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Bayer and Nanoledge join forces to develop nanotube-reinforced epoxy composite

Bayer MaterialScience, a producer of carbon nanotubes, and Nanoledge, a specialist in the design of nanotube-based materials, have joined forces and introduced a surfboard and skis made from nanotube-reinforced epoxy resin.

Most modern surfboards are made from polyurethane/polyester systems, but epoxy is fast gaining the attention of surfboard makers. Epoxy is normally combined with carbon fibre in high-performance applications, and there are many sporting tools on the market made from carbon fibre-reinforced epoxy.

With nanotubes, the difference is that the tubes are filled with resin, and Nanoledge claims that its NANO IN RES technology offers significantly improved performance over carbon-fibre composites, with 50% greater flexural strength, up to 150% more impact resistance, and compression strength increased by up to 20%.

Carbon nanotubes are not cheap, however, even when mass-produced by Bayer MaterialScience. But this is not a significant issue, according to Martin Schmid, business manager for Baytubes: 'The material cost added by adding carbon nanotubes to epoxy is comparatively small due to the low content needed. One needs to look at the cost of the whole system and the related benefits which are the really important factors.'

The new surfboard was developed by Nanoledge in collaboration with US-based sporting goods company Entropy Research Labs. The companies claim that the board combines the flexural response sought by surfers with low weight and high durability. The skis were developed by in partnership with French firm Axunn.

While the focus is now on sporting goods, Bayer MaterialScience and Nanoledge hope to find other applications for their new composite.

Nanocomposite surfboard developed by Nanoledge and Entropy Research Labs, incorporating Baytubes carbon nanotubes from Bayer MaterialScience

Source: Bayer MaterialScience

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derived from the light-harvesting porphyrin pigments plants use for photosynthesis.

Like other types of organic photovoltaics, the demonstration cells developed at the NRC are well-suited to generating electricity in low-light conditions. The photosynthesising dyes could be incorporated into tinted windows, roofing materials and walls, and Campbell's group has received expressions of interest from New Zealand companies.

'There are still many obstacles to be overcome in cell construction,' says Campbell. 'We are currently not at the stage of commercialisation, and are primarily involved in the design and synthesis of the dye. The solar cell technology that uses the dye, known as the Grätzel Cell, is well developed. Some companies, including Konarka and Dyesol, already have commercial licenses to produce these cells).'

Campbell claims that the green solar cells are more environmentally friendly than silicon-based photovoltaics as they are made from titanium dioxide – a non-toxic white mineral in plentiful supply in New Zealand's black sand. Titanium dioxide is already widely used in consumer products such as toothpaste, white paints and cosmetics.

A proof-of-concept cell has been developed by Dyesol using one of the green dyes, and Campbell and his colleagues are currently gathering data on cell lifetimes.

Porphyrin demo cell

Source: Wayne Campbell, Massey University

Why defects are not always a bad thing

Defects in material structure usually mean trouble. But despite the negative connotations of terms such as 'radiation damage' and 'defect', engineers can make effective use of defect structures in order to deliberately modify carbon nanomaterials.

Oleg Yazyev and a team at the École Polytechnique Fédérale de Lausanne have carried out a theoretical study of radiation-induced damage in graphite, and shown how it is possible to predict defect structures and describe mechanisms for their formation. This is known as defect-assisted engineering, and could have application in the manufacture of nanoelectromechanical systems (NEMS).

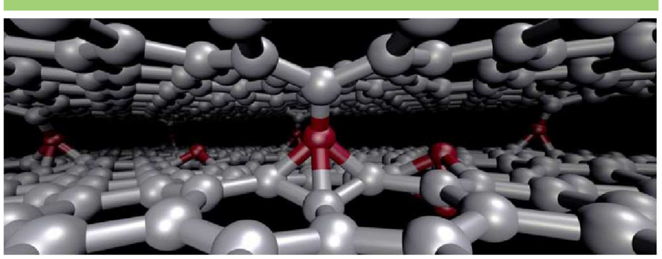
Yazyev's molecular dynamics modelling was inspired by experimental work carried out by his colleague László Forró, in which a 30-fold increase in the bending modulus of carbon nanotube bundles was achieved by irradiating the material with a beam of 80 keV electrons.

Modifying the nanotubes in this way eliminates an obstacle in the fabrication of macroscopic fibres from nanotube bundles. 'Unknown covalent cross-links bridging carbon nanotubes were postulated to be responsible for the reinforcement effect,' says Yazyev. 'Our research elucidated their structure and predicted the range of electron beam energies at which such purposeful reinforcement can be achieved.'

There is talk of using multiwalled carbon nanotubes as bearings in NEMS. By creating interlayer defects between individual nanotube components, one can weld them together with an electron beam. These defects (known as intimate Frenkel pairs) can be thermally annealed, so the welding can in principle be reversed, which adds an extra degree of freedom to the manufacturing processes.

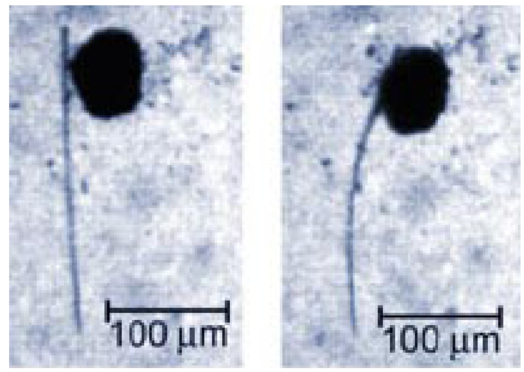
For Florian Banhart, a chemist at the University of Mainz, in Germany, the subject is interesting as it has been shown experimentally that irradiation of graphite with energetic charged particles can lead to new and unexpected morphologies. 'In this context, theoretical studies such as the present one are important and necessary to understand the atomic mechanisms during particle impact. These happen on a timescale that is much too short for experimental observation.'

Radiation-induced defects between the two graphene layers, obtained through molecular dynamics simulations. Displaced carbon atoms are shown in red



Source: Oleg Yazyev, EPFL

An organic crystal fibre bends when exposed to ultraviolet light, pushing a gold particle some 90 times its weight 30 microns across a glass slide. Shining visible light on the crystal straightens it



Source: Masahiro Irie, Kyushu University

Bendy crystals respond to light

Japanese researchers have discovered organic crystals that change shape when illuminated with ultraviolet light, and return to their original form when exposed to visible light.

Such shape-changing crystals could be used in tiny machines driven remotely by light, instead of electrical impulses requiring physical contacts which are a challenge to fabricate on such a small scale. Potential applications include microfluidic chips that pump tiny volumes of liquids through narrow channels, and switches in optical communications systems.

In a recent *Nature* paper, Masahiro Irie and colleagues at Kyushu University report on rectangular crystals that contract by 5–7% of their length.'

While the crystals can be deformed by relatively small amounts, this is enough for certain applications, says Irie. '7% deformation is enough for micro-tweezers to control the movement of cells. The crystals also may find applications in micro-reactors for chemical analysis.'

For Michael McBride, a chemist at Yale University, US, what is most remarkable is the precise reproducibility over 80 cycles of bending and straightening. 'Clearly such an observation is inconsistent with accumulation of damage. I know of no other examples where crystal shape changes have been so rapid and resilient, and it is not clear to me what features of these particular crystals gives them this potentially useful property.'

Irie claims that the property is explainable partly by the presence of fluorine atoms in the crystal molecules, and cites the strong electronegativity of fluorine. But the relevance of electronegativity is far from clear, and was not mentioned in the *Nature* paper. More work is therefore required to explain the resilience of Irie's bendy crystals.