Laser light exposes the properties of materials used in batteries and electronics

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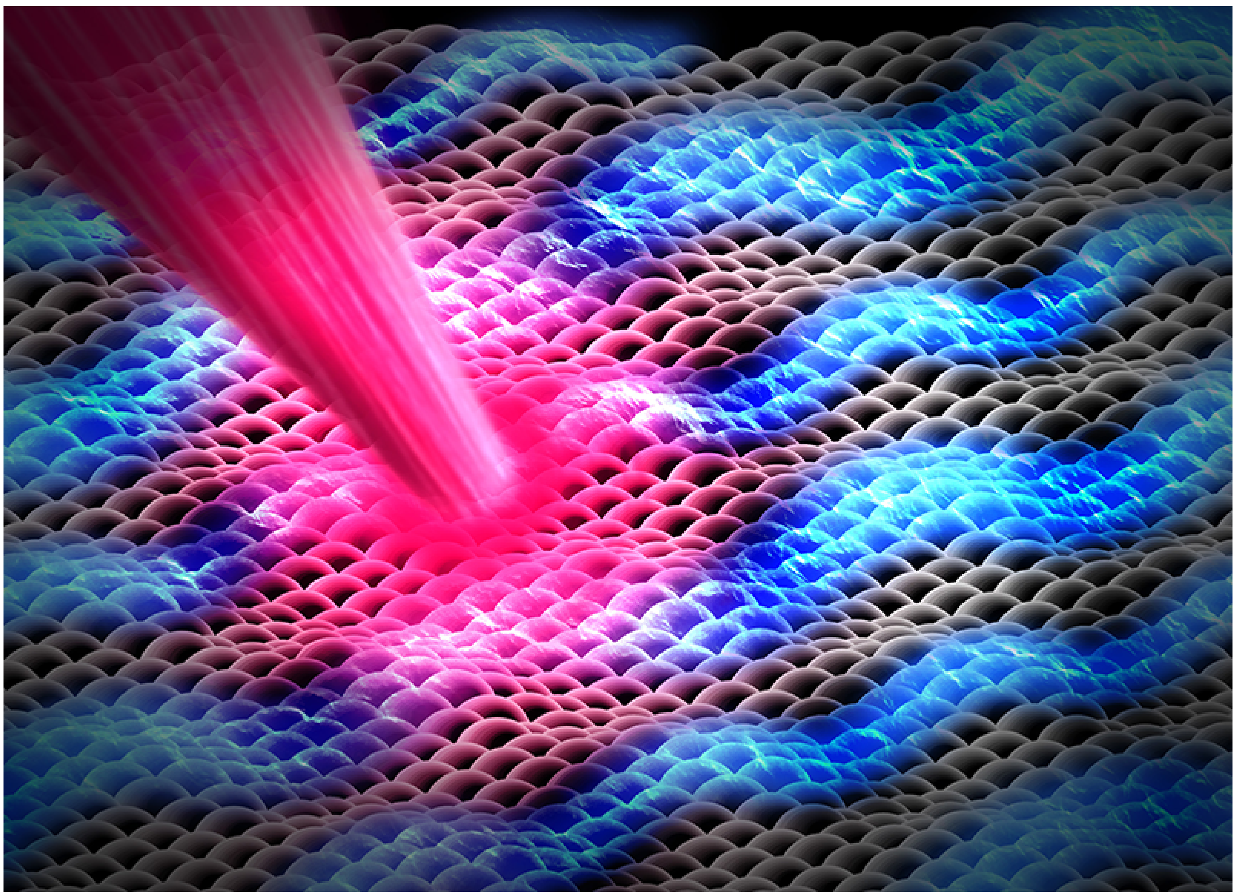

A three-atom-thick material wrinkles in response to a laser pulse. Understanding these dynamic ripples could provide crucial clues for the development of next-generation solar cells, electronics and catalysts. Credit: SLAC National Accelerator Laboratory

Creating the batteries or electronics of the future requires understanding materials that are just a few atoms thick and that change their fundamental physical properties in fractions of a second. Cutting-edge facilities at SLAC National Accelerator Laboratory and Stanford University have allowed researchers like Aaron Lindenberg to visualize properties of these nanoscale materials at ultrafast time scales.

In one experiment, a team led by Lindenberg showed atoms shifting in trillionths of a second to produce a wrinkle in a 3-atom-thick sample of a material that might someday be used in flexible electronics. Another study observed semiconductor crystals—called "quantum dots" because they defy classical physics at the nanoscale—expand and shrink in response to ultrafast pulses of laser light.

Revealing such intriguing properties at the nanoscale gives clues about the fundamental nature of materials and how they perform in applications we rely on for energy or information.

"Even though some of these materials are completely embedded in everyday technologies, not a lot is understood about how they work," says Lindenberg, who is an associate professor of materials science and engineering and of photon science. He is also a principal investigator for two SLAC/Stanford joint institutes—Stanford Institute for Materials and Energy Sciences and Stanford PULSE Institute.

"Part of the reason some phenomena are not well understood is because they happen so fast – in billionths, trillionths or even quadrillionths of a second. For the first time, we have tools that allow us to see these things," he says.

Working at the intersection of materials science and engineering, Lindenberg and his team have a particular focus on finding promising materials for next-generation electronics, light-based data storage technologies and energy applications.

"There are a broad range of new properties that emerge at the nanoscale," Lindenberg says. "The tiniest samples, with just tens or hundreds of atoms, can have nearly flawless structures that make them ideal test tubes for very fundamental questions about what happens when a material transforms."

The team uses different types of laser light at SLAC and Stanford labs to learn how simple tweaks in the size, shape and design of materials can change their basic properties in unexpected ways, which could lead to new applications. Taking advantage of the powerful X-rays at SLAC facilities, including the Linac Coherent Light Source and the Stanford Synchrotron Radiation Lightsource, they explore ultrafast changes in nanoscale samples.

"We are trying to understand how electrons or atoms move in materials, which in turn determines, for example, the efficiency of solar cells and other energy-related materials, and how materials switch between different forms," he says. "Ultrafast techniques allow you to see these kinds of things in a completely new way."

Provided by Stanford University

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