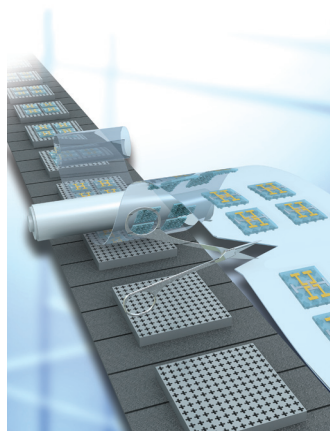


# ADVANCED FUNCTIONAL MATERIALS

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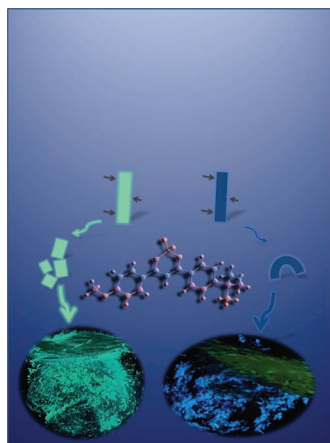
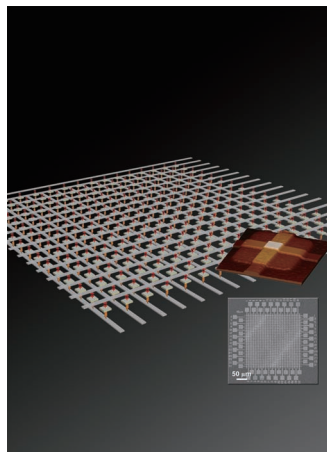


## Microcontact Printing

Sticker-type electronics give electronic functions to unconventional substrates. On page 1375 Heung Cho Ko and co-workers demonstrate an advanced methodology to guarantee both stability in device fabrication and high-efficiency transfer printing of final devices to enable such a stick-and-play system. They employ a water-soluble sacrificial layer on a dimpled handling substrate, which enables the topological confinement of the ultrathin substrate.

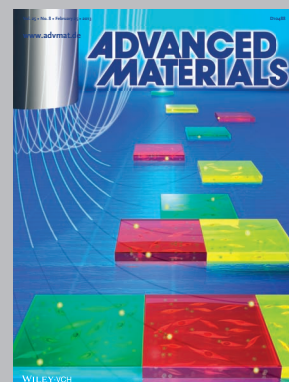
## Resistive Memory

Fully functional crossbar array ReRAM devices with  $32 \times 32$  memory block size are reported by Cheol Seong Hwang and co-workers on page 1440. The schematic structure of the 1 diode-1 resistor crossbar array devices is shown in the image. The adopted Schottky diode, serially connected with a unipolar resistive switching memory element, suppresses the sneak-current flow. It also controls the conducting path formation during switching and protects the memory from noise during retention.



## Crystal Engineering

Quantification of mechanical properties using a nanoindentation technique in a polymorphic, mechanochromic luminescent (ML) material allows a structure-mechanical response in the stiff and soft forms to be established. This explains the quick recovery and a very prominent reversible ML behavior of the two forms. On page 1422, Upadrasta Ramamurty, Chilla Malla Reddy, and co-workers report that the introduction of slip planes in crystals is the key to achieving an efficient ML property in fluorophores or a soft nature in organic functional materials.



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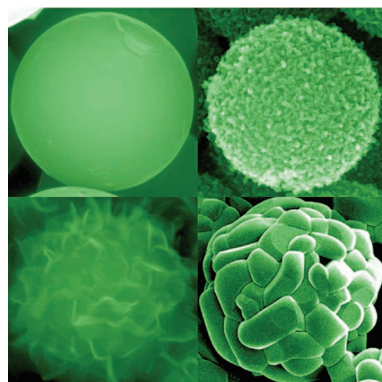
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## FEATURE ARTICLE

## Spherical Nanostructures

D. Chen, R. A. Caruso\* .....1356–1374

## Recent Progress in the Synthesis of Spherical Titania Nanostructures and Their Applications



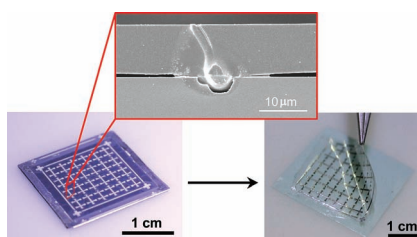
Advances in the fabrication and application of diverse spherical titania nanostructures over the last decade are summarized. These nanostructures show excellent performance in applications including biomolecular separation, clean energy utilization, conversion and storage, photoluminescence, electrorheological fluids, catalysis, drug delivery, and gas sensing.

## FULL PAPERS

## Microcontact Printing

S. H. Kim, J. Yoon, S. O. Yun,  
Y. Hwang, H. S. Jang,  
H. C. Ko\* .....1375–1382

## Ultrathin Sticker-Type ZnO Thin Film Transistors Formed by Transfer Printing via Topological Confinement of Water-Soluble Sacrificial Polymer in Dimple Structure

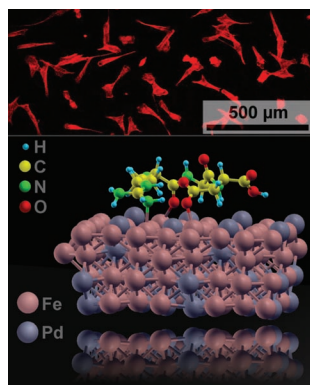


Topologically confining a water-soluble sacrificial polymer layer on a dimpled handling substrate enables controllability of the interfacial adhesion force between the ultrathin substrate and a handling substrate. This technology provides a high yield of transfer printing in a deterministic manner without altering the position of printable designs to formulate sticker-type ZnO thin film transistors.

## Smart Materials

M. Zink, F. Szillat, U. Allenstein,  
S. G. Mayr\* .....1383–1391

## Interaction of Ferromagnetic Shape Memory Alloys and RGD Peptides for Mechanical Coupling to Cells: from Ab Initio Calculations to Cell Studies

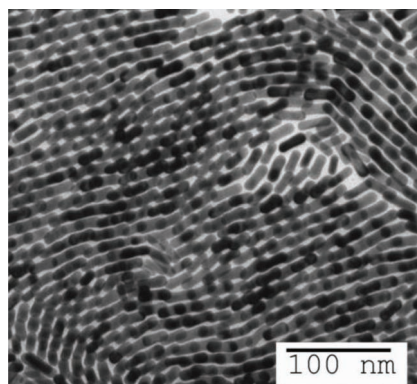


The ferromagnetic shape memory alloy Fe-Pd bears enormous potential for bio-medical actuators and sensors. The physics of bonding of arginine-glycine-aspartic (RGD), the major binding motif for cells, to Fe-Pd surfaces is explored by employing a combination of ab initio calculations, delamination experiments, and cell tests. Due to strong RGD–Fe-Pd binding, which exceeds the RGD–integrin interaction by an order of magnitude, effective mechanical coupling to cells is established.

## Liquid Crystals

S. Umadevi, X. Feng,  
T. Hegmann\* .....1393–1403

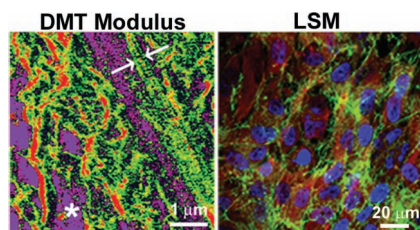
## Large Area Self-Assembly of Nematic Liquid-Crystal-Functionalized Gold Nanorods



Fascinating nematic- and smectic-like self-assembled arrays are observed for gold nanorods partially capped with either laterally or terminally substituted nematic liquid crystals upon slow evaporation of an organic solvent on transmission electron microscopy (TEM) grids. These arrays can be manipulated and reoriented by applying an external magnetic field from quasi-planar to vertical, similar to a Fréedericksz transition of common organic nematic liquid crystals.

## FULL PAPERS

**Nanoscale replication of the hierarchical organization of minerals in naturally mineralized tissues** is successfully achieved by using a coprecipitation procedure based on two biomimetic analogs. This highly ordered mineralized collagen matrix, with improved nanomechanics and cytocompatibility, offers the opportunity for its potential use as a scaffold in bone grafting and tissue engineering.

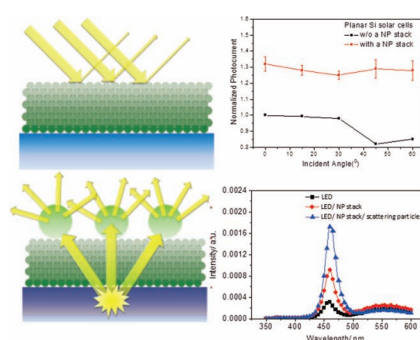


## Biomimetics

Y. Liu, D. Luo, X.-X. Kou, X.-D. Wang, F. R. Tay, Y.-L. Sha, Y.-H. Gan,\*  
Y.-H. Zhou\* ..... 1404–1411

**Hierarchical Intrafibrillar Nanocarbonated Apatite Assembly Improves the Nanomechanics and Cytocompatibility of Mineralized Collagen**

**Nanoparticles (NPs) enhance both the omnidirectional light harvesting of solar cells and the light extraction of light-emitting diodes (LEDs).** The photocurrent of silicon-based solar cells can be significantly improved omnidirectionally using an optical gradient of a NP stack and the light-extraction efficiency of LEDs can also be enhanced, due to both the graded refractive index and the moderate surface roughness.

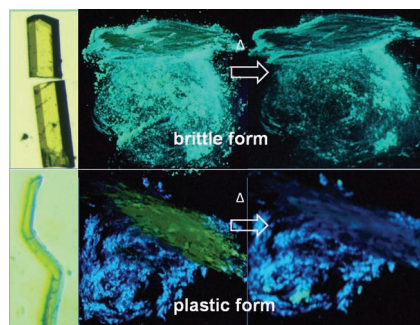


## Dielectric Nanoparticles

C. Y. Fang, Y. L. Liu, Y. C. Lee, H. L. Chen,\* D. H. Wan,  
C. C. Yu ..... 1412–1421

**Nanoparticle Stacks with Graded Refractive Indices Enhance the Omnidirectional Light Harvesting of Solar Cells and the Light Extraction of Light-Emitting Diodes**

**Quantification of mechanical properties using a nanoindentation technique in a polymorphic, mechanochromic luminescent (ML) material** allows a structure-mechanical response in the stiff and soft forms to be established. This explains the quick recovery and a very prominent reversible ML behavior of the two forms. The structural analysis suggests that the introduction of slip planes in crystals is the key to achieving an efficient ML property in fluorophores or a soft nature in organic functional materials.

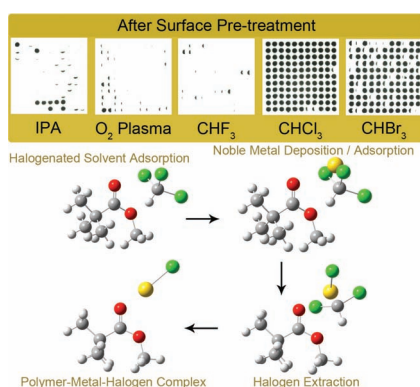


## Luminescence

G. R. Krishna, M. S. R. N. Kiran, C. L. Fraser, U. Ramamurty,\*  
C. M. Reddy\* ..... 1422–1430

**The Relationship of Solid-State Plasticity to Mechanochromic Luminescence in Difluoroboron Avobenzone Polymorphs**

**Noble metal deposition onto polymeric substrates** is important for electrodes in biomedical, microelectronic, and microfluidic applications. Optical microscopy images of adhesion tests on substrates are shown poly(methyl methacrylate) (PMMA) for arrays of Au dots deposited via electron beam evaporation pretreated with isopropyl alcohol, a remote  $O_2$  plasma, fluoroform vapor, and spin-cast with chloroform and bromoform. Density functional theory calculation of a model PMMA/ $CHCl_3$ /Au system shows that residual solvent molecules result in improved metal adhesion with hydrohalocarbon pretreatment.



## Thin Films

A. K. Mo, V. L. Brown, B. K. Rugg, T. C. DeVore, H. M. Meyer, X. Hu, W. C. Hughes,  
B. H. Augustine\* ..... 1431–1439

**Understanding the Mechanism of Solvent-Mediated Adhesion of Vacuum Deposited Au and Pt Thin Films onto PMMA Substrates**

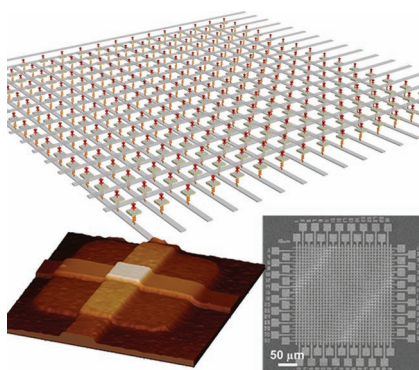


## FULL PAPERS

## Resistive Switching

G. H. Kim, J. H. Lee, Y. Ahn, W. Jeon,  
S. J. Song, J. Y. Seok, J. H. Yoon,  
K. J. Yoon, T. J. Park,  
C. S. Hwang\* .....1440–1449

**32 × 32 Crossbar Array Resistive Memory Composed of a Stacked Schottky Diode and Unipolar Resistive Memory**

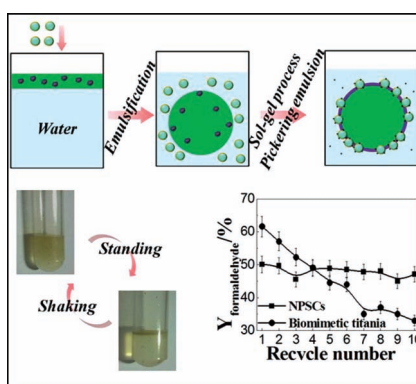


**1 diode 1 resistor (1D1R) resistive memory devices with the crossbar array configuration** composed of a stacked Schottky diode (Pt/TiO<sub>2</sub>/Ti/Pt) and unipolar resistive (URS) memory (Pt/TiO<sub>2</sub>/Pt) elements are fabricated, and their fluent functionality is proven. Atomic force microscopy is used to image one memory cell and scanning electron microscopy is used to study the 32 × 32 memory array.

## Pickering Emulsions

J. F. Shi, X. L. Wang, W. Y. Zhang,  
Z. Y. Jiang,\* Y. P. Liang, Y. Y. Zhu,  
C. H. Zhang .....1450–1458

**Synergy of Pickering Emulsion and Sol-Gel Process for the Construction of an Efficient, Recyclable Enzyme Cascade System**



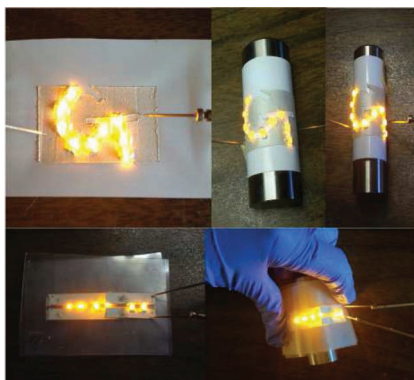
**An efficient and recyclable enzyme cascade system** enabled by nanoparticle-stabilized capsules is constructed through the synergy between a Pickering emulsion and sol-gel process. When utilized for CO<sub>2</sub> conversion, the enzyme cascade system exhibits high activity, long-term stability, and superior recyclability.

## Flexible Electronics

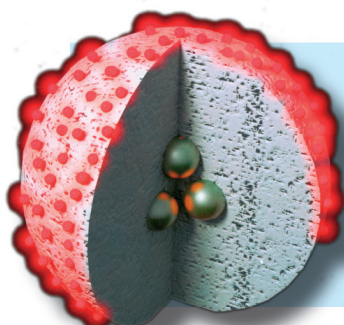
Z. Li, R. Zhang, K.-S. Moon,  
Y. Liu, K. Hansen, T. Le,  
C. P. Wong\* .....1459–1465



**Highly Conductive, Flexible, Polyurethane-Based Adhesives for Flexible and Printed Electronics**



**A highly conductive polyurethane (PU)-based adhesive** is developed by generating and sintering silver nanoparticles in situ during the curing of silver/PU composites. With the high conductivity, mechanical compliance, good adhesion, and compatibility with various flexible substrates, the PU-based adhesive is promising in support of various advanced interconnection techniques for flexible electronics, including flip-chip and 3D integration.



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## FULL PAPER

## Photovoltaic Devices

H.-S. Duan, W. Yang, B. Bob, C.-J. Hsu,  
B. Lei, Y. Yang\* ..... 1466–1471

**The Role of Sulfur in Solution-Processed  
 $\text{Cu}_2\text{ZnSn}(\text{S,Se})_4$  and its Effect on Defect  
Properties**

Defect properties of  $\text{Cu}_2\text{ZnSn}(\text{S,Se})_4$  with different sulfur content are investigated through admittance spectroscopy and charge density profiling, which are consistent with the cells' characteristics deduced from current density–voltage measurements. As the sulfur content increases, the bandgap of the absorber is enlarged, leading to open-circuit voltage increases, accompanied by a stronger recombination due to higher defect density.

