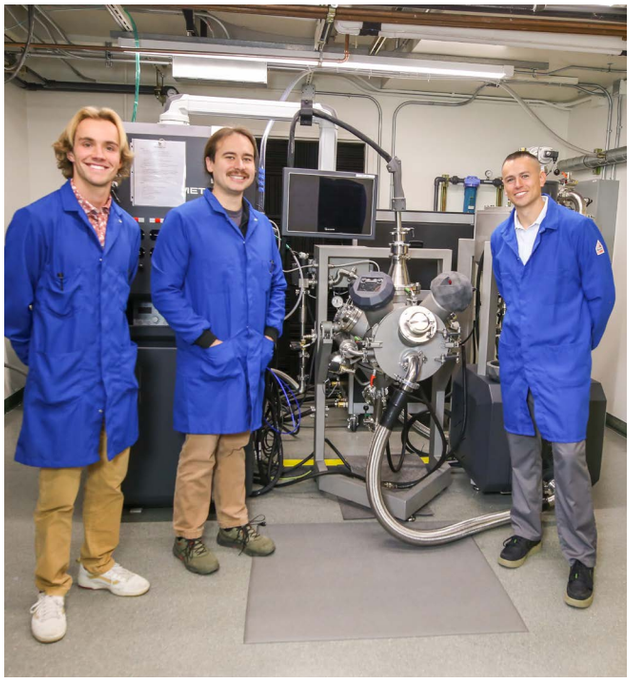
The majority of those photocarriers lose most of their energy within a few picoseconds (trillionths of a second), which is why photovoltaics harvest but a fraction of the carriers' energy in their "hot" state before they cool down and release the excess energy as waste heat. The hot state holds potential related to energy efficiency but also presents challenges within the semiconductor material. It is therefore important to understand how hot carriers behave as they move through semiconductor materials and, in particular, across the interface, or heterojunction, of two different materials.

"If you excite charges in the uniform silicon or germanium regions, the hot carriers move very, very fast, with a very high speed initially because of their high temperature," Liao explained. "But if you excite a charge near the junction, a fraction of the carriers are actually trapped by the junction potential, which slows them down." Such trapped hot charges result in reduced carrier mobility, which can negatively affect the performance of devices that separate and collect hot charges.

"The really exciting thing about this work is that we were able to visualize how the charges, once generated, actually transfer across the junction," Liao said.



The scanning ultrafast electron microscope in the Bolin Liao lab.



Lucas Erich (left) with (from left) second-year materials PhD student Logan Winston and materials assistant professor Daniel Oropeza, will use the ultrasonic atomizer (shown) to produce metal powders for 3D printing as part of his NASA project.

MATERIALS PHD STUDENT RECEIVES HIGHLY ACCLAIMED NASA FELLOWSHIP

Lucas Erich, a second-year materials PhD student at UC Santa Barbara, has received a prestigious NASA Space Technology Graduate Research Opportunities (NSTGRO) Fellowship. The NSTGRO program supports researchers who are pursuing ideas that could contribute to the agency's goal of creating innovative space technologies.

"I am extremely excited and grateful," said Erich. "I've been fascinated by space for a while, so I feel fortunate to receive an opportunity from NASA to merge my passions for powder metallurgy and nuclear propulsion with my interest in space."

As an NSTGRO Fellow, Erich will receive up to $84,000 annually to cover expenses for up to four years, and to pursue innovative, space-technology research at UCSB with his advisor, **Daniel Oropeza,** an assistant professor in UCSB's Materials Department. He will also complete internships every summer at a NASA Center, where he will be matched with a NASA Subject Matter Expert who will serve as his research collaborator and act as a conduit into the larger technical community.

"Lucas is an incredibly intelligent and passionate student," said Oropeza, who also received a NASA Space Technology Research Fellowship as a graduate student at the Massachusetts Institute of Technology in 2017. "This fellowship gives him the chance to work on exactly what he wants to do, complete summer rotations at up to four different NASA Centers, and develop deep connections at NASA. It's a unique, amazing, and well-deserved opportunity."

Erich's research project is related to NASA's pursuit of nuclear-thermal- and nuclear-electric-propulsion rocket-engine systems, technologies that draw energy from nuclear fission instead of traditional chemical reactions.