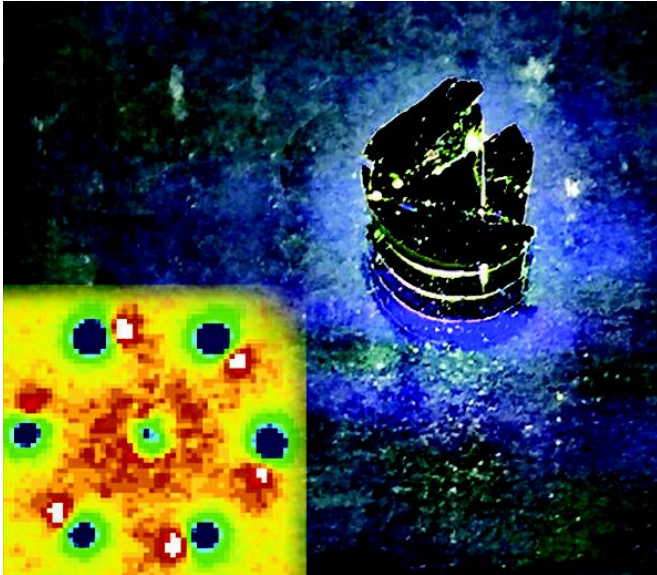


# Building a better semiconductor

26 June 2015



MSU researchers have found that by shooting an ultrafast laser pulse into a material, it can change its properties, a process that can lead to the development of new and improved semiconductors. The image on the right is an illustrated view of a material irradiated by the laser pulses. The one of the left is an image of the material showing subtle structural changes as a result of what's known as photo-doping. Credit: MSU Department of Physics and Astronomy.

Research led by Michigan State University could someday lead to the development of new and improved semiconductors.

In a paper published in the journal *Science Advances*, the scientists detailed how they developed a method to change the [electronic properties](#) of materials in a way that will more easily allow an electrical current to pass through.

The electrical properties of semiconductors depend on the nature of trace impurities, known as dopants, which when added appropriately to the material will allow for the designing of more efficient solid-state electronics.

The MSU researchers found that by shooting an ultrafast laser pulse into the material, its properties would change as if it had been chemically "doped." This process is known as "photodoping."

"The material we studied is an unconventional [semiconductor](#) made of alternating atomically thin layers of metals and insulators," said Chong-Yu Ruan, an associate professor of physics and astronomy who led the research effort at MSU. "This combination allows many unusual properties, including highly resistive and also superconducting behaviors to emerge, especially when 'doped.'"

An ultrafast electron-based imaging technique developed by Ruan and his team at MSU allowed the group to observe the changes in the materials. By varying the wavelengths and intensities of the laser pulses, the researchers were able to observe phases with different properties that are captured on the femtosecond timescale. A femtosecond is 1 quadrillionth, or 1 millionth of 1 billionth, of a second.

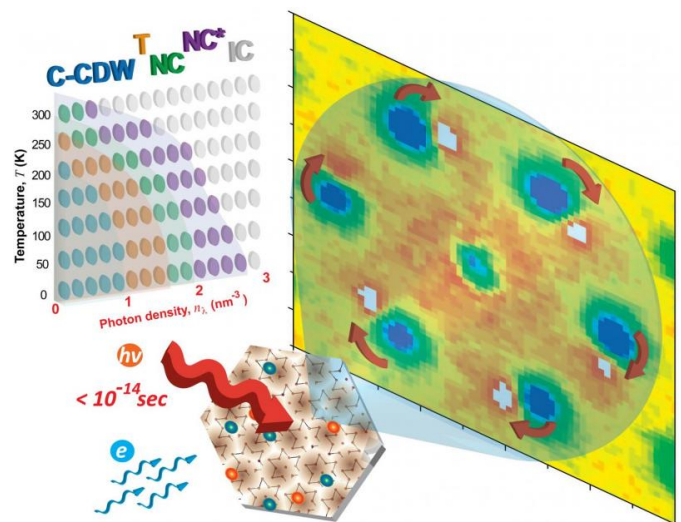


Image shows that the femtosecond ( $10^{-15}$  seconds) laser pulses can be used to change the electronic properties of materials so that they transiently behave as

if they have been chemically doped. These changes are recorded in the femtosecond electron crystallography pattern (right). Varying the intensities of the laser pulses, the conditions for the emergence of metastable and hidden phases (as labeled in C-CDW, T, NC, and NC\*) can be rapidly surveyed via the method stated above to construct a comprehensive phase diagram (upper-left) without the confounding effects frequently associated with chemical doping. Credit: Faran Zhou and Chong-Yu Ruan

"The laser pulses act like dopants that temporarily weaken the glue that binds charges and ions together in the materials at a speed that is ultrafast and allow new electronic phases to spontaneously form to engineer new [properties](#)," Ruan said. "Capturing these processes in the act allows us to understand the physical nature of transformations at the most fundamental level."

Philip Duxbury, a team member and chairperson of the department of physics and astronomy, said ultrafast photo-doping "has potential applications that could lead to the development of next-generation [electronic materials](#) and possibly optically controlled switching devices employing undoped semiconductor materials."

A semiconductor is a substance that conducts electricity under some conditions but not others, making it a good medium for the control of [electrical current](#). They are used in any number of electronics, including computers.

**More information:** Exploration of metastability and hidden phases in correlated electron crystals visualized by femtosecond optical doping and electron crystallography, [advances.sciencemag.org/content/1/5/e1400173](https://advances.sciencemag.org/content/1/5/e1400173)

Provided by Michigan State University

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