Focus on DVDs

One strategy to put more information on 12-cm-diameter CD, DVD or Blu-ray silver disks is to reduce the wavelength of the laser beam that reads out the information from the disk. In addition, a higher numerical aperture is needed to focus the laser onto a smaller spot, which also means the lens has to be brought closer to the disk. The development of enhanced lenses is therefore necessary, as future high-density disks will require even more demanding optics. In particular, the tolerance for variation in laser wavelength as well as insensitivity towards temperature changes are challenging criteria. Benno Hendriks and colleagues (*Jpn J. Appl. Phys.* **44**, 6564–6567; 2005) have applied a non-periodic phase structure to these lenses that leads to an increase in the temperature tolerance. Annular steps in the lens thickness induce phase changes equal to multiples of 2π. Although they do not modify the light wavefront at the design temperature, they counter the intrinsic wavefront distortion caused by the lens material once the temperature changes. The successful manufacturing of the lenses by injection moulding underlines this method's potential for future optical drives.

BIOLOGICAL HYDROGEN PRODUCTION

Hydrogen is attractive as an alternative fuel because water, its oxidation product, is environmentally benign, and hydrogen itself is lightweight and abundant. The search is on for catalysts that can produce hydrogen efficiently using renewable sources such as solar energy. Trevor Douglas and colleagues now report the biomimetic synthesis of an artificial hydrogenase that catalyses the reduction of protons to produce hydrogen gas (*Nano Lett.* **5**, 2306–2309; 2005). The catalytic active sites are made of a well-defined protein cage architecture into which platinum clusters are introduced. Proton reduction is driven by visible light through a coupled reaction between a photocatalyst and methyl viologen to act as an electron-transfer mediator. Hydrogen production rates are comparable to those of known hydrogenase enzymes and better than those of previously described platinum nanoparticles. The protein cage architecture keeps the clusters intact and remains stable up to 85 °C. Biomimetic approaches clearly can prove advantageous in the design of nanoscale catalysts for hydrogen production.

Glowing pH sensor

Water-soluble sensor systems capable of detecting pH changes through fluorescence resonance energy transfer (FRET) would simplify wet analyses because they would only require an ultraviolet–visible spectrophotometer. To this end, a group of Korean researchers synthesized a water-soluble polymeric chain with a donor fluorophor at one extremity and an acceptor fluorophor at the other (S. W. Hong *et al. Chem. Mater.* doi:10.1021/cm051663o; 2005). This polymeric chain is similar to a spring: when the pH is higher than 7 the chain is extended, but as the pH drops lower than 7, it immediately shrinks so that its two extremities become close and energy transfer between donor and acceptor is possible. Other pH-sensitive systems previously reported were based on polymeric chains that transition between the extended and the shrunk conformation in the pH range between 4 and 6, which is mostly irrelevant to biomedical applications. The key feature in the new sensor that allowed the Korean group to observe the FRET signal at physiological pH was the precise polymerization of a well-defined chain containing sulphonamide groups — more acid than the carboxylate, sulphonate or sulphate groups used in earlier polymeric sensors.

Ordered melting

The solid–liquid interface plays an important role in many processes, such as crystal growth, solidification, lubrication and so on. Previous studies of such interfaces have involved indirect methods such as X-ray scattering. Now Wayne Kaplan and colleagues report a direct study of the solid–liquid interface of aluminium and single-crystalline alumina (α-Al_2O_3, sapphire) at the atomic scale using high-voltage atomic-resolution transmission electron microscopy and electron energy-loss spectroscopy (*Science* **310**, 661–663; 2005). They found that on heating α-Al_2O_3 above the melting point of aluminium (660 °C), dissociation of the alumina is observed, followed by the formation of liquid drops of aluminium. During heating, real-time movies showed layer-by-layer growth of the crystal into the liquid by ledge migration. Also observed were reproducible periodic contrast perturbations both perpendicular and parallel to the surface, which proved to be due, in part, to the ordering of the liquid. These observations show that crystals can induce ordering in liquids, which may play an important role in wetting and liquid-phase epitaxial growth.

Simulating nanocrystals

Silicon nanocrystals could prove to be important building blocks in the construction of thin-film solar cells. A widely used method for nanocrystal production is plasma-enhanced chemical vapour deposition (CVD). The physical mechanism underlying the crystal formation during this process is poorly understood, however. By using a combination of theoretical techniques, Holger Vach and Quentin Brulin investigate the formation of crystal structures in a CVD plasma reactor (*Phys. Rev. Lett.* **95**, 165502; 2005). By varying the flux of atomic hydrogen within a molecular dynamic simulation of the CVD chamber, the authors are able to 'tune' the hydrogen content of the resulting silicon structures. At a hydrogen flux of one hydrogen atom for every two SiH_4 molecules, cylindrical configurations of atoms are formed that exhibit a permanent dipole moment (see figure). Density functional theory calculations show that the dipole moments of these particles are approximately equal in strength to that of a water molecule, and are due to an off-centre silicon atom along the axis of the structure. The existence of this significant dipole moment allows the individual silicon clusters to self-assemble into longer nanowires, as has been observed experimentally.