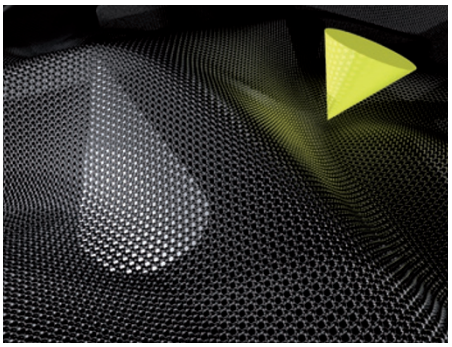
GRAPHENE

A view from both sides

Nano Lett. http://doi.org/k9s (2013)



Scanning probe microscopes, such as the scanning tunnelling microscope (STM), are often used to reveal the morphology of a sample. With graphene, however, the sample will follow the tip rather than the other way round and images of graphene's surprisingly undulating landscape are dominated by tip-induced deformations. Jannik Meyer and colleagues at the University of Vienna have now been able to measure these deformations by using an STM set-up with two tips.

The researchers use a custom-made instrument in which two independent STM units face each other and a sample of few-layer graphene is suspended between them. This set-up allows them to simultaneously probe the same point on both sides of the graphene membrane. The STM tip is found to modify the graphene morphology during every scan and can permanently alter the shape of the graphene through attractive and repulsive tip–sample interactions. However, Meyer and colleagues also show that the tip can be used to precisely control the local curvature and height of the membranes. *OV*

METAL DICHALCOGENIDES

Electroluminescence appears

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Bulk molybdenum disulphide (MoS_2) is an indirect semiconductor, but a single layer of it has a direct semiconducting bandgap. It has previously been shown that single-layer MoS_2 can be used to make transistors and can emit photoluminescence in the visible range. Phaedon Avouris, Mathias Steiner and colleagues have now detected electroluminescence — light emitted in response to the application of an electric voltage — from a single layer of MoS_2 embedded in a field-effect transistor.

Electroluminescence is usually observed when negative electrons and positive holes, injected from different electrodes, recombine to emit photons. However, in these latest experiments, only electrons are injected from the electrodes, which suggests that electroluminescence occurs through a different mechanism. In particular, the researchers — who are based at the IBM T. J. Watson Research Center, the University of Cambridge, Karlsruhe Institute of Technology and the Technische Universität Darmstadt — suggest that electron–hole pairs are created through the scattering of high-energy electrons injected in the MoS_2 layer, a phenomenon previously observed in other nanostructures like carbon nanotubes.

This mechanism is confirmed by the observation that the electroluminescence intensity increases abruptly above a threshold voltage, that is, only when high-energy electrons are injected. Furthermore, the light is emitted primarily from the region close to one of the metal contacts of the field-effect transistor, which is another signature of electron–hole pairs being generated as a result of the scattering of high-energy electrons. *FP*

TWO-DIMENSIONAL ELECTRON GASES

Digging up band structures

Phys. Rev. Lett. **110,** 136801 (2013)

A two-dimensional electron gas (2DEG) is an ensemble of electrons spatially confined in the vertical direction. In silicon, 2DEGs can form as a result of doping with phosphorus impurities that act as electron donors when they are doped in a vertically sharp profile. To screen the charge carriers from surface effects, 2DEGs are usually located several nanometres beneath the surface, making it challenging to directly probe their electronic properties. Justin Wells and colleagues at the Norwegian University of Science and Technology, the University of New South Wales and Aarhus University have now directly measured the band structure of a buried 2DEG using angle-resolved photoemission spectroscopy (ARPES).

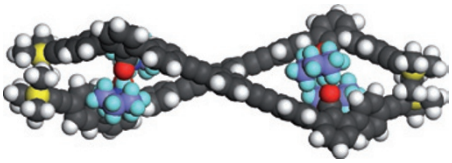
The researchers measured the band structure of a silicon sample with phosphorus dopants buried 2 nm below the surface, and compared these measurements with those of a silicon sample without phosphorus impurities. The ARPES measurements of the doped sample revealed sharp states close to the Fermi energy, which were identified as being two-dimensional, and a shift of the entire band structure. The probing depth of ARPES is in fact less than 1 nm, but the 2DEG states could be observed because of a resonant enhancement of the photoemission.

Wells and colleagues also suggest that the approach is not limited to investigating buried phosphorus dopants in silicon, and could also be used to extract parameters such as the electron effective mass. *ED*

HELICAL NANOSTRUCTURES

Chirality from the inside

Angew. Chem. Int. Ed. http://doi.org/f2b582 (2013)



The double helical structure of DNA is often a source of inspiration for synthetic supramolecular chemists, and researchers have previously created double helices made from strands of two distinct but complementary polymers that are held together through non-covalent interactions. Eiji Yashima and colleagues at Nagoya University have now self-assembled double helices from two strands of the same polymer.

The polymer has an *m*-terphenyl-based backbone; the *m*-terphenyl group consists of three benzene groups connected in a crescent shape by single carbon–carbon bonds. A carboxylic acid recognition group is attached to the central benzene and drives the self-assembly process through the formation of hydrogen bonds between the carboxylic acid groups on two polymer strands.

The homopolymer system does not have a preferred helicity (the crystal structure is racemic), but amplification of helical chirality can be achieved in solution by adding a chiral molecule. In particular, Yashima and colleagues show that if a chiral amine sits between the two strands to form a sandwiched structure, it can transfer the chiral information to the strands by inducing aggregation of the double helix into a preferred handedness. The self-assembly mechanism is driven by an acid–base recognition motif between the amine and the carboxylic groups of the two strands. *AM*

Written by Elisa De Ranieri, Alberto Moscatelli, Fabio Pulizzi and Owain Vaughan.