Graphene metamaterials

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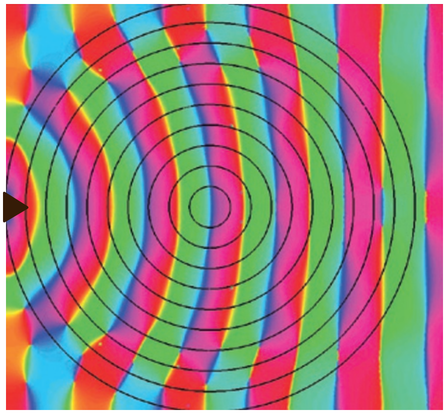

Most photonic metamaterials devices are based on plasmon resonances at the surface of metals, whose high electrical conductivity minimizes detrimental losses. However, there is no fundamental reason to fabricate metamaterials from other compounds. In particular, Ashkan Vakil and Nader Engheta now suggest that graphene, which is also highly conducting, could be used to fabricate two-dimensional metamaterials. A key advantage of using graphene is not only that it can be easily fabricated into devices, but also that its electronic states can be tuned through electric fields. As Vakil and Engheta show, even a simple physical step in the substrate on which graphene is placed can lead to a noticeable effect on its plasmonic properties that could be used to fabricate waveguides. On the other hand, more complex metamaterials, such as advanced lenses, may need an electrical bias applied through the substrate. Although these designs are limited to THz and infrared frequencies, these predictions open a new field of two-dimensional photonic metamaterials. It will be interesting to see how graphene-based devices can compete with conventional designs. *JH*

Catalysis up close

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From ensemble measurements, it is well known that the catalytic activity of Pt nanoparticles depends on their size and shape, but such experiments naturally average over many different particles. A study by Patrick Unwin and colleagues now reveals the role morphology plays in catalysis at the scale of single Pt particles on a carbon nanotube. The researchers have developed a method to image the electrochemical reactivity of surfaces with micrometre resolution. The electrochemical cell in their scanning probe system is formed at the tip of an electrolyte-filled, dual-barrelled pipette, which has been pulled to a diameter of a micrometre. As the pipette is brought in contact with a surface, the current across the electrolyte meniscus provides information on the electrochemical activity of the sample, as well as the tip–sample distance. Using their method, the researchers are able to resolve the electroreduction of a few hundred oxygen molecules, and they observe large variations in catalytic activity even for similarly sized Pt nanoparticles. Reducing the size of the tip could further enhance the spatial resolution of their instrument. *CM*

Water-filled nanotubes

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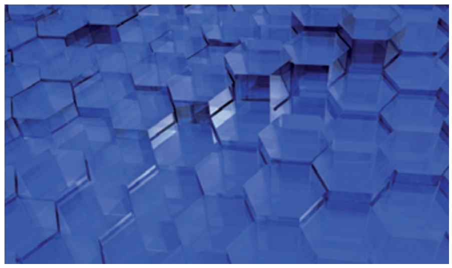
Carbon nanotubes spontaneously fill with water, as experiments and theory have shown. From a molecular perspective, this wetting phenomenon is counterintuitive because the nanotubes are hydrophobic and confinement limits the number of hydrogen bonds that water molecules can satisfy. Using molecular dynamics simulations, Yousung Jung and colleagues have now provided an explanation for this spontaneous infiltration. They find that it is indeed connected to the restricted hydrogen bonding under confinement, but that its origin is entropic: water gets into the nanotubes because hydrophobic confinement increases its entropy. With increasing nanotube diameter, infiltrated water takes gas, ice-like and liquid forms. Compared with bulk water, the authors find that the gas is stabilized by higher rotational and translational entropy, whereas the liquid is stable owing to the lower density and larger translational entropy of the water molecules close to the nanotube wall. The ice-like phase is stabilized by enthalpy, however. These findings may also advance the understanding of water flow in carbon nanotubes and under nanoscale confinement more generally. *CM*

Hexagonal ice

Phys. Rev. Lett. **106,** 206101 (2011)



You would think that we knew everything about water. On the contrary, scientists are still working hard to understand the properties of the most abundant substance on Earth. In particular, it has been very hard to perform atomic resolution microscopy of solid water (ice), mostly owing to the fact that the bonds between oxygen and hydrogen atoms can be easily broken by exposure to electron irradiation. Now however, by using a dedicated sample-preparation strategy and very-low-energy electron microscopy, Keita Kobayashi and colleagues have succeeded in imaging ice particles with atomic resolution. In particular they were able to establish the position of oxygen atoms — hydrogen atoms are too light to be seen with their technique. They could distinguish perfectly the cubic ice phase from a hexagonal one. The results are particularly intriguing if we keep in mind that the technique could be applied to ice particles directly transferred from outer space. *FP*

Knitting knots

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Introducing colloidal particles in a nematic liquid crystal (NLC) disrupts the orientation of the NLC molecules that surround the particles. Orientational frustration arises because the particles tend to induce pinning and alignment of the NLC molecules normal to the particles' surface, which results in loops of molecules with a lower degree of orientational order. Such topological defect loops circling the particles — also called Saturn rings — scatter light and are therefore visible with an optical microscope. Interestingly, Saturn rings from particles at close distance have been observed to merge into linked and knotted loops that tend to minimize their total length and thus their free energy. Igor Muševič and collaborators now show that links and knots in tangles of strands of defects can be rewired at will by cutting and reconnecting the strands with optical tweezers. The authors assembled colloidal clusters that form interlaced loops of defects — such as trefoil and pentafoil knots — and, more excitingly, used tweezers-assisted knitting to weave complex tangled assemblies, such as Borromean rings of NLC defect loops. *PP*

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