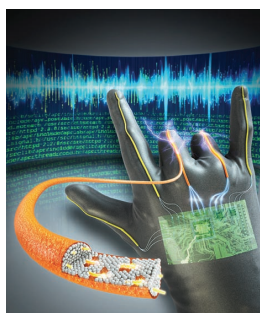


# ADVANCED FUNCTIONAL MATERIALS

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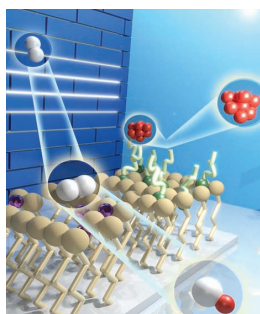
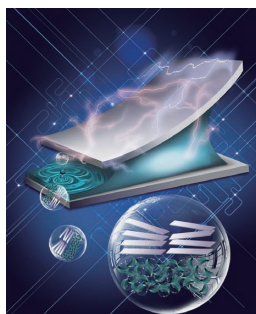


## Stretchable Electronics

Stretchable conductive fiber is spotlighted by T. Lee on page 3114 because of the possibility of being utilized in wearable and foldable electronics. Highly stretchable conductive fiber composed of silver nanowires and nanoparticles in a stretchable polymer can be fabricated by using a simple wet spinning method and the use of silver precursor. The composite fiber can be embedded into gloves to perceive human motions.

## Thin Films

On page 3131, Z. Bao, H. Ade, and colleagues demonstrate that the solution shearing can control molecular orientation at donor/acceptor interface of BHJ organic solar cells with polarized soft X-ray scattering. This effect is further extended to binary organic blend in which one of the components forms fibrils or aggregates.

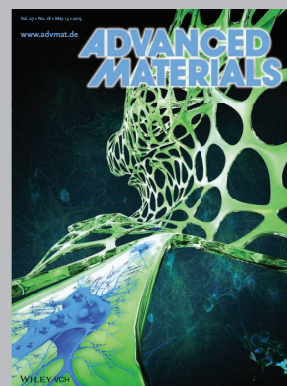
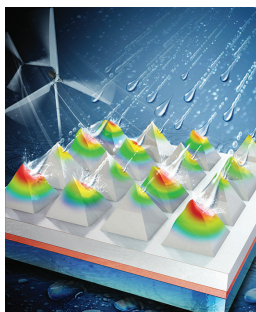


## Energy Barriers

H-bonded peptide  $\beta$ -sheet-assembled porous shells are prepared by a simple, rapid, and robust bottom-up strategy involving controlled surface-initiated ring-opening polymerization. As reported by G. G. Qiao and co-workers on page 3147, the exploitation of the hollow shells by non-covalent interactions demonstrates the ability to entrap small molecules, nanoparticles, proteins, drugs, and polymers to form functional materials for various potential applications.

## Energy Harvesting

S.-W. Kim and co-workers report a novel highly sensitive piezoelectric nanogenerator (PNG) for self-powered pressure sensors based on a micro-patterned piezoelectric polymer P(VDF-TrFE) thin film. The micro-structured PNGs presented on page 3203 has five times larger output power compared to the flat film-based PNG. The micro-structured PNG shows high sensitivity and mechanical durability under various circumstances such as rain drop and wind blow.



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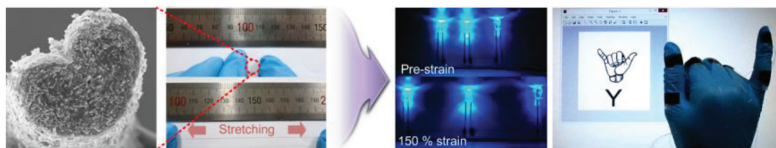
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## FULL PAPERS

**Ag nanowire reinforced highly stretchable conductive fiber** is developed using simple wet spinning method, which consists of silver nanowires and nanoparticles embedded in elastomeric polymer matrix. The composite fiber can preserve its electrical property under large strain and has superior strain-sensing behavior. It can be utilized in the wearable smart glove for detecting human motions such as sign language.

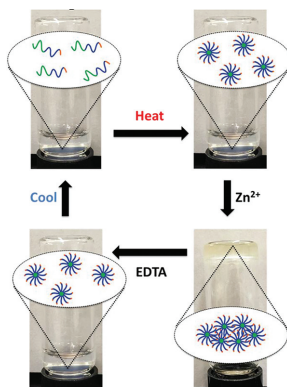


## Stretchable Electronics

S. Lee, S. Shin, S. Lee, J. Seo, J. Lee, S. Son, H. J. Cho, H. Algadi, S. Al-Sayari, D. E. Kim, T. Lee\* .....3114–3121

### Ag Nanowire Reinforced Highly Stretchable Conductive Fibers for Wearable Electronics

**Hydrogels with enhanced mechanical properties** are made by cross-linking recombinant polypeptide micelles through coordination chemistry. The micelles are created from a genetically engineered, amphiphilic, elastin-like polypeptide, which contains a hydrophilic block that is terminated with a bioinspired metal-ion binding domain. Heating polypeptide chains in solution triggers self-assembly of the biopolymers into monodisperse micelles, which are then reversibly cross-linked into self-healing gels with very high modulus.

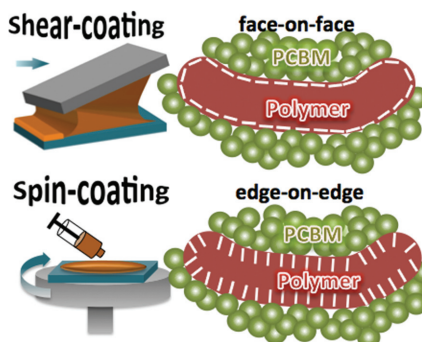


## Self-Healing Materials

A. Ghoorchian, J. R. Simon, B. Bharti, W. Han, X. Zhao, A. Chilkoti, G. P. López\* .....3122–3130

### Bioinspired Reversibly Cross-linked Hydrogels Comprising Polypeptide Micelles Exhibit Enhanced Mechanical Properties

The enhancement of local molecular orientation correlations of aggregates is achieved by shear-coating compared to spin-coating, the most widely used research fabrication tool. Molecular orientation is measured via polarized resonant soft X-ray scattering. Such an orientation has been previously shown to be a critical structure factor that impacts the performance of devices. Shearing might thus be a method to improve device performance.

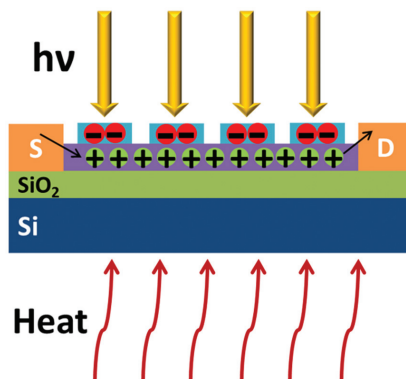


## Thin Films

W. Ma, J. Reinspach, Y. Zhou, Y. Diao, T. McAfee, S. C. B. Mannsfeld, Z. Bao,\* H. Ade\* .....3131–3137

### Tuning Local Molecular Orientation–Composition Correlations in Binary Organic Thin Films by Solution Shearing

A donor material, PSeTPTI, is used for fabricating organic phototransistors. Through introducing the heterojunction by depositing PC<sub>61</sub>BM on top of PSeTPTI, the performance is improved. The photodetectors can detect not only visible light but also ultraviolet. More attractively, the devices can work normally at high temperature, even up to 200 °C.



## Organic Electronics

Z. Qi, J. Cao, H. Li,\* L. Ding,\* J. Wang\* .....3138–3146

### High-Performance Thermally Stable Organic Phototransistors Based on PSeTPTI/PC<sub>61</sub>BM for Visible and Ultraviolet Photodetection

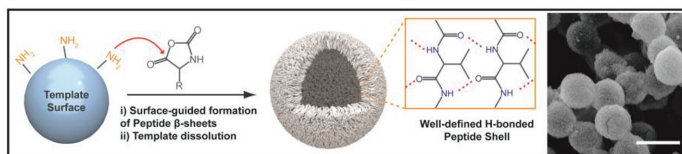
# FULL PAPERS

## Polypeptides

S. H. Wibowo, A. Sulistio, E. H. H. Wong, A. Blencowe, G. G. Qiao\* ..... 3147–3156

### Functional and Well-Defined $\beta$ -Sheet-Assembled Porous Spherical Shells by Surface-Guided Peptide Formation

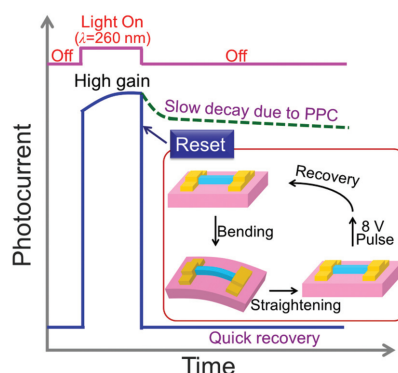
Well-defined peptide  $\beta$ -sheet-assembled porous shells with tailored dimensions are prepared by a simple, rapid, and robust bottom-up strategy involving surface-initiated ring-opening polymerization. Further exploitation of the hollow shells demonstrates the ability to non-covalently entrap small molecules, nanoparticles, proteins, drugs, and polymers to form functional materials for various potential applications.



## Photodetectors

K. Liu,\* M. Sakurai, M. Aono, D. Shen ..... 3157–3163

### Ultrahigh-Gain Single $\text{SnO}_2$ Microrod Photoconductor on Flexible Substrate with Fast Recovery Speed

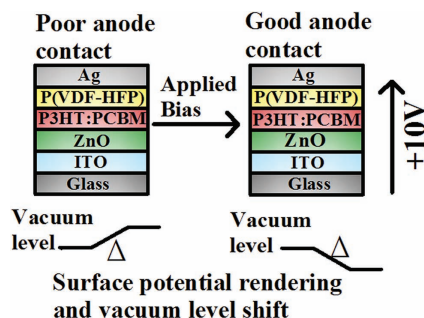


A single  $\text{SnO}_2$  microrod photoconductor is demonstrated on a flexible substrate with the photoconductive gain as high as  $\approx 1.5 \times 10^9$ . More interestingly, the recovery time can be reduced from more than 1 d to less than 1 s by a novel “reset” process: bending and straightening the microrod and subsequently applying a voltage pulse.

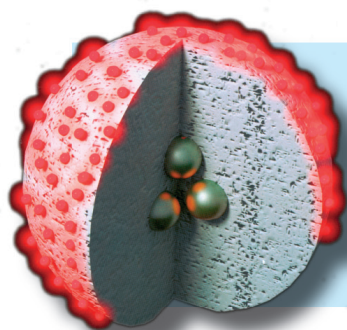
## Tunable Dipoles

W. Zhong, L. Chen, S. Xiao, L. Huang, Y. Chen\* ..... 3164–3171

### A Versatile Buffer Layer for Polymer Solar Cells: Rendering Surface Potential by Regulating Dipole



Poly(vinylidene fluoride-hexafluoropropylene) (P(VDF-HFP)) is demonstrated as an efficient buffer layer in cathode/anode interface of conventional/inverted solar cells, with tunable dipole rendering surface potential of active layers. Integer charge transfer (ICT) model is employed to unveil the effect of surface potential on electrode contact and device performance. Understanding the function of dipole makes P(VDF-HFP) a versatile buffer layer for PSCs.



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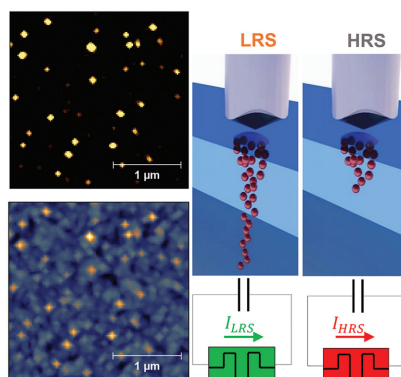
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## FULL PAPERS

The origins of multifilamentary resistive switching in high-performance  $\alpha$ -STO memristive devices are investigated to realize donor-doped devices with improved switching characteristics, capable of stable field-dependent multi-state switching operation. The non-linear switching characteristics of the donor-doped  $\alpha$ -STO nanoswitches can be mechanically modulated via force-controlled nanocontact experiments.

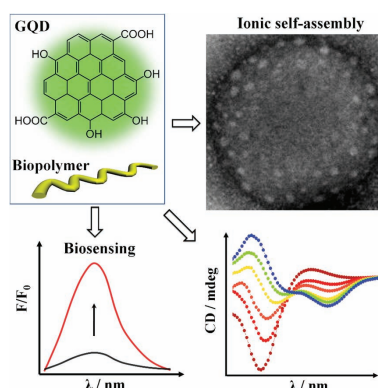


## Memristors

H. Nili,\* S. Walia, A. E. Kandjani, R. Ramanathan, P. Gutruf, T. Ahmed, S. Balendhran, V. Bansal, D. B. Strukov, O. Kavehei, M. Bhaskaran, S. Sriram\* ..... 3172–3182

### Donor-Induced Performance Tuning of Amorphous SrTiO<sub>3</sub> Memristive Nanodevices: Multistate Resistive Switching and Mechanical Tunability

Ionic self-assembly of disc-shaped graphene quantum dots (GQDs) and biopolymers are employed to design versatile biosensors, in which the GQDs serve as photoluminescent probes and the biopolymers confer biological activity. Three key strategies are proposed to design label-free sensors of pH, glycosaminoglycans, and protease.

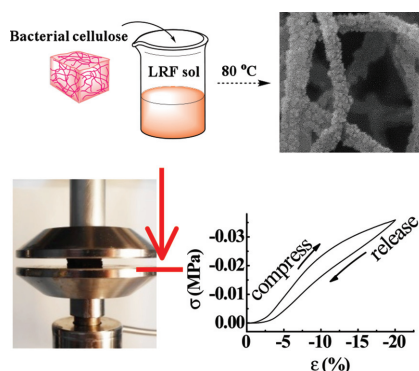


## Biosensors

Y. Lin, R. Chapman, M. M. Stevens\* ..... 3183–3192

### Integrative Self-Assembly of Graphene Quantum Dots and Biopolymers into a Versatile Biosensing Toolkit

Intrinsically brittle lignin–resorcinol–formaldehyde carbon aerogels undergo large reversible deformation after bacterial cellulose toughening, and exhibit exceptional areal capacitance.

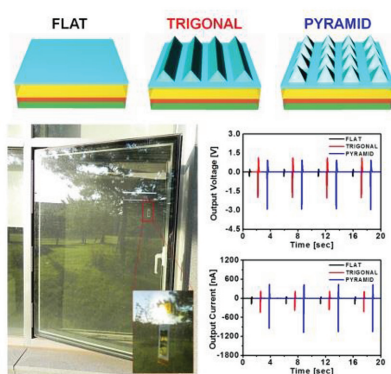


## Energy Storage

X. Xu, J. Zhou, D. H. Nagaraju, L. Jiang,\* V. R. Marinov, G. Lubineau,\* H. N. Alshareef, M. Oh ..... 3193–3202

### Flexible, Highly Graphitized Carbon Aerogels Based on Bacterial Cellulose/Lignin: Catalyst-Free Synthesis and its Application in Energy Storage Devices

Micropatterned poly(vinylidene fluoride-co-trifluoroethylene) P(VDF-TrFE) film-based piezoelectric nanogenerators with high power-generating performance for highly sensitive self-powered pressure sensors are successfully demonstrated. The microstructured P(VDF-TrFE)-based PNGs have nearly five times larger power output compared to the flat film-based PNG. The microstructured nanogenerator efficiently converts external force into electric output with superior mechanical durability under various circumstances, such as rain drops and wind blow.



## Energy Harvesting

J.-H. Lee, H.-J. Yoon, T. Y. Kim, M. K. Gupta, J. H. Lee, W. Seung, H. Ryu, S.-W. Kim\* ..... 3203–3209

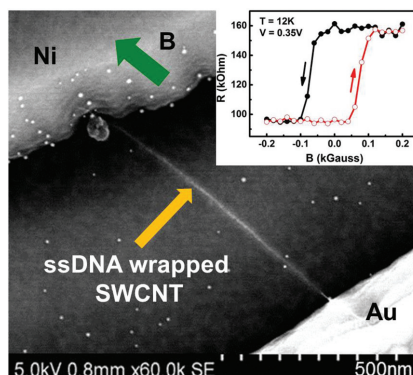
### Micropatterned P(VDF-TrFE) Film-Based Piezoelectric Nanogenerators for Highly Sensitive Self-Powered Pressure Sensors

## FULL PAPERS

## Spintronics

K. M. Alam, S. Pramanik\*.... 3210–3218

## Spin Filtering through Single-Wall Carbon Nanotubes Functionalized with Single-Stranded DNA

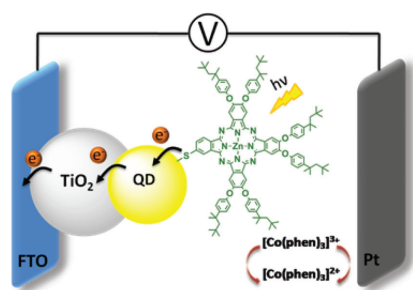


Spin filtering through single-wall carbon nanotubes (SWCNTs) wrapped with single-stranded DNA is demonstrated. Significant spin polarization, larger than typical transition metal ferromagnets, is observed at low temperatures. The helical wrapping of the ssDNA induces an inversion asymmetric electric field in the SWCNT channel, which results in a Rashba-type spin-orbit interaction and polarizes carrier spins.

## Photovoltaics

V. M. Blas-Ferrando, J. Ortiz, V. González-Pedro, R. S. Sánchez, I. Mora-Seró, F. Fernández-Lázaro, Á. Sastre-Santos\*..... 3220–3226

## Synergistic Interaction of Dyes and Semiconductor Quantum Dots for Advanced Cascade Cosensitized Solar Cells

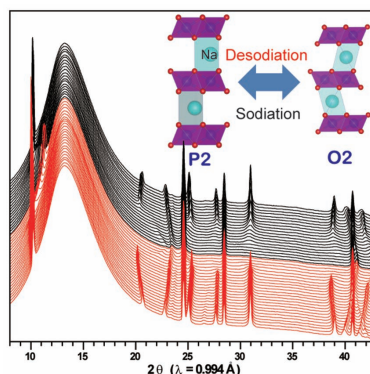


The cascade co-sensitization concept is demonstrated by the sensitization of TiO<sub>2</sub> electrodes with CdS quantum dots (QDs) covalently linked to zinc phthalocyanines (ZnPcs) via a sulfur atom. The efficiency of co-sensitized CdS QD-SZnPc cells, using Co(phen)<sub>3</sub><sup>3+</sup>/[Co(phen)<sub>3</sub>]<sup>2+</sup> as electrolyte, is 212% higher than that of a solar cell sensitized just with CdS QD.

## Sodium-Ion Batteries

Y. H. Jung, A. S. Christiansen, R. E. Johnsen, P. Norby, D. K. Kim\*..... 3227–3237

## In Situ X-Ray Diffraction Studies on Structural Changes of a P2 Layered Material during Electrochemical Desodiation/Sodiation



The phase transition of a sodium layered material with P2 stacking during electrochemical desodiation/sodiation is studied by in situ synchrotron X-ray diffraction using a capillary-based microcell. P2-Na<sub>0.7</sub>Fe<sub>0.4</sub>Mn<sub>0.4</sub>Co<sub>0.2</sub>O<sub>2</sub> is transformed to an O2 structure in the voltage plateau at 4.1 V, and the O2 phase shows a rapid change in the *c* lattice until a fully charged state.

## Electrochemical Cells

A. Asadpoordarvish, A. Sandström, C. Larsen, R. Bollström, M. Toivakka, R. Österbacka, L. Edman\*... 3238–3245

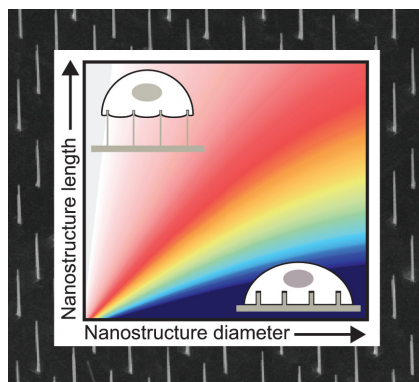
## Light-Emitting Paper



A surface-emitting light-emitting electrochemical cell (LEC) is fabricated on a conventional low-cost paper substrate. It is notable that all of the device layers, including the cathode, active material, and anode, are deposited from solution under ambient air using a handheld airbrush. The main merits of the paper-LEC are the highly flexible and robust form factor, the low weight, and the cost-efficient and fault-tolerant fabrication.

## FULL PAPERS

**Cell settling on nanostructure (NS) arrays** is modeled and the effect of geometrical and cell-related parameters is systematically evaluated. It is found that cell settling is highly dependent on both single-NS dimensions and NS density, and predictive tools are developed for any NS array or cell type, thus allowing a rational design of future NS arrays for biological applications.

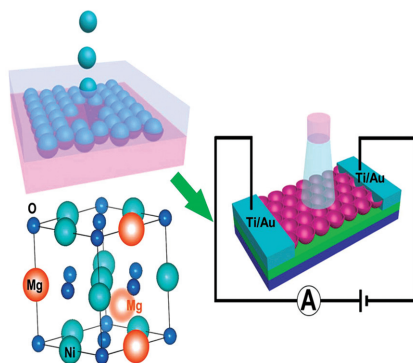


## Nanotopography

N. Buch-Månson, S. Bonde, J. Bolinsson, T. Berthing, J. Nygård, K. L. Martinez\* .....3246–3255

**Towards a Better Prediction of Cell Settling on Nanostructure Arrays—Simple Means to Complicated Ends**

A series of high-quality monolayer  $\text{Ni}_x\text{Mg}_{1-x}\text{O}$  ( $0.7 \leq x \leq 1$ ) bowl-shaped array films are successfully fabricated by a simple one-step assembly of polystyrene colloidal spheres and metal oxide precursors at oil–water interface. The  $\text{Ni}_x\text{Mg}_{1-x}\text{O}$  film-based device shows significantly enhanced photocurrent due to the doping of  $\text{Mg}^{2+}$  ions and higher optoelectronic properties than the previously reported counterparts.

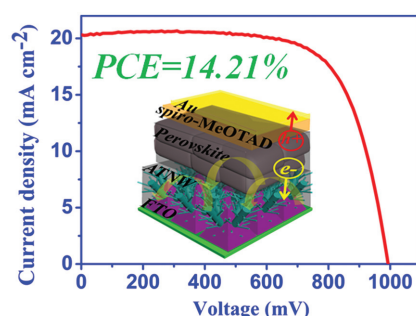


## Semiconductors

Y. Zhao, L. Hu, S. Gao, M. Liao, L. Sang, L. Wu\* .....3256–3263

**One-Step Self-Assembly Fabrication of High Quality  $\text{Ni}_x\text{Mg}_{1-x}\text{O}$  Bowl-Shaped Array Film and Its Enhanced Photocurrent by  $\text{Mg}^{2+}$  Doping**

A facile solution-based route to fabricate thin films of dendritic anatase  $\text{TiO}_2$  nanowires on TCO substrates is developed. Solar cells containing the perovskite-infiltrated nanowire layer and uniform perovskite capping layer yield impressive power conversion efficiencies (>14%) due to efficient light harvesting and charge collection in the bilayer structure.



## Perovskite Photovoltaics

W.-Q. Wu, F. Huang, D. Chen,\* Y.-B. Cheng,\* R. A. Caruso\* ...3264–3272

**Thin Films of Dendritic Anatase Titania Nanowires Enable Effective Hole-Blocking and Efficient Light-Harvesting for High-Performance Mesoscopic Perovskite Solar Cells**