Fluctuation effects on catalysts

A clear molecular-level understanding of the underlying processes governing heterogeneously catalysed reactions is still lacking, which has led some to describe this field as 'black magic'. Nanoscale effects have been predicted to play a significant role in catalytic activity — these effects include the influence of molecular coverage fluctuations, arising as a consequence of the dimensions of the active particles. Writing in *Science* (http://dx.doi.org/10.1126/science.1097513), V. Johánek and colleagues report experimental evidence for the direct influence of these fluctuations on the global kinetics of CO oxidation on oxide-supported Pd catalyst surfaces. They observe the appearance of two coexisting stable kinetic regimes in their model catalysts; as particle size decreases, this coexistence vanishes, and a single regime becomes stable. The effect is attributed to fluctuation-induced transitions between the two coexisting kinetic regimes, with a transition rate controlled by surface defects and particle size. The authors believe that this effect represents a general phenomenon affecting reaction kinetics on a wide range of nanostructured surfaces.

Nanoscale conveyor belts

The very shape of carbon nanotubes suggests their potential as nanoscale pipelines for transporting materials from one place to another. But most attempts to exploit nanotubes for applications such as drug delivery and hydrogen storage use them not as channels for conveying continuous streams of material, but rather as individual containers for delivering discrete amounts of a substance. Writing in *Nature* (**428**, 924–927; 2004), Chris Regan and colleagues address this apparent oversight by demonstrating the continuous transport of metal atoms down the length of a single multiwalled carbon nanotube. They find that when a voltage is applied between the two ends of a carbon nanotube that is decorated with a small number of indium nanoparticles, the nanoparticles at one end shrink while at the other they grow (see figure) — consistent with the constant movement of indium atoms down the outside of the nanotube. Moreover, reversing the voltage changes the direction in which the indium atoms move. As well as transporting indium, the authors have demonstrated the use of their 'nanoscale mass conveyors' for moving many other metal species, including gold, platinum and tin.

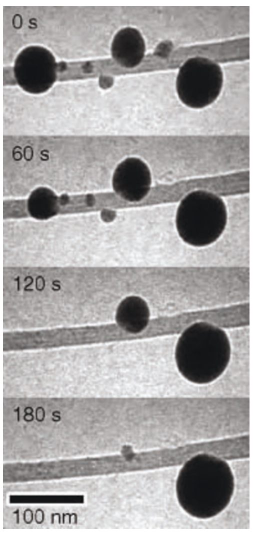

Image (*Nature* **428**, 924–927; 2004) reproduced with permission.

Seeing into the heart

One of the main aims of cardiovascular tissue engineers is to construct viable heart valves. But to monitor and improve the overall architecture of the cellular and extracellular components of heart valves, researchers at present only have invasive techniques that involve tissue removal, slicing and staining. These procedures are not only tedious, but also do not allow observation of tissue development processes and intact functioning tissues. An imaging technique reported by a group of German researchers now promises to solve these problems, and enable us to watch the collagen and elastic fibres — the critical structural elements of heart valves— hundreds of micrometres into the tissue, without any invasive procedure (K. König *et al. Biomaterials* http://dx.doi.org/10.1016/j.biomaterials.2004.02.09). The new technique uses two nonlinear optical effects, induced by a femtosecond laser: two-photon excited autofluorescence of elastic fibres, and second-harmonic generation in collagen. The authors can peer into heart tissue, and distinguish collagen from elastic fibres simply by changing the excitation wavelength. They also envisage the creation of multiphoton endoscopes to look directly inside organs of the body.

A POTENTIALLY GOOD METHOD

Conventional methods of measuring the phase transitions of solids are often made difficult by the conditions required, sometimes limiting the range of substances and temperatures that can be measured. In addition, different methods are required for the different types of phase transition. However, researchers in Poland have now developed a way to measure the critical points of different phase transitions in solids, based solely on changes in chemical potential — this means the use of only one method for all measurements. Matlak and co-workers glue a solid sample of the material being investigated — for example, Gd — to a silver platelet (contact electrode) that has silver wires attached to opposite points, through which a constant voltage is applied (*Physica Status Solidi B* 241, R23–R26; 2004). The system is placed in a thermostat, and the current flow though the contact electrode is measured as a function of temperature. A change in the chemical potential of the sample affects the resistivity of the contact electrode, resulting in kinks in the temperature profile that correspond to particular phase transitions. Using this method, the researchers measured Curie and Néel temperatures for Gd of 20 °C and 52 °C respectively, which are in agreement with literature values.

Manipulating spins in semiconductors

Physicists are currently trying to exploit the spin of the electron in addition to its charge in order to create 'spintronic' devices that will be smaller, more versatile and more robust than current silicon chips and circuit elements. However, for spintronics devices to become a reality, researchers must first demonstrate that the magnetism resulting from the large-scale alignment of spins in a magnetic semiconductor can be externally manipulated. As reported at the MRS Spring Meeting, Masaaki Tanaka and colleagues have now achieved electrical and optical control of ferromagnetism in semiconductor heterostructures at relatively high temperatures (abstract G1.4, MRS Spring Meeting; 2004). Tanaka and colleagues studied a Mn-doped GaAs quantum well embedded within a field-effect transistor structure that enabled electrical measurements. The researchers were able to electrically modulate the ferromagnetic transition temperature over the range 105–120 K, and were also able to manipulate the magnetism using irradiation with polarized light. Although the modulated temperature range is small and still well below room temperature, the work provides a promising indication that functional spintronics devices could be fabricated using more suitable semiconductor heterostructures.