

# Energy & Environmental Science

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## IN THIS ISSUE

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**Cover**  
See Henghui Zhou, Limin Qi et al., pp. 1924–1930. Image reproduced by permission of Limin Qi from *Energy Environ. Sci.*, 2014, 7, 1924.



**Inside cover**  
See S. Cosnier et al., pp. 1884–1888. Image reproduced by permission of S. Cosnier from *Energy Environ. Sci.*, 2014, 7, 1884.

## OPINION

1806

### Redefining efficiency for outdoor lighting

C. C. M. Kyba,\* A. Hänel and F. Höller\*

Lighting policies intended to reduce energy use must focus on energy consumed per year, rather than on luminous efficiency.



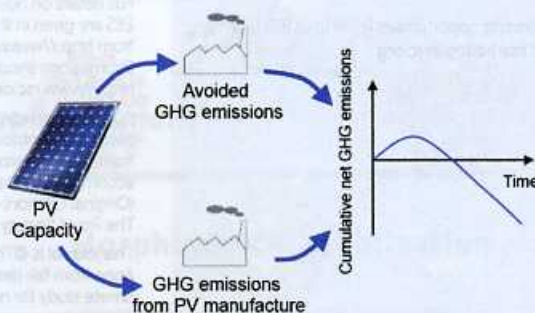
## ANALYSIS

1810

### Dynamic carbon mitigation analysis: the role of thin-film photovoltaics

C. J. M. Emmott,\* N. J. Ekins-Daukes and J. Nelson

We assess the net carbon emissions during a transition to photovoltaic power generation, comparing established and emerging thin-film PV technologies.



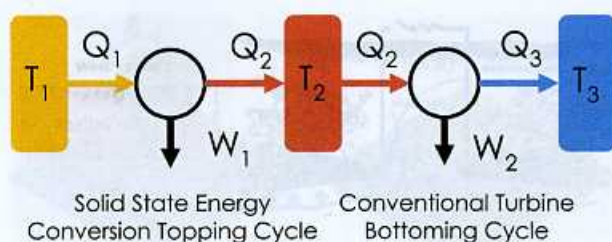


1819

### The prospect of high temperature solid state energy conversion to reduce the cost of concentrated solar power

Asegun Henry\* and Ravi Prasher

At extreme temperatures, solid state energy conversion devices may be able to survive, because they do not involve moving parts.



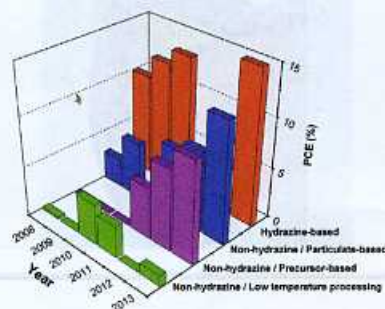
## REVIEWS

1829

### Towards low-cost, environmentally friendly printed chalcopyrite and kesterite solar cells

Hamed Azimi,\* Yi Hou and Christoph J. Brabec

Solution-processed organic and inorganic semiconductors offer a promising path towards low-cost mass production of solar cells.

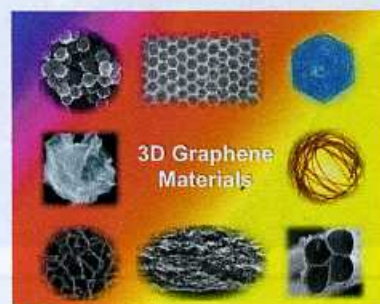


1850

### Three-dimensional graphene materials: preparation, structures and application in supercapacitors

Xiehong Cao, Zongyou Yin and Hua Zhang\*

This article reviews the recent progress on the preparation, properties and supercapacitor application of 3D graphene materials (3DGMs) with novel structures.



## PERSPECTIVE

1866

### Applications of functional fullerene materials in polymer solar cells

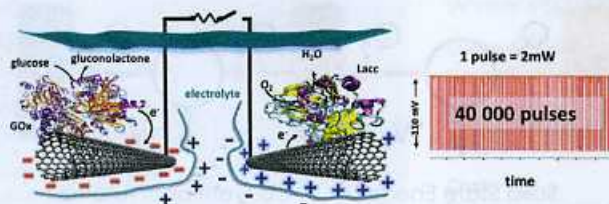
Yu-Ying Lai, Yen-Ju Cheng\* and Chain-Shu Hsu\*

Recent progress on applications of functional fullerene materials in PSCs is reviewed and the device efficiency/stability can be enhanced accordingly.





1884

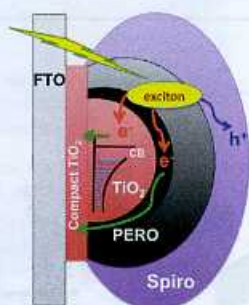


**Supercapacitor/biofuel cell hybrids based on wired enzymes on carbon nanotube matrices: autonomous reloading after high power pulses in neutral buffered glucose solutions**

C. Agnès, M. Holzinger, A. Le Goff, B. Reuillard, K. Elouarzaki, S. Tingry and S. Cosnier\*

An original supercapacitor/biofuel cell hybrid system based on compression of enzyme-carbon nanotubes enables high power discharge cycles with autonomous reloading.

1889

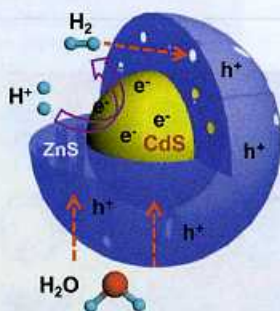


**Investigating charge dynamics in halide perovskite-sensitized mesostructured solar cells**

V. Riat, S. Colella, G. Lerario, L. De Marco, A. Rizzo, A. Listorti\* and G. Gigli

Evidence of complementary carrier percolation paths in halide perovskite-sensitized mesostructured solar cells.

1895

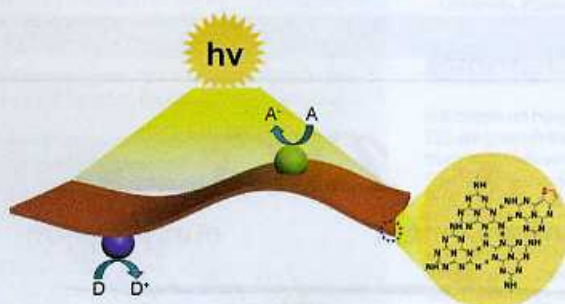


**CdS-mesoporous ZnS core-shell particles for efficient and stable photocatalytic hydrogen evolution under visible light**

Ying Peng Xie, Zong Bao Yu, Gang Liu,\* Xiu Liang Ma and Hui-Ming Cheng\*

A CdS-mesoporous ZnS core-shell structure exhibits high activity and stability in photocatalytic hydrogen evolution as a result of the mesoporous shell and spatial separation of photoexcited charge carriers.

1902



**Two dimensional conjugated polymers with enhanced optical absorption and charge separation for photocatalytic hydrogen evolution**

Mingwen Zhang and Xinchun Wang\*

Fusion of aromatic motifs into a carbon nitride nanosheet can red-shift its optical absorption and promote charge separation, and thus efficiently improve its photocatalytic activity for hydrogen evolution.

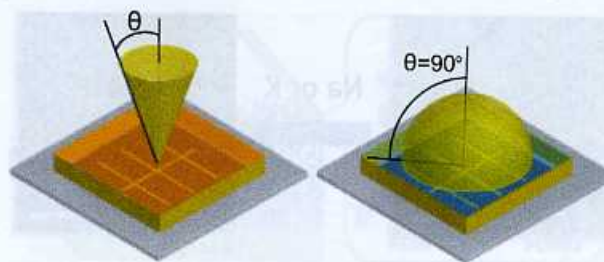


1907

### Experimental demonstration of enhanced photon recycling in angle-restricted GaAs solar cells

Emily D. Kosten, Brendan M. Kayes and Harry A. Atwater\*

Enhanced open-circuit voltage demonstrated in a high quality GaAs solar cell by limiting the angles of emitted light from the cell.



1913

### Functional graphene nanomesh foam

Yang Zhao, Chuangang Hu, Long Song, Lixia Wang, Gaoquan Shi, Liming Dai and Liangti Qu\*

Structure-hierarchical graphene nanomesh foam is assembled, providing a new material platform with favorable mass transport and richly available graphene edges.



1919

### Highly active and durable non-precious-metal catalysts encapsulated in carbon nanotubes for hydrogen evolution reaction

Jiao Deng, Pengju Ren, Dehui Deng,\* Liang Yu, Fan Yang and Xinhe Bao\*

Novel non-precious-metal catalysts encapsulated in N-doped carbon nanotubes exhibit high activity and remarkable stability towards hydrogen evolution reaction (HER) in acidic medium.



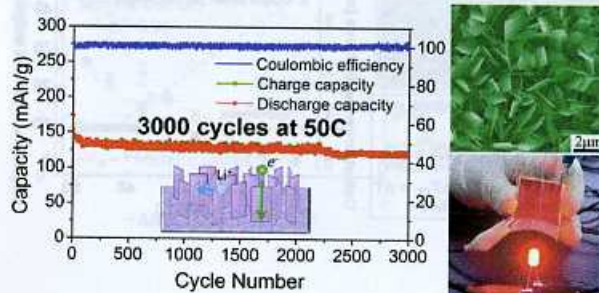
## PAPERS

1924

### Self-supported $\text{Li}_4\text{Ti}_5\text{O}_{12}$ nanosheet arrays for lithium ion batteries with excellent rate capability and ultralong cycle life

Shuai Chen, Yuelong Xin, Yiyang Zhou, Yurong Ma, Henghui Zhou\* and Limin Qi\*

$\text{Li}_4\text{Ti}_5\text{O}_{12}$  nanosheet arrays are used as a binder-free anode for lithium ion batteries with excellent rate capability and outstanding cycling performance.





1931

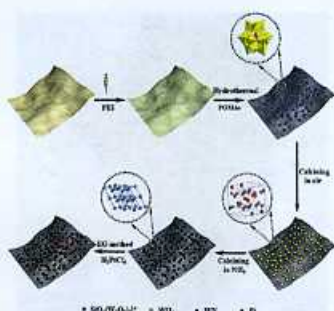


### Alkali-metal-enhanced grain growth in $\text{Cu}_2\text{ZnSnS}_4$ thin films

M. Johnson, S. V. Baryshev, E. Thimsen, M. Manno, X. Zhang, I. V. Veryovkin, C. Leighton\* and E. S. Aydil\*

Copper zinc tin sulfide (CZTS) is an emerging photovoltaic material comprised of earth abundant elements. Presence of very small amounts of sodium and potassium during the synthesis of thin CZTS films enhances grain growth and leads to microstructures ideally suited for solar cells.

1939

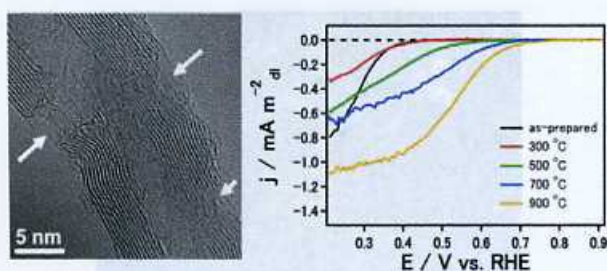


### Small-sized and high-dispersed WN from $[\text{SiO}_4(\text{W}_3\text{O}_9)_4]^{4-}$ clusters loading on GO-derived graphene as promising carriers for methanol electro-oxidation

Haijing Yan, Chungui Tian,\* Li Sun, Bo Wang, Lei Wang, Jie Yin, Aiping Wu and Honggang Fu\*

WN nanoparticles of 2–3 nm are grown on graphene, which can be used as promising carriers for methanol electro-oxidation.

1950

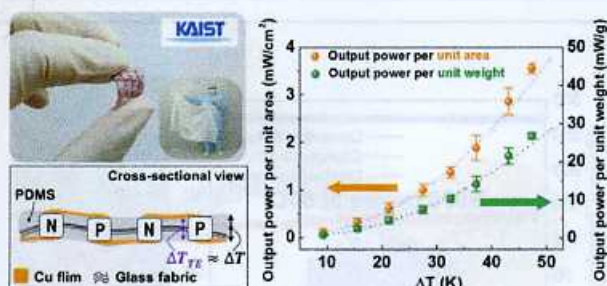


### Non-nitrogen doped and non-metal oxygen reduction electrocatalysts based on carbon nanotubes: mechanism and origin of ORR activity

Keiko Waki,\* Raymond A. Wong, Haryo S. Oktaviano, Takuya Fujio, Takuro Nagai, Koji Kimoto and Koichi Yamada

The proposed origin of the improved ORR activity is unlikely to be from residual metal impurities but from the creation of topological defects caused by the removal of high temperature CO desorbing oxygen functional groups.

1959



### A wearable thermoelectric generator fabricated on a glass fabric

Sun Jin Kim, Ju Hyung We and Byung Jin Cho\*

A glass fabric-based flexible TE generator prepared using a screen printing technique and a self-sustaining structure permits thin ( $\sim 500 \mu\text{m}$ ), light ( $\sim 0.13 \text{ g cm}^{-2}$ ), and flexible properties with high output power density.

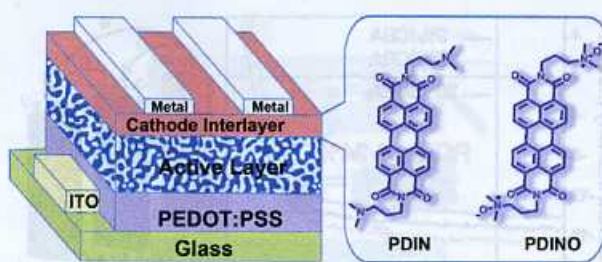


1966

### Perylene diimides: a thickness-insensitive cathode interlayer for high performance polymer solar cells

Zhi-Guo Zhang, Boyuan Qi, Zhiwen Jin, Dan Chi, Zhe Qi, Yongfang Li\* and Jizheng Wang\*

Two easy-accessible perylene diimide based thickness-insensitive cathode interlayers are developed for high performance polymer solar cells. Their high conductivities, suitable energy levels and work function tuning effects make them work well.



1974

### An inversion layer at the surface of n-type iron pyrite

Moritz Limpinsel, Nima Farhi, Nicholas Berry, Jeffrey Lindemuth, Craig L. Perkins, Qiyin Lin and Matt Law\*

Numerical modeling of Hall effect data reveals a hole inversion layer on the surface of n-type iron pyrite ( $\text{FeS}_2$ ) single crystals. Tunneling through part of this inversion layer may account for the low  $V_{OC}$  of pyrite photocells.



1990

### A reversible $\text{Br}_2/\text{Br}^-$ redox couple in the aqueous phase as a high-performance catholyte for alkaline batteries

Yu Zhao, Yu Ding, Jie Song, Lele Peng, John B. Goodenough and Guihua Yu\*

An aqueous catholyte based on the sole bromine/bromide redox couple shows an operating potential of  $\sim 4$  V, a reversible capacity of  $290 \text{ mA h g}^{-1}$ , and a specific power density approaching  $1000 \text{ W kg}^{-1}$ , making it a potential candidate for sustainable electrical energy storage.

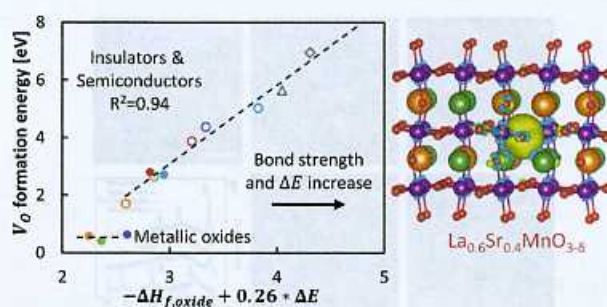


1996

### Oxide enthalpy of formation and band gap energy as accurate descriptors of oxygen vacancy formation energetics

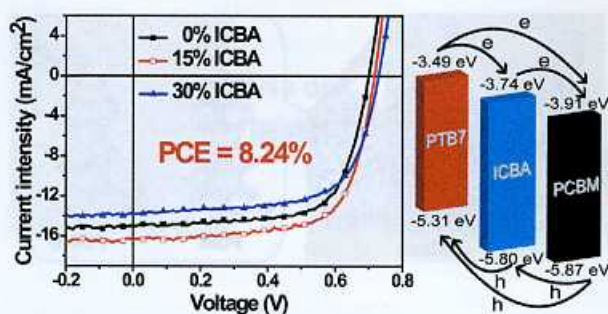
Ann M. Deml, Vlada Stevanović, Christopher L. Muhich, Charles B. Musgrave\* and Ryan O'Hayre\*

A new approach for predicting oxygen vacancy formation energies using intrinsic bulk material properties also provides improved fundamental understanding.





2005

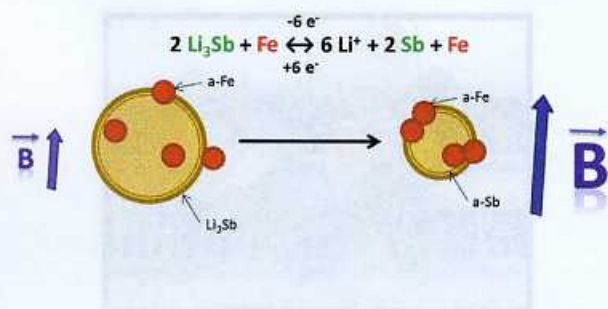


### Efficient ternary blend polymer solar cells with indene- $\text{C}_{60}$ bisadduct as an electron-cascade acceptor

Pei Cheng, Yongfang Li and Xiaowei Zhan\*

ICBA was used as an electron-cascade acceptor material in PTB7:PC<sub>71</sub>BM polymer solar cells, which exhibited power conversion efficiencies as high as 8.24%.

2012

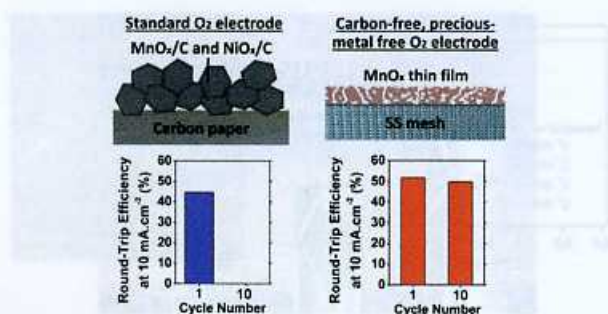


### Operando electron magnetic measurements of Li-ion batteries

Gregory Gershinsky, Elad Bar, Laure Monconduit and David Zitoun\*

Operando measurements of electron magnetism provide microscopic and quantitative data on the amorphous Fe nanostructures formed during cycling of a Li-ion battery based on a  $\text{FeSb}_2$  electrode.

2017

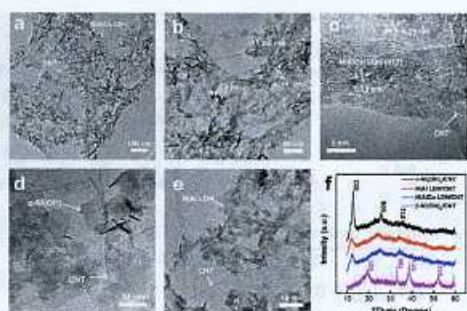


### A carbon-free, precious-metal-free, high-performance $\text{O}_2$ electrode for regenerative fuel cells and metal-air batteries

Jia Wei Desmond Ng, Maureen Tang and Thomas F. Jaramillo\*

We report a high-performance precious-metal-free and carbon-free bifunctional  $\text{O}_2$  electrode synthesized via facile electrodeposition of  $\text{MnO}_x$  on a stainless steel substrate.

2025



### Ultrafast high-capacity NiZn battery with NiAlCo-layered double hydroxide

Ming Gong, Yanguang Li, Hongbo Zhang, Bo Zhang, Wu Zhou, Ju Feng, Hailiang Wang, Yongye Liang, Zhuangjun Fan, Jie Liu and Hongjie Dai\*

High-performance, low-cost, safe and environmentally friendly batteries are important for portable electronics and electric vehicles.

# A hybrid solar-redox scheme for liquid fuel and hydrogen coproduction

Feng He, James Trainham, Gregory Parsons,  
John S. Newman and Fanxing Li\*

A ferrite based oxygen carrier promoted with a mixed ionic–electronic conductor support is used in a hybrid solar-redox scheme. Based on both experiments and simulations, this scheme has the potential to co-produce liquid fuel and hydrogen from methane and solar energy at high efficiency with near zero life cycle CO<sub>2</sub> emission.

