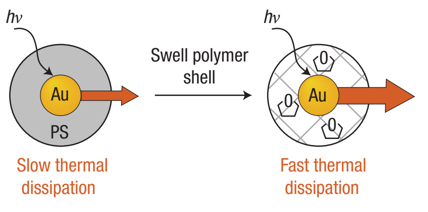
Fast heat dissipation in gold

Metal nanoparticles are considered to be promising candidates as targeted thermal agents for use in drug delivery and medical therapies — that is, where the particles are activated by external means and used to target specific areas such as a tumour. Gold nanoparticles are particularly attractive because of their biocompatibility and because their optical properties can be optimized by layered structures that exhibit large absorption coefficients in the near-infrared where biological tissues are transparent. Zhenbin Ge and colleagues (*Nano Letters* http://dx.doi.org/10.1021/nl047944x) have now investigated effective thermal conductivity in aqueous suspensions of gold-core polymer-shell nanoparticles by time-resolved measurements of optical absorption. The addition of an organic co-solvent to the suspension causes the polystyrene component of the polymer shell to swell, and this change in the microstructure of the shell increases its effective thermal conductivity by a factor of two. The corresponding cooling rate of these nanoparticle suspensions is much faster (100 ps) than expected from previous work, which makes this novel approach important, for example, in applications where quick release of a transported drug is important.



LESS TRAVEL, MORE WORK

Although lithium-ion batteries are used extensively in consumer electronic devices, such as laptops and mobile phones, their performance is poor at low temperatures, which precludes their use in many applications. However, Charles Martin and Charles Sides describe in *Advanced Materials* (**17**, 125–128; 2005) how simply reducing the particle size of the cathode material should go some way to resolving this problem. These batteries work by the diffusion of ions from a lithium-bearing anode across an electrolyte and into a porous or high-surface-area cathode. Consequently, the speed with which Li^+ ions diffuse from anode to cathode is an important factor in the battery's performance. The authors hypothesized that by reducing the size of the particles that make up the cathode, its surface area and the rate of ion diffusion into it could be increased, thereby improving the battery's performance. They compared the performance of batteries having two different types of V_2O_5 cathode, consisting of either 70-nm-diameter fibres or 800-nm-diameter ones. They find that the battery having the smaller fibre cathode had up to two orders of magnitude greater electrical storage capacity (depending on the discharge rate) than that made with the larger-fibre cathode, consistent with their hypothesis.

Cleaning up the air

Ceria holds great promise for the future. This oxide has already shown its worth in solid-oxide fuel cells, catalysis of hydrocarbon oxidation reactions and removal of organic compounds from polluted water. Now researchers in Japan have shown that it could also be useful as an air filter to clear the nasty vapours generated by paints, varnishes, tobacco smoke, disinfectants, fuels and other common household products (A. K. Sinha and K. Suzuki *Journal of Physical Chemistry B* **109**, 1708–1714; 2005). The magic of ceria comes from the electrochemical properties of this material: the ability to shift between its two oxidation states, Ce(III) and Ce(IV), and the high mobility of bulk oxygen species — properties that allow ceria to behave as an oxygen buffer. But ceria's instability at high temperature considerably limits its usefulness. This is why the Japanese researchers mixed it with titania, the best light-activated catalyst, so as to obtain, through a wet-chemistry route, a ceria–titania mesoporous ceramic with enhanced thermal stability. The authors demonstrated the potential of this material as an indoor air-purification system by measuring its ability to absorb and decompose toluene (a model organic volatile pollutant) and they have already found a way to greatly improve this performance through impregnation with platinum, which acts synergistically as an oxidation catalyst.

Structure over size

Alloyed metal nanoclusters, such as ferromagnetic FePt nanoparticles, are promising candidates for a variety of device applications. However, researchers are still puzzled over what drives alloy formation at scales approaching the molecular limit. Nanoscale alloy formation has been observed for metals known to be immiscible in the bulk phase, and surface-segregated nanoparticles have been produced in systems such as Pd–Ag, which are fully miscible in the bulk phase. Hans-Gerd Boyen and colleagues *Physical Review Letters* **94**, 016804; 2005) have now investigated the effect of the electronic state on the alloying behaviour of gold nanoparticles supported on silicon substrates. The researchers prepared gold particles with sizes ranging from 0.8 nm (where they are molecular-like and insulating) to 2.9 nm (where they are bulk-like and metallic). Using X-ray photoelectron spectroscopy, Boyen and colleagues investigated the effect of evaporating four monolayers of indium on top of the isolated gold nanoparticles. They found that the nanoparticles reacted completely to form the intermetallic compound $AuIn_2$, independently of electronic size effects. The only exceptions were the 'magic' Au_{55} clusters, which have a close-packed full shell, and are thus extraordinarily stable against alloying.

Lasey silicon

For many decades now, technological progress has seen the processing power and speed of computers doubling approximately every eighteen months. As the performance of conventional electronics approaches fundamental limits, however, the rate of this progress is expected to slow significantly. Many scientists believe that by using light signals instead of electrical signals to perform many of the operations carried out on a modern computer chip — such as passing information between different sections — this slowdown could be postponed. Writing in *Nature*, Haisheng Rong and colleagues describe a silicon laser that is able to generate the continuous light that is likely to be needed for such processing (*Nature* **433,** 725–728; 2005). Although the authors had already demonstrated laser action in silicon in another report (*Nature* **433,** 292–294; 2005),optical losses in their system limited this to pulsed operation only. To overcome these losses, they have incorporated a rectifying diode structure perpendicular to their silicon-laser cavity. By applying a reverse bias to this diode, the photogenerated electron–hole pairs that cause much of this loss are swept out of this cavity, enabling them to achieve continuous-wave laser operation.