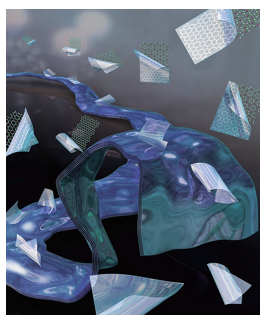


# ADVANCED FUNCTIONAL MATERIALS

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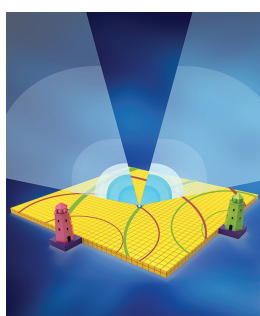
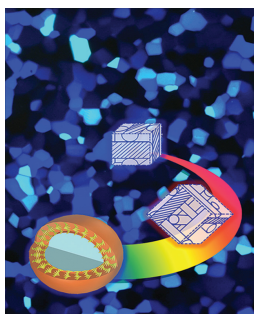


## Sustainable Synthesis

On page 111, Z. Wang, J. Qiu, and co-workers report a scalable and economic approach for sustainable production of B/N co-doped carbon nanosheets by templating the biomass materials against two-dimensional crystals. The doped carbon nanosheets feature very thin thickness, ultrahigh aspect ratio, and excellent flexibility, enabling the assembly of flexible thin films for superior charge storage in supercapacitors.

## Liquid-Crystal Nanostructures

Nature is a fabulous gallery of 3D photonic nanostructures, formed through evolution and natural selection over billions of years. Soft nanotechnology—i.e., exploiting self-organized soft materials in nanotechnology—is emerging as a vibrant field of research in the bottom-up nanofabrication of intelligent, stimuli-driven 3D photonic materials and devices. On page 10, L. Wang and Q. Li provide a glimpse of the advancements in design, fabrication, and applications of self-organized 3D liquid crystalline photonic nanostructures.

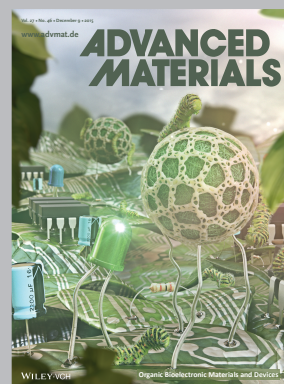
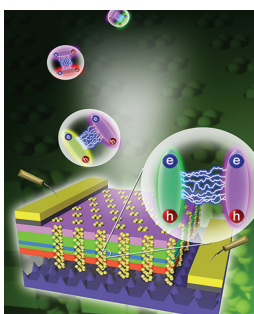


## Holographic Metasurfaces

T. J. Cui and co-workers propose, on page 29, a new method to design planar dual-functional devices using isotropic holographic metasurface, in which two different functions are written on the same hologram with no mutual coupling. Via specific design, double-beam or double-polarization radiating devices are realized independently by orthogonal excitations. Scanning radiating beams controlled only by frequency are demonstrated with different performances under orthogonal polarizations.

## Light-Emitting Diodes

On page 36, Z. Zhuang, B. Liu, R. Zhang, and co-workers demonstrate a white light-emitting diode with a novel hybrid nanohole nitride/nanocrystals structure, exhibiting high color-conversion efficiency and effective quantum yield by utilizing an efficient nonradiative energy transfer. These devices can achieve a very high color rendering index with warm white, natural white, or cold white emission, providing great prospects for mass production in future.



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EDITORIAL

Open Choices

J. Ritterbusch .....9

FEATURE ARTICLE

Soft nanotechnology—i.e., exploiting self-organized soft materials in nanotechnology—is emerging as an attractive paradigm in the bottom-up nanofabrication of intelligent stimuli-driven 3D photonic materials and devices. Liquid-crystalline materials undoubtedly represent such an elegant dynamic system that combines the liquid-like fluidity and crystal-like ordering from molecular to macroscopic levels. This review provides a glimpse of the advancements in design, fabrication and applications of stimuli-directing self-organized 3D liquid-crystalline photonic nanostructures.



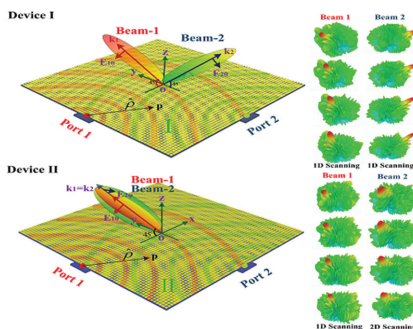
Liquid-Crystal Nanostructures

L. Wang, Q. Li\* .....10–28

Stimuli-Directing Self-Organized 3D Liquid-Crystalline Nanostructures: From Materials Design to Photonic Applications

FULL PAPERS

A new method is proposed to design planar dual-functional devices using isotropic holographic metasurface, in which two different functions are written on the same hologram with no mutual coupling. In this specific design, double-beam or double-polarization radiate devices are realized independently by orthogonal excitations. Scanning radiate beams that are only controlled by frequency with different performances under orthogonal polarizations are demonstrated.

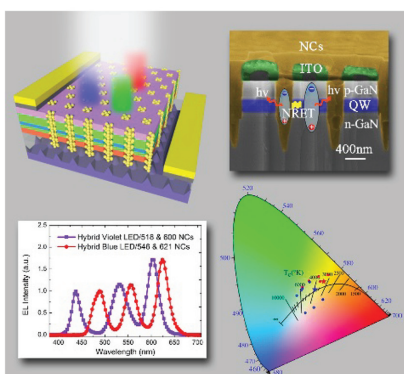


Holographic Metasurfaces

Y. B. Li, B. G. Cai, Q. Cheng, T. J. Cui\* .....29–35

Isotropic Holographic Metasurfaces for Dual-Functional Radiations without Mutual Interferences

White light-emitting diodes, with a novel nanohole nitride quantum well/II–VI nanocrystal hybrid structure, are demonstrated. High color-conversion efficiency and high effective quantum yield are achieved in these devices by utilizing an efficient nonradiative energy transfer. Moreover, they can realize a high color rendering index, covering different correlated color temperatures corresponding to warm white, natural white, and cold white.



Light-Emitting Diodes

Z. Zhuang, X. Guo, B. Liu,\* F. Hu, Y. Li, T. Tao, J. Dai, T. Zhi, Z. Xie, P. Chen, D. Chen, H. Ge, X. Wang, M. Xiao, Y. Shi, Y. Zheng, R. Zhang\* .....36–43

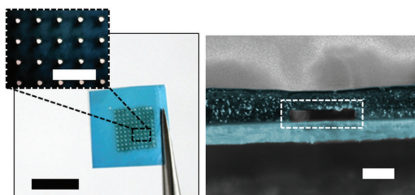
High Color Rendering Index Hybrid III-Nitride/Nanocrystals White Light-Emitting Diodes

**FULL PAPERS**

**Silk Fibroin**

M. A. Brenckle, B. Partlow, H. Tao,  
M. B. Applegate, A. Reeves, M. Paquette,  
B. Marelli, D. L. Kaplan,  
F. G. Omenetto\* ..... 44–50

**Methods and Applications of Multilayer Silk Fibroin Laminates Based on Spatially Controlled Welding in Protein Films**

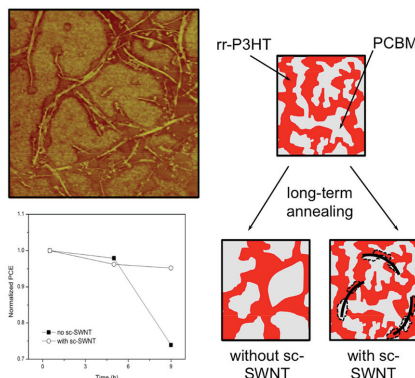


A thermal processing method for producing patterned multilayer laminates in silk fibroin is presented, based on thermal reflow of amorphous protein films. The method is able to produce laminates with strength on the order of the bulk material, and features as small as 100 μm. Applications of geometries produced by this method in bioelectronics and drug delivery are also presented.

**Photovoltaic Devices**

T. Salim, H.-W. Lee, L. H. Wong,  
J. H. Oh, Z. Bao,\* Y. M. Lam\* ..... 51–65

**Semiconducting Carbon Nanotubes for Improved Efficiency and Thermal Stability of Polymer–Fullerene Solar Cells**

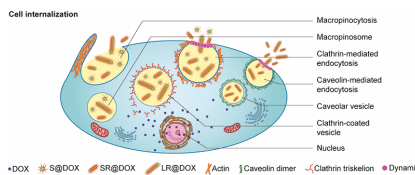


Semiconducting single-walled nanotubes (sc-SWNTs) with high purity improve both device performance and thermal stability of organic solar cells based on a blend of a conjugated polymer and a fullerene derivative. The presence of sc-SWNTs induces the organization of the polymer phase, while suppressing the excessive phase separation of the blend materials.

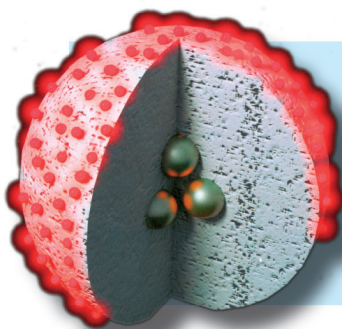
**Drug Delivery**

D. Li, Z. M. Tang, Y. Q. Gao,  
H. L. Sun, S. B. Zhou\* ..... 66–79

**A Bio-Inspired Rod-Shaped Nanoplatfom for Strongly Infecting Tumor Cells and Enhancing the Delivery Efficiency of Anticancer Drugs**



A novel bio-inspired rod-shaped micellar system is developed as a nanoplatfom for highly effectively delivering anticancer drugs. The nanoplatfom has a great capacity of escaping the rapid clearance of reticuloendothelial system in blood, a high internalization rate of tumor cells, and a significant enhancement of therapeutic agent potency against artificial solid tumors.



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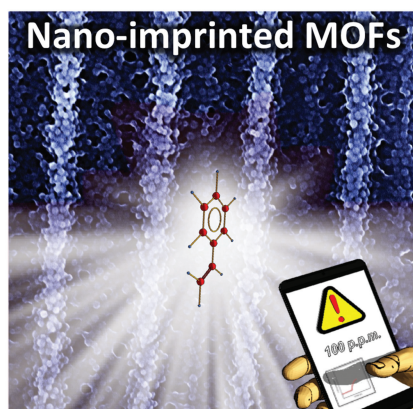
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## FULL PAPERS

**2D Photonic metal–organic framework (MOF)-based homo- and heterostructures** are fabricated by soft-lithographic approaches. This versatile approach allows preparation of large-scale patterned surfaces on several substrates including flexible plastics. The materials are used as selective optical sensing platform. Detection of toxic vapors such as styrene is performed by using an easy transduction method, compatible with smartphone camera technology.

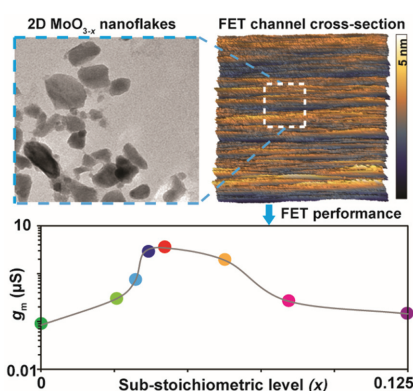


## Vapor Sensing

O. Dalstein, D. R. Ceratti,  
C. Boissière, D. Grosso,  
A. Cattoni,\* M. Faustini\* .....81–90

**Nanoimprinted, Submicrometric, MOF-Based 2D Photonic Structures: Toward Easy Selective Vapors Sensing by a Smartphone Camer**

**Electronic inks of 2D MoO<sub>3-x</sub> flakes** based on a solar light irradiation in liquid-phase exfoliated method are used for developing channels FETs for future high-performance printed nano-electronic devices. It is shown that the carrier concentration, energy band, and carrier charge mobility in 2D MoO<sub>3-x</sub>-based FETs can be tuned and the optimal substoichiometric value with the maximum transconductance is obtained.

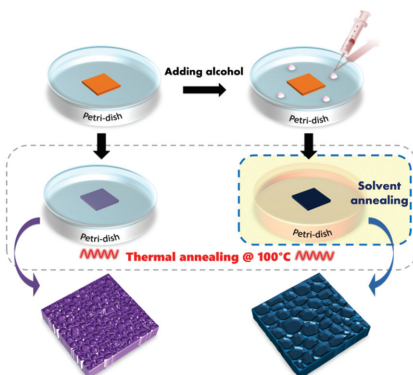


## Field-Effect Transistors

M. M. Y. A. Alsaif,\* A. F. Chrimes,  
T. Daeneke, S. Balendhran,  
D. O. Bellisario, Y. Son, M. R. Field,  
W. Zhang, H. Nili, E. P. Nguyen,  
K. Latham, J. van Embden, M. S. Strano,  
J. Z. Ou,\* K. Kalantar-zadeh\* .....91–100

**High-Performance Field Effect Transistors Using Electronic Inks of 2D Molybdenum Oxide Nanoflakes**

**High performance of perovskite photovoltaics (perovskite solar cells and perovskite photodetectors)** is realized by alcohol-vapor solvent annealing treatment on CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> thin films to enhance the crystal growth and the grain size of the CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> crystals.

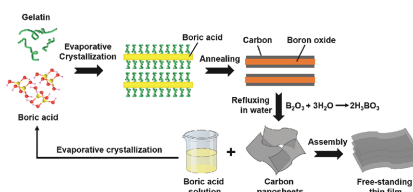


## Perovskite Photovoltaics

C. Liu, K. Wang, C. Yi, X. Shi,  
A. W. Smith, X. Gong,\*  
A. J. Heeger .....101–110

**Efficient Perovskite Hybrid Photovoltaics via Alcohol-Vapor Annealing Treatment**

**B/N co-doped carbon nanosheets with ultrahigh aspect ratio** are synthesized by assembling the biomass molecule in long-range order on recyclable 2D hard template followed by annealing. The unique structural features allow them to be assembled to flexible thin films and ultralight aerogels for superior charge storage in supercapacitors.



## Sustainable Synthesis

Z. Ling, Z. Wang,\* M. Zhang, C. Yu,  
G. Wang, Y. Dong, S. Liu, Y. Wang,  
J. Qiu\* .....111–119

**Sustainable Synthesis and Assembly of Biomass-Derived B/N Co-Doped Carbon Nanosheets with Ultrahigh Aspect Ratio for High-Performance Supercapacitors**

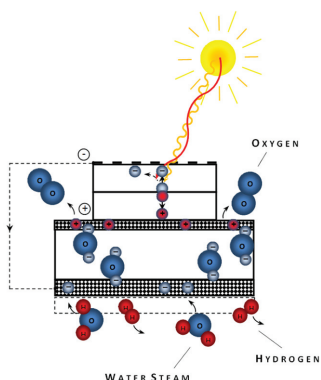


FULL PAPERS

High Temperature Photoelectrochemistry

G. C. Brunauer,\* B. Rotter, G. Walch, E. Esmaili, A. K. Opitz, K. Ponweiser, J. Summhammer, J. Fleig\* ..... 120–128

UV-Light-Driven Oxygen Pumping in a High-Temperature Solid Oxide Photoelectrochemical Cell

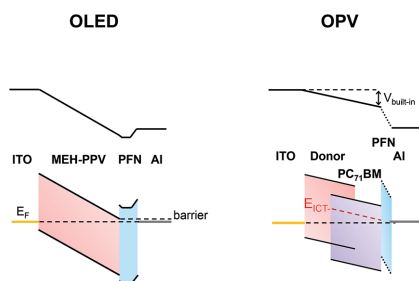


Photon-driven electrochemical energy storage is realized by stacking a high-temperature oxide-based solar cell and a zirconia-based oxygen pump. The solar cell part exhibits more than 900 mV cell voltage at 400 °C and this driving force is transferred to the electrochemical process by a shared electrode in the single stack device.

Organic Electronics

Z. Hu, Z. Zhong, Y. Chen, C. Sun, F. Huang, J. Peng, J. Wang,\* Y. Cao ..... 129–136

Energy-Level Alignment at the Organic/Electrode Interface in Organic Optoelectronic Devices

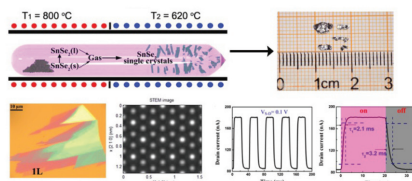


There is no agreement on the dipole direction of the cathode interfacial layer in organic electronic devices in the literature. By splitting the device at different interfaces to study the energy-level alignment, the energetic diagrams of the organic light-emitting diode (OLED) and the organic photovoltaic (OPV) device are clarified. The vacuum level is aligned across the organic/metal interface in OLED, while energy pinning occurs in OPV.

Photodetectors

P. Yu, X. Yu, W. Lu, H. Lin, L. Sun, K. Du, F. Liu, W. Fu, Q. Zeng, Z. Shen, C. Jin, Q. J. Wang,\* Z. Liu\* ..... 137–145

Fast Photoresponse from 1T Tin Diselenide Atomic Layers



A high performance atomically layered SnSe<sub>2</sub> photodetector has been first successfully fabricated for the first time. The photodetector displays a good responsivity of 0.5 A W<sup>-1</sup> and a fast photoresponse down to ≈2 ms at room temperature, one of the fastest response times among all types of 2D photodetectors.

Organic Memory Devices

Q. Zhang, J. He, H. Zhuang, H. Li,\* N. Li, Q. Xu, D. Chen, J. Lu\* ... 146–154

Rational Design of Small Molecules to Implement Organic Quaternary Memory Devices

A donor–acceptor structured small molecule is rationally designed to contain three distinct electron acceptors. Organic quaternary memory behavior is demonstrated for the first time induced by a stepwise charge-transfer process. The threshold voltages of the memory device are distinct, and the current ratio of the four states is identified, which indicate a low possibility of read and write errors.

