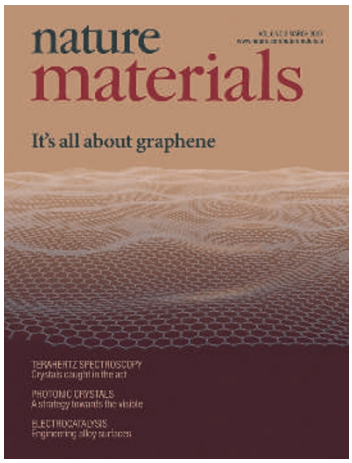


COVER STORY

Vol.6 No.3 March 2007

Graphene is a one-atom-thick layer of carbon, which can be seen as the basic element of all graphitic forms — bulk graphite, carbon nanotubes and fullerene. Its free-standing form (represented in this image inspired by an idea from Jannik Meyer, MPI Stuttgart) was first isolated in 2004, and since then a number of experiments have demonstrated electronic properties never before observed in condensed-matter physics. Andre Geim and Kostya Novoselov review the brief but intense history of this purely two-dimensional crystal, highlighting the experimental observations that have made it a playground for condensed-matter physics, and suggesting the possibilities that this intriguing material offers for device applications.
[Progress Article p183]

FORECAST FOR SKATING CONDITIONS

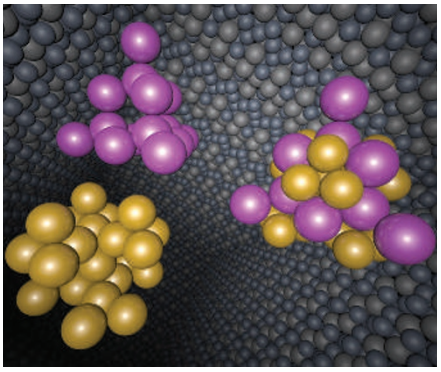
The need to reduce wear in micro- and nanoelectromechanical systems and modern engines (where operating conditions of temperature, speed and pressure become extreme) puts demands on industry to explore unprecedented regimes of friction. Molecular dynamics simulations performed by Tania Zykova-Timan and co-workers reveal a regime of nanoscale friction in which a blunt tip advances much more slowly than a sharp, ploughing tip. This counterintuitive phenomenon is found at high temperatures, close to the melting point. It is explained by the presence of a thin layer of liquid that forms on the solid surface in contact with a sharp tip.
[Article p230; News & Views p180]

COPPER IS THE ANSWER

In almost all cuprate high-temperature superconductors, transport occurs via positive charges (holes). Electron-doped superconductors also exist, but, since their discovery, one characteristic has puzzled scientists: doping is not enough, they also need annealing or they remain insulators. All explanations so far have relied on the creation, with heating, of oxygen vacancies, which produce even more electrons. Pengcheng Dai and co-authors show that the answer is in the copper instead. The as-grown material has too many copper vacancies that are repaired on annealing. The findings may also have implications for the general mechanism of superconductivity.
[Article p224; News & Views p179]

SEE THEM SOON!

Photonic effects in the visible region are commonplace, such as the strikingly colourful wings of some butterflies. However, no fully three-dimensional material with a complete photonic bandgap — where all light is reflected regardless of the incident direction — has yet been demonstrated in the visible. Antti-Pekka Hynninen and colleagues now propose a feasible strategy towards this elusive photonic crystal. Their approach is based on an assembly of two types of colloidal spheres in a structure similar to $MgCu_2$. According to the authors' calculations, removing (by burning) either the 'Mg' or the 'Cu' spheres could indeed lead to a photonic crystal in the visible region.
[Letter p202; News & Views p177]



The fabrication of photonic crystals in the visible wavelength region may soon be possible.

p202

DIODES UNDER REMOTE CONTROL

The mention of miniature self-propelling devices — 'microbots' — conjures vivid images of futuristic micromachines in the imagination. Until now, very few methods of propelling such devices have been reported. Velev and colleagues present millimetre-sized semiconductor diodes that self-propel in water. The diodes move by harvesting energy from an external a.c. electric field — they rectify the voltage induced between their electrodes and are propelled by particle-localized electroosmotic flow towards the cathode or anode depending on the diodes' surface charge. The diodes can emit or respond to light, be controlled by internal logic, and, when embedded into the walls of microfluidic channels, can provide local pumping and mixing.
[Article p235]

A DENSE PHASE

Polymorphism — the occurrence of a material in different phases — is commonplace, for example, graphite transforms into diamond at high pressures. A similar effect, polyamorphism, can occur in amorphous materials such as ice, which shows different phases of distinct densities under pressure. Common to all reported polyamorphs is the fact that they tend to show some form of directional bonding. To this, Hongwei Sheng and co-workers add the observation of polyamorphism in $Ce_{55}Al_{45}$, a metallic glass with a bonding of non-directional nature. This observation might lead to the development of metallic glasses with improved mechanical properties.
[Letter p192; News & Views p181]

ELECTROCATALYTIC TRENDS

Improving the electrocatalytic activity and stability of nanoparticles for oxygen–reduction reactions is crucial for many clean-energy applications. Catalysts prepared by alloying two or more metals have proved particularly promising, but the effect of alloying on electroactivity remains unclear. Stamenkovic and colleagues predict the variation in oxygen–reduction reactivity caused by alloying platinum with 3*d* transition metals. The proposed relationship exhibits a 'volcano-type' behaviour, where the catalytic activity is governed by a balance between adsorption energies of reactive intermediates and surface coverage by blocking chemical species. These findings should provide a basis for the development of cathode catalysts in fuel cells.
[Article p241]