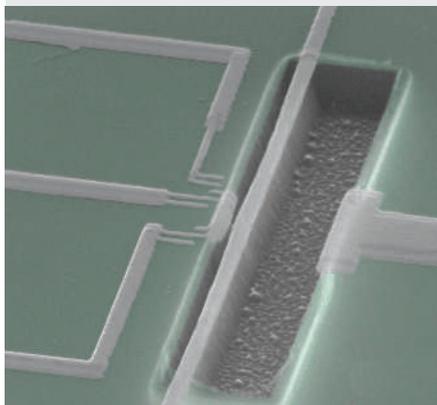


NANOMECHANICS

Looking cool



Nature **443**, 193–196 (2006)

As researchers continue to develop nanomechanical systems for a variety of applications, they are also following a profitable sideline in fundamental explorations of quantum mechanics. In the latest example of this, Keith Schwab of the University of Maryland and

co-workers have discovered that making measurements on a nanobeam can actually lead to the structure becoming cooler.

The beam, which is made of silicon nitride and aluminium, is 8.7 μm long, 200 nm wide and 140 nm thick. It is clamped at both ends and vibrates with a natural resonance frequency of about 21 MHz. Schwab and co-workers use a superconducting single-electron transistor (SSET) to measure the motion of the beam with a sensitivity of better than 1 femtometre. The SSET is coupled to the beam electrostatically and converts the vibrations into electrical signals.

However, the movement of the charge carriers in the SSET — both single electrons and Cooper pairs of electrons — also influences the motion of the beam. Indeed, under certain conditions this quantum 'back-action' can cool the beam, similar to the way that lasers can cool atomic gases.

clusters and reactive carbon fragments. The metal clusters acted as nucleating agents onto which the carbon atoms grew into SWNTs.

Electron microscopy images showed the samples were mainly long bundles of SWNT with diameters between 20–30 nm. Further characterization using spectroscopic methods confirmed that the material was very similar to those made using the standard HiPco procedure.

NANOSENSORS

Bring it on

Anal. Chem. **78**, 7211–7215 (2006)

Surface-enhanced Raman spectroscopy (SERS) is a popular technique for analysing material surfaces and identifying chemical compounds. SERS relies on detecting Raman shifts in light scattered by molecules and, as its name suggests, the signal is enhanced when the molecules are close to a surface.

However, problems in getting the molecules of interest close to a SERS-active surface, while excluding non-target compounds such as proteins, has stopped the technique from being used to detect biomolecules in living systems. Now, researchers at Northwestern University in the US have overcome this problem by adding a self-assembled monolayer of hydrophobic and hydrophilic molecules to a standard SERS substrate to make a glucose detector.

The extra monolayer introduced by Richard Van Duyne and co-workers improved the SERS signal by localizing the glucose molecules to within a few nanometres of the substrate surface, while excluding non-target molecules. When implanted under the skin of rats, their device was just as accurate as standard glucometers, and could detect changes in glucose concentration over timescales as short as 30 seconds. Although further refinements are needed, this approach could lead to improved glucose sensors for diabetics.

NANOWIRES

Behind the mask

J. Am. Chem. Soc. **128**, 13342–13343 (2006)

One of the most important considerations in the synthesis of nanosized materials is the ability to control both their size and shape. Moreover, in order to make working devices from these very small components, they must be assembled into ordered arrangements.

QUANTUM DOTS

RNA in control

J. Am. Chem. Soc. **128**, 12598–12599 (2006)

The properties of semiconductor nanocrystals are largely dictated by their size, and so the control of this is one of the most important aspects of their synthesis. One way to address this issue is to use a template of a given size to direct their growth. Large biomolecules, with their deliberate and defined shapes necessary to carry out precise cellular functions, are ideal candidates.

Now, Shana Kelley and co-workers at Boston College in the US have used RNA molecules as scaffolds for the formation of CdS nanocrystals. One particular class of these molecules — known as transfer RNAs (tRNAs) — are an essential part of the cellular machinery that makes proteins. These L-shaped molecules are roughly 5 nm in diameter, and were shown to template the formation of stable, well-dispersed 6-nm tRNA–CdS nanocrystals. In the absence of tRNA, only poorly soluble aggregates were produced.

Furthermore, the importance of using a template with a well-defined shape was underscored when the experiment was repeated with a mutant tRNA molecule deliberately designed to have no

organized three-dimensional structure. In this case, a broader range of nanocrystal sizes was observed.

NANOTUBE SYNTHESIS

Ferrocene's double act

J. Phys. Chem. B **110**, 20973–20977 (2006)

Bulk quantities of single-walled carbon nanotubes (SWNTs) can be made by the well-known high-pressure carbon monoxide disproportionation process (HiPco). This method produces SWNTs by flowing a gaseous mixture of carbon monoxide and a small amount of an iron catalyst through a reactor at high temperature.

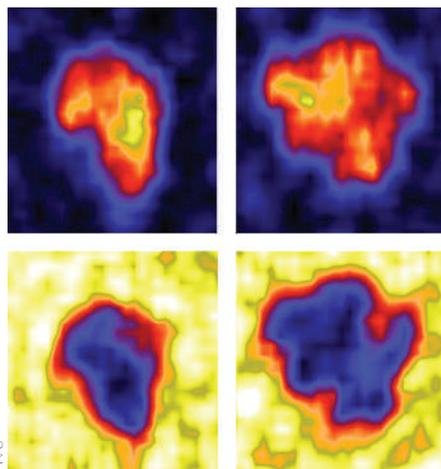
Now, researchers at the Leibniz-Institut für Festkörper- und Werkstofforschung Dresden in Germany and the Universitat Autònoma de Barcelona in Spain have shown that a single compound can serve as the carbon source as well as the catalyst. Amelia Barreiro and co-workers flowed a mixture of gaseous argon and ferrocene — a chemical compound composed of an iron atom sandwiched between two five-membered carbon rings — through a heated reactor. At temperatures exceeding 500 °C, ferrocene spontaneously decomposed into iron

Now, John Wiley and co-workers at the University of New Orleans and Louisiana State University in the USA have used a combination of two well-known techniques to produce patterned arrays of either silver, gold or nickel nanowires. By using a standard photolithographic procedure, a particular pattern — as defined by the photo-mask — can be created on top of a porous alumina template, thereby sealing off the pores it covers. The surface is then coated with a thin layer of silver or gold, which serves as an electrode for the electrochemical deposition of metal — from the other side — into the pores that were not initially sealed. A sodium hydroxide wash removes the alumina template, leaving behind a pattern of free-standing metallic nanowires.

A wide range of patterns can be generated using different masks, and individual nanowire dimensions can be controlled by varying the pore size of the template and the duration of the deposition process. Although Wiley and co-workers have focused on metal nanowire patterns in this study, they suggest that the process could be applied to other materials such as oxides and semiconductors.

MASS SPECTROMETRY

Weighing up surfaces



Science **313**, 1948–1951 (2006)

Mass spectrometry is an analytical technique that can be used to weigh molecules. Although many variations exist, the basic principles are the same; the sample of interest is ionized and the ions are separated, according to their mass-to-charge ratio, and counted. Now, researchers in the USA have shown how mass spectrometry can be used to map

out the distribution of two different lipids in a membrane.

Steven Boxer and co-workers from Stanford University, the University of California, Davis, and Lawrence Livermore National Laboratory look at bilayers in which two different isotopically labelled lipids separate into domains. As a focused beam of caesium ions scans across the surface of a freeze-dried membrane, the lipid molecules fragment to form ions. These ‘secondary’ ions — which retain the isotopic signature of their parent lipids — are then detected and give a spatially resolved picture of the membrane.

Individual membrane components can be resolved at the molecular level with electron microscopy, and optical imaging probes much larger length scales. Boxer’s technique falls in between, however, and can image the lateral organization of lipids within a membrane with 100 nm resolution as well as providing chemical composition data.

SPINTRONICS

Mix and match

Phys. Rev. Lett. **97**, 146101 (2006)

Thin films of MnGa and GaAs doped with Mn atoms are being widely studied for fabricating spintronic devices. Such materials are usually deposited on GaAs substrates by molecular beam epitaxy — a process where evaporated atoms condense on a surface and can react with one another. The growth of MnGa on GaN substrates has proved to be difficult, however, because Mn and Ga form non-crystalline phases that do not exhibit the sort of magnetic properties necessary for spintronic applications.

Now, Erdong Lu and colleagues of Ohio University and Ohio State University in the USA have successfully deposited crystalline MnGa thin films on GaN substrates. Using a molecular-beam epitaxy system fitted with a nitrogen plasma source, high-quality films can be grown in which the ratio of Mn to Ga is carefully controlled. Film growth was monitored by scanning tunnelling microscopy and a high-energy electron diffraction technique.

Significantly, the magnetic moments of the films depend on their composition and structure, which can be varied by altering the flux of either the Mn or Ga atoms. This discovery offers an additional degree of freedom in the design and construction of optical spintronic devices operating at short wavelengths.

TOP DOWN BOTTOM UP

Viruses beware

Chemistry and physics join the fight against infectious diseases.

Ralph Tripp, professor of infectious diseases at the University of Georgia in the USA, was looking for a way to detect viruses that was both rapid and sensitive to different strains of the same virus, but did not involve the use of antibodies or costly polymerase chain reaction assays. It was at a nanotechnology meeting organized by his university that he heard about surface-enhanced Raman spectroscopy (SERS), a popular technique for analysing surfaces and identifying chemical compounds, and met colleagues from the physics and chemistry departments. This multidisciplinary collaboration has now demonstrated the potential of SERS for detecting trace levels of viruses such as the respiratory virus that infects children, the elderly and people with compromised immune systems (*Nano Lett.* doi:10.1021/nl061666f; 2006).

The SERS approach involves illuminating a sample and detecting Raman shifts in the light that is scattered. If the sample is placed on a suitably nanostructured metal surface, the signal is enhanced by orders of magnitude, which improves the sensitivity of the technique.

In the Georgia collaboration, Tripp prepared samples of different viruses, Yiping Zhao fabricated the substrates from silver nanorods, and Richard Dluhy made the measurements. The SERS spectra revealed that each virus had its own ‘molecular fingerprint’. Moreover, the different strains could be easily identified by comparing the shifts and relative intensities of the peaks in the spectra.

As a Georgia Research Alliance scholar, Tripp was able to get the project started with funds from his own laboratory, and his colleagues did the same. However, he admits that “it is often difficult to ‘learn the language’ of different sciences, particularly physics”. It is also important to be persistent and to be a good communicator, he adds. “I guess it is a lot like being a salesman.”

The definitive versions of these Research Highlights first appeared on the *Nature Nanotechnology* website, along with other articles that will not appear in print. If citing these articles, please refer to the web version.