A better harvest

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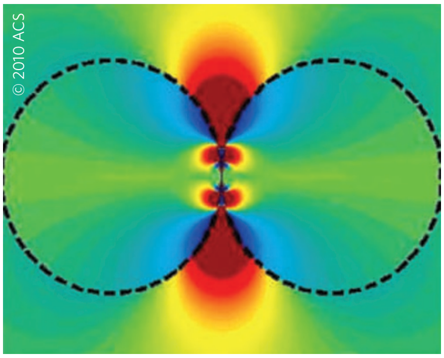
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In the quest to improve the conversion efficiency of light into electricity, an increasing focus has been placed on structures that enhance the interaction of light with the solar-cell material. An example is the use of surface plasmons, where collective electronic excitations on the surface of metallic nanostructures can be used to focus light better into photovoltaic cells. Alexandre Aubry *et al.* have now devised a method to optimize plasmonic structures for this purpose. They make use of transformation optics, a powerful technique of conformal coordinate transformations adapted from the design of metamaterial devices. As an example of their approach, the researchers investigate the plasmon resonances of two touching metallic cylinders. At the meeting point of the cylinders they find a highly localized but very strong enhancement in the optical field that occurs over a broad range of wavelengths (pictured). These findings suggest not only the possibility of using cylindrical nanostructures for applications such as solar cells or in surface-enhanced Raman scattering, but also highlight the potential of transformation optics for the design of new plasmonic structures.

Snowing down

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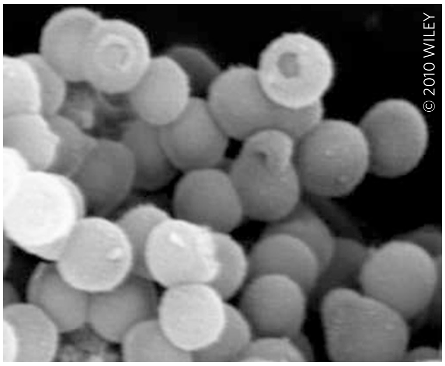
The parameters thought to affect friction between a material and snow have long been debated. Jan L. Giesbrecht *et al.* have now shown that the friction generated between snow and the polymer on the bottom of a moving ski is essentially independent of the chemical composition of the polymer. Instead the ski speed is related to the size of the sole roughness and the water-layer thickness produced by frictional heat. The roughness size was varied, and both random and orientated structures were studied. Smoother surfaces resulted in a longer descent for hydrophilic polymers compared with the hydrophobic ones, and skis with orientated surfaces had quicker descents. The movement of skis with smooth soles (roughness smaller than the water layer) is dominated by capillary suction of the meltwater; any increase in roughness decreases the wetted contact area and the friction decreases. On the other hand, when the roughness is similar in thickness to the water layer, more snow-ploughing occurs, increasing the friction coefficient. For skiers this means that in cold conditions, smooth ski soles will be faster, and in warmer conditions, roughened soles will be faster.

Porous eggs

Angew. Chem. Int. Ed. doi:10.1002/anie.201001252 (2010)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Yolk–shell structures are a special type of core–shell structure with interstitial hollow spaces between the core and shell sections. Their unique architecture suggests exciting potential for applications such as drug delivery and as nanoreactors. However, synthetic routes towards these materials are not straightforward and lack controllability. Liu *et al.* now report a surfactant-based strategy to synthesize highly uniform and monodisperse yolk–shell nanoparticles with porous shells (pictured). First, a core–vesicle complex is formed by adding fluorocarbon surfactants to the core material. Polymerization of tetraethoxysilane, followed by hydrolysis and condensation, forms the SiO$_2$ shell. The surfactants are removed by calcination, forming yolk–shell nanostructures with mesoporous shells. The method can encapsulate cores of different size (less than 700 nm), shape and composition, including SiO$_2$ spheres, Au particles or magnetic Fe$_3$O$_4$ particles, within the shells. It is also possible to create a hierarchical structure composed of a mesoporous SiO$_2$ nanoparticle within the mesoporous shell. These nanostructures show a three-step release pattern for the model drug, ibuprofen.

DNA-programmed lipids

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Stimuli-responsive nanomaterials can dramatically change their morphology and structure in response to the environment, making them essential to many applications in materials science and biomedicine. Such nanomaterials respond to changes in pH, temperature, light, ions or small molecules. These triggering mechanisms work by tuning the properties of the building blocks that the nanomaterials are made of. Thompson *et al.*, inspired by the success of colloid- and lipid-anchored oligonucleotides, have gone a step further by designing programmable building blocks. They synthesized DNA-encoded lipids that self-assemble into spherical, lamellar vesicles or spherical micelles about 20 times smaller, switching reversibly between the two through DNA hybridization and strand invasion. DNA hybridization modifies the steric and electronic repulsion of the lipid head groups (which consist of short, single-stranded DNA) and, therefore, the morphology of the aggregate. With this approach, it should be possible to manipulate the size, shape and charge of the polar head group of lipids and surfactants to design stimuli-responsive assemblies that undergo a series of reversible, programmed morphological transitions.

The emergence of plasmarons

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The X-shaped electronic band structure, technically known as the Dirac cone, has become an iconic image appearing in most papers on the electronic properties of graphene. Nevertheless, although the Dirac cone may be appropriate for describing single electrons or holes, it is not really adequate at describing the electronic structure of doped graphene, when a large number of electrons are present in the graphene plane. This is what Aaron Bostwick and colleagues showed with careful angle-resolved photoemission spectroscopy measurements. The vertex of the cone, or Dirac point, transforms into a diamond feature revealing the presence of plasmarons, that is, complex states resulting from the interaction of single electrons and plasmons — collective oscillation of the charge density. Plasmarons had been predicted to exist in graphene but have not yet been observed. Understanding the interaction of electrons and plasmons, hence the structure of plasmarons, is particularly important for plasmonic devices that merge photonics with electronics.