Invisible metamaterials

Metamaterials, materials with a negative index of refraction, have seen a dramatic increase in interest, and new designs and applications are constantly being invented. One such class of metamaterials are plasmonic structures — nanopatterned thin metallic films. The tiny holes in the films strongly influence the transmission of light through the structures. Following earlier theoretical predictions, J. W. Lee and colleagues (*Opt. Expr.* **13,** 10681–10687; 2005) demonstrate that such plasmonic metamaterials, designed to have an effective dielectric constant of –2 and with a sufficient number of holes, do indeed transmit light perfectly, showing no reflection or absorption of light at all. Indeed, the light exits the material with the same phase as it enters it and nothing would suggest the presence of any material. Unfortunately, this has only been demonstrated at teraherz wavelengths that are invisible to the eye. Efforts are currently under way to develop plasmonic materials showing such effects at shorter wavelengths, possibly even down to the visible. Once successful, such an approach could mean that science enterprises do indeed catch up with science fiction.

NANOTUBE NETWORKS

The controlled assembly of carbon nanotubes into ordered arrays is a promising strategy for building functional nanostructures. Most protocols rely on non-specific bonding interactions with no strong directional bias. However, researchers from Akron University in the USA have demonstrated the reversible formation of nanotube networks by using a geometrically defined metal–ligand coordination approach (P. Wang *et al. Chem. Commun.* doi:10.1039/b515124d; 2006). In the knowledge that certain metal ions can effectively crosslink molecules with two or more carboxylate groups, Newkome and co-workers simply mixed oxidized single-walled carbon nanotubes (SWNTs), which have carboxylate groups on their ends and walls, with a copper–terpyridine complex. Studies of the resulting material with an atomic force microscope revealed an interconnected network structure possessing a range of junction geometries. The linking of nanotubes was also supported by luminescence measurements, which suggested an extended π-electron conjugation throughout the array. Although thermally robust, complete disassembly of the network was induced on treatment with potassium cyanide. Facile and reversible, this metallo–organic assembly paradigm is another step along the road to functional SWNT architectures.

Tackling wear

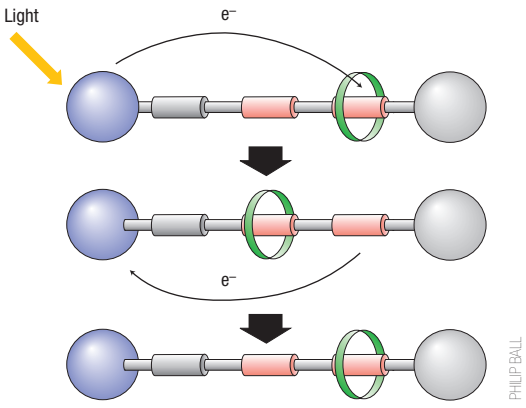
Nanoelectromechanical systems (NEMS) offer great promise for sensing, transport and patterning applications. The ultimate performance of these devices is largely dependent on their size, and those built on nanometre scales are expected to have enhanced characteristics compared with those built on larger scales. As these structures become smaller, however, friction and wear limit the operation of NEMS devices that have moving parts. Bern Gotsmann and colleagues (*Nano Lett.* doi:10.1021/nl0520563; 2006) have now found a way of controlling the wear behaviour of synthetic polymers for mechanical contact operation in NEMS. Molecular relaxation of copolymers of styrene and benzocyclobutene, chosen as a model system, was chemically confined by varying the spacing between crosslinks. A transition in the mechanical properties from a ductile to a brittle wear mode was found when spacing between crosslinks matched the length scale required for segmental backbone relaxation, that is, between 1 and 3 nm. Critical to future NEMS design and devices will be the ability to tailor the mechanical properties by controlling the internal degrees of freedom available for molecular relaxation.

Built-in chirality

A new 3D framework structure has been unveiled by Chinese chemists (H.-Y. An *et al. Angew. Chem. Int. Edn* 45, 904–908; 2005). The architecture is unique not only in that it is optically active (it can be obtained as either one of the two chiral forms) but also because it is made of an unusual combination of building blocks: a polyoxometalate anion, which is a highly charged cluster, a metal cation (Cu^{2+}), and a chiral amino acid that acts as a ligand for the Cu^{2+}. This amino acid can also engage in hydrogen bonding with the polyoxometalate, and, crucially, transmits the chirality through the copper ion to the whole framework as it forms. On performing the standard synthetic procedure with these ingredients, the authors obtained polyoxometalate-based open frameworks with channels filled with water, and with the peculiarity of being optically active due to the presence of two intertwined double helices. The synthesis of this chiral 3D open framework could open the door to other such structures based on polyoxometalate anions that may come in useful in the areas of asymmetric catalysis, separation and even medicine.

Making light work of it

In contrast to motors in nature, artificial ones generally require one input to cause motion, followed by another to reset the motor. Often these inputs are chemical fuels, and therefore generate waste products, as well as requiring intervention at each stage. Now Balzani *et al.* report an autonomous motor powered simply with light (*Proc. Natl Acad. Sci.* 103, 1178–1183; 2006). The motor consists of a rotaxane — a ring threaded around a dumbbell-shaped component of two electron-acceptor sites, or 'stations', for the ring to move between, with a bulky stopper group on each end. Absorption of a photon at a stopper group initiates electron transfer to the station where the ring rests, causing displacement to the second station. An electron can then transfer back to the stopper group from the now-free first station, and the ring can return to its original position. The motor works analogously to a four-stroke engine, with fuel injection and combustion, piston displacement, exhaust removal and piston-replacement steps. The motors of Balzani *et al.* rely exclusively on intramolecular processes and light absorption, and therefore do not consume chemical fuel or produce waste.



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