Carbon nanotubes used to form fast, flexible circuitry

By Yun Xie | Published: July 23, 2008 - 12:01PM CT

Flexible circuits are in demand for medical probes, aerospace instruments, military electronics, semiconductor research, and numerous other applications. Unlike the rigid circuits that are produced with glass plates or semiconductor wafers, circuits made on plastic sheets like polymide are lighter, have higher circuit density, and are often more robust. Commonly, polymers and small, organic molecules make up the semiconductor portion of these flexible integrated circuits.

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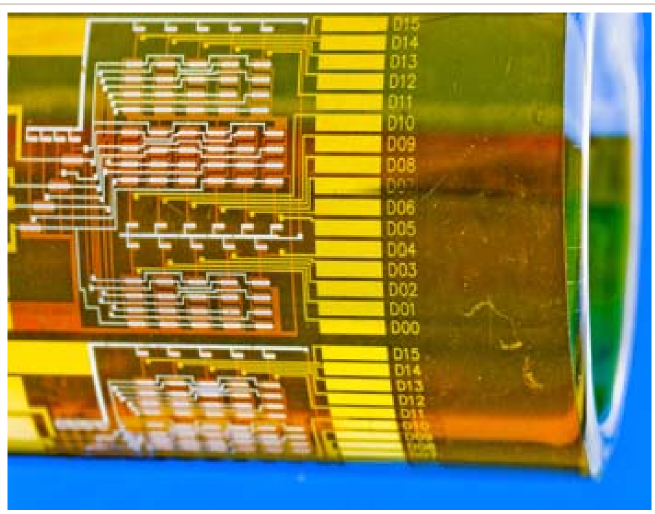
These conventional materials are serviceable, but there is room for improvement in quite a few of their properties, including field-effect mobilities and transconductance. Single-walled carbon nanotubes are an appealing option for providing an upgrade in performance. Networks of carbon nanotubes are flexible, have high current-carrying capacities, and can be printed on a layer of plastic using well-established procedures. Thus, they have great potential as components of flexible integrated circuits.

To determine if carbon nanotubes were indeed capable of use in commercial electronics, chemists and engineers from the University of Illinois at Urbana-Champaign and Purdue University teamed up for a research collaboration; the results are presented in a the issue of *Nature* that will be published later today.

The team grew random networks of single-walled nanotubes and printed them on sheets of polymide to create a semiconductor network layer over each thin sheet of plastic. Even though the growth was random, the process produced circuits with nearly 100 transistors. After conducting tests on the performance of these circuits, the team discovered that carbon nanotubes are better than many conventional materials.



Most noticeably, the carbon nanotube transistors are much more mobile. The field-effect mobilities from polymer and small-molecule circuits are 1 cm^2 V^{-1} s^{-1} or lower, which is insufficient for many applications. In contrast, the mobilities of transistors from carbon nanotube circuits are normally 70 cm^2 V^{-1} s^{-1} and can reach 80 cm2 V-1 s-1. For context, transistors in a liquid crystal or electroluminescent display need mobilities of at least 10 cm^2 V^{-1} s^{-1} in order to display a standard television signal.

Carbon nanotube circuits also have good flexibility, high switching speeds (in the kilohertz range), and operating voltages below 5 V. Furthermore, most of the circuits are uniform in character, which makes them good candidates for mass production. With more tweaking, it is possible to improve the properties of carbon nanotube circuits even more—mobilities to 2,500 $cm^2 V^{-1} s^{-1}$ or higher should be achievable. This work provides a proof-of-concept for technology with the potential to take us towards the replacement of silicon in microelectronics, giving us near-terahertz processing and less power consumption.

Nanotube circuits flexed around a glass tube
Image: Beckman Institute, University of Illinois

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