Researchers study electron spin relaxation in organic nanostructures

March 19 2007

Researchers have made an important advance in the emerging field of 'spintronics' that may one day usher in a new generation of smaller, smarter, faster computers, sensors and other devices, according to findings reported in today's issue of the journal *Nature Nanotechnology*.

The research field of 'spintronics' is concerned with using the 'spin' of an electron for storing, processing and communicating information.

The research team of electrical and computer engineers from the Virginia Commonwealth University’s School of Engineering and the University of Cincinnati examined the ‘spin’ of electrons in organic nanowires, which are ultra-small structures made from organic materials. These structures have a diameter of 50 nanometers. The spin of an electron is a property that makes the electron act like a tiny magnet. This property can be used to encode information in electronic circuits, computers, and virtually every other electronic gadget.

“In order to store and process information, the spin of an electron must be relatively robust. The most important property that determines the robustness of spin is the so-called ‘spin relaxation time,’ which is the time it takes for the spin to ‘relax.’ When spin relaxes, the information encoded in it is lost. Therefore, we want the spin relaxation time to be as long as possible,” said corresponding author Supriyo Bandyopadhyay, Ph.D., a professor in the Department of Electrical and Computer Engineering at the VCU School of Engineering.

“Typically, the spin relaxation time in most materials is a few nanoseconds to a few microseconds. We are the first to study spin relaxation time in organic nanostructures and found that it can be as long as a second. This is at least 1000 times longer than what has been reported in any other system,” Bandyopadhyay said.

The team fabricated their nanostructures from organic molecules that typically contain carbon and hydrogen atoms. In these materials, spin tends to remain relatively isolated from perturbations that cause it to relax. That makes the spin relaxation time very long.

The VCU-Cincinnati team was also able to pin down the primary spin relaxation mechanism in organic materials, which was not previously known. Specifically, they found that the principal spin relaxation mechanism is one where the spin relaxes when the electron collides with another electron, or any other obstacle it encounters when moving through the organic material. This knowledge can allow researchers to find means to make the spin relaxation time even longer.

“The organic spin valves we developed are based on self-assembled structures grown on flexible substrates which could have a tremendous impact on the rapidly developing field of plastic electronics, such as flexible panel displays,” said Marc Cahay, Ph.D., a professor in the Department of Electrical and Computer Engineering at the University of Cincinnati. “If the organic compounds can be replaced by biomaterials, this would also open news areas of research for biomedical and bioengineering applications, such as ultra-sensitive sensors for early detection of various diseases.”

“These are very exciting times to form interdisciplinary research teams and bring back the excitement about science and engineering in students at a very young age to raise them to become the future generations of nanopioneers,” Cahay said.

The fact that the spin relaxation time in organic materials is exceptionally long makes them the ideal host materials for spintronic devices. Organic materials are also inexpensive, and therefore very desirable for making electronic devices.

The VCU-Cincinnati research advances nanotechnology, which is a rapidly growing field where engineers are developing techniques to create technical tools small enough to work at the atomic level. Additionally, by using nanoscale components researchers have the ability to pack a large number of devices within a very small area. The devices themselves are just billionths of a meter; and trillions of them can be packed into an area the size of a postage stamp. Furthermore, they consume very little energy when they process data.

In 1994, Bandyopadhyay and colleagues were the first group to propose the use of spin in classical computing. Then two years later, they were among the first researchers to propose the use of spin in quantum computing. The recent work goes a long way toward implementing some of these ideas.

Sandipan Pamanik, a graduate student in the VCU School of Engineering's Department of Electrical and Computer Engineering, was first author of the study. The research team also included Carmen Stefanita, Ph.D., and graduate student, Sridhar Patibandla, both in the VCU Department of Electrical and Computer Engineering; and graduate students Kalyan Garre and Nick Harth from the University of Cincinnati's Department of Electrical and Computer Engineering.

Source: Virginia Commonwealth University

Citation: Researchers study electron spin relaxation in organic nanostructures (2007, March 19)