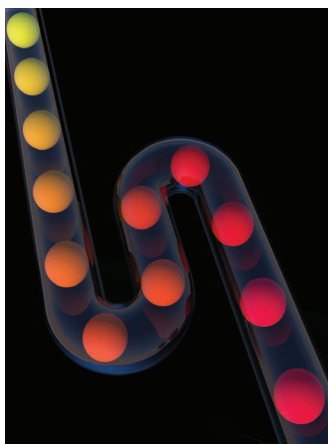


# ADVANCED FUNCTIONAL MATERIALS

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## Microfluidic Reactors

On page 2123 Martin Heeney, John C. de Mello, and co-workers describe a method for the controlled synthesis of device-grade semiconducting polymers using a droplet-based microfluidic reactor. The use of a droplet reactor provides a controlled and stable environment for polymer synthesis and avoids the usual deterioration in materials quality that can occur when conventional batch syntheses are scaled from the sub-gram level to higher quantities.

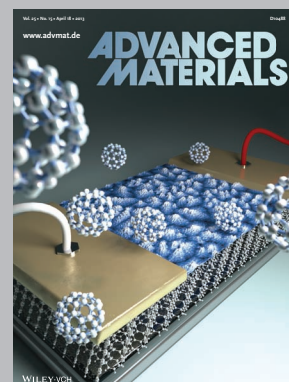
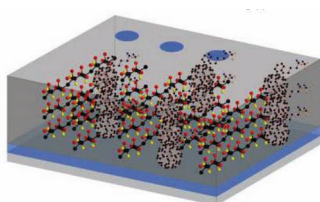
## Hierarchical Structures

The Linglong ball, a Chinese handicraft, has a hierarchically structured hollow architecture. On page 2162 Shunsheng Cao, Yi Ge, Anthony P. F. Turner, and co-workers report a high-efficiency enzyme-immobilization formulation based on the synthesized hierarchically structured hollow silica host. This shows significant advantages over existing pure hollow silica matrices, thus facilitating further multifarious applications for enhanced enzyme immobilization, biosensing, and bio-catalysis.



## Ferroelectric Materials

All-polymer, nonvolatile, bistable memory devices are fabricated from blends of ferroelectric poly(vinylidene fluoride–trifluoroethylene) (P(VDF-TrFE)) and n-type semiconducting [6,6]-phenyl-C61-butyric acid methyl ester (PCBM). As reported by H. N. Alshareef and co-workers on page 2145, the devices show excellent performance with good ON/OFF ratios, low read voltages and long retention times.



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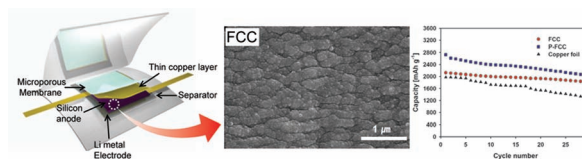
## FULL PAPERS

## Lithium-Ion Batteries

J.-Y. Choi, D. J. Lee, Y. M. Lee,  
Y.-G. Lee, K. M. Kim, J.-K. Park,\*  
K. Y. Cho\* .....2108–2114

### Silicon Nanofibrils on a Flexible Current Collector for Bendable Lithium-Ion Battery Anodes

A nanofibril structured silicon anode on a flexible current collector is demonstrated for a high energy capacity bendable lithium ion battery. The flexible batteries show over 99% coulombic efficiency with the reversible capacity over 30 cycles at 2000 mAh g<sup>-1</sup>. This new, flexible current collector suggests a new approach to utilize Si anodes for flexible batteries.

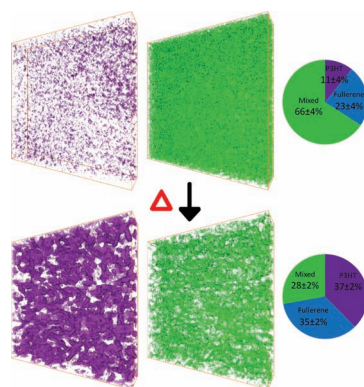


## Endohedral Fullerenes

J. D. Roehling, K. J. Batenburg,  
F. B. Swain, A. J. Moulé,\*  
I. Arslan\* .....2115–2122



### Three-Dimensional Concentration Mapping of Organic Blends

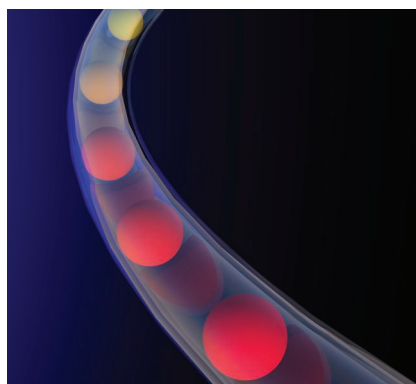


Mixtures of polymers and fullerenes (for use in solar cells) called bulk-heterojunctions (BHJs), exhibit some mutual solubility. Annealing causes the mixed regions of a BHJ to phase-segregate into its pure components, which can increase the overall device performance. By measuring the morphology of the pure and mixed regions in three dimensions, it is observed that after annealing, the remaining mixed region can allow a BHJ to more easily maintain an optimal morphology, demonstrating a possible method to increase device lifetimes.

## Semiconducting Polymers

J. H. Bannock, S. H. Krishnadasan,  
A. M. Nightingale, C. P. Yau, K. Khaw,  
D. Burkitt, J. J. M. Halls, M. Heeney,\*  
J. C. de Mello\* .....2123–2129

### Continuous Synthesis of Device-Grade Semiconducting Polymers in Droplet-Based Microreactors

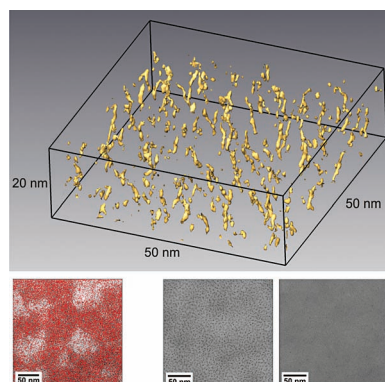


The controlled synthesis of semiconducting polymers in droplet-based microreactors is described. Using poly(3-hexylthiophene) (P3HT) as a test polymer, a product of controllable molecular weight and high regioregularity (>98%) is obtained at rates of up to 60 g/day. The droplet-synthesized P3HT yields power conversion efficiencies of 4% when combined with [6,6]-phenyl-C61-butyric acid methyl ester (PCBM) in bulk heterojunction solar cells.

## Organic Electronics

D. Donhauser,\* M. Pfannmöller,  
L. Dieterle, K. Schultheiß,  
R. R. Schröder, W. Kowalsky,  
M. Kröger .....2130–2136

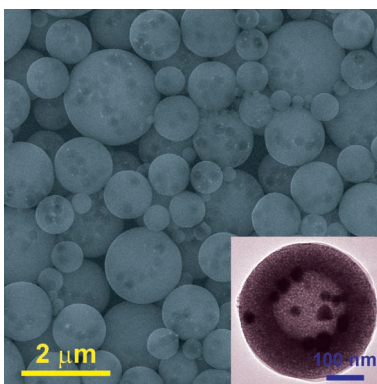
### Observation of Filamentous Nanostructures in Organic-Inorganic Composite Thin Films Deposited by Co-Evaporation



Organic-inorganic composites fabricated via co-evaporation of two materials reveal a filamentous nanostructure with filaments preferentially oriented perpendicular to the substrate plane. This growth process can be controlled by changing the substrate temperature so that for films evaporated on cooled substrates no filament growth can be detected.

## FULL PAPERS

**Polystyrene nanospheres are employed simultaneously as the template** for creating hollow interiors and as the carrier for bringing noble metal nanocrystals in mesoporous metal oxide microspheres. The preparation relies on aerosol spray-assisted assembly. The Pd nanocube-embedded hollow mesoporous  $\text{ZrO}_2$  microspheres exhibit much better catalytic performances than a commercial Pd/C catalyst.

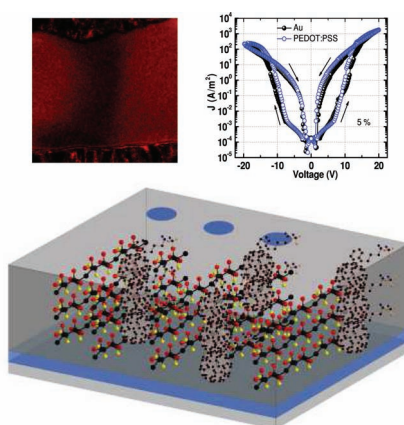


## Mesoporous Materials

Z. Jin, F. Wang, F. Wang, J. X. Wang, J. C. Yu, J. F. Wang\* .....2137–2144

**Metal Nanocrystal-Embedded Hollow Mesoporous  $\text{TiO}_2$  and  $\text{ZrO}_2$  Microspheres Prepared with Polystyrene Nanospheres as Carriers and Templates**

**All-polymer nonvolatile resistive memory devices** are fabricated using a blend of ferroelectric poly(vinylidene fluoride–trifluoroethylene) (P(VDF-TrFE)) and n-type semiconducting [6,6]-phenyl-C61-butyric acid methyl ester (PCBM) with doped poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) electrodes. The nanometer-scale phase separated films consist of PCBM domains that extend from the bottom to the top electrode, surrounded by a ferroelectric P(VDF-TrFE) matrix. The devices show excellent performance with good ON/OFF ratios, low read voltages, and long retention times.



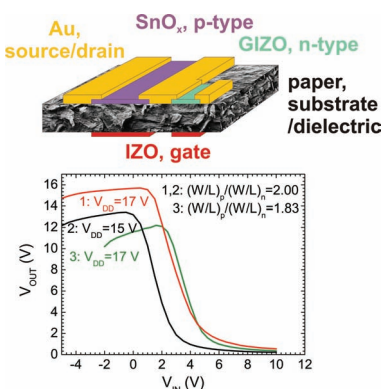
## Ferroelectric Materials

M. A. Khan, U. S. Bhansali, D. Cha, H. N. Alshareef\* .....2145–2152

**All-Polymer Bistable Resistive Memory Device Based on Nanoscale Phase-Separated PCBM-Ferroelectric Blends**



**Cross-sectional schematic of the complementary inverter circuit with, and on paper** with gallium-indium-zinc-oxide (GIZO) as the n-channel and  $\text{SnO}_x$  as the p-channel transistor. The use of thin semiconductor films leads to a mesh-like channel layer, which gives the circuits unique electrical and mechanical properties.

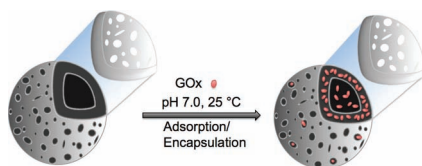


## Flexible Electronics

R. F. P. Martins,\* A. Ahnood, N. Correia, L. M. N. P. Pereira, R. Barros, P. M. C. B. Barquinha, R. Costa, I. M. M. Ferreira, A. Nathan,\* E. E. M. C. Fortunato\* .....2153–2161

**Recyclable, Flexible, Low-Power Oxide Electronics**

**The enhanced surface area and higher stability of the hierarchically structured hollow silica** are shown to offer significant advantages for the encapsulation of glucose oxidase from aqueous media. Enhanced loading, enhanced bioactivity, and decreased leaching are demonstrated.



## Hierarchical Structures

S. Cao,\* L. Fang, Z. Zhao, Y. Ge,\* S. Piletsky, A. P. F. Turner\* .....2162–2167

**Hierarchically Structured Hollow Silica Spheres for High Efficiency Immobilization of Enzymes**

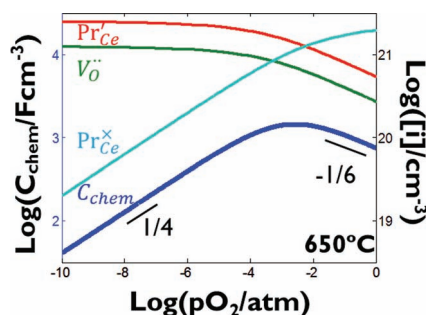


## FULL PAPERS

## Thin Films

D. Chen, S. R. Bishop,  
H. L. Tuller\* .....2168–2174

**Non-stoichiometry in Oxide Thin Films: A Chemical Capacitance Study of the Praseodymium-Cerium Oxide System**

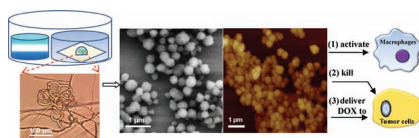


Chemical capacitance is demonstrated to reliably measure the oxygen content of an oxide thin film. A key step in this analysis, the derivation of absolute oxygen vacancy concentration, is achieved using defect equilibria based power laws (see figure). Thermodynamic constants defining defect generation are extracted from the data and general agreement with bulk values is found, despite evidence to the contrary in the literature.

## Nanoparticles

Y. Wang, L. Sun, S. Yi, Y. Huang,  
S. C. Lenaghan,  
M. Zhang\* .....2175–2184

**Naturally Occurring Nanoparticles from *Arthrobotrys oligospora* as a Potential Immunostimulatory and Antitumor Agent**

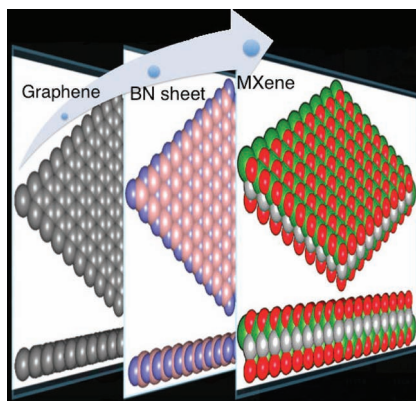


A nematode-trapping fungus, *Arthrobotrys oligospora*, cultured in a sitting drop culture system, produces abundant spherical nanoparticles. The fungal nanoparticles have an average size of 360–370 nm, with a zeta potential of –33 mV. They contain glycosaminoglycan and protein components, and demonstrate potential activity as an immunostimulatory and antitumor agent for cancer immunochemotherapy.

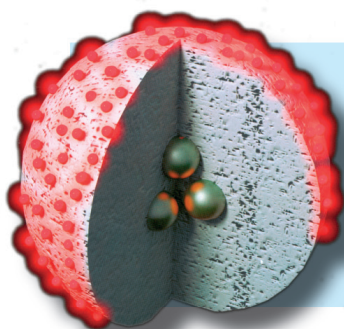
## Semiconductors

M. Khazaei,\* M. Arai, T. Sasaki,  
C.-Y. Chung, N. S. Venkataramanan,  
M. Estili, Y. Sakka,  
Y. Kawazoe .....2185–2192

**Novel Electronic and Magnetic Properties of Two-Dimensional Transition Metal Carbides and Nitrides**



**2D, single-layer nanostructures** of transition metal carbides and nitrides, so-called MXene, here  $M_2C$  ( $M = \text{Sc, Ti, V, Cr, Zr, Nb, Ta}$ ) and  $M_2N$  ( $M = \text{Ti, Cr, Zr}$ ), which are chemically functionalized by F, OH, and O groups, are shown to have potential applications in optoelectronic, spintronic, and thermoelectric nanodevices based on first-principles calculations.



## How to contact us:

## Editorial Office:

Phone: (+49) 6201-606-286/531  
Fax: (+49) 6201-606-500  
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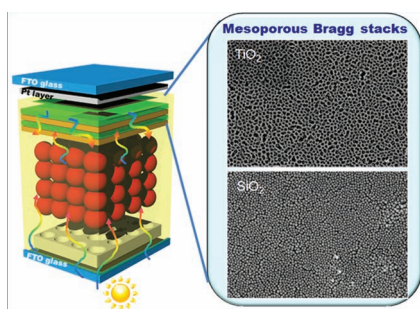
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# FULL PAPERS

A heterostructured photoanode based on mesoporous titania layer with a Bragg stack results in high efficiency dye-sensitized solar cells (6.6% for solid electrolyte). The efficiency improvements are due to improved light collection, decreased interfacial resistance at electrode/electrolyte, and excellent electrolyte infiltration.

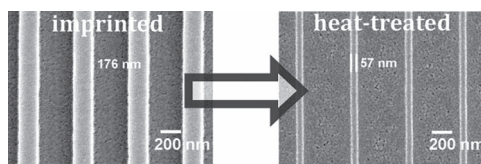


## Mesoporous Materials

J. T. Park, J. H. Prosser, S. H. Ahn,  
S. J. Kim, J. H. Kim,\*  
D. Lee\* .....2193–2200

**Enhancing the Performance of Solid-State Dye-Sensitized Solar Cells Using a Mesoporous Interfacial Titania Layer with a Bragg Stack**

By combining the benignant elements from sol-gel and methacrylate routes and mitigating the disadvantages associated with these methods, a universal method of direct thermal nanoimprinting of oxides is demonstrated using precursors produced by reacting an alkoxide with 2-(methacryloyloxy)ethyl acetoacetate (MAEAA). MAEAA possesses  $\beta$ -ketoester and methacrylate groups; the former forms an environmentally stable precursor while the latter enables polymerization during imprinting.

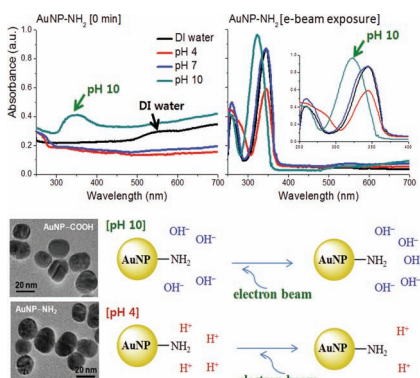


## Lithography

S. S. Dinachali, M. S. M. Saifullah,\*  
R. Ganesan,\* E. S. Thian,  
C. He .....2201–2211

**A Universal Scheme for Patterning of Oxides via Thermal Nanoimprint Lithography**

**Surface properties of functionalized nanoparticle (NPs) under different solvent conditions are modified by electron beam treatment.** The specific surface layer (proximity length) of the NPs is activated, which modifies the NPs' light-responsiveness. For example, amine-functionalized NPs activated by the electron beam, exhibit UV-vis absorbance at the lower wavelength than that those without electron beam treatment. This NP activation technology is advantageous for effective light energy use.



## Nanoparticles

S. Ahn,\* S. Y. Jung,  
S. J. Lee\* .....2212–2217

**Surface-Activated Nanoparticles for Controlled Light-Responsiveness**