ELECTROCATALYTIC NANOMATERIALS

Reactivity mapping

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Scanning electrochemical microscopy has been integrated with different scanning probe techniques to simultaneously characterize the electrochemical reactivity and topography of electrocatalytic nanomaterials. However, the reproducibility of probes and the stability of tip responses remain challenging. Now, Kang *et al.* report precise and high-resolution tip current measurements of the electrocatalytic oxidation of borohydride at ensembles of gold nanoparticles (AuNPs) on a carbon-fibre support in alkaline media, using scanning ion-conductance microscopy (SCIM) with a nanopipette probe.

The researchers follow the electrocatalytic activity of the nanoparticles by probing the ionic composition changes around the particles, which are caused by the depletion of hydroxide ions and release of water during the electrochemical reactions. They find the sensitivity of SCIM to the substrate reaction is better at a positive bias, and that the substrate-to-tip distance needs to be optimized to achieve the desired resolution while ensuring the tip does not block the reaction flux. By using a self-referencing hopping-mode protocol and carefully controlling the substrate potential, the topography and electrochemical activity of single nanoparticles is mapped at high precision and 30-nm resolution, commensurate with the probe size. Furthermore, they report for the first time that the ion flux on the top of a nanoparticle is different from that in the narrow gap between the AuNPs and the support, which they further explain with finite-element method simulations. *WS*

2D MATERIALS

Some like it hot

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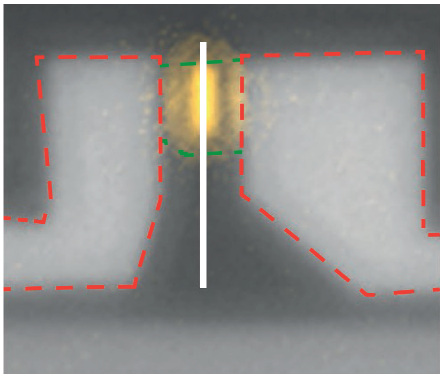

WILEY

Monolayer transition-metal dichalcogenites (TMDs) are direct-bandgap semiconductors characterized by strong light–matter interaction, the sought-after property in optoelectronics and photonics. Besides, low thermal conductivity and large thermopower of TMDs endows them with potential for applications in thermoelectrics. Now, L. Dobusch *et al.* exploit these properties and show thermal–visible light emission from a monolayer MoS_2 that occurs as the result of Joule power dissipation.

A MoS_2 flake, serving as a field-effect transistor channel, is suspended over a pre-patterned 150-nm-wide trench. Light emission localized to the suspended region sets in when the transistor is reverse biased with the gate voltage above the threshold. Electrons in the TMD monolayer can reach extremely high temperatures due to intrinsically inefficient heat transfer and poor vertical heat dissipation in the substrate-free region. Thus, hot carriers can quickly populate excitonic states and radiatively recombine in the centre of the device. The onset of the light emission is in the negative differential conductance regime. Its intensity increases at larger negative voltages until the device finally breaks down. From a practical point of view, the results suggest that thermal management may be needed to ensure reliability and stable performance of TMD electronics. *OB*

GRAPHENE

One plasmon per electron

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Light–matter interaction at the nanoscale can be enhanced by exciting plasmons; graphene plasmons, in particular, show tunable properties dependent on doping level or interaction with dielectric materials. However, graphene plasmons are in the mid-infrared region, and although high doping levels and lateral confinement can push the wavelength towards the visible, the coupling between far-field light and graphene will remain weak. Now, de Vega and García de Abajo propose a methodology for visible-plasmon generation in graphene that requires no light at all. Instead, plasmons are generated from tunnelling electrons.

The researchers consider a graphene–hexagonal boron nitride (hBN)–graphene sandwich structure. The hBN layer is 1-nm thick and the two graphene monolayers have different Fermi energy. Applying a bias between the two graphene sheets produces tunnelling electrons through the gap. The researchers find a happy voltage window in which the tunnelling electrons lose energy through the excitation of a propagating optical plasmon rather than dissipate through coupling with the hBN phonons (low bias) or electron–electron interactions (high bias). According to the calculations, using graphene layers with 0.5- and 1.0-eV Fermi energy, the electron-to-plasmon yield can reach unity with a bias lower than 1 V nm^{-1}. Plasmonic devices made in this way, which do not require the mediation of photons, can also be used in reverse as sensors, where a change in the graphene plasmon properties is translated into a voltage readout. *AM*

SPIN CURRENTS

The utility of incoherence

Phys. Rev. Mater. **1,** 031401(R) (2017)

The precession of magnetic moments in ferromagnetic materials can be used to inject pure spin currents through the interface with adjacent materials. These precessions can be induced coherently by external magnetic fields under conditions of ferromagnetic resonance or incoherently by thermal gradients — leading to the so-called spin pumping and spin Seebeck effects, respectively. Although these phenomena have been widely studied, a systematic investigation of the influence of the degree of crystallinity of the ferromagnetic material on the injection process is still missing.

Now, Chang *et al.* report on insulating yttrium iron garnet (YIG) thin films grown by radiofrequency magnetron sputtering on different materials — gadolinium gallium garnet (GGG), silicon and glass. The actual substrate determines the quality of the YIG crystallinity, which is high only in the case of GGG substrates. The injection of spin currents in adjacent platinum layers is then investigated under the effect of microwave magnetic fields or thermal gradients, and the amplitude of the effect is quantified via the detection of an inverse spin Hall voltage across platinum.

The results demonstrate that the polycrystalline morphology of YIG layers strongly limits the spin pumping efficiency. However, the incoherent nature of the thermal excitation leads to a substantial insensitivity of the spin-injection efficiency on the degree of crystallinity of the ferromagnet, with relevant implications for technological applications of the spin Seebeck effect in polycrystalline materials. *GP*

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