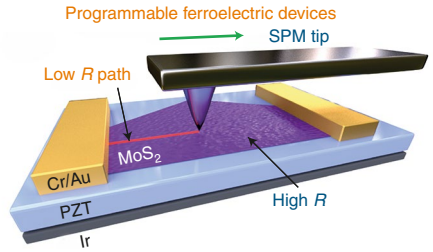
QUANTUM TECHNOLOGY

Write and erase

Nano Lett. http://doi.org/c4vw (2019)



Credit: American Chemical Society

Two-dimensional (2D) and ferroelectric materials can be used in contact to create devices like field-effect transistors (FETs) or switchable tunnel junctions, where a polarization inversion of the ferroelectric changes the conductance of an adjacent 2D material. Now, Lipatov et al. combine these two types of devices to produce a programmable FET. The conductance of a MoS_2 monolayer is reversibly tuned by imprinting one or more well-defined conductance channels into the ferroelectric layer underneath.

The device consists of a flake of monolayer MoS_2 on a ferroelectric Pb(Zr,Ti)O_3 (PZT) layer (pictured). Two electrodes on top of the MoS_2 act as source and drain. The polarization of the PZT layer determines the conductivity of the MoS_2 and, hence, the FET state. The source–drain current depends on the number of channels with high conductance that connect the two electrodes. Through the use of voltage pulses applied with the conductive tip of a scanning probe microscope (SPM) through the MoS_2, the researchers can imprint and erase areas of low resistance (R). While the overall conductance change is not extraordinarily high, the ability to write, erase and rewrite one, two or more channels — and the possibility of connecting several electrodes via flexible channels — makes this approach interesting for its memristive functionalities and, though a little speculative at this stage, for artificial synapsis application. *BH*

https://doi.org/10.1038/s41565-019-0456-4

CELL MICROSCOPY

The movement within

Nat. Commun. **10**, 1652 (2019)

Cell function results from the interplay between the nanoscale organization of macromolecules and their dynamic behaviour. Yet understanding how they are linked has proven challenging due to the limitations of current microscopy techniques, which can only probe a few molecules at a time and which require the addition of an exogenous — often cytotoxic — dye, frequently leading to heterogeneous labelling and photobleaching.

In their recent paper, Gladstein and co-authors present a label-free optical technique named dual partial wave spectroscopy (dual-PWS), which measures the spectral and temporal variation of the interference signal of light back-scattered from macromolecular assemblies within a cellular sample. The technique provides information on the spatial organization and motion of intracellular macromolecular structures at a single-cell level, with nanoscale and millisecond resolution. For example, it confirms the high mobility and structural heterogeneity of chromatin in stem cells, which enables access to several genes for cell differentiation. Using dual-PWS the authors also show that, in cells exposed to UV radiation, the intracellular macromolecule ensemble experiences a previously unnoticed burst of activity — dubbed cell paroxysm — connected to cytoskeleton and cell membrane damage, which they suggest might be related to the early phases of cell death. *CP*

https://doi.org/10.1038/s41565-019-0457-3

GRAPHENE OXIDE MEMBRANES

Photo-accelerated ions

Nat. Commun. **10**, 1171 (2019)

Biological systems can harvest light to regulate proton transport across cell membranes. During the past decade, artificial photo-induced active transport systems, capable of transporting protons or metal ions and mimicking natural photosynthetic process, have successfully been built. Now Yang and co-workers report a photo-induced fast ion transport phenomenon through graphene oxide membranes (GOMs).

They prepare GOMs by vacuum filtration of GO and thermal annealing. The test device is then composed of the GOMs and two solution reservoirs placed on each end. When an off-centre position is illuminated, photocurrent and ionic current flow through, without the application of an external potential. Besides, the researchers observe cation transport against a tenfold concentration gradient under asymmetric light illumination and find that both enhancing the illumination intensity and prolonging the illumination time can facilitate ion transport. However, no ionic transport is present when part of the GOM is directly heated, excluding a light induced thermal effect. The researchers propose a plausible mechanism of a photo-induced charge profile redistribution. Photonic ion switches, photonic ion diodes and photonic ion transistors are subsequently developed based on the GOMs. The authors believe that these fundamental elements can find their use in ionic sieving and artificial photosynthesis in the future. *WS*

https://doi.org/10.1038/s41565-019-0458-2

2D MATERIALS

Organic touch

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Integrating two-dimensional (2D) materials with organic molecules into hybrid hererostructures is far less common than fabricating conventional van der Waals stacks. However, this combination may provide an attractive strategy for making devices with a functionality tailored through molecular design. Now, Y. Zhao et al. demonstrate a generic approach for designing optically switchable field-effect transistors (FETs), based on photochromic molecules physisorbed on 2D semiconductors.

To fabricate hybrid heterostructures, alkoxy-substituted (AZO) molecules are selectively deposited onto a patterned channel area comprising either MoS_2 or black phosphorus (BP). Then, to reduce interfacial trap density and improve the photoresponse speed of the optoelectronic devices, the researchers introduce the trap-free polymer benzocyclobutene. The reversible light-induced doping/undoping of the 2D FET channel occurs via the tuning of the population ratio of *trans*-/*cis*-AZO molecules, resulting in the observation of several conductance states in the MoS_2 FET and the long retention time of the metastable *cis*-AZO — exceeding 15 hours. Finally, using the reversible isomerization property of AZO, Zhao and colleagues successfully created ambipolar BP FETs as well as lateral light-tunable p–n diodes. *OB*

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