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Spin-based Electronics

The next generation of computers may make use of the "spin" of electrons instead of their charge.

Spintronics relies on manipulating these spins to make them capable of carrying data. The technique has been shown in a number of materials at low temperatures before. But researchers writing in Nature have made use of these "spin-polarized" electrons in silicon at room temperature for the first time. The result could lead to computers that require far less power than conventional ones.

The fact that the effect has been demonstrated in silicon — the material that already underpins the computer industry — means that devices exploiting it could be made on a commercial scale more easily. The problem with silicon is that, as the individual features on silicon chips get smaller and smaller, they require more and more power to move the charged electrons around to represent 0s and 1s of binary code. That rise in power also means that future chips will run into problems with heating.

Spintronics has long been touted as a future potential mechanism for computing, but so far advances have come slowly. The idea rests on manipulating the "spins" of electrons, which can be either "up" or "down," a choice between two states that is analogous to the on/off or zero/one of conventional, digital electronics.

This "spin" isn't really a direction the electrons are spinning in, but rather a convenient way to express one of the two "quantum mechanical" states an electron might be found in.

A number of laboratory demonstrations has shown that it is possible to create bunches of electrons with their spins aligned and to detect those spins in a range of materials, most importantly silicon. However, they have all been at extremely low temperatures.

Now, researchers at the University of Twente in the Netherlands have demonstrated the manipulation and detection of these spin-polarized electrons in silicon at a temperature some 150ºC warmer than the previous record.

"We've shown for the first time that this can be done at room temperature, which is obviously something you would need if you wanted to really commercialize this technology," said Ron Jansen, who led the research. The trick, Dr Jansen said, was careful design of the interface where the electrons enter the silicon — the materials must be pure and of a precisely determined thickness in order to preserve the delicate spin polarization.

"Let's say it's the first real step towards a real working technology," Dr Jansen told BBC News. "The next one is actually to build real electronic circuits and show that they are better than the electronic circuits that we have available right now."

Robert Hicken, a spintronics researcher at the University of Exeter, called the work "an important step in the development of spintronics technology. This tells us that one can now begin to look at room temperature, silicon-based electronic devices; the exact design of such a device we don't know yet, but this was a prerequisite for doing it."

What remains unclear, Professor Hicken told BBC News, is whether spintronics can overcome the problem of heating that conventional electronics faces as individual devices become ever more tiny.

…By Jason Palmer
Science and technology reporter, BBC News
http://news.bbc.co.uk/2/hi/technology/8379708.stm

Paper Batteries

Stanford scientists are harnessing nanotechnology to quickly produce ultra-lightweight, bendable batteries and supercapacitors in the form of everyday paper. Simply coating a sheet of paper with ink made of carbon nanotubes and silver nanowires makes a highly conductive storage device, said Yi Cui, assistant professor of materials science and engineering.

"Society really needs a low-cost, high-performance energy storage device, such as batteries and simple supercapacitors," he said. Like batteries, capacitors hold an electric charge, but for a shorter period of time. However, capacitors can store and discharge electricity much more rapidly than a battery.

Cui's work is reported in the paper "Highly Conductive Paper for Energy Storage Devices," published online this week in the Proceedings of the National Academy of Sciences.

"These nanomaterials are special," Cui said. "They're a one-dimensional structure with very small diameters." The small diameter helps the nanomaterial ink stick strongly to the fibrous paper, making the battery and supercapacitor very durable. The paper supercapacitor may last through 40,000 charge-discharge cycles — at least an order of magnitude more than lithium batteries. The nanomaterials also make ideal conductors because they move electricity along much more efficiently than ordinary conductors, Cui said.

Cui had previously created nanomaterial energy storage devices using plastics. His new research shows that a paper battery is more durable because the ink adheres more strongly to paper (answering the question, "Paper or plastic?"). What's more, you can crumple or fold the paper battery, or even soak it in acidic or basic solutions, and the performance does not degrade. "We just haven't tested what happens when you burn it," he said.

The flexibility of paper allows for many clever applications. "If I want to paint my wall with a conducting energy storage device," Cui said, "I can use a brush." In his lab, he demonstrated the battery to a visitor by connecting it to an LED (light-emitting diode), which glowed brightly.

A paper supercapacitor may be especially useful for applications like electric or hybrid cars, which depend on the quick transfer of electricity. The paper supercapacitor's high surface-to-volume ratio gives it an advantage.

"This technology has potential to be commercialized within a short time," said Peidong Yang, professor of chemistry at the University of California-Berkeley. "I don't think it will be limited to just energy storage devices," he said. "This is potentially a very nice, low-cost, flexible electrode for any electrical device."

Cui predicts the biggest impact may be in large-scale storage of electricity on the distribution grid. Excess electricity generated at night, for example, could be saved for peak-use periods during the day. Wind farms and solar energy systems also may require storage.

"The most important part of this paper is how a simple thing in daily life — paper — can be used as a substrate to make functional conductive electrodes by a simple process," Yang said. "It's nanotechnology related to daily life, essentially."

Cui's research team includes postdoctoral scholars Liangbing Hu and JangWook Choi, and graduate student Yuan Yang.

…by Janelle Weaver
Stanford Report,
December 7, 2009
URL:
http://news.stanford.edu/news/2009/december7/nanotubes-ink-paper-120709.html

January Calendar

January 4 — Amiga-By-The-Loop Chapter
7:00 PM — Main Grand Prairie Library
901 Conover Drive, Grand Prairie

January 4 — MCCC Board of Director's Meeting
Approximately 9:15 PM — Location TBD

January 23 — Newsletter Deadline — 7:00 AM