

The tooth theory

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Enamel, the biomineral forming the outer shell of a tooth, is made up of microscale prisms of apatite and protein. Its strength and toughness are explained by various coexisting mechanisms. For example, the sliding movement of prisms in the event of microscale indentation prevents failure of the material. On a smaller scale, it is known that enamel can bear mechanical loads using similar survival mechanisms to steel. Now, in an attempt to rationalize the molecular mechanism behind these steel-like properties, Dirk Zahn has used molecular dynamic simulations to investigate the application of a mechanical load to a biomimetic apatite–collagen composite. Under the load, the biomimetic composite is shown to undergo inelastic deformation initiated near the collagen molecules. The crystalline order of the composite is destabilized by collagen and the apatite ions become disordered, but only close to the applied load. The localized nature of the ionic disorder results in a pseudo-elastic, reversible deformation. When the load is removed, the ordered apatite regions that remain allow the restoration of the destabilized crystalline regions.

Graphene implantation

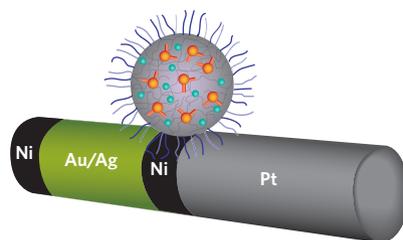
Appl. Phys. Lett. **97**, 183103 (2010)

Among the techniques to grow graphene in a scalable way, the most notable is arguably chemical vapor deposition (CVD). Hydrocarbons are deposited on a metallic substrate which is then heated to dissolve the deposited carbon. Once the metal is cooled the carbon solubility is decreased; the carbon is segregated to the surface and forms graphene. The drawbacks of this method,

however, are the difficulty in growing multiple layers, and the limited choice of substrates with high enough carbon solubility. Slaven Garaj and colleagues have now demonstrated a technique with some similarities to CVD, based on direct implantation of the carbon atoms in the metal. Raising the temperature promotes carbon diffusion through the metal, and subsequent cooling again results in crystallization on the surface in the form of one or, in this case, more layers of graphene. The characteristics of the films grown are comparable to those of CVD-graphene. However, because implantation is not affected by solubility, any metal can be in principle used, substantially widening the choice of substrate.

Nanoshuttles for liposomes

Small doi:10.1002/sml.201001257 (2010)



Drug delivery via biocompatible nanostructures — liposomes, for instance — is often inefficient. Off-target delivery and limited penetration depth are two of the problems that prevent therapeutic efficacy of drug-loaded carriers. A method to transport the carriers rapidly to targeted areas in the body would thus be a welcome development. Now, Wang and colleagues, by taking advantage of previously designed, chemically powered catalytic nanomotors — also known as nanoshuttles — have reported a proof-of-concept of directed delivery of

polymeric and liposomal drug carriers. First, the nanoshuttles are magnetically guided towards the iron-oxide-encapsulated liposomes, which bind to the nanowire-shaped nanoshuttle through the weak magnetic attraction with its nickel segment. The carrier is then transported by the nanoshuttle along a 2-mm-long microfluidic channel within two minutes, more than three orders of magnitude faster than by random diffusion. Finally, by triggering a rapid reversal of the direction of the nanoshuttle, a drag force is imposed on the liposome, causing its release. Although the advantages of these self-powered nanoshuttles are obvious, work remains to adapt this technology to *in vivo* situations.

A push and a squeeze

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Oxide heterostructures, layered thin films of different oxide compounds, promise control over various fundamental properties. Oxide compounds show a broad variety of phenomena such as magnetism and superconductivity. Placing oxide materials close to each other influences their respective properties, and Christos Panagopoulos and colleagues now demonstrate how this effect can be used to control magnetism at the interface between a ferromagnet and an antiferromagnet. They use a three-layer heterostructure made of different manganese oxides sandwiched between layers of the ferromagnet SrRuO₃. These trilayers are grown on two different substrates, SrTiO₃ and LaAlO₃. The LaAlO₃ has a small lattice constant, which means that parallel to the substrate the trilayer structure is strongly compressed. For SrTiO₃, on the other hand, there is only a weak strain. This has striking consequences for the magnetism at the interface between SrRuO₃ and the manganite layers. On LaAlO₃ the interface shows ferromagnetic order, whereas it is antiferromagnetic on SrTiO₃. Depending on the strain from the substrate, the electrons in the manganite occupy different orbitals. This comprehensive study shows how the intricate relationship between structure and properties in oxide heterostructures can be deliberately controlled.

Hopping along

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Although they study the conductive properties of rather similar molecules, researchers in molecular and organic electronics draw on very different models of charge transport. Films of organic semiconductors are generally governed by energetic disorder, resulting in the hopping of charge carriers. Transport across single molecules, on the other hand, usually occurs by tunnelling. The transition between these two regimes has only recently been probed directly. Following up on earlier work, Choi and Frisbie have now found evidence of hopping transport in molecular wires as long as 20 nm. Starting from a gold substrate, molecules with a backbone of alternating donor and acceptor subunits were synthesized step by step and probed using the gold-coated tip of an atomic force microscope. In the shortest wires the conductance dropped exponentially with increasing length, as expected for tunnelling. Molecules longer than 5 nm, however, showed a much smaller distance dependence and thermally activated field-driven transport, in agreement with the hopping mechanism. These experiments could soon contribute to a better understanding of molecular conduction.

Correction

In the Research Highlight 'Topological thermoelectrics' (*Nature Mater.* **9**, 786; 2010), the wording "Tretiakov and colleagues had previously predicted" should have read "Ran *et al.* had previously predicted (*Nature Phys.* **5**, 298; 2009)". Corrected in the HTML and PDF versions after print: 19 October 2010.