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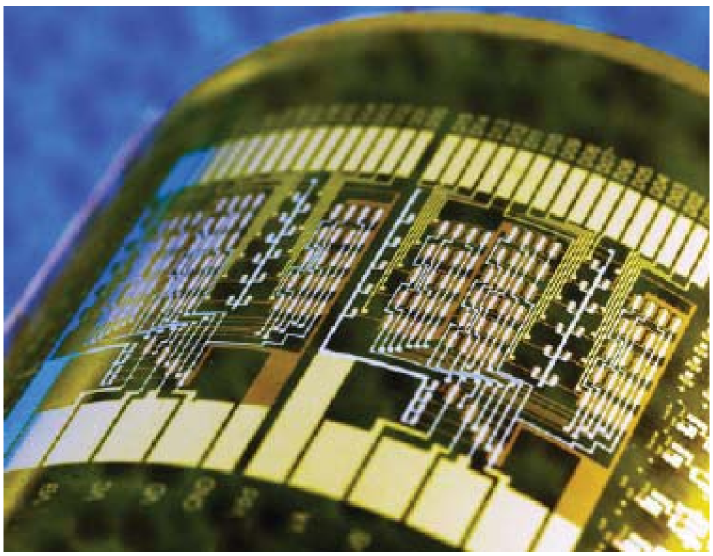
Flexible CNT circuits move on

Researchers in the US report on a significant advance in thin-film integrated circuits consisting of carbon nanotube networks on plastic substrates. The circuits show excellent electronic properties and could find use in a host of applications, such as paper-like displays, smart food packaging and wearable personal health-monitoring devices.



CNT webs for flexible electronics

"We have demonstrated, for the first time, all the key pieces – ranging from materials and integration strategies, to physics and circuit modelling tools – for a nanotube-based electronics technology that could be interesting for applications in flexible electronics," team leader John Rogers of the University of Illinois at Urbana-Champaign told *nanotechweb.org*. "The attraction of our approach is that it offers significant performance advantages compared with the more widely explored systems that use amorphous silicon or polymers for the semiconductor."

Rogers and co-workers built their circuits using large random networks of carbon nanotubes as an effective thin-film semiconductor on plastic substrates. By etching certain patterns into the networks, the researchers found (both experimentally and in calculations) that it was possible to control the device in a way that allows good, reproducible properties. These devices can then be integrated into circuits using layer-by-layer processing similar to that already routinely used in thin-film electronics.

Good device-to-device repeatability

"A key point here is that each transistor device uses tens of thousands of nanotubes," explained Rogers. "In this way, device-to-device repeatability can be good, even with little control over the electronic properties, spatial positions or orientation of any individual tube."

The small to medium-scale circuits consist of up to nearly 100 transistors and the properties of the individual devices are much better than similar, previously made structures based on amorphous silicon, polymer or small molecule organic semiconductors. For example, the circuits have mobilities as high as 80 cm^2V^{-1}, sub-threshold slopes as low as 140 m V dec^{-1} and operating voltages less than 5 V. Moreover, they have on/off ratios as high as 10^5 and switching speeds in the kilohertz range – even for coarse, 100 µm device geometries. They also have good mechanical flexibility and can easily be produced.

Possible applications in flexible electronics include paper-like displays, smart food packaging, personal or structural health monitors and radiofrequency identification tags, says Rogers. "The improved performance enabled by the structured nanotube networks facilitates these applications and will also allow new ones that were previously difficult or impossible to achieve because of performance constraints," he added. One new application example might be in emissive, organic light emitting diodes, where the demands on the active matrix driver circuits are significant.

The team is now trying to achieve similar device and circuit results using nanotube networks formed by solution deposition. "We are also exploring the possibility of building both n and p channel devices on a single substrate for low power, complementary logic applications," revealed Rogers.

The work was reported in *Nature*.

About the author

Belle Dumé is contributing editor at *nanotechweb.org*