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Single walled nanotubes grown at 350°C

by **Steve Bush**
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Researchers at the University of Cambridge have grown single-wall carbon nanotubes (SWCNTs) at the CMOS-compatible temperature of 350°C.

“Thus far the growth of nanotubes has been carried out at very high temperatures, and growth below 500° C was believed impossible. This made the direct implementation of nanotubes into electronic devices unthinkable,” said the University’s engineering department. “Trying to integrate nanotubes above 400-450° C would in fact damage the inter-metal dielectrics commonly employed in CMOS device fabrication.”

Low temperature growth is the result of painstaking work. “There is no particular trick. In principle it is easy,” scientist Mirco Cantoro told EW. “You need careful control of the thickness of the catalyst, down to a small part of a nanometre, and an understanding of the pre-growth stage is important for proper catalyst distribution on the surface.”

Although others could be suitable, said Cantoro, the catalyst in this case is iron; sputtered on at room temperature to form the right sized islands of the right thickness.

Nanotubes are then grown by chemical vapour deposition from an unusually low pressure acetylene atmosphere of 10-4mbar. “Most groups grow at atmospheric pressure or slightly below. Pure acetylene at our very low pressure reduces the chance of contamination,” said Cantoro.

The result is all single-walled tubes, with none of the less useful multi-walled tubes, growing vertically from the surface. The tube diameter distribution can also be narrowed using the process control techniques developed.

However, Cantoro pointed out that his nanotubes are not yet defect-free and grow vertically, whereas electronic devices are likely to need horizontal CNTs. “Guided growth horizontally is still a challenge,” he said.

Nor has the work shed any light into the other big nanotube mystery: how to selectively grow semiconducting rather than non-semiconducting CNTs. “So far, no one has established a way to control this,” said Cantoro.

A finding of the work is that during CNT growth the catalyst can be solid. “Previously, the assumption that the catalyst has to be liquid often dominated carbon nanotube growth model considerations, but at these lower temperatures evidence has been found of a solid catalyst,” said Cambridge.

This points the way to further advances, said Cantoro: “In principle it is possible to lower the temperature. There is no thermodynamic barrier.”

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