research highlights

MICROSCOPY

Sensing hot electrons

Nano Lett. **18**, 2165–2171 (2018)

Scanning tunnelling spectroscopy has developed into a versatile tool to investigate standing waves of hot carriers in a variety of materials, such as noble metals, high-temperature superconductors, Weyl semimetals, or topological insulators. Yet, the position of the probe tip determines both the point of charge injection and the detection point. Hence, the mapping of hot carriers away from the injection spot becomes impossible. Leisegang and colleagues now use a single molecule as a sensor for hot carriers. By doing so, they can separate the injection from the detection and track the evolution of the carrier concentration away from the tip position.

The researchers deprotonate a free-base phthalocyanine molecule on a Ag(111) surface, creating a tautomerization switch sensitive to hot electrons. With the tip positioned at a spot away from the molecule, voltage pulses inject hot carriers, which eventually switch the position of the hydrogen atom in the molecule. The switching probability depends on the carrier concentration at the molecule site. Leisegang and co-workers then move the tip over the molecule and read out the state of the switch by non-invasive topographic imaging. To demonstrate the wave nature of hot electrons, they built an atomic-scale interferometer, where two pairs of Ag adatoms act as mirrors. Constructive or destructive interference occur between direct and scattered electron waves depending on the distance between the atomic mirrors. If a second molecule and a second interferometer are added, carriers are more likely to travel to one of the two molecules when their wavelength matches the interference conditions of the respective interferometer. *BH*

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GENE EDITING

A tailored snip

ACS Nano **12**, 994–1005 (2018)

The lack of tissue and cell specificity of CRISPR–Cas9 delivery systems represents a major obstacle to the in vivo application of this gene editing technology for therapeutic purposes. The design of nanoparticles for targeted delivery has partially solved the problem, but residual mistargeting raises concerns of side effects arising from the DNA cleaving activity of the Cas9 nuclease in non-targeted cells.

The CRISPR–Cas9 system can typically be delivered in the form of a plasmid encoding the components of the editing machinery and a promoter that drives cellular expression of Cas9. Now, Luo and co-workers substitute the classical universal promoter with a cell-specific promoter that induces activation of CRISPR–Cas9 only in macrophages and monocytes. The system is encapsulated in cationic lipid-assisted polymeric nanoparticles. In vitro, different cells are able to take up the loaded nanoparticles, but only macrophages and monocytes can efficiently express Cas9. As a consequence, gene editing is also restricted to these cell types, as observed in the presence of a guide RNA directed against *Nnt1*. This gene, which encodes the protein netrin-1, is a potential therapeutic target in macrophages for type 2 diabetes.

Considering the in vitro cell specificity, the authors also perform experiments to investigate whether macrophage-specific CRISPR–Cas9 activation shows promise for therapeutic gene editing in animal models. Indeed, diabetic mice treated with the developed gene editing system directed against *Nnt1* show a macrophage-specific decrease of netrin-1 concentration with negligible off-target effects, recapitulating the in vitro results. Moreover, the animals displayed normalized blood glucose levels and improved insulin sensitivity. *CP*

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2D MATERIALS

A new metallene arrival

Sci. Adv. **4**, e1701373 (2018)

The fast-growing family of 2D materials span the entire range of electronic classes including insulators, semiconductors, magnets and superconductors. However, examples of stable and readily available 2D metals are still sparse. Now, Kochat and colleagues report an exfoliation method to obtain atomically thin metallic gallenene from the molten phase of bulk gallium.

In the so-called solid–melt exfoliation process, a liquid gallium droplet is brought into contact with a Si/SiO_2 substrate that provides sufficient stabilization for the formation of gallenene. Structural analysis shows that the exfoliated 2D material can be stabilized on the substrate in two distinct crystallographic orientations and is four to six layers thick. Gallenene behaves as a metal with a low thermal conductivity and shows a strong chemical interaction with its substrate. The latter implies that its fundamental electronic properties can be readily tuned by changing the substrate material. In particular, the authors show that gallenene creates a good 2D contact with MoS_2 by inducing the MoS_2 to transform from a semiconductor to a metal. The solid–melt exfoliation technique is not limited to gallenene and could be used to exfoliate other 2D materials from low-melting pure metals and alloys. OB

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ANISOTROPIC NANOWOOD

Scalable thermal insulator

Sci. Adv. **4**, eaar3724 (2018)

Thermal insulating materials are highly desirable for various practical applications. Among such materials, nanocellulose is attracting attention because of its abundance and eco-friendly properties. It is known that anisotropic nanocellulose composites can serve as good thermal insulators. However, their poor mechanical properties prevent their large-scale application. Li and colleagues now report a scalable, anisotropic, light, strong and super thermally insulating nanowood made of naturally aligned cellulose nanofibrils.

The authors fabricated the nanowood by heating and chemically treating natural wood and subsequently freeze drying it. The formed nanowood is mesoporous with porosity as high as 91%. It is composed of hierarchically aligned cellulose nanofibril aggregates with large surface-to-volume ratios and high aspect ratios. Even though the nanowood is light, its mechanical strength is much higher than existing thermal insulating materials, which can be attributed to the bonding between the cellulose fibrils. Moreover, the nanowood exhibits low emissivity, capable of reflecting 95% of the solar thermal energy. The anisotropic property of the nanowood leads to anisotropic heat flow. The axial thermal conductivity is two times the transverse thermal conductivity. Consequently, the thermal dissipation in the axial direction is faster than in the transverse direction, which further enhances the transverse thermal insulation. The authors find that when the top surface is heated by a solar simulator, the backside of the nanowood is 27 °C lower than that of a silicon aerogel. *WS*

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