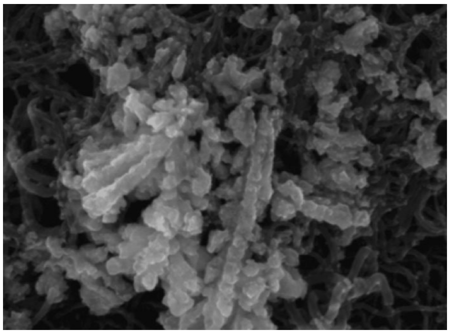
CO_2 REDUCTION

A reversible morphology

Nat. Commun. **9**, 415 (2018)



Credit: Macmillan Publishers Ltd

The electrocatalytic reduction of carbon dioxide to methane, one of the possible paths towards reducing greenhouse gas concentration and generating fuels sustainably, is a challenging reaction to catalyse as it can yield several other partially reduced compounds. Therefore, designing effective catalysts for the CO_2-to-CH_4 transformation requires an in-depth mechanistic understanding of the reaction conditions. Recently, a Cu(II) phthalocyanine complex showed attractive activity and selectivity properties. Weng et al. now report an in situ study and show that this complex undergoes a morphological transformation that is responsible for the high activity recorded.

The researchers carry out X-ray absorption spectroscopy, cycling the electrochemical potential between the open circuit voltage (~0.80 V) and the voltage where the maximum catalytic activity occurs (−1.06 V). They observe the appearance of Cu(I) and then Cu(0) peaks. The peaks disappear as the potential is cycled back to less reducing conditions. Morphological analysis and theoretical calculations show the presence of Cu–Cu metallic bonds and the formation of Cu clusters of ~2 nm at −1.06 V. It is likely that these clusters are stabilized by the phtalocynanine ligands. Weng et al. therefore conclude that the superior catalytic performance of the copper complex is due to the reversible formation of the Cu(0) cluster. *AM*

https://doi.org/10.1038/s41565-018-0101-7

FUNCTIONAL NANOMATERIALS

Crystal casting

Sci. Adv. **4**, eaao5758 (2018)

The low-temperature growth of high-quality large-scale 2D organic single crystals is a prerequisite for the development of low-cost, high-yield organic nanoelectronic devices and circuits. Despite several recent demonstrations of ultrathin large-area organic single crystals, the realization of monolayer wafer-scale sheets has never before been reported. Now, using a well-established low-temperature fabrication technique, Yamamura et al. reveal a simple growth method that can further promote the scaling-up of uniform high-mobility organic semiconductors for high-speed electronic circuits.

Organic crystalline films of C8-DNBDT-NW were fabricated via a meniscus-driven solution method, also known as continuous edge casting, at the optimized substrate temperature and shearing speed. With only two parameters to control during the one-shot growth procedure, the resulting thickness of the films can be precisely tuned from a mono- or bilayer to a few layers. Taking advantage of the large size of the crystalline films, the authors demonstrate several hundreds of transistors with uniform all-around performance. The high quality of the fabricated films is further exemplified by the champion bilayer transistor that exhibits a channel carrier mobility of 13 $cm^2\ V^{-1}\ s^{-1}$, high switching speed and low-voltage operation. *OB*

https://doi.org/10.1038/s41565-018-0098-y

MAGNESIUM-ION BATTERIES

A frustrated solution

Chem http://doi.org/cknh (2018)

Magnesium-ion batteries have been purported as one of the candidate technologies to surpass lithium-ion batteries. But with safety concerns less pressing and theoretical energy density about five times that of commercial Li-ion batteries, the most demanding problem in Mg-ion batteries research is the shortage of cathode materials that can reversibly intercalate and de-intercalate magnesium ions. Part of the issue resides in the greater charge-to-radius ratio of Mg^{2+} with respect to Li^+. When Mg^{2+} ions intercalate they tend to polarize the cathode material, generating strong electrostatic interactions that limit Mg^{2+} diffusion. Andrews et al. have now shown that a metastable phase of V_2O_5 (ζ-V_2O_5) can reversibly intercalate and de-intercalate magnesium ions.

The ζ-V_2O_5 phase is a polymorph with an open tunnel framework that allows Mg^{2+} ions to diffuse within the material. Within this open framework there are several sites that magnesium can coordinate to, but the interactions remain weak at all of these sites. The researchers call this situation 'frustrated coordination', and it helps Mg^{2+} diffuse through the channels without needing to overcome large energy barriers. It is also worth noting that magnesation is accompanied by only a small volumetric change of <1%. Using this material, Andrews et al. show a Mg-ion battery with reversible capacity of 90 mAh g^{-1} over 100 cycles. *AM*

https://doi.org/10.1038/s41565-018-0100-8

SPINTRONICS

Twofold topology

Nano Lett. **18**, 1057–1063 (2018)

Topological matter possesses a characteristic that is robust against perturbation as long as the disturbance is not too violent. This topological protection makes such materials candidates for fault-tolerant application in spintronics or quantum computation. Over the past years, researchers in physics, chemistry and materials science have been predicting, synthesizing and exploring new types of topological matter. Zhang et al. now combine two topological properties in a single sample. They create a skyrmionium, a combination of two skyrmions with opposite winding number, in a ferromagnetic film by coupling it to a magnetic topological insulator (TI).

The researchers grow a film of Cr-doped Sb_2Te_3 by molecular beam epitaxy. This bulk insulator possesses a topological surface state that is fully spin-polarized at low temperatures. On top, they deposit a wedge of $Ni_{80}Fe_{20}$ as ferromagnetic layer with varying height. By means of X-ray photoemission electron microscopy, Zhang and co-workers show how a skyrmionium can develop in the NiFe layer when cooling the sample below the transition temperature for magnetic order in the TI. The observed magnetic texture is absent both for the ferromagnetic film being coupled to a non-magnetic TI and for the magnetic TI alone. Hence, the appearance of a skyrmionium is directly linked to the coupling between the NiFe film and the spin-polarized topological surface state. The combination of two prominent classes of topological matter is a first step towards a set of complex samples with combined topological properties. *BH*

https://doi.org/10.1038/s41565-018-0099-x

Olga Bubnova, Benjamin Heinrich and Alberto Moscatelli