INTERFACES

Flexible repellent

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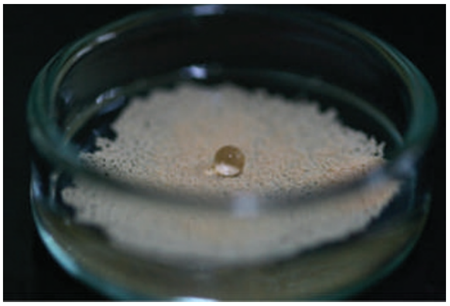

The natural world is often a source of inspiration for researchers looking to develop new synthetic materials. Substances that repel water, such as lotus leaves, are of particular interest and their structures have been mimicked to develop a range of practical superhydrophobic surfaces. However, these artificial surfaces have been predominately formed on flat solids. Shin-Hyun Kim, Su Yeon Lee and Seung-Man Yang at KAIST have now created microspheres that can act as a flexible superhydrophobic interface.

Inspired by small water-repelling objects such as the scales of butterflies, the researchers synthesized microspheres that have both a superhydrophobic and a hydrophilic face using Pickering emulsions, in which solid particles stabilize the interface between two immiscible liquids. Monodisperse emulsion droplets of a photocurable resin, which also contained silica particles and iron oxide nanoparticles, were first generated using a glass capillary device. The droplets were then photopolymerized, creating microspheres decorated with an array of silica particles. Next the silica particles were removed using wet-etching, leaving cavities on the surface of the microspheres. Half of each microsphere was then coated in a hydrophobic layer by reactive-ion etching with sulphur hexafluoride.

When placed at the interface between air and water, the microspheres provide a flexible monolayer in which the hydrophilic hemispheres face the liquid phase. This microsphere membrane can support a droplet of water on top and retain integrity when disturbed by a glass stick. Furthermore, the microspheres can coat a water droplet to form liquid marbles that can be manipulated with magnets or tweezers.

ELECTRON MICROSCOPY

Learning more about atoms

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The ability of electron microscopes to reveal the locations of the atoms in samples has increased steadily over recent decades, but there has been less progress in their ability to identify these atoms. Now Ondrej Krivanek of Nion, a company based in the US, and co-workers have shown that an approach known as annular dark-field electron microscopy is capable of identifying various light atoms, and can also detect sub-ångström distortions in an atomic lattice.

Krivanek and co-workers — who are based at Nion, Oak Ridge, Oxford and Vanderbilt University — used a scanning transmission electron microscope to image single layers of hexagonal boron nitride. They selected a beam energy of 60 keV to avoid damaging the sample, and used sophisticated electron optics to correct for aberrations. The resulting beam measured just 1.2 Å across.

The annular dark-field approach can identify atoms because the electrons collected to form the image have been Rutherford scattered in the sample, and the amount of scattering depends on atomic number. Krivanek and co-workers were able to identify boron and nitrogen atoms, and also carbon and oxygen impurity atoms, in their samples. They also detected changes as small as 0.1 Å in the inter-atomic spacings caused by these impurities.

NANOWIRES

On the dot

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Quantum dots confine electric charges in three-dimensional cages and are widely used owing to their unique electrical and optical properties. Although confinement is typically achieved by using small particles, other techniques such as electrostatic gating have been used to create dots in one-dimensional structures such as nanotubes. Now, Val Zwiller and colleagues at Delft University and the Laboratory for Photonics and Nanostructures, CNRS, have made a quantum dot in a nanowire by controlling the nanowire's crystal phase.

The wurtzite- and zinc-blend crystal phases of an indium phosphide nanowire serve as barriers to electrons and holes, respectively. By growing alternating layers of these phases, Zwiller and colleagues confined charges along the direction of the nanowire. The small diameter of the nanowire also confined charges in the remaining two dimensions. The successful confinement of charges by the quantum dots was then demonstrated in four different ways. The colour, decay speed and timing of photons emitted by the nanowire under illumination reflected the energies of the trapped charges and their degree of separation. Transmission electron microscope images of the nanowire structure also showed the variations in its crystal structure.

The results demonstrate that nanowire crystal phases can be modulated to create structures with useful electronic properties. Nanowire quantum dots could find application in spin-based memories and solar cells, both of which require opposite charges to be separated.

QUANTUM DOTS

Another barrier

Small **6,** 670–678 (2010)

Quantum dots made of small semiconductor nanocrystals have been promising alternatives to organic fluorescent dyes in various biomedical imaging applications. However, heavy metals such as cadmium that make up these dots have proved to be toxic. Because of their smallness, quantum dots can penetrate blood vessel walls, tissues and animal skin, but their ability to cross other immunological barriers in the body remains unknown. Now, Maoquan Chu of Tongji University and co-workers at Shanghai Jiaotong University show that quantum dots can penetrate the placental barrier in mice and be transferred to the fetus.

Chu and colleagues made three types of cadmium-containing quantum dots each coated with either 3-mercaptopropionic acid, polyethylene glycol or silicon dioxide, and injected them into pregnant mice. Cadmium atoms were detected in the mice pups after injection of quantum dots coated in 3-mercaptopropionic acid, and the concentration detected was higher with increasing dosages and in those pups whose mothers received smaller quantum dots. Tissue samples showed that most dots were taken up by the mother's tissues and only a small amount was transferred to the pups, suggesting that the material was transferred to the fetus, but partially blocked by the placental barrier. Even though polyethylene-glycol- and silicon-dioxide-coated dots have been touted as safer varieties, a small amount of cadmium atoms was still detected in the mice pups after injection of these dots.

Although the mechanistic aspects remain unknown, it was suggested that because of the slow clearance of quantum dots and their ability to penetrate skin, pregnant women should not handle quantum-dot solutions.