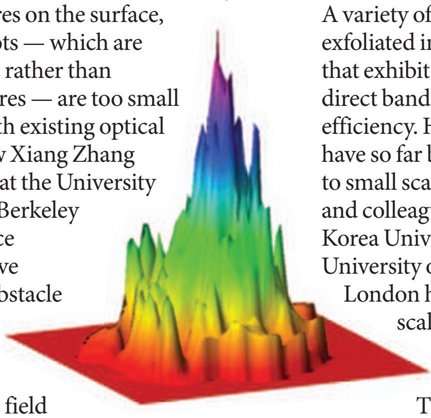
IMAGING

## A closer look at hotspots

*Nature* **469,** 385–388 (2011)

Surface-enhanced Raman spectroscopy (SERS) allows researchers to detect small numbers of molecules because the light scattered by the molecules can be enhanced by factors of up to a million. SERS relies on light being concentrated into hotspots by nanoscale features on the surface, but these hotspots — which are electromagnetic rather than material structures — are too small to be imaged with existing optical techniques. Now Xiang Zhang and co-workers at the University of California in Berkeley and the Lawrence Berkeley Lab have overcome this obstacle by using molecules to measure the electromagnetic field of individual hotspots.





The Berkeley team submerged their samples — thin layers of aluminium films and silver nanoparticle clusters — in a solution of dye molecules and recorded the fluorescence from the molecules with a charge-coupled device. The molecules were moving so fast that their fluorescence was a background blur. However, when one of the molecules was adsorbed at the hotspot, it stopped moving and its fluorescence was enhanced by the electromagnetic field there, so it showed up as a bright spot on the image. By using a dye solution that was so weak that only one molecule was adsorbed at a given time, Zhang and co-workers were able to image single hotspots as small as 15 nm with an accuracy down to 1.2 nm.

TWO-DIMENSIONAL CRYSTALS

## In solvent

*Science* **331,** 568–571 (2011)

Although graphene is the most famous two-dimensional crystal, it is not the only one. A variety of bulk layered materials can be exfoliated into single- and few-layer forms that exhibit distinct properties, including direct bandgaps and enhanced thermoelectric efficiency. However, exfoliation procedures have so far been relatively complex, or limited to small scales. Now, Jonathan Coleman and colleagues at Trinity College Dublin, Korea University, Texas A&M University, the University of Oxford and Imperial College London have demonstrated a simple and scalable method to exfoliate layered materials into individual two-dimensional flakes.

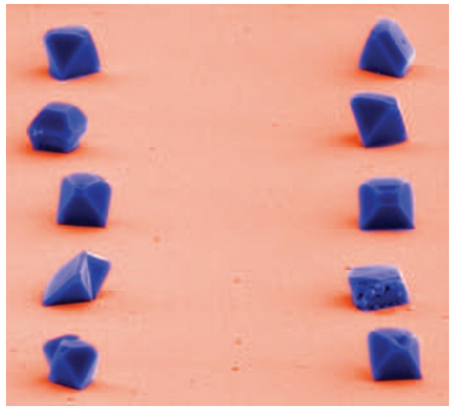
The researchers sonicated commercial powders of various layered materials in common solvents, and centrifuged the resulting dispersions. By choosing solvents with appropriate surface tensions, this procedure yielded two-dimensional nanoscale flakes tens to thousands of nanometres in lateral size. Transmission electron microscopy showed that the exfoliation left the crystal structure of the materials unaffected, in contrast to alternative approaches such as lithium intercalation.

Coleman and colleagues were also able to use these exfoliated materials to make free-standing films and composites. The composites consisted of a thermoplastic material filled with nanoscale flakes, and demonstrated enhanced mechanical properties comparable to the reinforcement achieved with graphene and nanoclay fillers. The new exfoliation technique is compatible with deposition onto substrates, and should be applicable to a wide variety of layered compounds.

METAL–ORGANIC FRAMEWORKS

## Grown in position

*J. Am. Chem. Soc.* doi:10.1021/ja2002428 (2011)





Lithography techniques based on scanning probe microscopy can pattern surfaces with high resolution by using the probe tip to transfer molecules or materials to an underlying substrate. In the past the techniques have been used to deposit a wide variety of species including small organic molecules, proteins and colloidal nanoparticles. Daniel Maspoch and colleagues at the Catalan Institute of Nanotechnology have now shown that arrays of single-crystal metal–organic frameworks (MOFs) can also be created with scanning probe lithography.

MOFs are porous crystalline materials made from metal ions and organic linkers, and they could be of use in applications such as gas storage, catalysis or sensing. Maspoch and colleagues were able to fabricate submicrometre crystals of a MOF called HKUST-1 at precise positions on a surface by delivering femtolitre droplets of solution containing copper ions and trimesic acid to the surface. The growth of the MOF crystals in these droplets was then controlled by the wettability of the alkanethiol-covered gold surface, which determined the extent that the droplets spread across the surface.

The Spanish team illustrate the capabilities of their approach by forming the word ‘MOFs’ from 400 single crystals and they expect that the technique could be used to form other types of MOF on various surfaces.

CARBON NANOTUBES

## The ins and outs of DNA

*Nano. Lett.* doi:10.1021/nl104116s (2011)

Carbon nanotubes and DNA molecules are two of the most intensively studied materials in nanotechnology. In general they are studied separately, although there have been attempts to use DNA to sort metallic and semiconducting nanotubes, and it has been suggested that it might be possible to sequence DNA by passing it through a nanotube. Now Aleksandr Noy and co-workers have studied the motion of single strands of DNA through a nanotube in detail.

The nanotubes are embedded in a polymer matrix to prevent the DNA strands interacting with their outside surface. The strands are attached to an atomic force microscope, inserted into the nanotubes and then pulled out again. By measuring how the force needed to extract the DNA from the nanotube varies with distance, Noy and co-workers — who are based at the University of California in Merced and Berkeley, the Lawrence Berkeley Lab and Porifera Inc — are able to explore the details of the interactions between the two materials.

They find that the force needed to extract the DNA remains almost constant, which they explain in terms of the strands sliding along the inner surface of the nanotube without friction, with the force being needed to overcome the unfavourable solvation energy of the DNA. They also conclude that van der Waals forces alone cannot explain the interactions between the DNA and the nanotubes.