

# ADVANCED FUNCTIONAL MATERIALS

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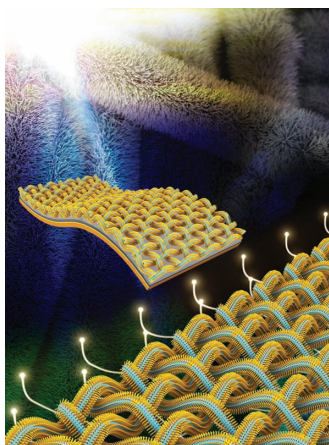


## Nanogenerators

Lead-free alkaline niobate particles generate electrical energy in nanocomposites with metal nanorods that can take on the roles of dispersing, reinforcing, and conducting agents for the enhancement of energy harvesting. On page 2620, K. J. Lee and co-workers demonstrate how to realize highly efficient and large-area piezoelectric nanogenerators without lead and carbon-related environmental problems.

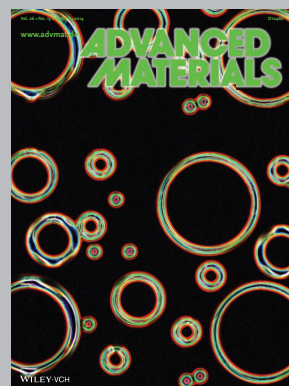
## Click Chemistry

Click chemistry has been employed as one of the most powerful paradigms in materials science. On page 2572, C. N. Bowman and co-workers deliver the highlights of the click reactions and their applications in materials science. This cover image illustrates how click reactions in the flask carry a flow of applications in materials science, such as polymers modification, bioconjugation, block copolymers, responsive materials, surfaces functionalization.



## Metal Oxides

Advanced electrodes composed of mesoporous  $\text{NiCo}_2\text{O}_4$  nanowire arrays on carbon textiles are efficiently fabricated by X. G. Zhang and co-workers. The electrode architectures presented on page 2630 promise fast electron transport by direct connection to the growth substrate and facile ion diffusion paths provided by both the abundant mesoporous structure in nanowires and the large open spaces between neighboring nanowires, which ensures that every nanowire participates in the ultrafast electrochemical reaction.



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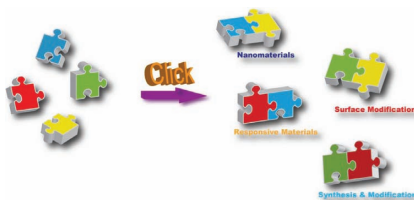
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## FEATURE ARTICLES

## Click Chemistry

W. Xi, T. F. Scott, C. J. Kloxin,  
C. N. Bowman\* ..... 2572–2590

## Click Chemistry in Materials Science

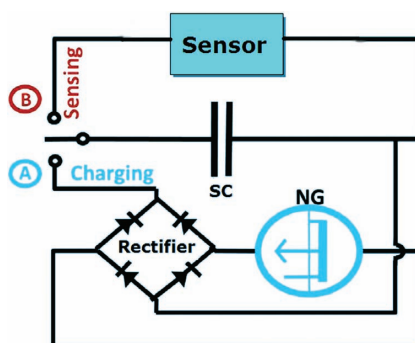


**Click chemistry** has become one of the most powerful paradigms in materials science, synthesis and modification. This feature article delivers highlights of the basic reactions, approaches, and applications of click chemistry in materials science as well as briefly looking to the future, enabling developments in this field.

## Photodetectors

L. Peng, L. F. Hu,  
X. S. Fang\* ..... 2591–2610

## Energy Harvesting for Nanostructured Self-Powered Photodetectors



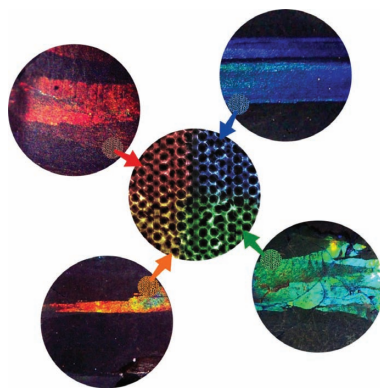
As a new field in self-powered nanotechnology-related research, self-powered photodetectors have been developed which exhibit a much faster photoresponse and higher photosensitivity than the conventional photoconductor-based photodetectors. Energy-harvesting techniques are discussed herein and their prospects for application in self-powered photodetectors are summarized. Moreover, potential future directions of this research area are highlighted.

## FULL PAPERS

## Porous Materials

A. Morelos-Gómez,  
P. G. Mani-González, A. E. Aliev,  
E. Muñoz-Sandoval, A. Herrera-Gómez,  
A. A. Zakhidov, H. Terrones, M. Endo,  
M. Terrones\* ..... 2612–2619

## Controlling the Optical, Electrical and Chemical Properties of Carbon Inverse Opal by Nitrogen Doping

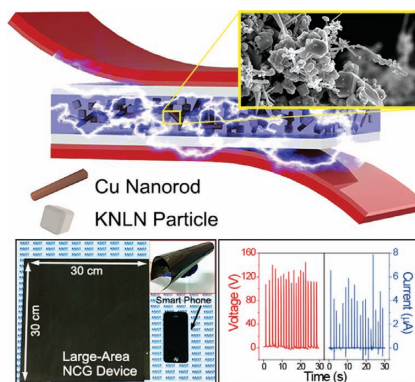


The optical, electrical, and chemical properties of carbon inverse opals are tailored by nitrogen doping. The amount of nitrogen precursor dictates the changes in the physical and chemical properties. The reflected colors of the carbon inverse opal can vary in the visible region from red to blue. In addition, the resistivity can be lowered from 0.30 to 0.02  $\Omega$  cm.

## Nanogenerators

C. K. Jeong, K.-I. Park, J. Ryu,  
G.-T. Hwang, K. J. Lee\* ..... 2620–2629

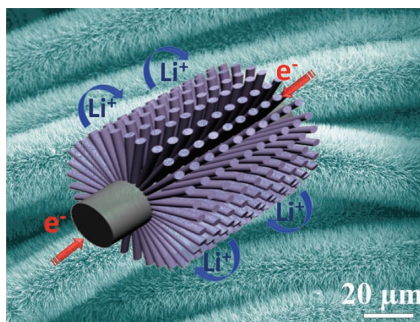
## Large-Area and Flexible Lead-Free Nanocomposite Generator Using Alkaline Niobate Particles and Metal Nanorod Filler



The lead-free and high-performance nanocomposite generator based on novel alkaline niobate particles and well-dispersible copper nanorods. A biocompatible as well as high-output nanocomposite generator is achieved by using the specific composition of alkaline niobate and the low aggregatability of copper nanorods. The flexible nanocomposite generator in this work shows remarkable stability and reliability for energy harvesting from mechanical deformations.

## FULL PAPERS

**Advanced electrode architectures consisting of carbon textiles** conformally covered by mesoporous  $\text{NiCo}_2\text{O}_4$  nanowire arrays are efficiently fabricated and directly applied as self-supported electrodes for energy storage devices, such as Li-ion batteries, supercapacitors. Because of its many advantageous structural features, such an electrode ensures that  $\text{NiCo}_2\text{O}_4$  participates in the ultrafast electrochemical reaction, enabling remarkable rate performance and excellent cycling stability.

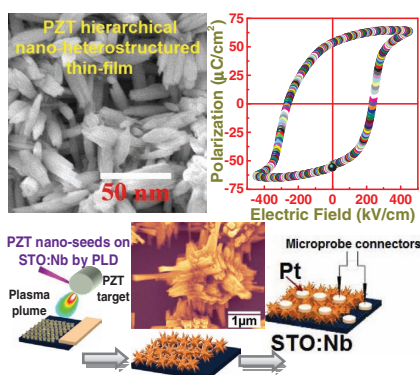


## Metal Oxides

L. F. Shen, Q. Che, H. S. Li,  
X. G. Zhang\* .....2630–2637

**Mesoporous  $\text{NiCo}_2\text{O}_4$  Nanowire Arrays Grown on Carbon Textiles as Binder-Free Flexible Electrodes for Energy Storage**

**Hierarchical PZT nano-heterostructures are grown on STO:Nb from PZT nano-seeds** using a combined pulsed laser deposition and hydrothermal process. Cross-linking of the structures result in a dense thin-film enabling the measurement of the ferroelectric properties without secondary fill-layer. Well-saturated and symmetric hysteresis showing high degree of squareness and enhanced remanent polarization are obtained.

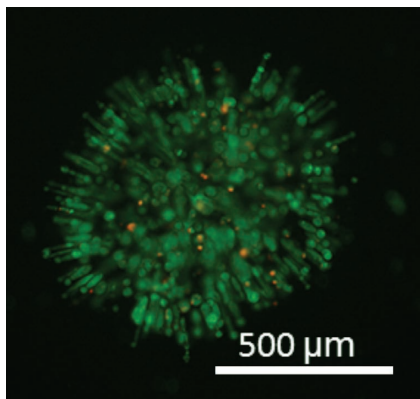


## Ferroelectrics

A. Datta,\* D. Mukherjee, S. Witanachchi,  
P. Mukherjee .....2638–2647

**Hierarchically Ordered Nano-Heterostructured PZT Thin Films with Enhanced Ferroelectric Properties**

**Three-dimensional cell culture techniques** are currently suboptimal. Parameters affecting bio-electrospraying to generate cell-containing microspheres incorporating extracellular matrix components are investigated. Cell viability is preserved and 3D bio-electrospray cell culture systems have great potential to permit study of cells in a physiologically relevant environment pertinent to a wide range of cell biology.

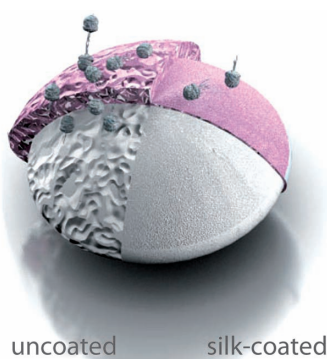


## Cellular Kinetics

V. L. Workman, L. B. Tezera,  
P. T. Elkington,  
S. N. Jayasinghe\* .....2648–2657

**Controlled Generation of Microspheres Incorporating Extracellular Matrix Fibrils for Three-Dimensional Cell Culture**

**Coating of medical grade silicone implants with recombinant spider silk protein** significantly reduces post-operative inflammatory reactions, synthesis, and re-modeling of extracellular matrix, as well as periprosthetic capsule formation. Spider silk coatings of silicone implants therefore improve the biocompatibility of the implant surface and lower the risk of secondary surgical interventions.



## Silicone Implants

P. H. Zeplin, N. C. Maksimovikj,  
M. C. Jordan, J. Nickel, G. Lang,  
A. H. Leimer, L. Römer,  
T. Scheibel\* .....2658–2666

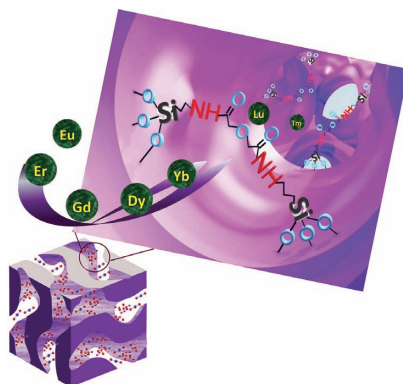
**Spider Silk Coatings as a Bioshield to Reduce Periprosthetic Fibrous Capsule Formation**

## FULL PAPERS

## Nanoporous Sorbents

J. Florek, F. Chalifour, F. Bilodeau,  
D. Larivière,\* F. Kleitz\* ..... 2668–2676

### Nanostructured Hybrid Materials for the Selective Recovery and Enrichment of Rare Earth Elements

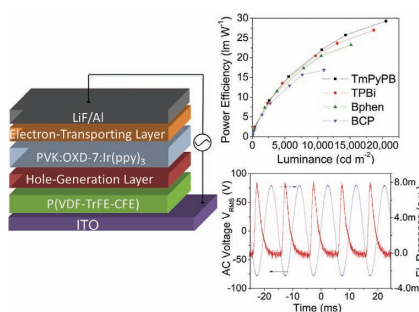


**Nanomaterials for lanthanide separation:** the importance of rare-earth elements in the global economy is booming as they are used in numerous advanced technologies. However, industrially, their extraction and purification remain tedious. Functional porous hybrid materials demonstrate enhanced selectivity towards heavier rare-earths compared to commercial products. Because of the grafting procedure used, these materials show high level of reusability, increasing their marketable potential.

## Thin Films

Y. Chen, Y. Xia, G. M. Smith, H. Sun,  
D. Yang, D. Ma,\* Y. Li, W. Huang,  
D. L. Carroll\* ..... 2677–2688

### Solution-Processable Hole-Generation Layer and Electron-Transporting Layer: Towards High-Performance, Alternating-Current-Driven, Field-Induced Polymer Electroluminescent Devices

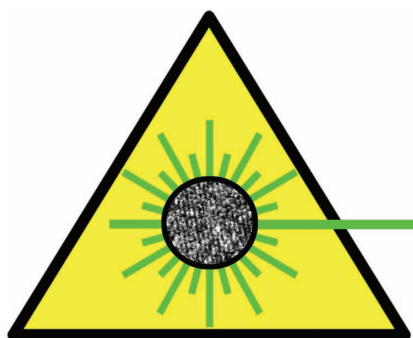


**The effect of solution-processed hole-generation layers and electron-transporting layers** is systematically investigated on the performance of AC-driven field-induced polymer electroluminescence (FIPEL) devices. A low turn-on voltage of 12 V, a maximum luminance of 20 500 cd m<sup>-2</sup>, and a maximum current and power efficiency of 110.7 cd A<sup>-1</sup> and 29.3 lm W<sup>-1</sup> are achieved. This study provides a pathway to high-performance FIPEL device engineering.

## Luminescence

S. Qu, X. Liu,\* X. Guo, M. Chu,  
L. Zhang, D. Shen\* ..... 2689–2695

### Amplified Spontaneous Green Emission and Lasing Emission From Carbon Nanoparticles

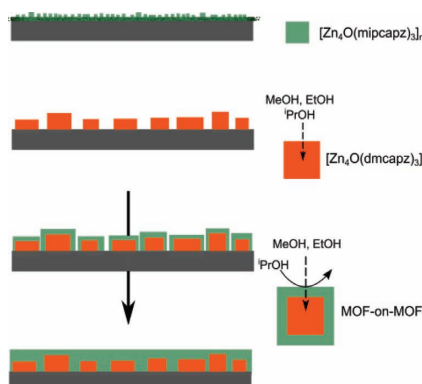


**Caution: Green Lasing emission** is achieved from carbon nanoparticles (CNP2) ethanol aqueous solution in a linear Fabry-Pérot cavity. The optical properties of carbon nanoparticles (CNPs) can be modulated by the dopant-N atom and sp<sup>2</sup> C-contents. The green emission from CNP2 is speculated to be attributed to intrinsic state emission.

## Porous Polymers

S. Wannapaiboon, M. Tu,  
R. A. Fischer\* ..... 2696–2705

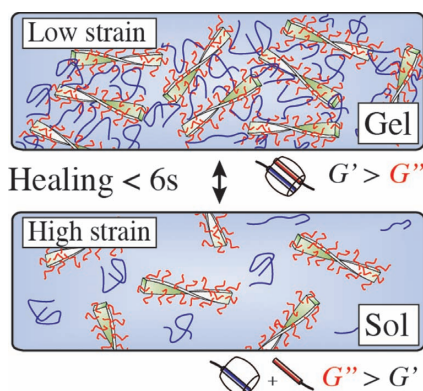
### Liquid Phase Heteroepitaxial Growth of Moisture-Tolerant MOF-5 Isotype Thin Films and Assessment of the Sorption Properties by Quartz Crystal Microbalance



**The step-by-step heteroepitaxial growth method** allows the fabrication of high-performance metal-organic framework (MOF)-on-MOF films. The MOF with sophisticated substituents that never achieves high crystallinity as a homo-structured film can be epitaxially grown on another lattice-matched crystalline MOF. The hybrid MOF film shows the excellent size selectivity of alcohol adsorption by the pore opening window of the MOF shell component.

## FULL PAPERS

**Nanocomposite hydrogels** are prepared by combining 'hard' functionalised cellulose nanocrystals with 'soft' functionalised poly(vinyl alcohol) via dynamic and selective three-component host-guest chemistry. The ensuing supramolecular hydrogels synergistically combine rapid hydrogel recovery (within a few seconds) from the processable sol state to the relaxed gel state; suppressed passivation in self-healing, even after several months' storage, and; a high storage modulus.

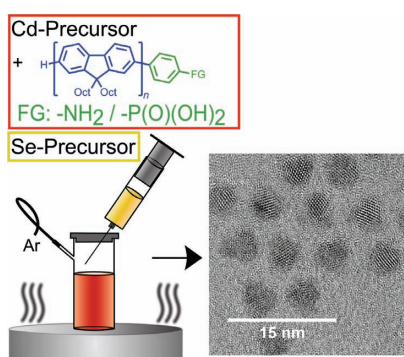


### Hydrogels

J. R. McKee, E. A. Appel, J. Seitsonen, E. Kontturi, O. A. Scherman,\*  
O. Ikkala\* .....2706–2713

**Healable, Stable and Stiff Hydrogels: Combining Conflicting Properties Using Dynamic and Selective Three-Component Recognition with Reinforcing Cellulose Nanorods**

**CdSe/polyfluorene hybrid particles** are directly obtained by high-temperature synthesis of CdSe nanocrystals in the presence of amine or phosphonic acid functionalized polyfluorenes. Analytical ultracentrifugation studies of these hybrid particles give a rare quantitative insight into the binding of the polyfluorene ligands to the nanocrystal. Efficient energy transfer from polyfluorene to the nanocrystal is revealed by single particle photoluminescence studies.

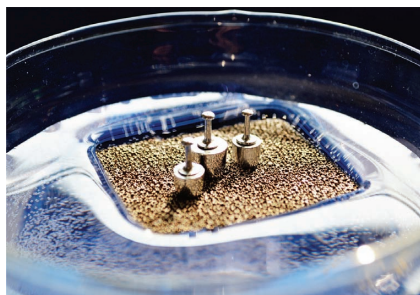


### Hybrid Materials

T. de Roo, J. Haase, J. Keller, C. Hinz, M. Schmid, D. V. Seletskiy, H. Cölfen, A. Leitenstorfer, S. Mecking\* ...2714–2719

**A Direct Approach to Organic/Inorganic Semiconductor Hybrid Particles via Functionalized Polyfluorene Ligands**

**Inspired by the optimized biological solutions from the lotus leaf with superhydrophobic self-cleaning, the water strider leg with durable and robust superhydrophobicity, and the light-weight bird bone with hollow structures, multifunctional metallic foams with multiscale structures are fabricated, demonstrating low adhesive superhydrophobic self-cleaning, striking load-bearing capacity, stable corrosion resistance, and oil/water separation.**

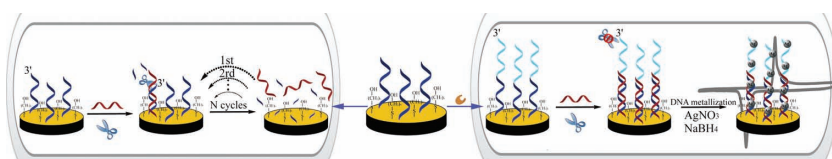


### Surface Chemistry

X. Jin, B. Shi, L. Zheng, X. Pei, X. Zhang, Z. Sun, Y. Du, J. H. Kim, X. Wang, S. Dou, K. Liu,\* L. Jiang .....2721–2726

**Bio-Inspired Multifunctional Metallic Foams Through the Fusion of Different Biological Solutions**

**Telomerase detection in circulating tumor cells (CTCs):** On the basis of enzyme-assisted background-noise suppression and DNA metallization-based signal amplification, the constructed biosensor shows ultrahigh sensitivity for telomerase detection. This work paves the way for a new PCR-free method for measuring telomerase activity in CTCs, and point-of-care diagnosis and individualized treatment of cancers via a noninvasive routine blood test.



### Cancer Diagnosis

L. Wu, J. Wang, J. Ren, X. Qu\* .....2727–2733

**Ultrasensitive Telomerase Activity Detection in Circulating Tumor Cells Based on DNA Metallization and Sharp Solid-State Electrochemical Techniques**

