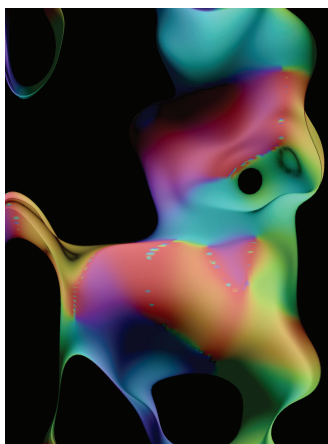


# ADVANCED FUNCTIONAL MATERIALS

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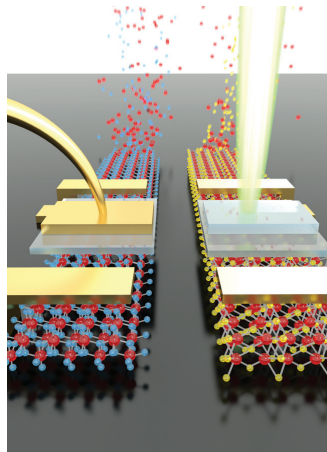


## Ferroelectrics

Y. Kim, S. V. Kalinin, and co-workers report ferroelectric domain wall motion in  $\text{Pb}(\text{Zr,Ti})\text{O}_3$  nanocapacitors, observed by 5D piezoresponse force microscopy. The nucleation and subsequent domain wall motions are spatially visualized and analyzed on page 3971. A universality of ferroelectric switching is observed to hold both on the spatially averaged level and also locally.

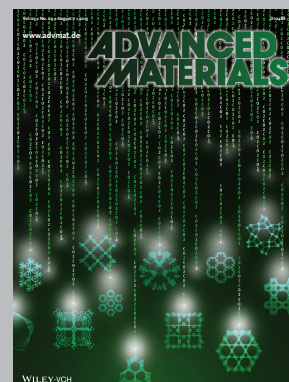
## Semiconductors

Alternative two-dimensional semiconductors are sought by S. Balendhran, K. Kalantar-zadeh, and co-workers. On page 3952, the authors describe the current state of the art of layered, two-dimensional molybdenum trioxide and dichalcogenides, including their fundamental properties, synthesis, and applications. The cover image portrays 2D  $\text{MoO}_3$  field-effect transistors and  $\text{MoS}_2$  phototransistors.



## Liquid Crystals

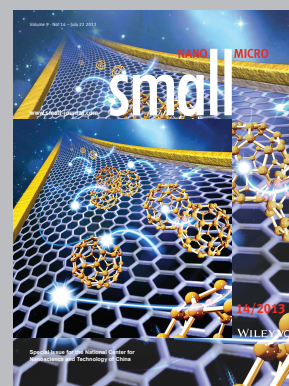
S. M. Eaton and co-workers report the first experimental proof of the bistability of nematic liquid crystals incorporated in a porous network with a controlled geometry. This configuration, described in detail on page 3990, is specifically designed to enhance memory effects by inducing a regular arrangement of topological defects. The cover image shows this three dimensional porous network, fabricated by femtosecond laser lithography, with the incorporated liquid crystals. This composite material could be exploited for future ultralow-power bistable displays.



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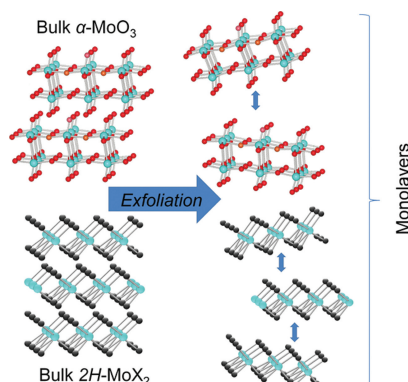
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## FEATURE ARTICLE

## Semiconductors

S. Balendhran,\* S. Walia, H. Nili,  
J. Z. Ou, S. Zhuiykov, R. B. Kaner,  
S. Sriram, M. Bhaskaran,  
K. Kalantar-zadeh\* .....3952–3970

### Two-Dimensional Molybdenum Trioxide and Dichalcogenides



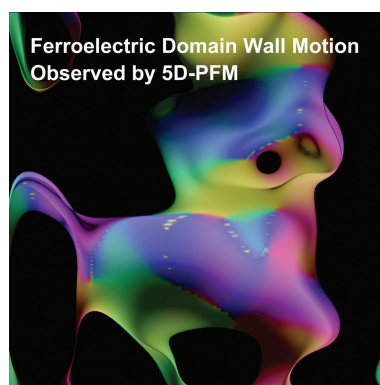
In the quest for alternative two-dimensional semiconductors, layered molybdenum trioxide and dichalcogenides are gaining significant scientific interest. This Feature Article delivers a comprehensive review of the fundamental properties, synthesis techniques, and applications of layered  $\text{MoO}_3$ ,  $\text{MoS}_2$ ,  $\text{MoSe}_2$ , and  $\text{MoTe}_2$  as well as exploring their future prospects in the field of two-dimensional semiconductors.

## FULL PAPERS

## Ferroelectrics

Y. Kim,\* X. Lu, S. Jesse, D. Hesse,  
M. Alexe, S. V. Kalinin\* .....3971–3979

### Universality of Polarization Switching Dynamics in Ferroelectric Capacitors Revealed by 5D Piezoresponse Force Microscopy

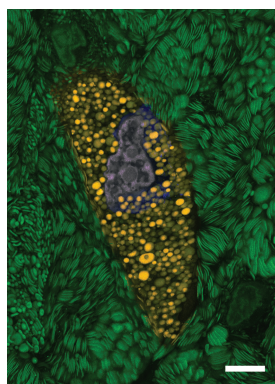


Ferroelectric polarization switching is sensitively affected by phenomena on multiple length scales, giving rise to complex voltage- and time-controlled behavior. Spatially resolved switching dynamics in ferroelectric nanocapacitors are explored as a function of voltage pulse time and magnitude. A remarkable persistence of formal macroscopic scaling laws for polarization switching based on classical models down to nanoscale volumes is observed.

## Biophotonics

L. M. Mäthger,\* S. L. Senft, M. Gao,  
S. Karaveli, G. R. R. Bell, R. Zia,  
A. M. Kuzirian, P. B. Dennis,  
W. J. Crookes-Goodson, R. R. Naik,  
G. W. Kattawar,  
R. T. Hanlon .....3980–3989

### Bright White Scattering from Protein Spheres in Color Changing, Flexible Cuttlefish Skin

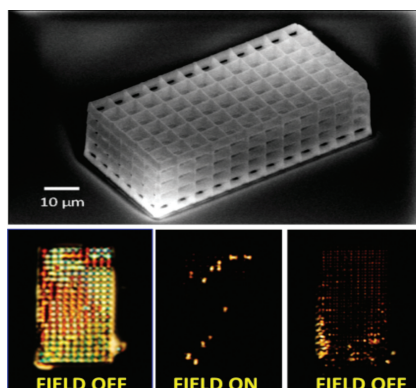


White light scattering cells in the flexible skin of cuttlefish (*Sepia officinalis*) are described. How the structure and composition of leucophores serve as passive reflectors approximating optical properties of a broadband Lambertian surface is investigated. The cuttlefish system may provide a template for bio-inspired approaches to efficient light scattering in materials science and optical engineering.

## Liquid Crystals

F. Serra, S. M. Eaton,\* R. Cerbino,  
M. Buscaglia, G. Cerullo, R. Osellame,  
T. Bellini .....3990–3994

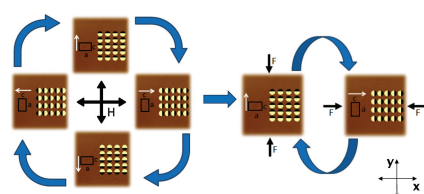
### Nematic Liquid Crystals Embedded in Cubic Microlattices: Memory Effects and Bistable Pixels



Nematic liquid crystals confined inside cubic scaffolds made by two-photon polymerization exhibit bistability and large memory effects in response to electric fields, due to topological defects interacting with the solid structure. When viewed through crossed polarizers, the pixels, which are initially bright, remain dark after the application of strong electric fields.

## FULL PAPERS

The magnetic shape memory alloy, Ni-Mn-Ga, is shown to exhibit multi-bit non-volatile memory behavior. Using nanoindentation, local modifications of the magnetic stray field enable the patterning of magnetic information. Four magnetic-based memory states are demonstrated due to magnetic field or stress-induced twin rearrangement along two crystal orientations, each with two possible magnetic orientations.

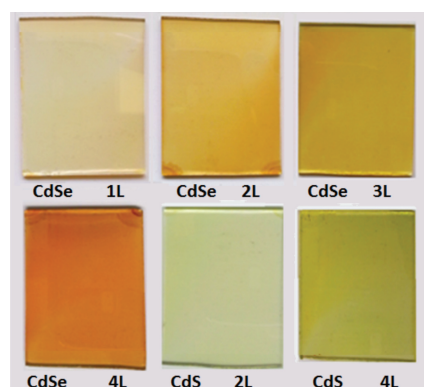


## Magnetic Memory

C. S. Watson,\* C. Hollar, K. Anderson, W. B. Knowlton, P. Müllner ....3995–4001

## Magnetomechanical Four-State Memory

High quality mesoporous metal titanate thin films are synthesized using a molten-phase-assisted self-assembly (MASA) method. The metal salts are used as a non-volatile solvent in the new assembly process. The films are converted into mesoporous titania-metal chalcogenides ( $\text{TiO}_2\text{-CdS}$ ,  $\text{TiO}_2\text{-CdSe}$ , and  $\text{TiO}_2\text{-ZnSe}$ ) under  $\text{H}_2\text{S}$  or  $\text{H}_2\text{Se}$  at room temperature and may find applications in solar cells, catalysis, photocatalysis, electronics, and optoelectronics.

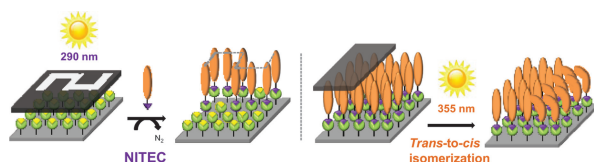


## Mesoporous Metals

C. Karakaya, Y. Türker, Ö. Dag\* .....4002–4010

## Molten-Salt-Assisted Self-Assembly (MASA)-Synthesis of Mesoporous Metal Titanate-Titania, Metal Sulfide-Titania, and Metal Selenide-Titania Thin Films

Patterned photoswitchable surfaces are prepared by employing a nitrile imine-mediated tetrazole ene cycloaddition (NITEC) photoinduced process in the presence of dipolarophiles based on photoresponsive azobenzene moieties. *Trans-to-cis* azobenzene isomerization of the surface allows for the spatially resolved tuning of the surface properties.

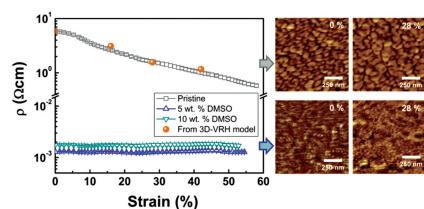


## Surface Modification

E. Blasco, M. Piñol, L. Oriol\*  
B. V. K. J. Schmidt, A. Welle,  
V. Trouillet, M. Bruns,  
C. Barner-Kowollik\* ..... 4011–4019

## Photochemical Generation of Light Responsive Surfaces

Tensile strain-resistivity response of poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) films is investigated according to doping with dimethylsulfoxide (DMSO) up to 60% strain without crack generation. The resistivity can be modulated under strain from invariant values to decreasing values up to 80%. The growth of conductive PEDOT-rich cores is the primary mechanism for the decrease in resistivity induced by applied strain.



## Flexible Electronics

Y.-Y. Lee, J.-H. Lee, J.-Y. Cho, N.-R. Kim, D.-H. Nam, I.-S. Choi,\* K. T. Nam,\* Y.-C. Joo\* .....4020–4027

## Stretching-Induced Growth of PEDOT-Rich Cores: A New Mechanism for Strain-Dependent Resistivity Change in PEDOT:PSS Films

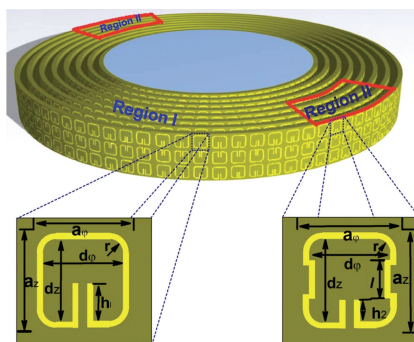


## FULL PAPERS

## Metamaterials

W. X. Jiang, C.-W. Qiu,\* T. Han,  
S. Zhang, T. J. Cui\* .....4028–4034

### Creation of Ghost Illusions Using Wave Dynamics in Metamaterials

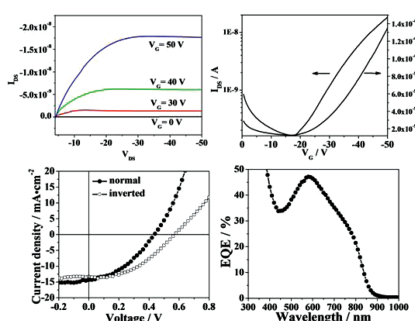


A functional “ghost” illusion device that uses inhomogeneous and anisotropic materials and is capable of creating multiple virtual images off the original object’s position under the illumination of electromagnetic waves is presented. The scattering signature of the object is thus perceived as multiple targets with different geometries and compositions.

## Hybrid Materials

H. Wei, H. Zhang, G. Jin, T. Na,  
G. Zhang, X. Zhang, Y. Wang, H. Sun,  
W. Tian, B. Yang\* .....4035–4042

### Coordinatable and High Charge-Carrier-Mobility Water-Soluble Conjugated Copolymers for Effective Aqueous-Processed Polymer–Nanocrystal Hybrid Solar Cells and OFET Applications

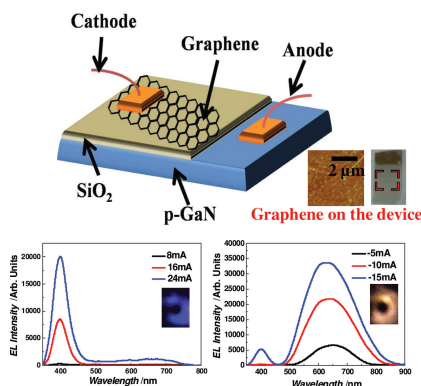


A new type of water-soluble conjugated polymer composed of poly[(3,4-dibromo-2,5-thienylene vinylene)-co-(p-phenylene-vinylene)] (PBTPV) is synthesized. Its excellent film-forming properties, stability, and photoelectric response show good potential for organic field-effect transistor and aqueous-processable hybrid solar cell applications. The carrier mobility of the aqueous PBTPV is about  $5 \times 10^{-4} \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$  and the power conversion efficiency of the water-processed PBTPV/CdTe nanocrystal hybrid photovoltaic devices reaches 3.3%.

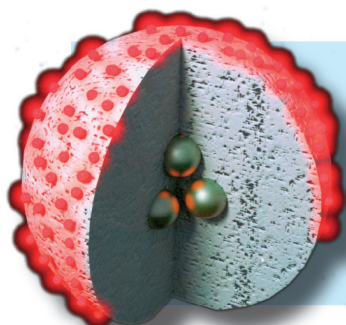
## Light-Emitting Diodes

C.-W. Chang, W.-C. Tan, M.-L. Lu,  
T.-C. Pan, Y.-J. Yang,  
Y.-F. Chen\* ..... 4043–4048

### Graphene/SiO<sub>2</sub>/p-GaN Diodes: An Advanced Economical Alternative for Electrically Tunable Light Emitters



Metal-insulator-semiconductor (MIS) light-emitting diodes (LEDs) consisting of a graphene electrode on p-GaN substrate separated by an insulating SiO<sub>2</sub> layer are reported. The novel MIS-LEDs have a unique tunability of the electroluminescence (EL) spectra depending on the bias conditions. The underlying mechanism can be interpreted as the tunneling of electrons and holes through the insulating layer in both polarities, which is different from the standard p-n junction model.



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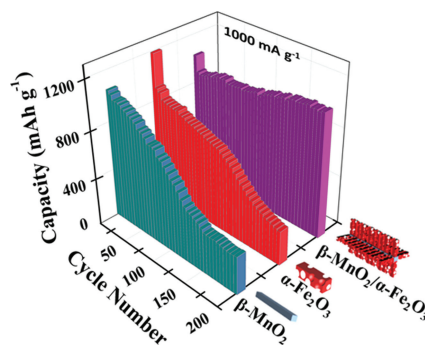
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## FULL PAPER

Branched nanorods with  $\alpha\text{-Fe}_2\text{O}_3$  as the branches and  $\beta\text{-MnO}_2$  as the stems are synthesized by the high-temperature annealing of  $\text{FeOOH}$  epitaxially grown on the  $\beta\text{-MnO}_2$  nanorods. These branched nanorods present an excellent lithium-storage performance in terms of reversible capacity, cycling stability, and rate capability.



## Batteries

X. Gu, L. Chen, Z. C. Ju, H. Y. Xu,  
J. Yang,\* Y. T. Qian.....4049–4056

**Controlled Growth of Porous  $\alpha\text{-Fe}_2\text{O}_3$   
Branches on  $\beta\text{-MnO}_2$  Nanorods for  
Excellent Performance in Lithium-Ion  
Batteries**