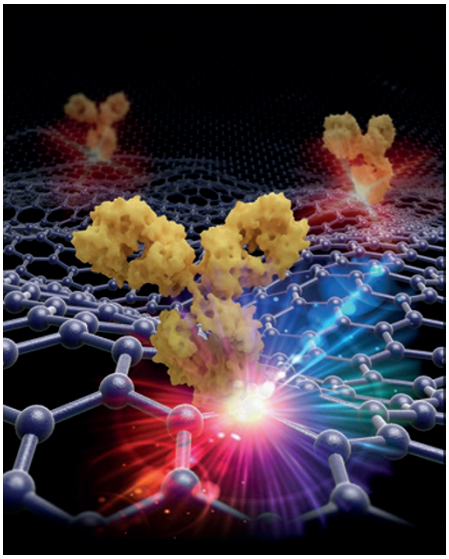
GRAPHENE

Ribbons for protein sensing

Science **349,** 165–168 (2015)



EPFL / MIGUEL SPUCH / DANIEL RODRIGO

Mid-infrared vibrational modes of biomolecules can be used for label-free sensing, but the sensitivity of this approach is undermined by the fact that the wavelength of light (2–6 μm) is much larger than the size of the biomolecules (less than 10 nm). One way to overcome this fundamental hurdle is to confine light to nanometre-scale volumes using localized surface plasmons. Light confinement in metals, however, leads to reduced spectral bandwidth, which is determined by the geometry of the system. Hatice Altug and colleagues at the École Polytechnique Fédérale de Lausanne, the Institut de Ciències Fotònique in Barcelona and Institució Catalana de Recerca i Estudis Avançats in Barcelona have now shown that some of these constraints can be relaxed by using graphene as a mid-infrared biosensor for proteins.

The researchers fabricated an array of 30-nm-wide graphene nanoribbons on top of a silica support and connected the ribbons to a gate electrode. They then shone a mid-infrared laser beam to excite the graphene plasmon resonance. By changing the voltage bias, Altug and colleagues could modulate the plasmon resonance so that it overlaps with specific vibrational frequencies. When they added a protein layer on top of the device, the C=O stretch and N–H bend modes at 1,660 and 1,550 cm^{-1}, respectively, coupled with the graphene plasmon resonance. As a result, the extinction spectrum showed distinct dips. Because graphene produces tighter light confinement than metals, the approach also has higher sensitivity than metallic devices working in the same spectral range. *AM*

QUASICRYSTALS

Grown under the microscope

Phys. Rev. Lett. **115,** 075501 (2015)

Solid materials that have long-range order but no periodicity are known as quasicrystals. They were first observed in 1982 by Dan Shechtman in electron diffraction experiments, a discovery for which he would later be awarded the Nobel Prize in Chemistry. Because of their unusual atomic arrangements, the structures have generated many questions about their growth mechanisms and a variety of theoretical models have been developed. Keiichi Edagawa and colleagues at the University of Tokyo and Tohoku University have now directly observed the growth of a quasicrystal with the help of *in situ* transmission electron microscopy.

The researchers examined a quasicrystalline alloy made from aluminium, nickel and cobalt ($Al_{70.8}Ni_{19.7}Co_{9.5}$), which has crystallographically 'forbidden' 10-fold rotational symmetry. A series of high-resolution images were taken with the samples held at 1,183 K, a temperature at which recrystallization can occur. Analysis of the images revealed that the growth process involves frequent structural errors and repairs, and that structures with nearly perfect quasicrystalline order can be obtained. The exact mechanisms by which this growth occurs remain unclear, but Edagawa and colleagues suggest that the process is distinct from ideal models previously proposed. *OV*

QUANTUM POINT CONTACTS

Measuring spins

Phys. Rev. Lett. **115,** 036601 (2015)

Quantum point contacts are narrow constrictions in a two-dimensional electron system formed by electrostatic gating. Owing to the lateral confinement, the conductance through the point contact is quantized in integer multiples of $2e^2/h$, where e is the fundamental charge and h is the Planck constant. An anomaly appears at $0.7 \times 2e^2/h$, the origin of which has been tentatively explained by competing theories that predict distinct spin arrangements. Now, Minoru Kawamura and colleagues at the RIKEN Center for Emergent Matter Science, Slovak Academy of Sciences and Ibaraki University have measured the electronic magnetization in the point contact, providing insight into the origin of the 0.7 feature.

The researchers measured the conductance of a point contact fabricated from GaAs/AlGaAs high-mobility heterostructures in the presence of an in-plane magnetic field, at a temperature of 20 mK. They demonstrated resistive detection of nuclear magnetic resonance, from which the electron magnetization can be inferred. This is a new technique of measuring the magnetization of a few electron spins. The team found that the magnetization changes smoothly as the gate voltage is increased; these results are consistent with a model in which there are no bound states in the point contact that could give rise to the 0.7 anomaly, ruling out theories that are inconsistent with this picture. *ED*

2D MATERIALS

Semimetallic black phosphorus

Science **349,** 723–726 (2015)

Graphene exhibits high electron mobility but is a semimetal — a semiconductor with zero bandgap. Ever since this two-dimensional material was first isolated from graphite, inducing a semiconductor gap in it has been a major research goal, as a finite gap between the conduction and valence bands is an essential requirement for use in digital electronic devices. An alternative approach to this problem is to find a different two-dimensional material that exhibits a gap in its natural state, and just over a year ago such a material was found: phosphorene. Keun Su Kim and colleagues have now shown that starting from a sample of black phosphorus, which consists of a few layers of phosphorene, it is possible to use external doping to reduce the gap and create a semimetal similar to graphene.

The researchers — who are based at Pohang University of Science and Technology, Yonsei University, the Institute for Basic Science in Pohang and Lawrence Berkeley National Laboratory — doped the black phosphorus by adsorbing potassium on its top surface. Variations in its electronic band structure were then monitored by angle-resolved photoemission spectroscopy. From an initial value of 0.6 eV, the gap was reduced to zero by increasing levels of doping. Kim and colleagues suggest that the reduction of the gap to zero is a consequence of the electric field generated by excess charge on the top surface created by the potassium dopant atoms, and this was confirmed through density functional theory calculations. *FP*

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