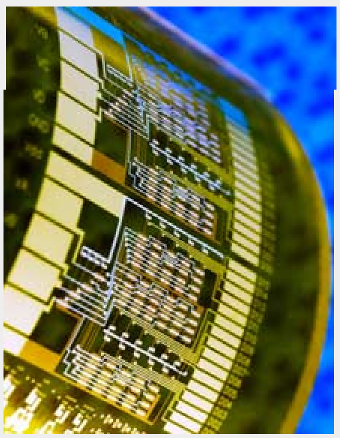
Wednesday, July 23, 2008

Bendable Nanotube Circuits

Carbon nanotubes combine high performance and flexibility for electronics.

By Lauren Rugani



Fast and flexible: An integrated circuit on a thin plastic sheet incorporates transistors made from single-walled carbon-nanotube networks. The carbon-based networks rival the performance of single-crystal silicon, but they can be easily printed onto the plastic from solution and have good mechanical properties that are useful for flexible electronics. Credit: Beckman Institute, University of Illinois

New research suggests that networks of single-walled carbon nanotubes printed onto bendable plastic perform well as semiconductors in integrated circuits. Researchers from the University of Illinois at Urbana-Champaign (UIUC) and Purdue University, whose work appears this week in *Nature*, say that these nanotube networks could replace organic semiconductors in applications such as flexible displays.

Development of flexible electronics has recently focused on organic molecules because, unlike silicon, they are compatible with bendable plastic substrates. Flexible electronics have potential in such applications as low-power electronic newspapers or PDAs that roll up into the size and shape of a pen. The problem with existing organic-electronic devices, however, is that "they aren't well developed for long-term reliability, and they perform far worse than silicon," says John A. Rogers, an engineering professor at UIUC and co-author of the *Nature* paper.

Carbon-nanotube networks, on the other hand, combine the performance of silicon with the flexibility of organic films on plastic. Rogers says that the speed of the nanotube device compares favorably with the speed of commercially used single-crystal silicon circuits. The transistors can also switch between on and off states in the range of several kilohertz, which is similar to the range of those used for liquid crystal displays and radio frequency identification (RFID) sensors. However, the on-off current ratio for carbon nanotubes is still a few orders of magnitude lower than that for silicon transistors.

The researchers made the networks by depositing nanotubes onto plastic by standard printing methods, which could lead to low-cost, large-scale fabrication. And the printed circuits can bend to a radius of about five millimeters without compromising the electrical performance of the device. "This method is good for flexible electronics that need to be printed over a large area," says Ali Javey, an assistant professor of electrical engineering at the University of California, Berkeley.

Using a technique called transfer printing, the researchers deposited randomly aligned carbon nanotubes onto a 50-micrometer-thick sheet of plastic, and then patterned gold electrodes and other circuit components onto the substrate. Because about one-third of the nanotubes in any network are metallic, which can short out the transistors, the researchers then etched narrow parallel lines through the network with soft lithography. By cutting the nanotubes, they can effectively eliminate the possibility of a purely metallic pathway connecting two electrodes while preserving the performance of the device.

Several challenges still remain before the nanotubes networks are ready for actual products. Devices need to be made in which the performance from device to device doesn't vary; billions of individual nanotubes have to be made with high purity and the right dimensions for optimal performance. The printing process also needs development, says George Gruner, a professor of physics at the University of California, Los Angeles. Gruner suggests that nanotubes could be dissolved into ink and then printed onto plastic. "These devices have to be cheap and disposable," especially for devices like RFID tags in food packaging, he adds.

Rogers's group's immediate goals are to work toward lower power and higher speed in the devices. "We want to push the limits to see how far we can go," he says.

Wire Stories

Electronics giants to create wireless HD standard
Court affirms online content law unconstitutional
Breaking up not so hard to do with Slydial
Possible shutdown of Navajo Internet pushed ba
Yahoo settles with Icahn to avert August showdo