'Spintronics' breakthrough holds promise for next-generation computers

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Hui Zhao, assistant professor of physics and astronomy.

Using powerful lasers, Hui Zhao, assistant professor of physics and astronomy at the University of Kansas, and graduate student Lalani Werake have discovered a new way to recognize currents of spinning electrons within a semiconductor.

Their findings could lead the way to development of superior computers and electronics. Results from their work in KU's Ultrafast Laser Lab will be published in the September issue of Nature Physics, a leading peer-reviewed journal, and was posted online in early August.

Zhao and Werake research spin-based electronics, dubbed "spintronics."

"The goal is to replace everything — from computers to memory devices

— to have higher performance and less energy consumption," said Zhao.

The KU investigator said that future advancements to microchips would require a different approach for transmitting the sequences of ones and zeros that make up digital information.

"We have been using the charge of the electron for several decades," said Zhao. "But right now the size of each device is just 30 to 50 nanometers, and you don't have many atoms remaining on that tiny scale. We can't continue that way anymore because we're hitting a fundamental limit."

Instead of using the presence or absence of electronic charges, spintronics relies on the direction of an electron's rotation to convey data.

"Roughly speaking, an electron can be viewed as a tiny ball that spins like a baseball," said Zhao. "The difference is that a baseball can spin at any speed, but an electron can only spin at a certain speed — either counterclockwise or clockwise. Therefore, we can use one spin state to represent 'zero' and another to represent 'one.' Because a single electron can carry this information, this takes much less time and much less energy."

However, one major hurdle for spintronics researchers has been the difficulty in detecting the flow of spinning electrons in real time.

"We haven't been able to monitor the velocity of those spinning electrons, but velocity is associated with the spin current," Zhao said. "So there's been no way to directly detect the spin current so far."

The discovery by Zhao and Werake changes that.

The KU researchers have discovered that shining a laser beam on a piece of semiconductor generates different color lights if the spinning electrons are flowing, and the brightness of the new light is related to the strength of the spin current.

The optical effect, known as "second-harmonic generation," can monitor spin-current in real time without altering the current itself. Zhao compares his new method with a police officer's radar gun, which tracks a car's speed as it passes.

This vastly improves upon spin-current analysis now in use, which the KU researcher says is akin to analyzing still photographs to determine a car's speed, long after the car has sped away.

"Spintronics is still in the research phase, and we hope that this new technology can be used in labs to look at problems that interest researchers," said Zhao. "As spintronics become industrialized, we expect this could become a routine technique to check the quality of devices, for example."

Provided by University of Kansas

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