Printable, Flexible Carbon-Nanotube Transistors

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Scientists from the University of Massachusetts Lowell and Brewer Science, Inc. have used carbon nanotubes as the basis for a high-speed thin-film transistors printed onto sheets of flexible plastic. Their method may allow large-area electronic circuits to be printed onto almost any flexible substrate at low cost and in mass quantities.

Applications for these flexible electronics include electronic paper, RFID (radio frequency identification) tags to track goods and people, and “smart skins,” which are materials and coatings containing electronic circuitry that can indicate changes in temperature or pressure, such as on aircraft or other objects.

Printing circuits onto plastic is not a new achievement. Researchers have created printed circuits at room temperature using various semi-conducting polymers as the carrier transport medium, and many, many research groups across the globe continue to work toward perfecting the process and product.

“A problem with these polymers is that they have limited carrier mobility, meaning electrons travel through them fairly slowly. This limits the speed of the devices made from them to only a few kilohertz,” said UMass Lowell Professor Xuejun Lu, the study's corresponding researcher, to *PhysOrg.com*.

Modern computers, by comparison, have speeds from hundreds of megahertz to more than one gigahertz.

As part of the printed-electronics effort, carbon nanotubes have been investigated as a medium for high-speed transistors, with very promising results. But one method of depositing the nanotubes onto the plastic, "growing" them with heat, requires very high temperatures, typically around 900°C, which is a major obstacle for fabricating electronic devices.

Additionally, transistors made from single carbon nanotubes or low-density nanotube films, which are produced by depositing a small amount of a nanotube solution onto a substrate, can carry only a small amount of current. High-density films (more than than 1,000 nanotubes per square micrometer, or millionth of a meter) are better, but most are not of sufficient quality, containing carbon "soot" that covers the nanotubes' sidewalls and hinders carrier flow.

To help solve these issues, Brewer Science, Inc. developed an electronic-grade carbon-nanotube solution. The researchers deposited a tiny droplet of the solution onto a plastic transparency film at room temperature using a syringe, a method similar to ink-jet printing.

"Our electronic-grade solutions contain ultrapure carbon nanotubes without using any surfactant. Our printed transistor's carrier mobility is much higher than similar devices developed by other groups, it exhibits a speed of 312 megahertz, and can carry a large current," said Dr. Xuliang Han, Senior Research Engineer at Brewer Science.

This research is described in the November 16, 2007, online edition of *Micro & Nano Letters.*

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