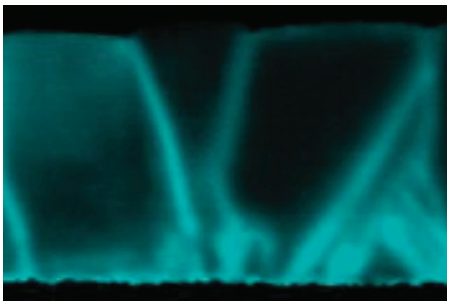
# research highlights

CADMIUM TELLURIDE SOLAR CELLS

## Selenium diffusion unveiled

*Nat. Commun.* **7,** 12537 (2016)



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Solar cells based on CdTe now reach competitive efficiencies of up to 22.1%, mostly due to increased short circuit current. Although cells with this record-high efficiency are proprietary technology, it is thought that such increases are achieved by bandgap engineering, using Se diffusion from a CdSe window layer that gives rise to a $CdTe_xSe_{1-x}$ layer with graded composition and bandgap. However, a microscopic understanding of the mechanisms of formation and photoresponse of the resulting $CdTe_xSe_{1-x}$ layers is still lacking. Now, Jonathan Poplawsky and colleagues from Oak Ridge National Laboratory, the University of Toledo and Vanderbilt University show that the photoactivity of the $CdTe_xSe_{1-x}$ layers depends on the Se content and on the crystalline structure of the alloy and they confirm an optimal thickness of 100 nm for the CdSe window.

The researchers investigate the structure, composition and photoactivity of $CdTe_xSe_{1-x}$ alloyed layers with nanoscale resolution in four solar cells with CdSe window thickness of 50, 100, 200 and 400 nm. For cells with 100-nm-thick windows, an average Se composition of 25% diffuses into the CdTe layer, and the entire alloyed layer has a zincblende structure with columnar grains that span from the front to the back contact, making it photoactive across the whole cross-section. As the Se composition varies through the alloyed layer, the bandgap is progressively reduced, increasing the photoresponse to less energetic photons. *ED*

CATALYSIS

## Locating coke

*Angew. Chem. Int. Ed.* http://doi.org/f3qtc5 (2016)

Converting methanol into hydrocarbons is an important step in pathways that use non-crude oil carbon sources such as natural gas, coal, biomass and $CO_2$ as feedstocks for synthesis of liquid transportation fuels. While zeolites — porous aluminosilicate materials — such as ZSM-5 are effective catalysts for the reaction, build-up of carbonaceous deposits (coke) as the reaction proceeds leads to their deactivation. Therefore, a deeper understanding of the properties at the nanoscale that give rise to the deposition of coke is needed to design improved catalysts. Now, Simon Bare, Bert Weckhuysen and colleagues in the US and the Netherlands use atom probe tomography (APT) with subnanometre resolution to investigate how fine-scale variations in catalyst composition affect coke deposition in ZSM-5.

The researchers first run the methanol-to-hydrocarbons reaction for 90 minutes at 350 °C, with $^{13}C$-labelled methanol, to partially deactivate a single crystal of ZSM-5 before using APT to spatially resolve in 3D the carbon distribution in the catalyst. Using cluster analysis, they find that on average the carbon clusters are composed of about 30–60 atoms. The amount of coke correlates with small fluctuations in the Al concentration, and clusters form preferentially in regions of increased Al content and, therefore, regions of increased Brønsted acid site density. This work highlights that the Si/Al ratio in the catalyst must be closely controlled on the nanoscale to regulate coke production. *JG*

BATTERIES

## One size fits all

*Energy Environ. Sci.* http://doi.org/bppt (2016)

In comparison with their non-aqueous counterparts, rechargeable aqueous batteries offer an alternative and attractive energy storage means owing to their low cost and high safety. However, rechargeable aqueous batteries using metal cations such as $Li^+$, $Mg^{2+}$ and $Al^{3+}$ as charge carriers often suffer from poor electrochemical performance. Furthermore, although many electrode materials possess promising properties for Li-ion batteries, in general those do not work well for non-$Li^+$ monovalent ion or multivalent ion batteries. David Lou and colleagues in Singapore and China have now reported reversible redox reactions of a bismuth oxide ($Bi_2O_3$) electrode material in a diverse range of metal ion salts and demonstrated high performance of an aqueous $Bi_2O_3/LiMn_2O_4$ full cell.

The researchers showed that the $Bi_2O_3$ material works as a remarkable rechargeable electrode in a total of seventeen metal ion electrolytes including $Na^+$, $K^+$, $Mg^{2+}$, $Ca^{2+}$, $Sr^{2+}$ and even $Al^{3+}$-based nitrates/chlorides/sulfates. In addition to showing the stable and significant redox behaviours, the $Bi_2O_3$ electrode also effectively suppressed hydrogen evolution, an undesired reaction that often occurs in aqueous electrolytes. The researchers ascribed the charge storage mechanism in the $Bi_2O_3$ electrode to a conversion reaction from the face-centred cubic $Bi_2O_3$ to elemental Bi, which is in contrast to the conventional intercalation mechanism that often does not involve significant changes in valence state. *CZ*

INNOVATION POLICIES

## The role of emerging countries

*Energy Policy* **97,** 27–38 (2016)

Technological innovation in the energy sector plays an important role in contributing to global security of supply. However, little research has been conducted on the interplay between fossil fuel rents — the difference between resource production at world prices and their total cost in percentage of gross domestic product (GDP) — and research and development (R&D) expenditure, particularly in developing economies. Now, Elina Brutschin from Webster University and Andreas Fleig from Heidelberg University use a Poisson process to model R&D expenditure and patent grants in 116 countries between 1980 and 2012, finding that countries such as China, Brazil, India and Turkey represent a growing share of patent activities in the energy sector.

Extending the analysis beyond the traditional OECD (Organisation for Economic Co-operation and Development) economies, the researchers find that higher oil prices are associated with an increase in R&D expenditure in oil-importing countries, whereas an increase in the fossil fuel rents is associated with a decreasing number of patents in exporting countries. GDP is positively correlated with R&D expenditures, as expected. The study highlights the rising weight of emerging economies in R&D in the energy sector and is consistent with the 'resource curse' literature, confirming the complexities in transforming resource rents into productive assets. It also improves our understanding of the uncertain, nonlinear effects that commodity prices might have on energy innovation. *AR*

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