

# ADVANCED FUNCTIONAL MATERIALS

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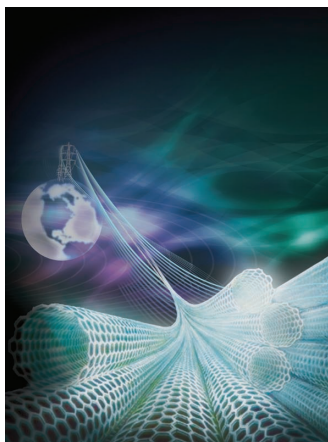


## Water Splitting

Ultrasmall, crystalline and dispersible NiO nanoparticles are prepared for the first time by T. Bein, D. Fattakhova-Rohlfing and colleagues using a solvothermal reaction in tert-butanol. On page 3123, these nanocrystals can be prepared with sizes tunable from 2.5 to 5 nm and are highly efficient catalysts for electrochemical oxygen generation. Credit: Cover by Christoph Hohmann, Nanosystems Initiative Munich (NIM).

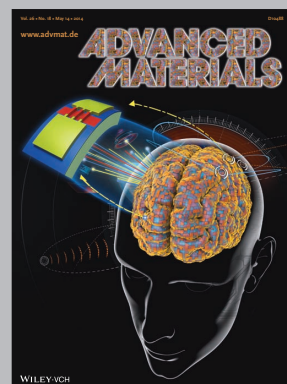
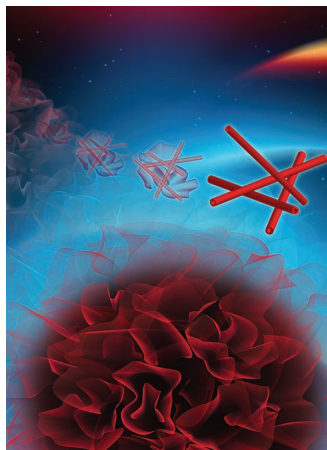
## MnO<sub>2</sub>

Manganese dioxide is considered as one of the most promising materials for supercapacitor energy storage applications. On page 3130, H. N. Alshareef and co-workers present the morphological and electrochemical cycling effects in MnO<sub>2</sub> nanostructures by three-dimensional electron tomography. The growth process of the various MnO<sub>2</sub> nanostructures is correlated to their electrochemical performance as supercapacitor materials. The study provides significant insight into the growth mechanism, electrochemical performance, and cycling behaviors of nanostructured MnO<sub>2</sub>.



## Carbon Nanofibers

Due to their high electrical and thermal conductivity and structural stability, carbon nanotubes (CNTs) can carry very high electrical currents before failure. On page 3241, J. Kono and team report a fiber consisting of tightly packed and well aligned CNTs. This fiber displays the highest current-carrying capacity (CCC) ever reported for a CNT power cable. When normalized by mass, the CCC value of the CNT cable largely surpasses copper wire, making the CNT cable promising for lightweight power transmission, such as in aerospace systems.



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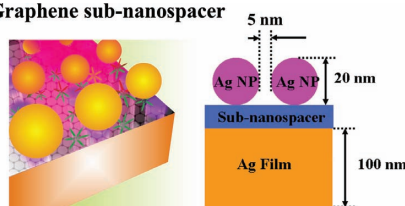
## FULL PAPERS

## Nanospacers

X. Li, W. C. H. Choy,\* X. Ren, D. Zhang, H. Lu ..... 3114–3122

### Highly Intensified Surface Enhanced Raman Scattering by Using Monolayer Graphene as the Nanospacer of Metal Film–Metal Nanoparticle Coupling System

Graphene sub-nanospacer

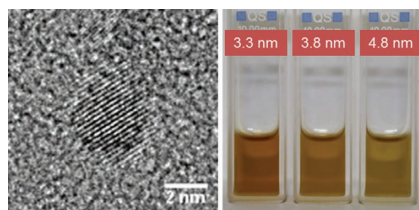


A novel metal NPs–metal film coupling system (G(graphene)–NFG) is demonstrated by introducing ultrathin monolayer graphene as well-defined sub-nanospacer between Ag NPs and Ag film. These results show that the G–NFG system offers tremendous near-field enhancement with one of the highest enhancement ratio (1700) reported to date in the graphene–metal plasmonic combination system and an additional chemical enhancement from the graphene sub-nanospacer.

## Water Splitting

K. Fominykh, J. M. Feckl, J. Sicklinger, M. Döblinger, S. Böcklein, J. Ziegler, L. Peter, J. Rathousky, E.-W. Scheidt, T. Bein,\*  
D. Fattakhova-Rohlfing\* ..... 3123–3129

### Ultrasmall Dispersible Crystalline Nickel Oxide Nanoparticles as High-Performance Catalysts for Electrochemical Water Splitting

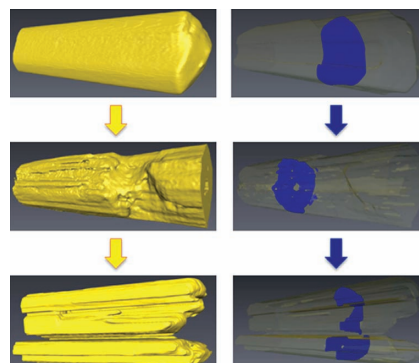


Ultrasmall, crystalline, and dispersible NiO nanoparticles are prepared for the first time using a solvothermal reaction in *tert*-butanol. These nanocrystals can be prepared with sizes tunable from 2.5 to 5 nm and are highly efficient catalysts for electrochemical oxygen generation.

MnO<sub>2</sub>

W. Chen, R. B. Rakhi, Q. Wang, M. N. Hedhili, H. N. Alshareef\* ..... 3130–3143

### Morphological and Electrochemical Cycling Effects in MnO<sub>2</sub> Nanostructures by 3D Electron Tomography

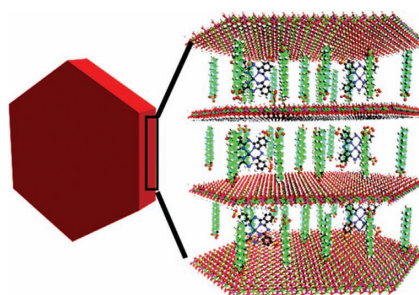


The preparation, characterization and supercapacitor application of MnO<sub>2</sub> nanostructures by 3D electron tomography are studied. The electrochemical performance of MnO<sub>2</sub> is correlated to its surface area, determined by the morphological effect, as well as the cycling effect, determined by the formation of defective regions on the nanostructures during electrochemical cycling tests.

## Photosensitizers

R. Liang, R. Tian, L. Ma, L. Zhang, Y. Hu, J. Wang, M. Wei,\* D. Yan,\* D. G. Evans, X. Duan ..... 3144–3151

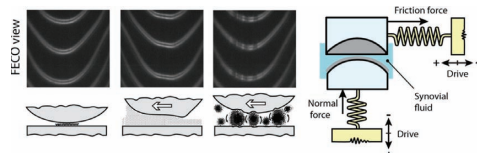
### A Supramolecular Photosensitizer with Excellent Anticancer Performance in Photodynamic Therapy



By incorporating zinc phthalocyanines (ZnPc) into the gallery of a layered double hydroxide (LDH), a supramolecular photosensitizer is fabricated which can serve as a promising photosensitizer in the field of photodynamic therapy (PDT) with excellent anticancer behavior, good biocompatibility, and low cytotoxicity.

## FULL PAPERS

**Shear-induced aggregation of synovial fluid components** is observed under boundary lubrication conditions. The aggregation process starts with the formation of a gel-like layer on the surfaces, which ultimately leads to the formation of rod-like aggregates. These aggregates provide enhanced wear protection and lubrication to the surfaces using rolling friction instead of pure sliding friction. This mechanism suggests new design criteria for future bioinspired lubricants.

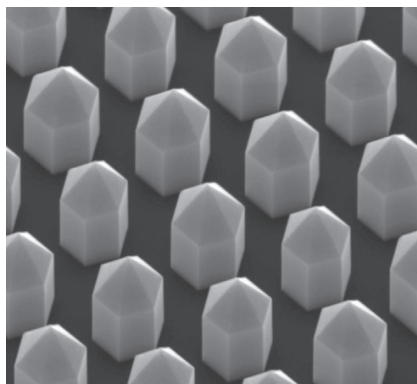


### Lubrication

X. Banquy, D. W. Lee, S. Das, J. Hogan, J. N. Israelachvili\* .....3152–3161

### Shear-Induced Aggregation of Mammalian Synovial Fluid Components under Boundary Lubrication Conditions

**GaN nanorods** are promising templates for novel electro-optical devices due to their superior material properties. Their formation on Ga-polar GaN by continuous mode metalorganic chemical vapor deposition selective area growth (MOCVD SAG) is achieved under a relatively Ga-rich condition. The continuous mode growth mechanism as well as the optical characteristics of the nanorods are discussed.

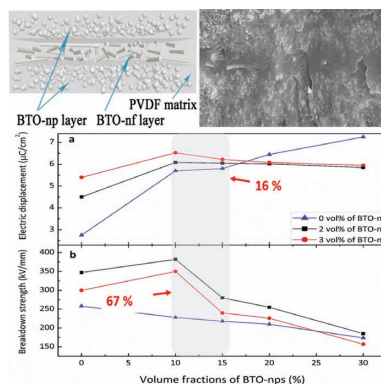


### Nanorods

Y.-T. Lin, T.-W. Yeh, Y. Nakajima, P. D. Dapkus\* .....3162–3171

### Catalyst-Free GaN Nanorods Synthesized by Selective Area Growth

In the **topological-structure modulated polymer nanocomposite** prepared by a facile layer-by-layer process, dielectric strength and electric polarization are enhanced simultaneously, giving rise to an extractable energy density of  $\sim 10 \text{ J/cm}^3$ , over 400% higher than that of BOPP, which is currently the benchmark dielectric.

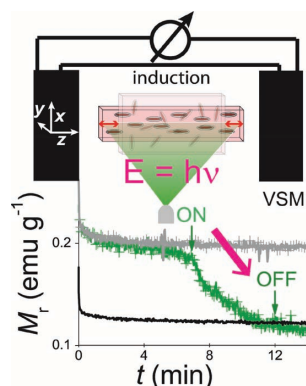


### Polymer Nanocomposites

P. H. Hu, Y. Shen,\* Y. H. Guan, X. H. Zhang, Y. H. Lin, Q. M. Zhang,\* C.-W. Nan .....3172–3178

### Topological-Structure Modulated Polymer Nanocomposites Exhibiting Highly Enhanced Dielectric Strength and Energy Density

An **oriented liquid-crystalline elastomer nanocomposite** is synthesized and its light-triggered reversible actuation is presented. Its performed shape changes can be wirelessly monitored on the basis of the remanent magnetization. This is due to the orientation changes of the incorporated magnetic nanoellipsoids. Both shape- and magnetization changes are temperature-triggered either during illumination or through the atmosphere.



### Smart Materials

J. M. Haberl, A. Sánchez-Ferrer, A. M. Mihut, H. Dietsch, A. M. Hirt, R. Mezzenga\* .....3179–3186

### Light-Controlled Actuation, Transduction, and Modulation of Magnetic Strength in Polymer Nanocomposites



## FULL PAPERS

## Ferrogels

M. Helminger, B. Wu, T. Kollmann,  
D. Benke, D. Schwahn, V. Pipich,  
D. Faivre, D. Zahn,  
H. Cölfen\* ..... 3187–3196

### Synthesis and Characterization of Gelatin-Based Magnetic Hydrogels

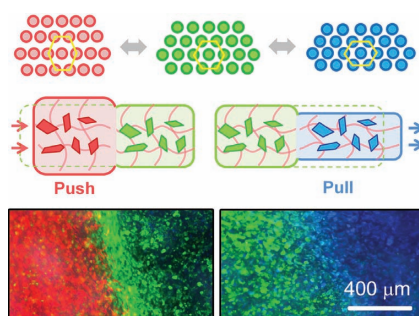


A simple preparation and characterization of gelatin-based ferrogels with adjustable magnetite contents of 20–70 wt% is reported. These gels are biodegradable and can be attracted by external magnetic fields. The gel structures are studied by small-angle neutron scattering using contrast variation, small-angle X-ray scattering, SQUID and microscopy. In addition, simulation studies show iron coordination along the triple helical structure of the gelatin.

## Photonic Gels

D. P. Yang, S. Y. Ye, J. P. Ge\* ... 3197–3205

### From Metastable Colloidal Crystalline Arrays to Fast Responsive Mechanochromic Photonic Gels: An Organic Gel for Deformation-Based Display Panels

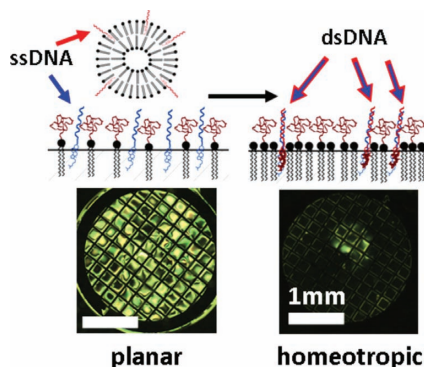


A mechanochromic photonic gel is prepared by fixing metastable  $\text{SiO}_2$  colloidal crystalline array in the mixture of EG and PEGMA through photopolymerization. Compared to traditional opal gels, it has improved mechanochromic sensitivity, a broad color tuning range, fast response, repeatable reflection signals in cycling and fatigue tests, and good resolution for localized deformation, which makes it a good deformation-based photonic display panel with controllable RGB pixels.

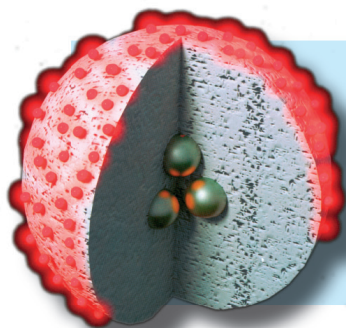
## Liposomes

P. S. Noonan, P. Mohan, A. P. Goodwin,  
D. K. Schwartz\* ..... 3206–3212

### DNA Hybridization-Mediated Liposome Fusion at the Aqueous Liquid Crystal Interface



An approach for monitoring receptor-mediated fusion using liquid crystals (LC) is presented. DNA hybridization between surface-anchored oligonucleotides promotes liposome fusion and induces LC re-orientation from a planar (bright) to homeotropic (dark) state. The applicability of this approach as a biosensing strategy is demonstrated by incorporating aptamer–ligand binding to modulate fusogenic activity.



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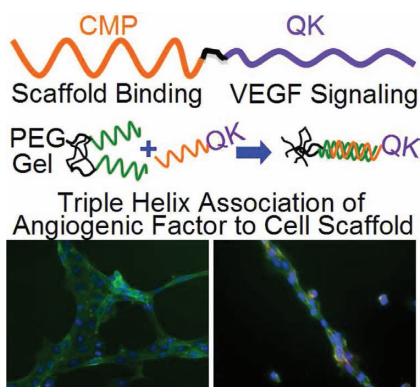
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## FULL PAPERS

**Angiogenic peptide** binds to synthetic poly(ethylene glycol) diacrylate scaffolds by triple helix hybridization of collagen mimetic peptide (CMP), and activates angiogenic response in endothelial cells similar to that induced by matrix bound vascular endothelial growth factor. CMP-QK can selectively modify photopatterned regions of hydrogels to promote spatially directed cell morphogenesis for potential tissue engineering applications.

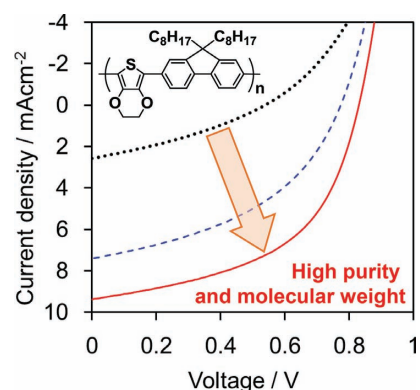


### Tissue Engineering

P. J. Stahl, T. R. Chan, Y.-I. Shen, G. Sun, S. Gerecht, S. M. Yu\* ..... 3213–3225

**Capillary Network-Like Organization of Endothelial Cells in PEGDA Scaffolds Encoded with Angiogenic Signals via Triple Helical Hybridization**

**Field-effect transistor and organic photovoltaic performances** strongly depend on the synthetic methods of a polymer owing to different purity and molecular weight. A high-purity, high-molecular-weight polymer exhibits a high FET hole mobility of  $1.2 \times 10^{-3} \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$  and high OPV performance with a power conversion efficiency of 4%, even though the polymer forms an amorphous film, which absorbed in a limited region of the spectrum.

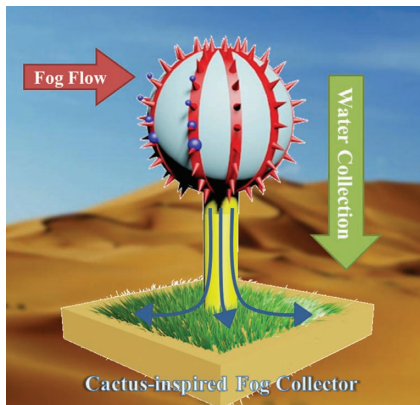


### Organic Photovoltaics

J. Kuwabara, T. Yasuda, S. J. Choi, W. Lu, K. Yamazaki, S. Kagaya, L. Han, T. Kanbara\* ..... 3226–3233

**Direct Arylation Polycondensation: A Promising Method for the Synthesis of Highly Pure, High-Molecular-Weight Conjugated Polymers Needed for Improving the Performance of Organic Photovoltaics**

**Inspired by the fog-harvesting behavior of the cactus**, a novel fog collector in large scale is first fabricated through integrating cactus spine-like hydrophobic conical micro-tip arrays with a hydrophilic cotton matrix, which can spontaneously and continuously collect, transport, and preserve fog water.

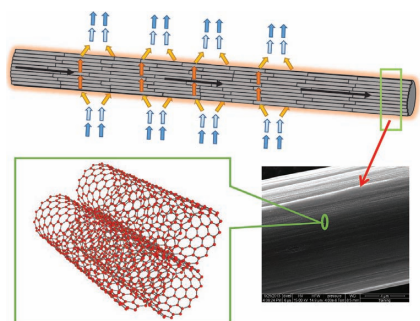


### Fog Collection

M. Cao, J. Ju, K. Li, S. Dou, K. Liu,\* L. Jiang ..... 3235–3240

**Facile and Large-Scale Fabrication of a Cactus-Inspired Continuous Fog Collector**

**The current-carrying capacity (CCC) of highly-conductive, light, and strong carbon nanotube (CNT) fibers** is characterized by measuring their failure current density and continuous current rating values. The specific CCC (i.e., normalized by the linear mass density) of our CNT fibers is demonstrated to be higher than that of copper, making those fibers promising for power transmission.



### Carbon Nanofibers

X. Wang, N. Behabtu, C. C. Young, D. E. Tsentalovich, M. Pasquali, J. Kono\* ..... 3241–3249

**High-Ampacity Power Cables of Tightly-Packed and Aligned Carbon Nanotubes**

## FULL PAPERS

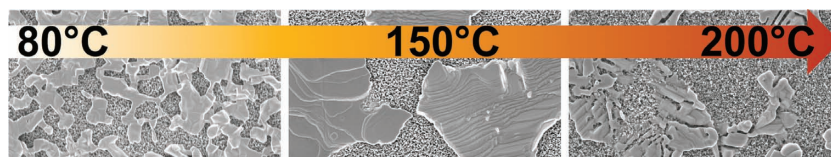
## Photovoltaics

A. Dualeh, N. Tétreault, T. Moehl,  
P. Gao, M. K. Nazeeruddin,\*  
M. Grätzel\* ..... 3250–3258



Effect of Annealing Temperature on  
Film Morphology of Organic–Inorganic  
Hybrid Perovskite Solid-State Solar Cells

The effect of the annealing temperature on the formation of the perovskite film is investigated. The temperature determines the rate of solvent vaporization and perovskite crystallization thus controlling the film morphology and composition, leading to the formation of  $\text{PbI}_2$  at very high temperatures. This is correlated with the device performance and working mechanisms.



## Adhesion

H. J. Meredith, C. L. Jenkins,  
J. J. Wilker\* ..... 3259–3267

Enhancing the Adhesion of a Biomimetic  
Polymer Yields Performance Rivaling  
Commercial Glues

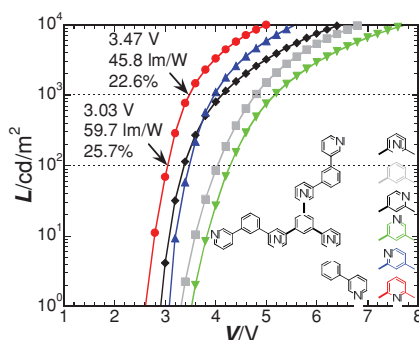


Marine mussels attach to surfaces by depositing proteins containing the unusual amino acid 3,4-dihydroxyphenylalanine (DOPA). Here, synthetic polymer mimics of these proteins are shown to adhere quite strongly. Systematic changes to several parameters (e.g., concentrations, fillers, etc.) brought about appreciable enhancements to adhesion. One of the simplest biomimetic systems, poly[(3,4-dihydroxystyrene)-*co*-styrene], can now exceed the bonding performance of common commercial glues.

## Organic Electronics

H. Ye, D. C. Chen, M. Liu, S.-J. Su,\*  
Y.-F. Wang, C.-C. Lo, A. Lien,  
J. Kido ..... 3268–3275

Pyridine-Containing Electron-Transport  
Materials for Highly Efficient Blue  
Phosphorescent OLEDs with Ultralow  
Operating Voltage and Reduced  
Efficiency Roll-Off



Unprecedented low operating voltages are realized for the FIrpic-based blue phosphorescent OLEDs by using pyridine-containing electron-transport materials, giving ever highest power efficiencies of 65.8 and 59.7  $\text{lm W}^{-1}$  at 1 and 100  $\text{cd m}^{-2}$ , respectively. The threshold voltage for electroluminescence can be 0.2–0.3 V lower than the minimum value of  $h\nu/e$  by using a host material with low  $\Delta E_{\text{ST}}$ .

## Flexible Electronics

H. Lee, K. S. Lee, J. T. Park, W. C. Kim,\*  
H. Lee\* ..... 3276–3283

Well-Ordered and High Density  
Coordination-Type Bonding to  
Strengthen Contact of Silver  
Nanowires on Highly Stretchable  
Polydimethylsiloxane

The well-ordered and high density coordination-type bonding silane molecule self-assembled on PDMS surface exhibits the strongest contact force with silver nanowire (AgNW), especially on junction side, and the longest maintenance of hydrophilicity. As a result, the AgNW PDMS film shows high conductivity with high transparency, excellent mechanical durability, and high stretchability.

