UC SANTA BARBARA

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A Research Hat-Trick

To solve some of the world's top energy needs, Bolin Liao is working at the front line of efforts to better understand the behaviors and interactions of the most fundamental energy carriers in materials, such as electrons, phonons and photons.

"By looking at particles on the atomic level in the smallest time and length scales, we can determine how particles collide, interact and transport heat and electrical current," said Liao, an assistant professor of mechanical engineering at UC Santa Barbara. "Understanding the smallest details of energy transport and conversion processes will lead to more efficient and cost-effective energy technologies."

Liao's experimental and computational approach to creating more efficient energy devices continues to receive significant support and accolades. Most recently, the National Science Foundation (NSF) bestowed upon him its most prestigious honor for junior faculty, the Early Career Development Award. The recognition includes a five-year, $500,000 federal grant for research and educational activities.

"I am very fortunate to receive this honor," said Liao, who supervises the Transport for Energy Applications Laboratory (TEALab) at UCSB. "The funding will allow me to focus on my work and spend more time running experiments to tackle fundamental issues."

Liao plans to use the NSF grant to study phonon-electron scattering, which occurs when the two elementary particles collide, and how this process can be controlled to tune the thermal transport properties of materials. While electrons are responsible

for a material’s electrical properties, phonons determine thermal properties and how fast heat can be transferred across the material. In particular, Liao's lab will explore mechanisms to introduce electrons into a material by applying an electric field or shining light to collide with phonons and modify how a material conducts heat.

“Understanding at the microscopic level will help us design thermal switches that turn on and off in response to temperature change,” said Liao. “The switches do not require a power source and could significantly improve thermal activity and efficiency in, for example, buildings and car engines.”

In the last six months, Liao has received three early career awards worth a combined $1,610,000 in research funding. Two months ago, the U.S. Army Research Office Young Investigator Program awarded him a total of $360,000 over a three-year period. The program recognizes outstanding young faculty whose research is relevant to the Army, in Liao’s case a focus on understanding the cooling process of electrons in two-dimensional materials. Because the energy carriers lose heat quickly, Liao will observe them using a scanning ultrafast electron microscope (SUEM). The microscope creates time-lapse images so scientists can visualize how electrons in a material cool, interact and move around.

“With further insight into the cooling process, we can design more efficient solar cells by harvesting electrons before they cool down,” added Liao, referring to devices that convert the energy of light directly into electricity. “The result will be more efficient photo-detectors and solar cells, which the Army sees as beneficial.”

In September 2018, Liao received an early-career research award from the U.S. Department of Energy (DOE), which included $750,000 in research funding to be spread over five years. The DOE project investigates the coherence of energy carriers in their transport process.

“I am thrilled to see Professor Bolin Liao receive three early-career research awards. He is another example of the high-quality young faculty we have in the College of Engineering,” said Rod Alferness, dean of the College of Engineering. “These awards are a testament to his exciting and innovative research into energy at the quantum scale in an effort to create more efficient and effective energy technology.”

Liao sees the culture of collaboration in the College of Engineering and throughout UC Santa Barbara as being key to his recognitions.

“My projects have collaborators from across campus, including materials science, chemical engineering, physics and more,” he said. “Collaboration at UCSB truly opens new horizons for researchers like myself.”

About UC Santa Barbara

The University of California, Santa Barbara is a leading research institution that also provides a comprehensive liberal arts learning experience. Our academic community of faculty, students, and staff is characterized by a culture of interdisciplinary collaboration that is responsive to the needs of our multicultural and global society. All of this takes place within a living and learning environment like no other, as we draw inspiration from the beauty and resources of our extraordinary location at the edge of the Pacific Ocean.