IMAGING

Looking for the penumbra

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In the aftermath of a stroke, severe neuronal loss occurs in the core ischemic zone, where the blood flow is more drastically reduced. Outside of the core zone, in the so-called ischemic penumbra, the cerebral tissue remains viable for several hours and can be recovered with reperfusion therapies upon prompt intervention. Computer tomography and magnetic resonance imaging (MRI) are currently employed to monitor the cerebral blood flow and identify the penumbra, but the former requires radiation exposure and the latter is susceptible to artefacts that limit its quantitative potential.

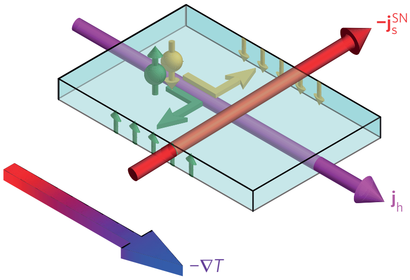
Now, Ludewig *et al.* apply magnetic particle imaging (MPI) to follow cerebral perfusion in murine acute stroke models. MPI is a radiationless, tomographic technique that images the distribution of superparamagnetic iron oxide nanoparticles (SPIOs) quantitatively and with high spatial and temporal resolution. After optimizing a MPI scanner for preclinical studies, the authors show that they can observe cerebral blood flow in healthy animals in real time and detect ischemic stroke of a few cubic millimetres in mice bearing a middle cerebral artery occlusion. Using a single dose of SPIOs, they image the occlusion, obtain anatomical information on the brain vasculature, and distinguish between arterial and venous vessels.

By comparison with traditional MRI, MPI offers fast diagnostic times and high temporal resolution in small animals. While the sensitivity and toxicity of the technique need to be further validated in bigger models, the results reported in the study suggest it can potentially become a useful clinical tool for the rapid assessment of the health of the vascular and cerebral tissues after a stroke. *CP*

SPIN CALORITRONICS

Spin Nernst effect

Nat. Mater. **16,** 977–981 (2017);
Sci. Adv. **3,** e1701503 (2017)



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External magnetic fields perpendicular to the propagation direction of current flows in condensed matter can generate the transverse accumulation of electrical charges — a phenomenon known as the Hall effect in the case of charge currents and as the Nernst effect for heat currents. The former phenomenon has a magnetic counterpart in the so-called spin Hall effect, where charge currents lead to a transverse spin accumulation in the presence of sizeable spin–orbit coupling. However, the spin Nernst effect — the generation of transverse spin accumulation caused by heat currents — has been theoretically postulated without any experimental demonstration so far.

Now, two independent groups report on the observation of the spin Nernst effect in magnetic multilayers. S. Meyer *et al.* use $Pt/Y_3Fe_5O_{12}$ bilayers and induce longitudinal thermal gradients ∇T — and heat currents $\mathbf{j}_h$ in turn — along the devices in a Hall-bar configuration, measuring the propagation of transverse spin currents $\mathbf{j}_s^{SN}$ in Pt as an electric signal generated by the inverse spin Hall effect. In order to rule out spurious contributions, the researchers investigate different boundary conditions for the spin transport by controlling the magnetic state of the adjacent $Y_3Fe_5O_{12}$ layer. Instead, P. Sheng *et al.* consider $Ta/Co_{20}Fe_{60}B_{20}/MgO$ and $W/Co_{20}Fe_{60}B_{20}/MgO$ heterostructures with different characteristic values for the thickness of the heavy metal. The researchers find that the magnitudes of the spin Nernst and spin Hall effects are comparable but of opposite sign. *GP*

WATER SPLITTING

Vacancy-filling with P

Energy Environ. Sci. http://doi.org/cgg7 (2017)

Harvesting hydrogen gas from water is an attractive method to replace fossil fuels with carbon-neutral fuels. However, catalysts are required to overcome the costly energy hurdles associated with splitting water. Cobalt oxide catalysts have shown a strong performance for the oxygen evolution half-reaction, but poor proton-reduction activity. Recent works have found that introducing defects, such as oxygen vacancies, can improve water-splitting activities at the cost of stability.

Li and Wang and colleagues report a means to improve water-splitting performance by adjusting cobalt oxide's defect chemistry. The researchers plasma-etched cobalt oxide nanosheets to both introduce and fill oxygen vacancies with phosphorus atoms. The P-doped cobalt oxide retained its parent structure without forming any impurity phases. Synchrotron X-ray absorption experiments with P-atoms show an altered distribution of tetrahedral and octahedral cobalt sites compared to pristine and oxygen-vacant cobalt oxide.

P-doped cobalt oxide presented enhanced total water-splitting capabilities compared to pristine and oxygen-vacant cobalt oxide. The phosphorus atoms lowered the material's proton reduction potential by 300 mV, compared to the parent cobalt oxide. Vacancy-filling also yielded more efficient oxygen evolution without diminishing sample stability after nearly 24 hours of continuous water splitting. The improved water-splitting performance arose from increased material conductivity and near-optimal hydrogen adsorption on the catalyst surface. *AW*

PLASMONICS

Chemistry in the gap

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The assembly of colloidal particles is usually attained as a result of random aggregation, but this approach prevents the formation of highly uniform aggregates. A better, if more challenging, approach would be to counteract the Brownian motion in the solution phase to direct the aggregation of nanoparticles. As an effort in this direction, Thrift *et al.* now report a methodology to make uniform nanoparticle assemblies in which the Brownian fluctuations in solution are tamed in virtue of the presence of a long-range electrokinetic interaction.

The researchers seed gold nanoparticles functionalized with lipoic acid ligands on top of a silicon electrode. Applying a voltage bias in the solution creates an electrostatic potential that attracts other functionalized particles from the solution phase towards the seeded nanoparticles. The attractive force is larger in the direction parallel to the surface. In this way, most of the aggregation occurs in the horizontal direction. As the particles gets close to one another, a chemical reaction between the lipoic acid ligands occurs in the presence of a carbodiimide molecule. As a result, an anhydride linker forms, which keeps the nanoparticles at a constant distance of 0.9 nm. Notably, Thrift *et al.* can follow the chemical reaction by surface-enhanced Raman spectroscopy (SERS), as the gap space benefits from the highest electromagnetic field intensity. Through their methodology, the researchers demonstrate a uniform SERS signal enhancement of 10% over an area of 1 mm^2. *AM*

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