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See Jinlong Gong *et al.*, pp. 2177–2196. Image reproduced by permission of Jinlong Gong from *Energy Environ. Sci.*, 2016, 9, 2177.



Inside cover

See Taiho Park *et al.*, pp. 2326–2333. Image reproduced by permission of Taiho Park from *Energy Environ. Sci.*, 2016, 9, 2326.

OPINION

2172

Aspects of science and technology in support of legal and policy frameworks associated with a global carbon emissions-control regime

Nathan S. Lewis

The resolution of the delegates to COP21 in Paris suggests a step toward a global carbon emissions-control regime. We explore technical aspects of such a regime, e.g., monitoring of regional CO₂ emissions and control and regulation of global temperatures.



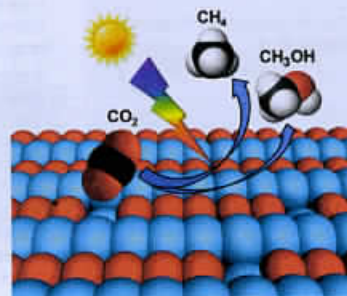
REVIEWS

2177

CO₂ photo-reduction: insights into CO₂ activation and reaction on surfaces of photocatalysts

Xiaoxia Chang, Tuo Wang and Jinlong Gong*

This review describes the current understanding of CO₂ photoreduction on the surface of heterogeneous catalysts with a particular focus on the reaction mechanism and pathways as well as the adsorption/activation of CO₂.

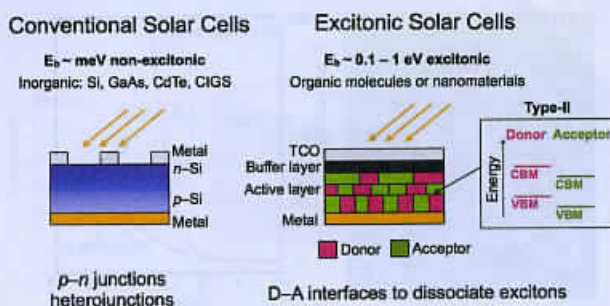


2197

Computer calculations across time and length scales in photovoltaic solar cells

Marco Bernardi* and Jeffrey C. Grossman*

Photovoltaic (PV) solar cells convert solar energy to electricity through a cascade of microscopic processes spanning over 10 order of magnitudes of time and length. We review the computational methods available to study PV solar cells, focusing on recent advances and open problems.



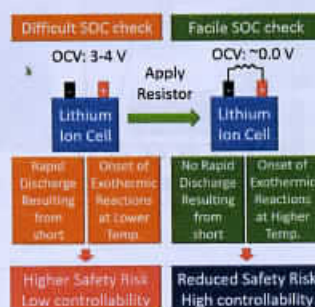
PERSPECTIVE

2219

Opportunities for near zero volt storage of lithium ion batteries

K. R. Crompton and B. J. Landi*

There are inherent safety risks associated with inactive lithium ion batteries leading to greater restrictions and regulations on shipping and inactive storage. Near zero volt storage under fixed load of all cells in a lithium ion battery is a promising approach to reduce or mitigate these safety risks in a highly controllable manner.



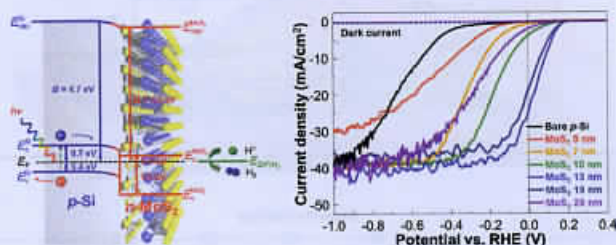
COMMUNICATIONS

2240

Wafer-scale transferable molybdenum disulfide thin-film catalysts for photoelectrochemical hydrogen production

Ki Chang Kwon, Seokhoon Choi, Kootak Hong, Cheon Woo Moon, Young-Seok Shim, Do Hong Kim, Taemin Kim, Woonbae Sohn, Jong-Myeong Jeon, Chul-Ho Lee, Ki Tae Nam, Seungwu Han, Soo Young Kim* and Ho Won Jang*

Wafer-scale $n\text{-MoS}_2/p\text{-Si}$ photocathodes with high hydrogen evolution reaction activities are demonstrated.

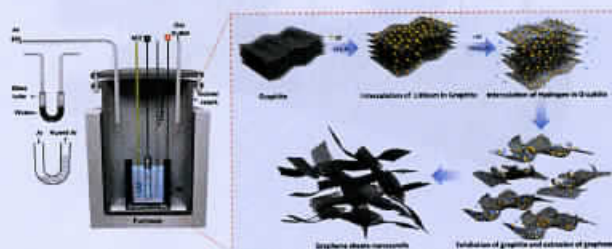


2249

Dual coexisting interconnected graphene nanostructures for high performance supercapacitor applications

Hyun-Kyung Kim, Ali Reza Kamali,* Kwang Chul Roh, Kwang-Bum Kim* and Derek John Fray*

A high-quality hierarchical carbon nanostructure consisting of graphene nanosheets and nanoscrolls can be synthesized by a facile and scalable molten salt method. This carbon nanostructure is here proposed as a high-performance supercapacitor electrode material.



2278

Light management in plastic–paper hybrid substrate towards high-performance optoelectronics

Yonggang Yao, Jinsong Tao, Jianhua Zou, Bilun Zhang, Tian Li, Jiaqi Dai, Mingwei Zhu, Sha Wang, Kun Kelvin Fu, Doug Henderson, Emily Hitz, Junbiao Peng* and Liangbing Hu*

We integrated plastic into mesoporous paper to achieve a new type of substrate plastic–paper for high performance optoelectronics.

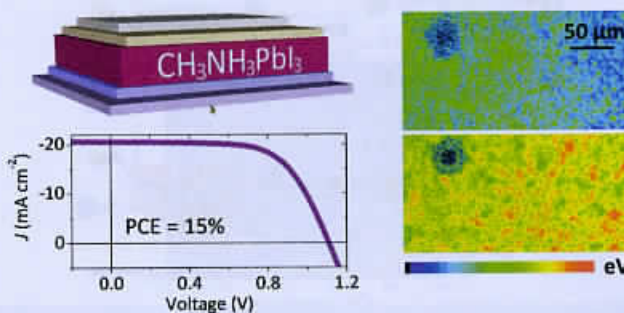


2286

Quantification of spatial inhomogeneity in perovskite solar cells by hyperspectral luminescence imaging

Gilbert El-Hajje, Cristina Momblona, Lidón Gil-Escrig, Jorge Ávila, Thomas Guillemot, Jean-François Guillemoles, Michele Sessolo, Henk J. Bolink* and Laurent Lombez*

Perovskite solar cells are analyzed by photo- and electroluminescence hyperspectral imaging. Significant spatial inhomogeneities in the quasi-Fermi level splitting are observed.

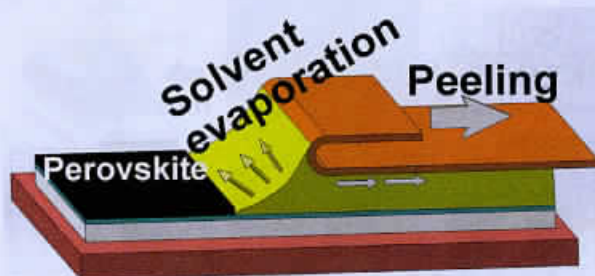


2295

Soft-cover deposition of scaling-up uniform perovskite thin films for high cost-performance solar cells

Fei Ye, Han Chen, Fengxian Xie, Wentao Tang, Maoshu Yin, Jinjin He, Enbing Bi, Yanbo Wang, Xudong Yang* and Liyuan Han*

A large area perovskite film with less structural defects and a high material utilization ratio was formed by a continuous solution processing method, soft-cover deposition.

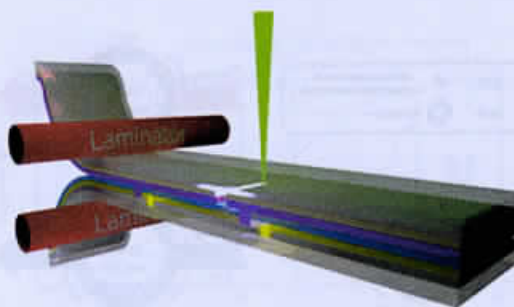


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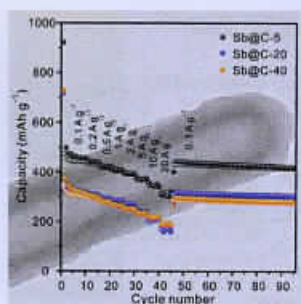
Organic and perovskite solar modules innovated by adhesive top electrode and depth-resolved laser patterning

George D. Spyropoulos,* César Omar Ramirez Quiroz, Michael Salvador, Yi Hou, Nicola Gasparini, Peter Schweizer, Jens Adams, Peter Kubis, Ning Li, Erdmann Spiecker, Tayebah Ameri, Hans-Joachim Egelhaaf and Christoph J. Brabec

We demonstrate an innovative solution-processing fabrication route for organic and perovskite solar modules.



2314

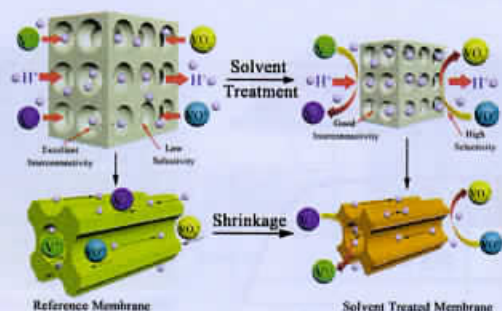


Sb@C coaxial nanotubes as a superior long-life and high-rate anode for sodium ion batteries

Zhiming Liu, Xin-Yao Yu, Xiong Wen (David) Lou* and Ungyu Paik*

Sb@C coaxial nanotubes have been designed and synthesized using a facile strategy starting with Sb_2S_3 nanorods. The as-obtained Sb@C nanotubes exhibit unprecedented sodium storage properties.

2319



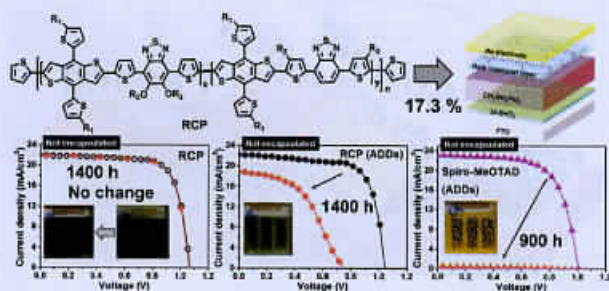
High-performance porous uncharged membranes for vanadium flow battery applications created by tuning cohesive and swelling forces

Wenjing Lu, Zhizhang Yuan, Yuyue Zhao, Xianfeng Li*, Huamin Zhang* and Ivo F. J. Vankelecom

A simple and effective solvent treatment method was developed to prepare high-performance porous membranes with a tunable morphology for VFBs.

PAPERS

2326

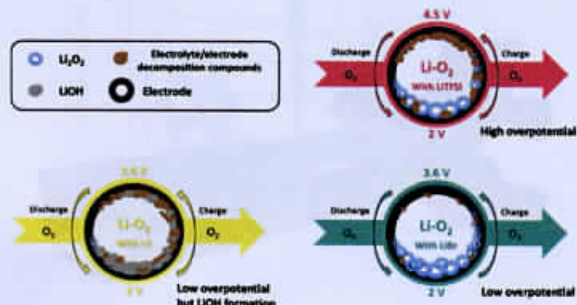


Dopant-free polymeric hole transport materials for highly efficient and stable perovskite solar cells

Guan-Woo Kim, Gyeongho Kang, Jinseck Kim, Gang-Young Lee, Hong Il Kim, Limok Pyeon, Jaechol Lee and Taiho Park*

A dopant-free polymeric hole transport material (HTM), RCP, based on benzo[1,2-*b*:4,5-*b'*]dithiophene and 2,1,3-benzothiadiazole exhibited a high efficiency of 17.3% in a perovskite solar cell and maintained its initial efficiency for over 1400 hours.

2334



Li-O₂ cells with LiBr as an electrolyte and a redox mediator

Won-Jin Kwak, Daniel Hirshberg, Daniel Sharon, Michal Afri, Aryeh A. Frimer, Hun-Gi Jung, Doron Aurbach* and Yang-Kook Sun*

Improved efficiency and cyclability of cells containing LiBr demonstrate that the appropriate choice of electrolyte solution is the key to a successful Li-O₂ battery.

2346

Iron based precursors in neutral n

Carlo Santoro
Mounika Koduru
Orianna Bretton
Plamen Atanasov
Fe-based catalysts showed high activity in AC (90–99%)

2354

A comparison of renewable

Matthew R. S...
and Eric W. ...
Solar H₂ production landscape for photovoltaic-conventional (artificial grass)

2372

In situ investigation of metastability in perovskite solar cells

Jeffery A. Agosti
Toshihiro Aoyama
Joseph J. Berry
Kai Zhu*

Organic-inorganic hybrid perovskites are an important class of materials for their remarkable light absorption and

2383

Pyroelectric tuning thermoelectric and magnetoelectric

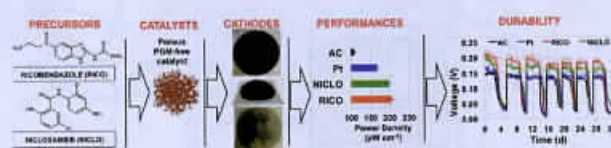
Gaurav Vats,
Chris R. Bowler
Demonstration of ferroelectric nanostructure conversion e

2346

Iron based catalysts from novel low-cost organic precursors for enhanced oxygen reduction reaction in neutral media microbial fuel cells

Carlo Santoro, Alexey Serov, Lydia Stariha, Mounika Kodali, Jonathan Gordon, Sofia Babanova, Orianna Bretschger, Kateryna Artyushkova and Plamen Atanassov*

Fe-based catalysts based on ricobendazole and niclosamide showed higher performance compared to Pt (20–25%) and AC (90–99%) and more durability in long terms operations.

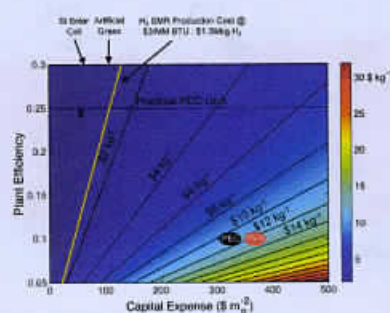


2354

A comparative techno-economic analysis of renewable hydrogen production using solar energy

Matthew R. Shaner, Harry A. Atwater, Nathan S. Lewis* and Eric W. McFarland*

Solar H₂ production cost (\$ kg⁻¹) techno-economic landscape for photoelectrochemical (PEC) and photovoltaic-electrolysis (PV-E). References include conventional H₂ production, robust outdoor material (artificial grass) and solar cell.

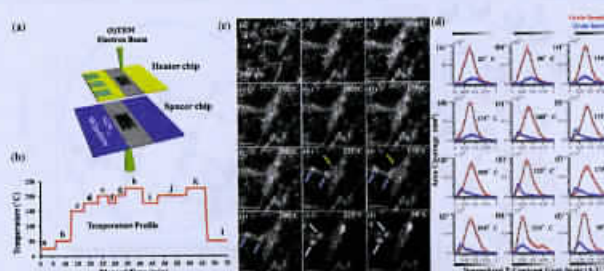


2372

In situ investigation of the formation and metastability of formamidinium lead tri-iodide perovskite solar cells

Jeffery A. Aguiar,* Sarah Wozny, Terry G. Holesinger, Toshihiro Aoki, Maulik K. Patel, Mengjin Yang, Joseph J. Berry, Mowafak Al-Jassim, Wellie Zhou* and Kai Zhu*

Organic-inorganic perovskites have emerged as an important class of next generation solar cells due to their remarkable low cost, band gap, and sub-900 nm absorption onset.

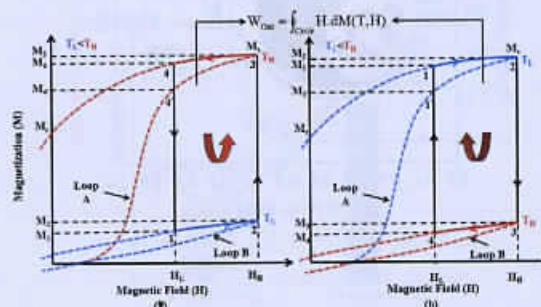


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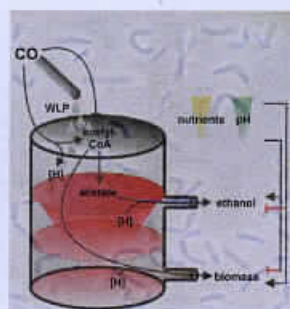
Pyroelectric control of magnetization for tuning thermomagnetic energy conversion and magnetocaloric effect

Gaurav Vats,* Ashok Kumar, Nora Ortega, Chris R. Bowen and Ram S. Katiyar

Demonstration of pyroelectric control of magnetization in ferroelectric/magnetic/ferroelectric multi-layered nanostructures for tuning thermomagnetic energy conversion efficiency and magnetocaloric effect.



2392



Ethanol production in syngas-fermenting *Clostridium ljungdahlii* is controlled by thermodynamics rather than by enzyme expression

H. Richter, B. Molitor, H. Wei, W. Chen, L. Aristilde* and L. T. Angenent*

A simplified overflow model (depicted as a rain barrel) is proposed to explain how ethanol is produced during syngas fermentation.

2400

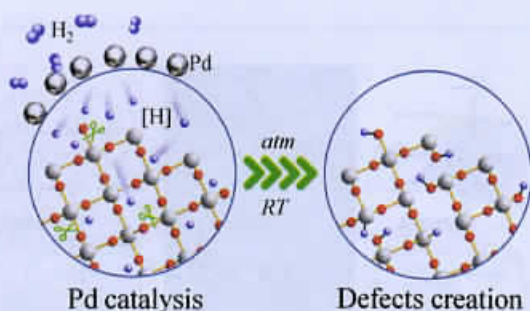


First demonstration of direct hydrocarbon fuel production from water and carbon dioxide by solar-driven thermochemical cycles using rhodium-ceria

Fangjian Lin, Matthäus Rothensteiner, Ivo Alxneit*, Jeroen A. van Bokhoven and Alexander Wokaun

Sustained production of methane directly from water and carbon dioxide by solar-driven thermochemical cycles is achieved for the first time with rhodium on ceria.

2410

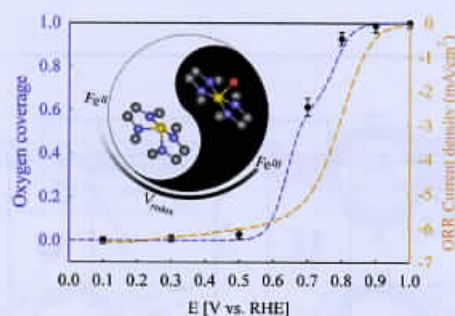


Pd-catalyzed instant hydrogenation of TiO₂ with enhanced photocatalytic performance

Yingfeng Xu, Chen Zhang, Lingxia Zhang, Xiaohua Zhang, Heliang Yao and Jianlin Shi*

This facile hydrogenation strategy is based on room temperature H₂ dissociation into [H] on Pd, providing a general methodology for transitional metal oxide hydrogenation under ordinary conditions for advanced photocatalysis systems.

2418



Structural and mechanistic basis for the high activity of Fe–N–C catalysts toward oxygen reduction

Jingkun Li, Shraboni Ghoshal, Wentao Liang, Moulay-Tahar Sougrati, Frédéric Jaouen, Barr Halevi, Samuel McKinney, Geoff McCool, Chunrong Ma, Xianxia Yuan, Zi-Feng Ma, Sanjeev Mukerjee* and Qingying Jia*

The biomimetic dynamic nature of the Fe–N–C active site with a near-optimal Fe^{2+/3+} redox potential facilitates ORR by balancing the site-blocking effect and O₂ dissociation.

2433

Water oxidation structural and inorganic

I. Zaharieva, M. R. Mohan, P. Chernev

Water oxidation where it is coupled with a Mn₄C become key

2444

Elimination of performance cells using

S. Shao, M. S. Adjokatsse, G. H. ten Br, J. C. Humm

The higher properties of synergistical effect and e

2453

Dye-sensit

Syed Ghufra, Shaik Moha, Michael Grä

Inkjet printing DSSCs with and patterns

2463

Enhancing SrTiO₃ exp photocatal

Linchao Mu, Zhiliang Wa, Ruotian Che, Can Li*

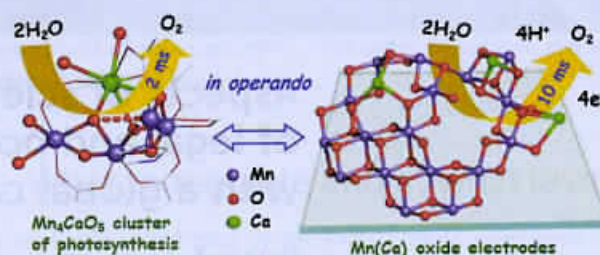
Spatial charge of high sym photocataly

2433

Water oxidation catalysis – role of redox and structural dynamics in biological photosynthesis and inorganic manganese oxides

I. Zaharieva,* D. González-Flores, B. Asfari, C. Pasquini, M. R. Mohammadi, K. Klingan, I. Zizak, S. Loos, P. Chernev and H. Dau*

Water oxidation is pivotal in biological photosynthesis, where it is catalyzed by a protein-bound metal complex with a Mn_4Ca -oxide core; related synthetic catalysts may become key components in non-fossil fuel technologies.

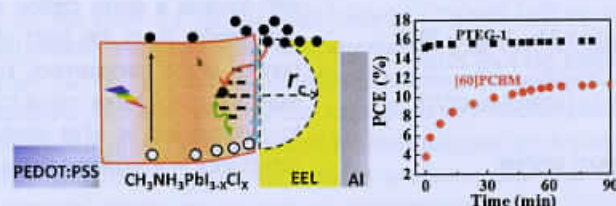


2444

Elimination of the light soaking effect and performance enhancement in perovskite solar cells using a fullerene derivative

S. Shao, M. Abdu-Aguye, L. Qiu, L.-H. Lai, J. Liu, S. Adjokatse, F. Jahani, M. E. Kammaing, G. H. ten Brink, T. T. M. Palstra, B. J. Kooij, J. C. Hummelen and M. Antonietta Loi*

The higher dielectric constant and electron donating properties of PTEG-1 electron extraction layer synergistically helps to eliminate the light soaking effect and enhance device performance.

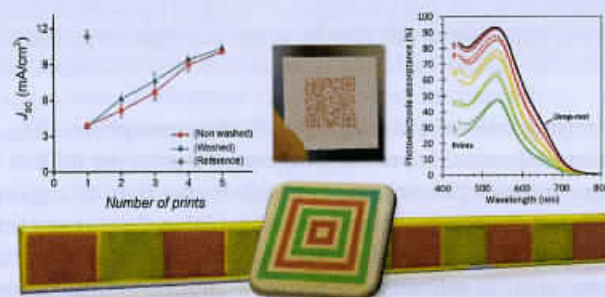


2453

Dye-sensitized solar cells with inkjet-printed dyes

Syed Ghufran Hashmi, Merve Özkan, Janne Halme,* Shaik Mohammed Zakeeruddin, Jouni Paltakari, Michael Grätzel and Peter D. Lund

Inkjet printing dyes on TiO_2 films enables the creation of DSSCs with tailored transparency, color density gradients, and patterns of multiple dyes on the same photoelectrode.



2463

Enhancing charge separation on high symmetry $SrTiO_3$ exposed with anisotropic facets for photocatalytic water splitting

Linchao Mu, Yue Zhao, Ailong Li, Shengyang Wang, Zhiliang Wang, Jingxiu Yang, Yi Wang, Taifeng Liu, Ruotian Chen, Jian Zhu, Fengtao Fan, Rengui Li* and Can Li*

Spatial charge separation achieved on the anisotropic facets of high symmetry $SrTiO_3$ nanocrystals for highly efficient photocatalytic overall water splitting.

