Spintronics: Scientists find new magic in magnetic material

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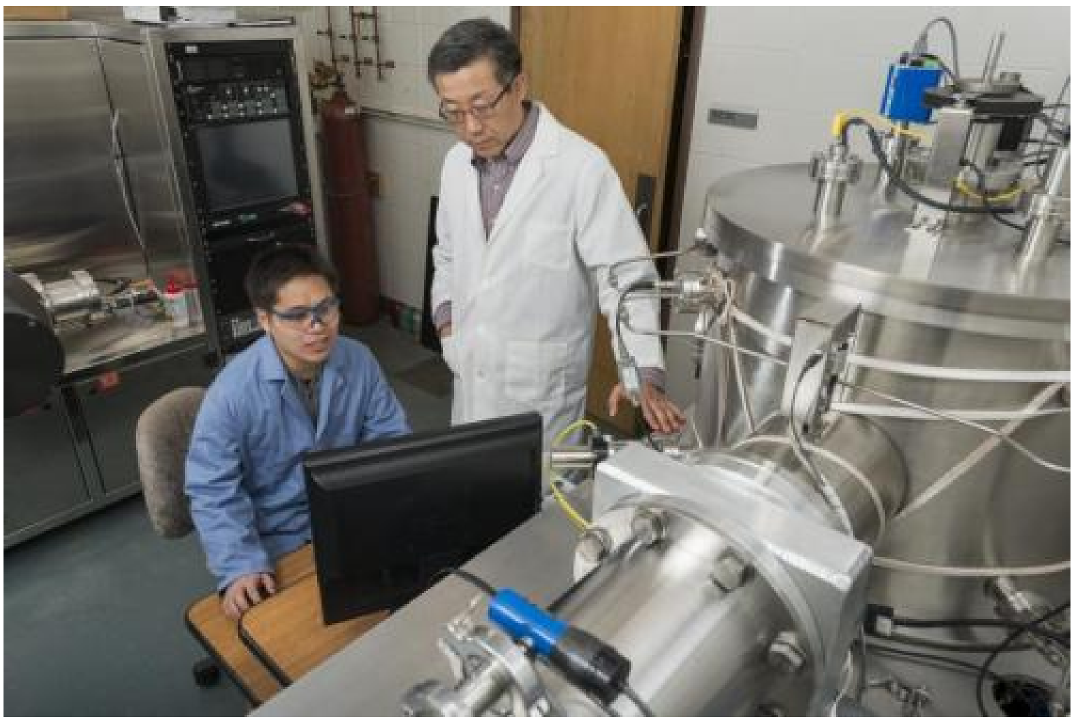

UD professor John Xiao (standing) and research associate Xin Fan work with the high vacuum magnetron deposition system, which is used to fabricate layered thin films in a vacuum for spintronics research. Credit: Evan Krape/University of Delaware

From powerful computers to super-sensitive medical and environmental detectors that are faster, smaller and use less energy—yes, we want them, but how do we get them?

In research that is helping to lay the groundwork for the electronics of the future, University of Delaware scientists have confirmed the presence of a magnetic field generated by electrons which scientists had theorized existed, but that had never been proven until now.

The finding, which is reported in the journal *Nature Communications*, expands the potential for harnessing the "spin" or magnetic properties of electrons—adding a fundamental new building block to the pioneering field of spintronics.

John Xiao, Unidel Professor of Physics and Astronomy at UD, is the lead author of the study. His co-authors include research associate Xin Fan, graduate students Jun Wu and Yunpeng Chen, and undergraduate student Matthew Jerry from UD, and Huaiwu Zhang from the University of Electronic Science and Technology of China.

Today's semiconductors, which are essential to the operation of a broad array of electronics, carry along the electrical charge of electrons, but make no use of the magnetic or "spin" properties of these subatomic particles. Xiao and his team are working to unveil those properties in UD's Center for Spintronics and Biodetection.

As Xiao explains, in the presence of a magnet, an electron will take a "spin up" or "spin down" position, correlating to the binary states of 1 or 0 that computers use to encode and process data. One spin state aligns with the magnetic field, and one opposes it. A spintronics device requires an excess number of either spin-up or spin-down electrons. Controlling the direction of the magnetization is a major goal in the fledgling field.

For the past few years, scientists have succeeded in generating a pure spin current in which electrons with opposite spins move in opposite directions. This is achieved by passing an electrical current through a heavy metal that's not magnetic, such as platinum, tungsten and tantalum.

However, in a double layer of heavy metal and ferromagnetic material (for example, iron or cobalt), this pure spin current will diffuse into the ferromagnetic material. When this occurs, Xiao and his team have detected a magnetic field, which can switch the material's magnetization.

This magnetic field is confined inside the ferromagnetic material unlike the conventional magnetic field generated from a magnet, which is difficult to shield. Xiao says this finding is particularly important to high-density integrated circuits, such as magnetic random access memory, in which shielding the magnetic field between cells is "a nightmare."

"This magnetic field was predicted previously but was never experimentally confirmed. We demonstrated that it's there," Xiao says. "We now have a new means of generating a magnetic field and controlling the direction of a nanomagnet, as well as a new measurement technique to characterize the magnetic field."

Advancing this nanoscale research requires specialized laboratory equipment and facilities. In addition to the sophisticated magnetometers in the Department of Physics and Astronomy at UD, Xiao and his team will have access to new, state-of-the-art facilities in the Interdisciplinary Science and Engineering Laboratory (ISE Lab), a 194,000-square-foot building set to open at UD this fall.

Among the core facilities in this major hub for teaching and research will be a 10,000-square-foot nanofabrication facility, which Xiao will co-direct. There, he will continue his research in the development of next-generation spintronic devices.

Provided by University of Delaware