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TECHNOLOGY UPDATE

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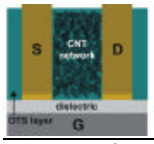
Ink-jet printing produces nanotube transistors

Ink-jet printing is an excellent method for placing electronic components on plastic substrates. Now, scientists in the UK and Canada have shown that it can also be used to fabricate large area, thin-film transistors made from carbon nanotubes. The devices have effective mobilities of around 0.07 cm^2/Vs and on/off current ratios of up to 100.

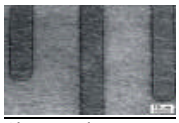
Recent developments in plastic electronics look set to revolutionize the electronic industry. A variety of applications are expected that are not possible with conventional silicon chips, which are rigid and limited in size.



CNT transistor

Ink-jet printing is one of the most promising techniques for making large area, inexpensive plastic electronics on which a range of electronic components can be printed. These include transistor circuits, photovoltaic films, organic light-emitting diodes and photovoltaic films.

Now, Paul Beecher and colleagues of the University of Cambridge and co-workers at the University of Waterloo and the London Centre for Nanotechnology have shown that ink-jet printing can be extended to dispensing solid materials like carbon nanotubes without clogging the ink-jet nozzles. "This significantly widens the scope of applications for which ink-jet printing is a viable fabrication technique," Beecher told *nanotechweb.org*.


Si nanowire arrays

The technique works by dispersing carbon nanotubes in appropriate solvents with the help of high-powered sonication and subsequent ultracentrifugation, followed by a filtering step. The resulting dispersion is then repeatedly printable without risk of clogging. To make the transistors, the carbon nanotube inks are then deposited on electrode bearing substrates that are made hydrophobic with self-assembled monolayers before printing. This ensures

that the printed carbon nanotubes are better aligned.

"The advantage of this technique is that ink-jet printing is a simple, low-cost process that also provides targeted deposition, which facilitates the placing of ordered arrays of devices," explain Beecher and team member Andrea Ferrari, also of Cambridge University. This is not possible with other techniques, such as spin coating, previously used to make carbon nanotube transistors. "Since ink-jet printing is at the core of printed electronics, this makes the nanotubes compatible with plastic logic," say the researchers.

The UK-Canada team now plans to make composites of carbon nanotubes and organic semiconducting material, which has already been widely studied because of its compatibility with plastic substrates. "The objective here is to improve the performance of devices fabricated using organic semiconductors by exploiting the superior electrical properties of carbon nanotubes," state Beecher and Ferrari.

The researchers would also like to extend their technique to a variety of nanowires, such as silicon nanowires. "This could be important for printing polymer/nanowires solar cells," adds Ferrari.

The work was reported in *J. Appl. Phys.*.

About the author

Belle Dumé is contributing editor at nanotechweb.org