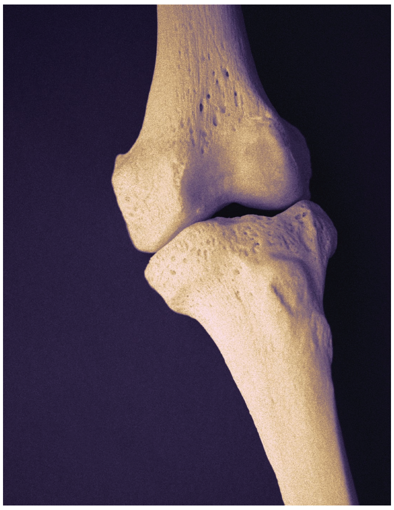
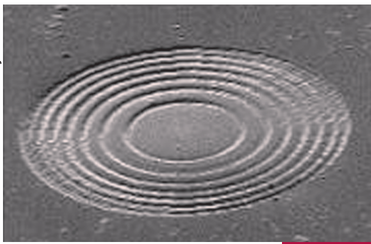
Switching liquid crystals with light

Organic photochromes — molecules that can be converted between two isomeric forms by light irradiation — have potential applications in rewritable optical memories and photonic switches. However, for optical memory applications, the organic materials must be stable under repeated writing and readout processes, and should have excellent fatigue resistance. Glassy materials, which can be easily processed into large-area films without grain boundaries, offer significant advantages in this respect. Shaw H. Chen and colleagues at the University of Rochester have reported in *Advanced Materials* (**15**, 1061–1065; 2003) the first morphologically stable photoresponsive glassy liquid crystals. The materials consist of a photochromic diarylathene core functionalized with nematogens, resulting in a monodomain glassy nematic film. Irradiation of the film with ultraviolet light converts the photoresponsive core molecules from an open-ring form to a closed-ring form, in which the electronic transition moment is aligned with the nematic director. This photochromic reaction results in a large refractive index change. The researchers hope to improve the photoresponsive properties of the material by increasing the degree of uniaxial alignment of the liquid crystalline films.

Synthetic bone



Animal tissues such as bone and muscle are composed of a hierarchical assembly of nanofibrils and mineralized collagen, which allows these specialized tissues to perform different functions. Zhang and colleagues in Beijing have now prepared these nanofibrils synthetically to form a structure and composition that resembles that of bone (*Chemistry of Materials* 15, 3221–3226; 2003). They took different compositions of monomeric collagen and solutions containing calcium and phosphate ions, then used either pH or temperature to induce the formation of collagen fibrils. Transmission electron microscopy at both low and high resolution revealed the different levels of organization. The authors found that nanocrystals of the minerals were deposited along the surface of the fibrils — giving the first direct evidence to support previous theories that this occurs. The authors suggest that the growth of the crystals is controlled by the fibrils themselves, in that the *c* axes of the crystals align themselves along the longitudinal axes of the fibrils. The mineralized fibrils then align parallel to each other to form fibres. These results should improve the understanding of collagen-mediated mineralization in other calcified tissues, and point the way to new functional materials for biomimetic engineering.



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POLISHING WITHOUT CRACKING

As you might expect, diamond films used in optical applications have to be extremely uniform. Diamond has many advantages over conventional optical coatings, such as optical transparency at many wavelengths, resistance to wear and even biocompatibility, which makes it especially useful in microfluidic devices. Owing to their exceptional hardness, however, diamond films are not easy to modify following deposition — micromachining usually results in cracking or peeling. In the August issue of the *Review of Scientific Instruments* (74, 3689–3692; 2003) Yongqi Fu and colleagues in Singapore offer a solution. Diamond films deposited by standard CVD processes were subjected to focused ion-beam milling with gallium ions, and were found to retain their optical and chemical properties. With this technique the authors etched a diffractive optical element, involving six concentric rings, directly into the surface of a diamond film. The diffraction efficiency of this optical element was 73%, which is acceptable for most applications.

Simultaneous bioassays

A more sophisticated tool for analysing blood that measures not only the glucose level but also the insulin concentration would help in the therapeutic management of diabetes. Moreover, it may facilitate the diagnosis of pancreatic malfunction and insulinoma, a tumour that produces excess insulin. This capability could soon become available through the combination of the enzymatic assay for glucose, and the immunological assay for insulin, in a microfluidic chip built by a group of researchers at the New Mexico State University (*Journal of the American Chemical Society* 125, 8444–8445; 2003). Through a judicious sequence of reactions and electrophoretic separation, the two different assays can be conducted simultaneously on the same blood droplet and without any interference problems, despite the two substances under analysis differing hugely in concentration (millimolar for glucose and nanomolar for insulin). Whether or not this particular chip will actually be used for the management of insulin-related diseases is hard to predict. But it definitely shows the possibility of combining bioassays based on distinct assay principles in a miniaturized analyser.

Ultrasensitive real-time sensing

Individual nanoscale particles are particularly attractive as platforms for *in vivo* sensing of chemical species and monitoring of dynamic processes inside biological cells. They have several advantages over traditional sensing approaches, such as their small size — making them non-invasive — and improved sensitivity. Richard Van Duyne and Adam McFarland at Northwestern University, writing in *Nano Letters* (http://dx.doi.org/10.1021/nl034372s), describe the use of dark-field optical microscopy to demonstrate the optical response of single silver nanoparticles to the adsorption of a monolayer of around 100 zeptomoles (100×10^{-21} moles) of small organic molecules. This suggests that the limit of detection for a single nanoparticle is well below 1,000 molecules for small-molecule adsorbates. The sensing principle relies on the electronic sensitivity of the noble-metal surface states to local changes in dielectric constant induced by the adsorbates. The kinetics of the nanoparticle response was also investigated and shown to be comparable to the kinetics of other real-time sensor technologies.

Chemical logic

You might call it physics-envy. Since the 1950s chemists have been trying to recreate solid-state circuits and devices using electrochemical systems. The first electrochemical cells that could amplify, rectify and integrate signals were called solions. In the 1980s, researchers used microelectrode arrays coated with conducting polymers to mimic some functions of diodes and field-effect transistors. In the *Journal of the American Chemical Society* (http://dx.doi.org/10.1021/ja0366585), Wei Zhan and Richard Crooks report the first successful diodes and transistors based on microfluidic electrochemical systems. Their devices consist of indium tin oxide electrodes patterned onto glass, and crisscrossed by microscale channels embedded in a polymer mould. When solutions containing electrolytes or other reagents flow through the channels, diode-like or transistor-like behaviour is observed. The authors use the same approach to construct optoelectronic devices, the most complex of which has seven electrodes and operates as a NAND gate.