ELECTROPORATION

Tips for cleaning water

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Current methods of disinfecting water, such as membrane filtration and ultraviolet disinfection, have high financial and energy costs; cheaper methods, such as adding chlorine, have been found to produce carcinogenic by-products. Electroporation, a technique often used in molecular biology, is an alternative method that works by applying a strong electric field, damaging the cell membranes of bacteria and viruses and causing death. However, the high external voltage required has implications in terms of cost, energy consumption and safety.

Yi Cui and colleagues at Stanford University have now developed a nanosponge filtration device, which incorporates nanomaterials into a commercial polyurethane sponge to achieve efficient disinfection by electroporation. Carbon nanotubes are added to the sponge to make it conductive and silver nanowires are added to create a large number of nanoscale tips. The tips increase the strength of the electric field that can be generated by several orders of magnitude compared with an electric field generated by flat surfaces.

The researchers evaluated the performance of the nanosponge using water sources containing various model bacteria and a model virus. Inactivation of the microorganisms increased with rising external voltage, with over 99% of bacteria and viruses inactivated at 10 V and 20 V, respectively. Additionally, no harmful by-products were formed during the process and the energy consumption at 10 V was 100 J l^{-1} compared with more than 500 J l^{-1} for membrane filtration. *SB*

TWO-DIMENSIONAL MATERIALS

Hafnium honeycombs

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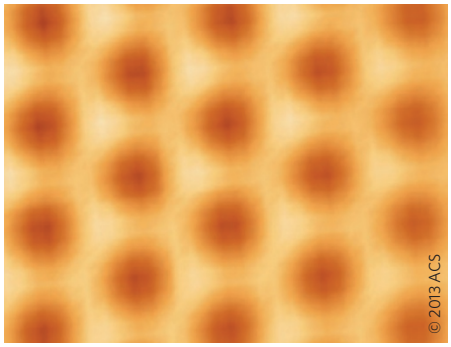

Graphene has a variety of intriguing properties because of its honeycomb lattice. Other materials with such two-dimensional structures are known including hexagonal boron nitride and silicene. However, these materials, like graphene, are typically made of *p*-block elements. Yeliang Wang, Shengbai Zhang, Hong-Jun Gao and colleagues have now shown that two-dimensional honeycomb lattice structures can also be created using transition metal atoms.

The researchers — who are based at Beijing National Laboratory of Condensed Matter Physics, Jilin University and Rensselaer Polytechnic Institute — created a crystalline layer of hafnium on an iridium(111) surface. To prepare the layer, hafnium atoms were deposited on the surface under ultrahigh-vacuum conditions using an electron-beam evaporator. The hafnium initially forms nanoclusters on the surface, but after annealing a well-ordered honeycomb structure was observed using low-energy electron diffraction and scanning tunnelling microscopy.

The experimental results, together with charge-density calculations, suggest that the hafnium forms its own honeycomb lattice with direct hafnium–hafnium bonds. A second hafnium layer can also be formed on top of the first by increasing the hafnium coverage on the surface. Furthermore, calculations suggest that freestanding layers of the material would be ferromagnetic. *OV*

ORGANIC SOLAR CELLS

Overcoming attraction

Nature Commun. **4,** 2334 (2013)

Solar cells convert solar energy into electrical signals. Alongside silicon-based photovoltaic devices, solar cells made from blends of conjugated polymer and fullerenes are being developed because of their inherently lower production costs. In these devices, the absorption of photons generates bound hole–electron pairs, which have to overcome Coulomb attraction to be separated into free electrons and holes. These charge carriers can subsequently be collected at electrodes to generate a photocurrent. The mechanism for charge separation is, however, not well understood, hindering optimization of material parameters. Vidmantas Gulbinas of Vilnius University and colleagues have now identified diffusion as the driving mechanism for charge separation.

The researchers examined charge-carrier dynamics in P3HT:PCBM solar cells on a timescale of pico- to nanoseconds. Using time-resolved electric field-induced second harmonic and Monte Carlo simulations they identified the respective contributions of drift and diffusion to carrier dynamics and charge separation. The displacement distances of the carriers was found to be very small on a subpicosecond timescale, ruling out the hypothesis of initial long-range carrier separation. Gulbinas and colleagues also find that charge separation is driven by fast diffusion rather than by drift in the applied electric field, up to distances at which the Coulomb attraction is overcome. The results highlight the importance of optimizing the carrier mobility, which is proportional to the diffusion coefficient, to fabricate efficient organic solar cells. *ED*

SEMICONDUCTOR NANOCRYSTALS

A common path

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Semiconductor nanocrystals such as cadmium selenide or zinc sulphide have been widely used for almost three decades, but exactly how they are formed from inorganic precursors is still unclear. What is known is that both a cationic precursor, which acts as a source for the metallic element, and an anionic precursor, which acts as a source for the chalcogenide element, are necessary. Alternatively, single compounds containing both precursors can be used. Using ^{31}P nuclear magnetic resonance and density functional theory, Kui Yu, Mingli Yang and colleagues at the National Research Council of Canada and Sichuan University have now shown that the reaction mechanism of the double-source and single-source approaches for the formation of cadmium selenide is essentially the same.

In the double-source approach, one equivalent of cadmium oleate and two equivalents of diphenylphsophine selenide readily react to form a compound containing one cadmium and two selenium atoms. After one selenium atom is eliminated, the reaction proceeds to form cadmium selenide and another compound containing the oleate and phenylphospine ligand residues. Although there is a competing path to this mechanism, the researchers show that the initial compound containing one cadmium and two selenium atoms is the same as the one that forms when using the single-source approach. From there, the two reactions proceed along the same path.

Yu, Yang and colleagues also show that the formation of semiconducting nanocrystals becomes thermodynamically favourable when cadmium selenide aggregates form a 13-member cluster. *AM*

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