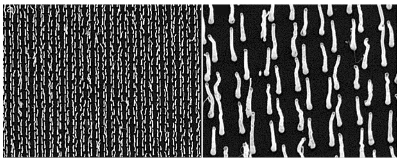
Nanotube photonics

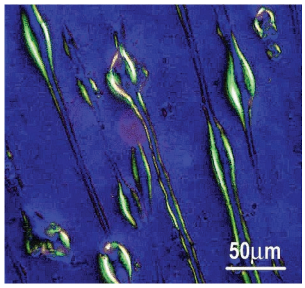


Periodic arrays of carbon nanotubes can be grown from catalytic dots deposited on a surface by electron-beam lithography, but this is an expensive and slow process. Zhifeng Ren and colleagues have developed an ingenious new technique for growing periodic nanotube arrays (see images), which can be developed into photonic bandgap crystals. As they report in *Nano Letters* (http://dx.doi.org/10.1021 nl0258271), the authors first generate self-assembled arrays of polystyrene nanospheres on a silicon substrate. The nanosphere arrays are then used as a mask during deposition of the nickel catalyst. Once the nanospheres have been chemically removed, they leave behind a honeycomb pattern of nickel dots. Growth of carbon nanotubes from these dots takes 10–15 min, using the established technique of plasma-enhanced chemical-vapour deposition. As well as displaying bright colours — owing to their strong reflection and diffraction of visible light — the honeycomb arrays of nanotubes can also act as two-dimensional photonic bandgap crystals. Previous studies have shown that a honeycomb array of rods, embedded in a material with a different dielectric constant, produces a photonic crystal structure, which perfectly reflects light at the frequency of the bandgap. Although they have yet to do so, the authors are confident that they will be able to demonstrate photonic bandgaps in the visible frequency range by using their carbon nanotube arrays.

Measuring spin decay

Spintronic devices, such as magnetic random access memories and spin transistors, rely on the manipulation of non-equilibrium spin. So device operations must be performed within the spin relaxation time — the characteristic time taken for the non-equilibrium spin to decay. Usually, this spin relaxation time is measured by using optical techniques or electron spin resonance. In *Applied Physics Letters* (82, 221–223; 2003), Sankar Das Sarma and colleagues at the University of Maryland report an all-electrical method of determining the spin relaxation time in inhomogeneously doped magnetic semiconductors. The researchers make use of the spin-voltaic effect, in which the injected non-equilibrium spin gives rise to a measurable spin-voltaic current that is highly sensitive to the spin relaxation time. In magnetic semiconductor p–n junctions, the spin relaxation time can then be determined by measuring the *I–V* characteristics of the device.

Cell imaging with liquid crystals



Liquid crystals (LCs) are crucial to advanced display technologies, but biocompatible LCs may find other uses. Any small imperfection in a surface in contact with LCs perturbs the orientational order of these systems. You can easily experience this effect by pressing a finger against an LC computer screen. Jiyu Fang and colleagues at the Naval Research Laboratory in Washington make a virtue out of these LC defects, and exploit them as an optical amplification medium to look at features of biological surfaces. In *Langmuir* (http://dx.doi.org/10.1021/la0264062) they report the imaging of three types of human cell immobilized on a microscope slide and covered with liquid crystals. Each of the cell types used — muscle cells, fat cells and neurons — have very different shapes, which are clearly distinguishable through the cross-polarized light of a common optical microscope (see image). By assuming perpendicular anchoring of the liquid crystals on the cell surface, the authors explain how the muscle and fat cells alter the alignment of the liquid crystals and how this is related to what is observed. So far, this theory fails to explain the images of neurons, suggesting more complex interactions between neural surfaces and the LCs. Understanding such interactions may shed light on the structure and behaviour of cell surfaces.

Composites by numbers

Computer simulations play an essential role in understanding the microstructure of many materials, and are growing more important in the area of material design. Salvatore Torquato and colleagues at Princeton University (*Phys. Rev. Lett.* **89**, 266601; 2002) use topology optimization techniques to show the effect of optimizing two competing properties on the microstructure of composite materials. Previously, such techniques have been used to maximize a single material property. In their paper, Torquato and colleagues calculate the optimal microstructure for two-phase composites that are good at conducting heat and electricity. Of course, there are many materials that are good at both these tasks, but the Princeton researchers chose to make 50:50 composites from two phases that excel at either one or the other. The way the two different materials mix at the microscopic scale is therefore a direct consequence of the competition between the two properties, as both need to be maximized to produce a true multifunctional material. The best three-dimensional structure for maximizing both conductivities turns out to be a bicontinuous composite with a triply periodic minimal surface. These complex structures occur naturally during self-assembly processes involving block copolymers, micelles or nanocomposites, and can be generated using sol–gel processing. The authors believe their approach is a general one and can be used to optimize other combinations of competing functions to guide the design of multifunctional materials with desirable mechanical, optical, chemical or flow properties.

ELECTRICALLY DRIVEN NANOWIRE LASERS

There is much interest in the optical properties of semiconducting nanowires because their cylindrical geometry and two-dimensional confinement of electrons and photons makes them attractive building blocks for nanoscale electronics and optoelectonic devices, including lasers. This is particularly true for electrically driven semiconductor lasers as the defect-free nanowire structures exhibit improved electrical transport and optical properties. Charles Lieber and colleagues (*Nature* 421, 241–245; 2003) have now investigated the properties of single-crystal cadmium sulphide nanowires and show that these structures can function as optical cavities (a property that is crucial for lasing). They also demonstrate lasing by using optical and electrical pumping. Their fabrication approach can be extended to other semiconductors and used to produce lasers of many colours that could be integrated directly with existing microelectronic technologies. The authors believe that these nanowire lasers could be further developed for applications as diverse as data storage, chemical and biological sensing, and medical therapeutics and diagnostics.

Erratum

In the Research News of the November issue (*Nature Materials* 1, 142; 2002), in the piece 'Materials get plugged in', the cation was mistakenly referred to as rubidium terpyridil (second column, line 1) and rubidium terbipyridil (second column, line 13). In both places this should read ruthenium bipyridyl.