New STM Microscope To Study Propeties of Electron Spin

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University of Arkansas scientists seek to harness an electron's spin to create tiny machines with large memories. To do this, they have built a microscope that may allow them to be the first researchers to measure the properties of electron spin injection in conducting materials.

Electrons have spin in addition to charge, but in the past this property has been little used or studied. By understanding and using the different states achieved when an electron's spin rotates, researchers could potentially increase information storage a million fold. This would allow vast quantites of information to be stored in a space the size of a sugar cube or transmitted from one tiny device to another in the blink of an eye.

Today's transistors store information by using two different states to save data or create words on the computer. Each bit in a given piece of information-a word or a computer program-can either be "on" or "off," meaning that the possibilities are based on two, or binary logic. However, the different states created when an electron's spin rotates could allow researchers to increase that base number from two to 10. This would create massive information storage and transmission capabilities.

Paul Thibado, associate professor of physics, won a $370,000 grant from the National Science Foundation to measure the properties of a spin-based transistor using a customized, two-tip Scanning Tunneling Microscope (STM) system. This work builds on a previous NSF grant of

$760,000, which was used to create the customized STM.

Researchers currently use STMs to inject electrons of a certain spin into a conducting material. However, they have not been able to study what happens to the electrons as they pass through the material because they would need a second STM to create a transistor, a miniature electronic switch used to power televisions, cars, radios, home appliances and computers. A traditional transistor consists of a source, a drain and a gate. When an electric field is placed on the gate, current moves from the source to the drain. Placing two STM tips next to one another won't work-the tips remain too far apart to create a transistor.

Thibado and his colleagues proposed building a different kind of instrument, one with two STMs placed at right angles to one another. This allows the tips to get close enough-about 10 nanometers apart-to create an effective detection device. Thibado and his colleagues will use one tip to inject electrons of a certain spin into a surface, while the other acts as a detection device, reading the actual spin of the injected electrons. By applying a magnetic field, the researchers can then change the electrons' spins, creating a field-effect transistor.

First, however, the researchers must learn more about how spin works, and Thibado's new equipment will allow that to happen. The UA team will use the modified instruments to measure the current and voltage properties of a spin-dependent transistor, examine the characteristics of the transistor at different temperatures and change the distance between the two STMs to determine the device's effectiveness at various distances. They also will use different materials on the tip of the STMs to determine how they affect the transistor's properties.

More information at advancement.uark.edu/