BLOCK COPOLYMERS

Templates in 3D

Science **336,** 1294–1298 (2012)

Composed of two chemically distinct domains within the same monomer, block copolymers self-assemble to form thin films with ordered structures with nanometre-scale periodicity. This peculiarity is attractive for large-scale patterning and lithographic applications, and various templates have been proposed to control their morphology. Karl Berggren, Caroline Ross and colleagues have now shown that three-dimensional block copolymer structures can be obtained by simply aligning arrays of functionalized posts.

The researchers — who are based at Massachusetts Institute of Technology — first fabricate a template that consists of ordered nanoposts functionalized with a polystyrene polymer brush. Allowing a block copolymer containing polystyrene and polydimethylsiloxane to self-assemble on top of the template produces two layers of in-plane cylindrical structures that run along defined directions with respect to each other. The resulting morphology is explained in terms of the intrinsic block copolymer periodicity and the distance between the nanoposts. For instance, if the distance between the nanoposts is a multiple of the block copolymer periodicity in one direction, the cylindrical structure will run perpendicular to that direction. As the nanoposts are functionalized with polystyrene — the major component of the block copolymer — it makes them repulsive to the cylinders thus providing the thermodynamic force for the template-assembly.

The interplay of geometry and thermodynamics allows the two block copolymer layers to be independently controlled in a single step and can be used to obtain complex structures, such as Y- or T-junctions, which could be useful in fabricating electronic devices. *AM*

PLASMA PHYSICS

Going to new lengths

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The plasma that is produced when a high-power laser is directed onto a solid target is of interest to researchers working in fields as diverse as laboratory astrophysics, particle acceleration and fusion energy. However, the extreme nature of these plasmas makes it difficult to study and control them. Now, Ravi Kumar of the Tata Institute of Fundamental Research in Mumbai and co-workers have shown that targets made of carbon nanotubes can overcome some of these problems.

The primary role of the laser in this work is to ionize the atoms in the target, but it also exerts forces on the ions and electrons that make up the plasma, and these interactions can lead to the generation of extremely high electron currents and magnetic fields. Such currents and fields are potentially useful, but the electron current, for example, can only travel a very short distance through the plasma before it breaks up into filaments.

Kumar and co-workers from India, the UK and the US illuminated their nanotube target with a high-power laser at the Tata Institute and found that magnetic fields as high as 120 megagauss were generated. Computer simulations confirmed that the electron currents must travel through the target, which is 1,100 μm thick, without breaking up. This is about 100 times longer than the typical distance travelled by an electron current in a laser-produced plasma. *PR*

IONIC BONDS

The strength of one

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The ionic bond is one of the most fundamental interactions in chemistry and is of primary importance in nature for building macromolecular structures and controlling cell metabolism. However, the strength of this interaction remains essentially unknown, unless it is probed in a vacuum. Evan Spruijt and colleagues at Wageningen University have now shown that force spectroscopy can be used to directly measure the strength of single ionic bonds in aqueous solution, where hydration and dielectric effects — absent in a vacuum — come into play.

Spruijt and co-workers deposited a negatively charged polyelectrolyte on a surface and attached a positively charged polyelectrolyte to the tip of an atomic force microscope. They then put the two in close proximity so that ionic bonds form. As the tip of the microscope is pulled away from the surface, a force versus distance curve is obtained. The curve has either a step-like shape, in which each step corresponds to the rupture of one ionic bond, or a single peak, in which the energy is released simultaneously by multiple interacting charges.

The measured strength of single ionic bonds ranges between one and six times the thermal energy at room temperature, values that correspond to lifetimes of milliseconds to years, respectively. Given such a large span of energy and tunability, which is chiefly controlled by salt concentration, ionic bonds could be useful for building large and reversible molecular structures. *AM*

GRAPHENE

Beneficial boundaries

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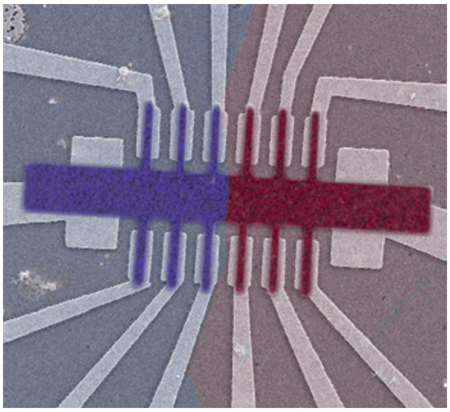

Chemical vapour deposition can be used to grow graphene films on the metre scale. These films are, however, polycrystalline and have numerous grain boundaries, which can scatter charge carries and adversely affect the electronic properties of the films. Jiwoong Park and colleagues at Cornell University and Columbia University have now shown that overlap between crystallites in such polycrystalline graphene can be used to improve the conductivity of the films.

The researchers used dark-field transmission electron microscopy to map the location and shape of domains in polycrystalline graphene that had distinct lattice orientations. The material was imaged in a specifically designed electron microscopy chip and, after imaging, an area of interest was selected and electron-beam lithography used to pattern a field-effect transistor device around it. Electrical measurements could then be carried out on individual grain boundaries.

Park and colleagues examined grain boundaries created using different growth conditions and found that overlapping domains could increase conductivity by an order of magnitude. They also suggest that the electrical performance of polycrystalline graphene with the appropriate stitching between domains could rival that of graphene fabricated by exfoliating graphite. *OV*

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