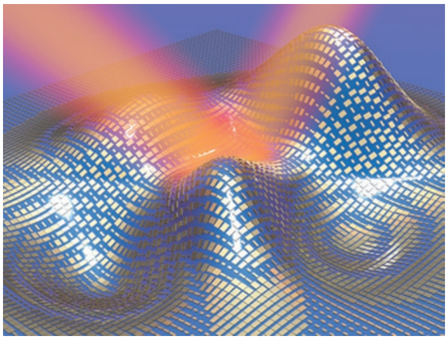
OPTICAL CLOAKING

A phase compensation trick

Science **349,** 1310–1314 (2015)



AAAS

A cloak is a device that makes objects invisible to an external observer. The first cloaks that could work with visible light used bulky containers with special optical properties, but, although they concealed the object, the containers could still be visible to an observer. Xiang Zhang and colleagues at the University of California, Berkeley have now reported a proof-of-principle cloaking device made of an 80-nm-thick surface that can be wrapped around objects of any shape, making them invisible to 730-nm light.

This ultrathin cloak reroutes light scattered from an object so that it seems as though the light has been reflected by a mirror. To obtain such an effect, the researchers patterned a gold surface with six differently sized gold nanoantennas with subwavelength dimensions that could compensate for the phase shift acquired by the scattered radiation. Because phase compensation occurs locally and covers the full spectrum (from 0 to 360°), objects with sharp edges can potentially be cloaked. To retain most of the light intensity, the team added a dielectric layer that increases the overall reflectivity of their metasurface. This design, which can in principle be scaled up, works for incoming light within 30° angles with respect to the perpendicular direction. *AM*

NANOCRYSTALS

Getting on your nerves

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Semiconductor nanocrystals could potentially be used to study the electrical activity of neurons by monitoring their luminescence during a firing event. The basic principle is that an electric field affects the spatial separation of electrons and holes in nanocrystals (a phenomenon known as the quantum confined Stark effect) and, therefore, affects the time it takes for these charges to recombine and ultimately the intensity of the luminescence emitted. To put this principle into practice, however, it is essential to understand the exact mechanism of luminescence variation and, above all, whether these variations occur on a timescale comparable to the firing events. James Delehanty and colleagues at the Naval Research Laboratory in the US have now explored these issues by experimentally simulating the action of neurons on nanocrystals.

The researchers fabricated a device in which an electric field can be applied in a controlled way to a film of nanocrystals. Increasing the applied electric field leads to a reduction of the luminescence intensity. However, the time variation of the luminescence, and hence the electron–hole recombination speeds, is barely affected. According to the team, this means that the luminescence is reduced by the electric-field-induced charging of the nanocrystals, rather than by the Stark effect. It is, in fact, known that in charged nanocrystals, the recombination of electrons and holes happens primarily through a non-radiative phenomenon known as the Auger effect.

Delehanty and colleagues also simulated a realistic neuron firing event by applying to the device an electric voltage pulse recorded independently from a murine cortical neuron. The intensity of the luminescence followed the voltage profile accurately, with a total variation of up to 5% in luminescence. *FP*

CONTRAST AGENTS

Nanobubbles that don't pop

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Microbubbles, which are typically made up of a lipid or protein shell and contain air or perfluorocarbon in the core, are useful contrast agents in ultrasound imaging because they reflect ultrasound waves differently from soft tissues in the body. Recently, nanobubbles have gained interest because they can traverse smaller capillary networks of organs and potentially be more widely applicable. However, stable nanobubbles are difficult to make. Now, Guojun Liu and colleagues at Queen's University in Canada show that stable and echogenic air nanobubbles can be prepared by lining the inside of the shell with highly hydrophobic fluorinated polymers.

Inspired by the water-repelling properties of perfluorinated coatings on cotton fabrics, the researchers made nanobubbles using a triblock polymer consisting of poly(acrylic acid), poly(2-cinnamoyloxyethyl methacrylate) and poly(2-perfluorooctylethyl methacrylate). As a control, a similar polymer with poly(glyceryl monomethacrylate) and poly(*tert*-butyl acrylate) replacing poly(acrylic acid) and poly(2-cinnamoyloxyethyl methacrylate), respectively, was made. When injected into a tube filled with water or human blood, the fluorinated nanobubbles could be detected by ultrasound. Further experiments show that their echogenicity is due to the air trapped in the cavity. Nanobubbles that are allowed to age for 4 hours or 3 weeks remain strongly echogenic. Furthermore, their average lifetime before signal decay was about 100 times longer than commercial microbubbles. Transmission electron microscopy showed that the ultrasonicated samples retained their structural integrity, confirming that no air was displaced by water. *ALC*

ORGANIC–INORGANIC PEROVSKITES

Now in two dimensions

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Hybrid organic–inorganic perovskites, such as $CH_3NH_3PbI_3$, are a class of semiconducting material that have attracted considerable research attention in recent years due to their potential in photovoltaic applications. The materials can be used to create solution-processed devices and rapid improvements in their capabilities mean that perovskite solar cells currently offer power conversion efficiencies of over 20%. Peidong Yang and colleagues at the University of California, Berkeley, Lawrence Berkeley National Laboratory and ShanghaiTech University have now shown that these layered materials can be grown as atomically thin two-dimensional sheets.

The researchers synthesized sheets of the hybrid perovskite $(C_4H_9NH_3)_2PbBr_4$ by dropping a dilute precursor solution on a silica surface and allowing it to dry under mild heating. With the approach, micrometre-sized crystals were created that had well-defined square shapes and were a single or a few unit cells thick. Detailed analysis of the materials revealed that they exhibit a structural relaxation that shifts their bandgap compared with the bulk material. The two-dimensional crystals also exhibit a blue photoluminescence that could be tuned by varying the thickness of the sheets or their composition. *OV*

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