Model of the future

CONFERENCE REPORT

Boston played host to around 5000 researchers at the Fall Meeting of the Materials Research Society last month. The record 42 parallel sessions had a decidedly green tinge this year with sessions devoted to the hydrogen cycle (generation, storage, and fuel cells), 'green' materials selection and life cycle analysis, biomaterials and biomimetics, and the application of physical science methods to the life sciences. The fun stuff came in the form of a fashion show of 'technologically advanced clothing'. Despite a lack of supermodels, George M. Whitesides of Harvard University predictably drew a large crowd to hear him describe his latest nanofabrication technique, nanosciving. This means of lateral slicing provides a novel and simple means of fabricating Au nanowires with diameters on the nanoscale. Whitesides believes that this technique could provide a very useful method for making two-dimensional nanostructures, such as cross-bar arrays. In future, he added, this technique could enable a simple route to three-dimensional structures.

A model of another type could be gracing our roads in the next decade, according to Alan Taub of General Motors. He believes that a commercially viable electric car could be on the drawing board by 2010. The automotive industry could be on the cusp of a major paradigm shift, not only to a possible new fuel in the form of hydrogen (if storage issues can be resolved) or electricity (with improved battery technology), but also in the application of mechamatronics – the use of smart materials in place of mechanical parts such as gears. The materials community is essential in driving forward these developments, he said, exhorting researchers to get on board.

Cordelia Sealy

Finding fault with carbon nanotubes

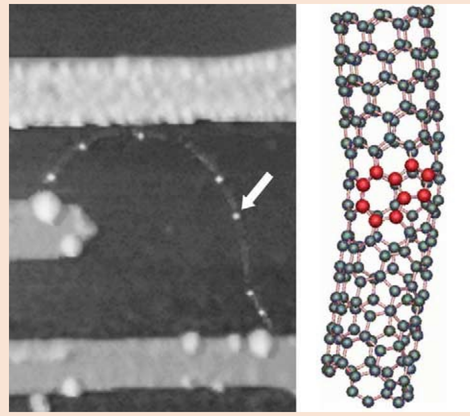
NANOTECHNOLOGY

Point defects in single-walled carbon nanotubes (SWNTs) have been labeled and quantitatively analyzed using an electrochemical method [Fan *et al.*, *Nat. Mater.* (2005) **4**, 906]. Philip G. Collins and colleagues at the University of California at Irvine identified on average one defect every 4 µm of the SWNT, which equates to 1 in 10^{12} chemical bonds. "Carbon nanotube purity is already as high as state-of-the-art Si crystals," says Collins. However, he notes that, because of the nature of conduction in nanotubes, defects at these low levels have significant implications for their possible use in microchips. "Because of their size, there is no alternate way for current to flow 'around' a defect site, and a single atomic defect can disrupt or dominate an entire circuit based on carbon nanotubes," says Collins.

This means that nanotubes may need to be produced at much higher purities than Si before they will be viable alternatives for electronic circuits.

It is difficult to image point defects in nanotubes directly. Scanning tunneling microscopy can be used in some circumstances but is slow. So, the researchers used selective electrochemical deposition to reveal defects in individual SWNTs and nanotube circuits.

The defect sites are more reactive than the rest of the nanotube lattice, and so Ni can be selectively deposited on them. The metal dots were then grown to the point where they could be counted. Atomic force microscopy was used in this study, but the dots could be grown large enough to be counted by optical microscopy, or even by eye.



Deposition of metal allows defect sites on SWNTs to be identified. (Courtesy of Philip G. Collins.)

The reactivity of the defect site also offers opportunities for the application of SWNTs as chemical or biological sensors. "The defect gives the circuit a 'chemical handle' to which a wide range of sensing molecules, like catalysts or antibodies, can be attached," explains Collins.

Ian Salusbury

Low-temperature growth of boron nitride nanotubes

NANOTECHNOLOGY

Boron nitride nanotubes (BNNTs) are structurally similar to carbon nanotubes (CNTs), but have electronic properties that are insensitive to the nanotube diameter or chirality. The 5 eV band gap can also be tuned using transverse electric fields, something that would be very useful for devices. Furthermore, BNNTs have high oxidation resistance up to 800°C, show excellent piezoelectricity, and could be a good room-temperature hydrogen storage material.

Growing these promising materials is challenging, however. BNNTs were first synthesized in 1995 and, in the ten years since, have been grown by arc discharge, laser ablation, ball milling, chemical vapor deposition, and using substitution reactions from CNTs. In each case, the BNNTs are dominated by impurities. As a result, large-scale synthesis and applications of BNNTs have been hampered by the high growth temperatures, low yield, and contaminants.

Now, researchers from Michigan Technological University, the University of California, Irvine, and Oak Ridge National Laboratory have grown BNNTs at low temperature directly on a substrate using plasma-enhanced pulsed-laser deposition at 600°C [Wang *et al.*, *Nano Lett.* (2005) doi: 10.1021/nl051859n]. The nanotubes have a high degree of order and are suitable for use without purification. The researchers believe this work will form the basis for the study of BNNTs, including their large-scale synthesis and doping.

A substrate coated with Fe catalyst particles is held at a negative bias voltage between -360 V and -450 V. This bias accelerates positive ions in the nitrogen radio-frequency (rf) plasma and the BN vapor to bombard the substrate surface. At the optimum combination of Fe film thickness, laser energy density, and substrate bias, BNNTs form. At this point, the rate at which BN thin films are deposited on the surface is cancelled out by the rate at which they are resputtered off. The Fe particles serve to capture the BN growth species, leading to vertical growth of the BNNTs from the nanoparticles through the vapor-liquid-solid mechanism.

Jonathan Wood