INTERMOLECULAR CONTRAST

Images under the microscope

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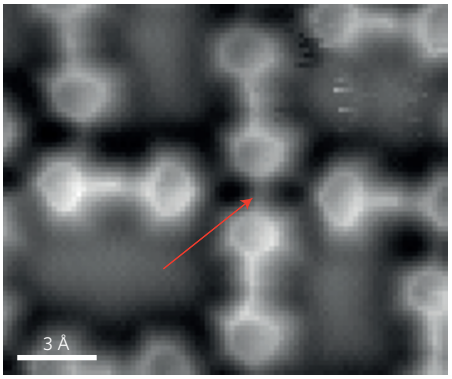

By attaching a CO molecule to the tip of an atomic force microscope (AFM), the instrument has recently been used to provide a number of remarkable insights. For example, it has been used to resolve individual atoms and bonds within an adsorbed organic molecule and to discriminate between different types of chemical bond. It has also been reported that the approach can image hydrogen bonds between adsorbed species. However, Peter Liljeroth, Ingmar Swart and colleagues now suggest such intermolecular contrast may in fact be an artefact.

The researchers — who are based at Aalto University School of Science and Utrecht University — examined bis(parar-pyridyl) acetylene (BPPA) molecules adsorbed on a gold surface. The molecules self-assemble into tetramers on the surface, stabilized by hydrogen bonds between the nitrogen and hydrogen atoms on the pyridine rings at the ends of the molecules. The formation of these structures also leads to nitrogen atoms on two opposing molecules being placed in close proximity without any bonds existing between them. AFM images of the tetramers, taken using a CO-terminated tip, showed apparent intermolecular bonds between regions where hydrogen bonds should exist, but also in the region between the two nitrogen atoms where they should not.

Liljeroth and colleagues suggest that the contrast observed is predominately the result of the CO molecule bending on the AFM tip, an effect that picks up the shape of the potential energy surface between two molecules. This explanation is also in line with recent theoretical work from Pavel Jelínek and colleagues (*Phys. Rev. B* **90,** 085421; 2014). *OV*

OPTOELECTRONIC DEVICES

Plasmonics shows potential

Science **346,** 828–831 (2014)

Metallic nanostructures can sustain collective oscillations of conduction electrons that have been stimulated by light. These oscillations have a specific frequency (the plasmon frequency) that can shift slightly to higher or lower values when the nanoparticle acquires or loses electrons, respectively. The number of charges can be modified by applying an external static electric field, for example. Now, Harry Atwater and colleagues have shown that the reverse process, in which light induces the creation of an electrostatic potential, can also occur.

The researchers — who are based at the California Institute of Technology and the FOM Institute AMOLF in the Netherlands — deposited a gold nanoparticle with a diameter of 60 nm on top of a conducting surface made of indium tin oxide (ITO). Then, using a Kelvin probe microscope, they measured the electric potential between the microscope tip and the nanoparticle, while scanning the frequency of the incoming light around the plasmon resonance. When the light frequency is slightly off-resonance, they can detect an electrostatic 'plasmoelectric' potential on the nanoparticle due to a change in the charge carrier density.

Atwater and colleagues suggest that if the two frequencies do not match, a transfer of electrons occurs from the nanoparticle to the ITO, or vice versa, depending on which side of the plasmon resonance they are working. This charge transfer is a thermodynamically favourable process, as the system tends to match the irradiation frequency to minimize free energy. *AM*

TOPOLOGICAL INSULATORS

Surface states spread magnetism

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In topological insulators, such as Bi_2Te_3, the bulk does not conduct electricity, but there are electronic states at the surface that are highly conductive. These surface states are protected against impurities and passivation by topology, and their spin is locked at right angles to their momentum, which makes topological insulators promising for applications in spintronics. The interaction of surface states with magnetic atoms is a means of achieving control of the spin texture of topological insulators. However, such capabilities have remained elusive. Paolo Sessi and colleagues in Germany and Russia now report on the role of surface states in the emergence of magnetic order in Co- and Mn-doped Bi_2Te_3 samples.

In contrast to previous studies, which used non-local probes, the researchers used scanning tunnelling microscopy to monitor the electronic interaction between the surface states of the topological insulator and the magnetic adatoms deposited on top of it. They find that the surface state mediates the magnetic coupling among adatoms, resulting in the onset of ferromagnetic order for a low coverage of magnetic dopants and in the dependence of the magnetic anisotropy of the individual adatoms. *ED*

2D SEMICONDUCTORS

Helping them shine

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Unlike graphene, single-layer metal dichalcogenides exhibit an electronic bandgap, which is essential for the realization of electronic devices. Furthermore, because of the bandgap, the interaction of electrons and holes with an electromagnetic field leads to optical absorption and photoluminescence emission, thus, these 2D semiconductors could, in principle, be used in optoelectronic devices such as light-emitting diodes and lasers. A disadvantage of being only one atom thick is, however, that the emission and absorption efficiencies are very low. Stefan Schwarz and colleagues in the UK and Russia have now shown that the photoluminescence emission can be enhanced considerably by placing thin films of metal dichalcogenides in properly designed optical cavities.

The researchers studied two types of configuration. In the first, a film of either MoS_2 or GaSe was placed on top of a distributed Bragg reflector, which reflects all of the downward emitted light from the film. This resulted in considerable enhancement of the photoluminescence emitted compared with the free-standing films. In the second experiment, the team placed a second distributed Bragg reflector on top of the film, creating a full optical cavity. The distance between the reflectors was tuned so that the wavelength of the cavity matched that of the film. This resulted in an additional enhancement of the photoluminescence intensity and a sharpening of the emission peak. A time-resolved measurement of the photoluminescence also revealed an increased radiative efficiency, which confirms that with the optical cavities there is a stronger interaction between the carriers in the semiconducting films and the electromagnetic field. *FP*

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