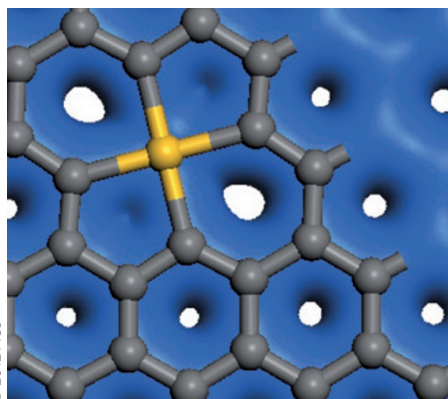


## GRAPHENE

### Distinguishing defects

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Advanced electron microscopes can now be used to routinely image with atomic resolution, and considerable research effort has recently been devoted to using such instruments to analyse graphene. This has led to precise images of graphene's honeycomb lattice and the atomic configuration of various types of atomic defects in this material. Quentin Ramasse and co-workers have now shown that an electron microscope can also be used to distinguish the electronic configuration surrounding two types of silicon defects in graphene.

The researchers — who are based at the SuperSTEM laboratory in Daresbury, the University of Leeds and the University of Manchester — used a scanning transmission electron microscope to locate three-fold and four-fold coordinated silicon defects.

They then performed electron energy-loss spectroscopy (EELS), which provided information on the modified electronic structure by measuring the energy lost by electrons scattered by the graphene structure in the region immediately surrounding the silicon impurity.

The two cases examined exhibit very different EELS spectra, which could be reproduced using density functional theory. For the four-fold defect, the electronic structure is relatively complicated and the researchers suggest that the deviation from purely  $sp^2$  bonding is probably due to a degree of  $d$ -band hybridization. The three-fold case is simpler, because here the silicon atom just substitutes one of the carbon atoms. However, density functional theory shows that the impurity introduces a degree of buckling in the lattice, mainly to accommodate the different length of the Si–C bond compared with the C–C bond. **FP**

## MOLECULAR MACHINES

### Peptide pick up

Science **339**, 189–193 (2013)

The ribosome is a molecular machine found in all living cells that can stitch together amino acids to form proteins. David Leigh and colleagues at the University of Manchester and the University of Edinburgh have now created an artificial molecular machine with similar, although distinctly more primitive, capabilities.

The machine is based on a rotaxane — a mechanically interlocked molecule that has a molecular ring threaded onto a molecular axle — and can synthesize a

short oligopeptide. The ring of the rotaxane is functionalized with a thiol-protected molecular arm, whereas the axle has an unreactive stopper on one end and three consecutive stoppers bearing the amino acids to be added to the ring's arm on the other.

The oligopeptide synthesis is activated by deprotecting the thiol group on the ring's arm, which then detaches the first amino acid from the axle and positions it at the end of the arm. This reaction also regenerates the reactive thiol group, and the ring can proceed autonomously along the axle, picking up the other two peptides in the order that they appear on the thread. When the last peptide is removed, the ring is free to slip off, and the final oligopeptide sequence can be recovered from the ring by simple hydrolysis. **AM**

## NANOPARTICLES

### Mixed in a pore

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A tiny hole, or nanopore, in a membrane could potentially be used to sequence DNA by threading the molecules through the pore under an applied potential and monitoring how the ionic current passing through the pore changes. Although DNA sequencing is the most prominent application for such devices, it is not the only one. They can, for example, be used to analyse other molecules in solution such as proteins. Marija Drndić and colleagues at the University of Pennsylvania have now shown that solid-state nanopores can also be used to synthesize gold nanoparticles.

Nanopores with diameters of between 4 and 20 nm were created in silicon nitride membranes using the electron beam of a transmission electron microscope. A membrane with a single nanopore was then used to separate two chambers of electrolyte. Negatively charged gold(III) chloride (a metal precursor) was injected into one chamber and positively charged hydrazine (a reducing agent) into the other. A potential was applied across the chambers that at first stopped the solutions reacting. However, once the sign of the voltage difference was reversed, the reagents were driven into the pore and reacted to form a gold nanoparticle.

The synthesis is self-limiting — the reaction is halted once the gold entirely fills the pore and the reagents can no longer mix — and can be monitored in real time by measuring the ionic current. **OV**

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

## MAGNETIC VORTICES

### Cores to order

Nature Commun. **3**, 1330 (2012)

Magnetic vortices have an outer region with an in-plane curling magnetization and a nanoscale inner core with an out-of-plane magnetization that points either up or down. Oscillating magnetic fields or electric currents can induce a gyrotropic (rotational) oscillation of the vortex core, and when vortices interact, this can lead to the generation of collective gyrotropic oscillations. The eigenfrequencies of these oscillations depend on the relative orientation of the cores' magnetization and on the chirality of the in-plane magnetized area. Valentyn Novosad and colleagues at Argonne National Laboratory and Oakland University have now developed a method to control the relative polarities of interacting vortex cores and select a specific gyrotropic mode.

The researchers studied the gyrotropic motion of coupled vortices in pairs of  $\text{Ni}_{80}\text{Fe}_{20}$  magnetic dots. The eigenfrequencies of the modes associated with a vortex pair with opposite and identical core polarity are 265 and 305 MHz, respectively. The system is first excited into a chaotic regime of continuous vortex core reversals using a large-amplitude signal at one of the eigenfrequencies. Then, as the driving amplitude is gradually reduced, the system relaxes to a steady-state motion with the other eigenfrequency.

The final state depends only on the excitation frequency, and not on the initial relative core polarities, and therefore tuning the excitation frequency can preselect either combination of core polarities. **EDR**