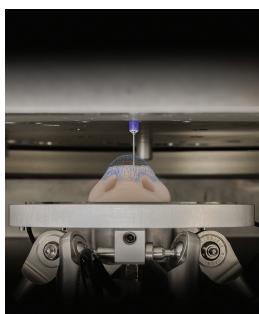


# ADVANCED FUNCTIONAL MATERIALS

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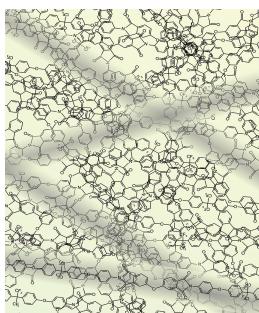


## Bioprinting

On page 7406, M. Zenobi-Wong and co-workers present a bioink which allows the bioprinting of complex cell-laden cartilaginous structures with regulatory-compliant biomaterials. The printed grafts have tunable mechanical properties and, since they can be developed to contain extracellular matrix particles, are also tissue-specific. Complex and overhanging structures can be printed using a co-extruded support polymer, which also acts as a cation-reservoir to rapidly crosslink the bioink.

## Carbon Nanotubes

A novel approach for producing water-soluble, electron-donor single wall carbon nanotube (SWCNT) hybrids is demonstrated by A. de la Escosura, D. M. Guldin, T. Torres, and co-workers on page 7418. The method is based on supramolecular immobilization of quaternized pyridyloxy phthalocyanines (ZnPc). The water-solubility and excellent electron-accepting features of these ZnPc derivatives switch the redox and photophysical properties of the SWNTs, which can actually be used for energy conversion.

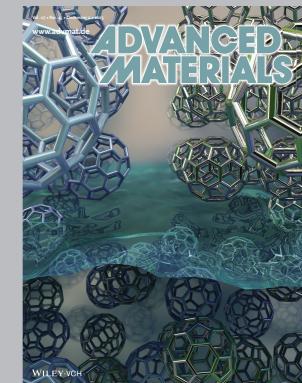
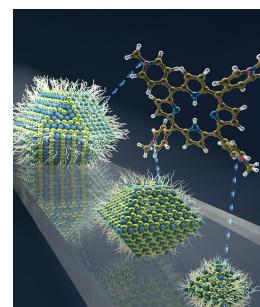
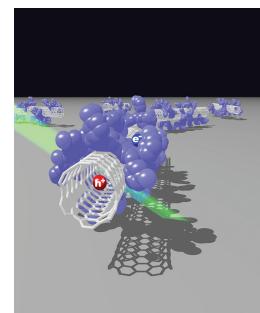


## Flexible Electronics

A thermally and mechanically robust, smooth, and transparent conductor composed of silver nanowires embedded in a colorless polyimide substrate is introduced by C. B. Arnold and co-workers on page 7428. This material is a new substrate-cum-electrode for optoelectronics devices and exhibits excellent thermal, mechanical, and chemical stability. As a substrate for a flexible organic light-emitting diode, improved device performance is achieved compared to a control device made on ITO coated glass.

## Quantum Dots

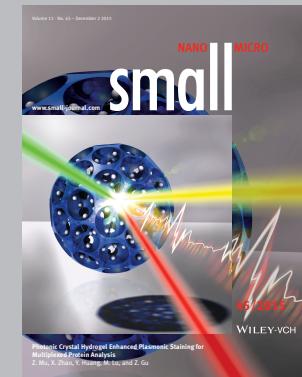
The interfacial electrostatic interaction between the positively-charged porphyrin and the negatively-charged quantum dot (QD) surface provides an additional driving force for efficient charge transfer (CT). On page 7435, O.F. Mohammed and co-workers show the occurrence of an ultrafast CT from small bandgap ( $>1$  eV) and large bandgap ( $<1$  eV) PbS QDs to a molecular acceptor, reaching beyond the previously reported cut-off CT bandgaps for PbS QDs.



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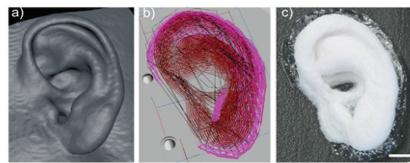
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**Complex, cell-laden cartilaginous structures** are printed with regulatory-compliant biomaterials. Printed grafts are tunable in mechanical properties and tissue-specific, as they can contain extracellular matrix particles. Bioprinting of overhanging structures is achieved using a co-extruded support polymer which also acts as a cation-reservoir to rapidly cross-link the bioink.

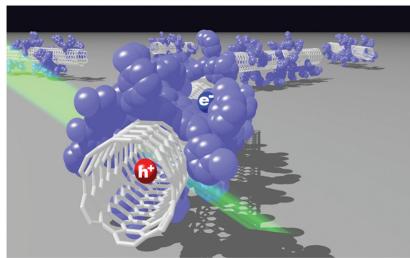


## Bioprinting

M. Kesti, C. Eberhardt, G. Pagliccia, D. Kenkel, D. Grande, A. Boss, M. Zenobi-Wong\* ..... 7406–7417

## Bioprinting Complex Cartilaginous Structures with Clinically Compliant Biomaterials

**Aqueous carbon nanotube hybrids** are developed through supramolecular immobilization of quaternized pyridyloxy phthalocyanines (ZnPc). The water-solubility and excellent electron-accepting features of these ZnPc derivatives switch the redox and photophysical properties of single wall carbon nanotubes, which can actually be used for energy conversion.

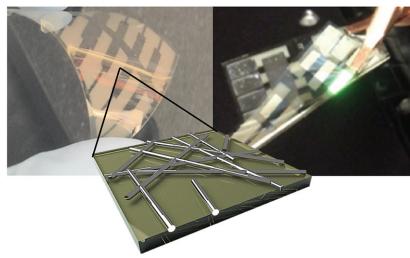


## Carbon Nanotubes

E. Anaya-Plaza, M. M. Oliva, A. Kunzmann, C. Romero-Nieto, R. D. Costa, A. de la Escosura,\* D. M. Guldin,\* T. Torres\* ..... 7418–7427

## Quaternized Pyridyloxy Phthalocyanines Render Aqueous Electron-Donor Carbon Nanotubes as Unprecedented Supramolecular Materials for Energy Conversion

**A fully solution processed composite material of a colorless polyimide, titania, and silver nanowires** is presented. This material is a new substrate-cum-electrode for optoelectronics devices, which exhibits excellent thermal, mechanical, and chemical stability. A green phosphorescent organic light-emitting diode device fabricated atop this electrode outperforms an indium-tin-oxide-on-glass substrate-cum-electrode control device.

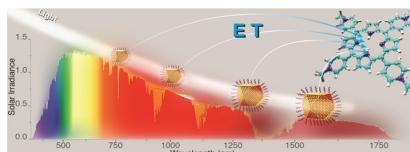


## Flexible Electronics

J. A. Spechler, T.-W. Koh, J. T. Herb, B. P. Rand, C. B. Arnold\* ..... 7428–7434

## A Transparent, Smooth, Thermally Robust, Conductive Polyimide for Flexible Electronics

**The interfacial electrostatic interaction** between the positively charged porphyrin and the negatively charged quantum dots (QDs) surface enables widening the effective bandgap ( $E_g$ ) range for charge transfer (CT) from PbS QDs. For the first time, the occurrence of an effective CT from large PbS QDs ( $E_g < 1$  eV) is shown to positively charged porphyrin, thus overcoming the previously reported cut-off CT bandgaps at PbS QD interface.



## Quantum Dots

A. O. El-Ballouli, E. Alarousu, A. R. Kirmani, A. Amassian, O. M. Bakr, O. F. Mohammed\* ..... 7435–7441

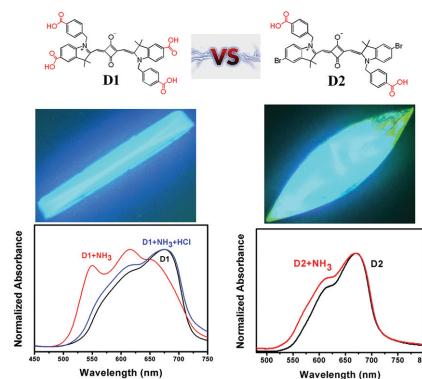
## Overcoming the Cut-Off Charge Transfer Bandgaps at the PbS Quantum Dot Interface

## FULL PAPERS

## Solid Gas Sensors

J. Li, B. Lv, D. Yan, S. Yan,  
M. Wei, M. Yin\* ..... 7442–7449

**Tunable Self-Assembled Micro/Nanostructures of Carboxyl-Functionalized Squarylium Cyanine for Ammonia Sensing**

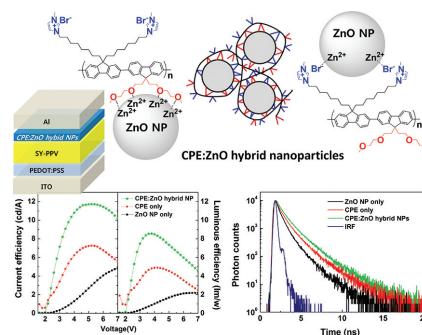


**Squarylium cyanine dyes D1 and D2**, containing different numbers of carboxylic acid groups, are utilized as a model system to investigate the self-assembly behaviors based on hydrogen bonding and  $\pi$ - $\pi$  stacking. These driving forces synergistically construct the unique morphologies of D1 and D2 by forming distinct distances in repeated units, which makes the D1 reversibly responsive to ammonia gas.

## Cathode Interfaces

K. Kim, M. Suh, J. Choi, D. Lee,  
Y. Kim, S. H. Cheong, D. Kim,  
D. Y. Jeon\* ..... 7450–7456

**Conjugated Polyelectrolyte Hybridized ZnO Nanoparticles as a Cathode Interfacial Layer for Efficient Polymer Light-Emitting Diodes**



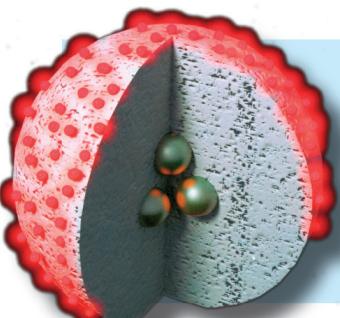
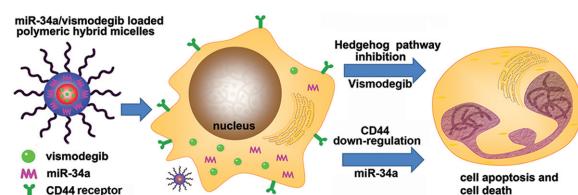
**High-efficiency polymer light-emitting diodes** ( $11.7 \text{ cd A}^{-1}$  at  $5.2 \text{ V}$  and  $8.6 \text{ lm W}^{-1}$  at  $3.8 \text{ V}$ ) are demonstrated using F8imFO<sub>4</sub> conjugated polyelectrolyte (CPE)-hybridized zinc oxide nanoparticles (ZnO NPs) as a cathode interfacial layer. The alkoxy sidechains and bromide anions of F8imFO<sub>4</sub> form a coordination bond to the ZnO surface, thus reducing fluorescence quenching of light-emitting polymer.

## Hybrid Micelles

H. Li, Y. Fu, T. Zhang, Y. Li, X. Hong,  
J. Jiang, T. Gong, Z. Zhang,  
X. Sun\* ..... 7457–7469

**Rational Design of Polymeric Hybrid Micelles with Highly Tunable Properties to Co-Deliver MicroRNA-34a and Vismodegib for Melanoma Therapy**

**A polymeric hybrid micelle system with highly tunable properties** is rationally designed and optimized to co-deliver Hedgehog pathway inhibitor vismodegib and microRNA-34a for melanoma therapy. The co-delivery system shows synergistic anticancer efficacy on B16F10-CD44<sup>+</sup> cells in vitro and in vivo, indicating the potential of PHM in co-delivery of small molecule and nucleic acid drugs.



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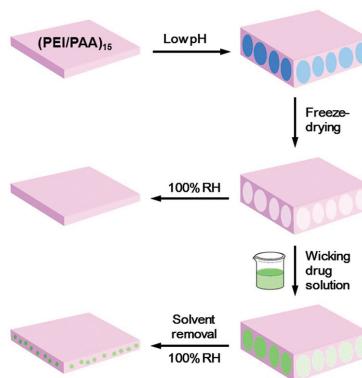
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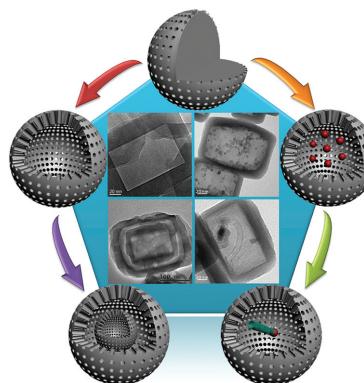
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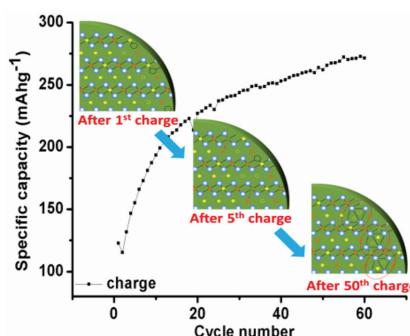
**Humidity can serve as a feasible trigger** to activate the self-healing of microporous polyelectrolyte multilayer film. Based on this, a facile and versatile means is suggested to directly integrate hydrophobic drugs into the films for biomedical coatings.



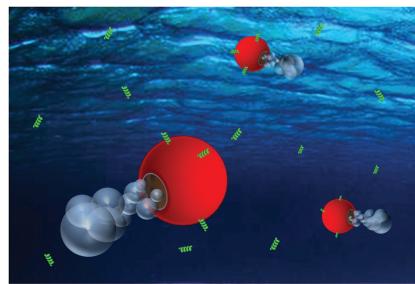
**Hollow ZSM-5 single crystals with double shells**, regular void in the crystal interior, enhanced acidity, increased Brønsted acid sites, silicon-rich exterior, adjustable Si/Al ratio, and crystal size, as well as with  $\text{Fe}_2\text{O}_3$ , bimetals ca. Cu-Pd, Cu-Pt, Fe-Au, and carbon nanotubes functionalized interior are prepared by “dissolution–recrystallization” strategy in tetrapropylammonium hydroxide solution.



**A Li-rich cathode material**  $\text{Li}_{1.87}\text{Mn}_{0.94}\text{Ni}_{0.19}\text{O}_3$  with low level of Ni doping exhibits interesting slow activating process of  $\text{Li}_2\text{MnO}_3$  phase, offering excellent platform to fundamentally understand the structural evolution of  $\text{Li}_2\text{MnO}_3$  during activation. Detailed electrochemical study and *in situ* structure characterization reveals that the transition metal diffusion process features much slower kinetics than  $\text{O}_2$  generation and determines the  $\text{Li}_2\text{MnO}_3$  activation rate.



**Cell-mimicking Janus micromotors** are constructed by integrating red blood cell (RBC) membranes and gold nanoparticles onto the exposed surface areas of magnesium microparticles to achieve efficient water-driven propulsion and rapid detoxification in biological matrices. The RBC-Mg Janus micromotors represent an exciting progress toward cell-mimicking microscale motors that hold considerable promise for diverse biomedical and biodefense applications.



## Drug Delivery

X.-C. Chen, K.-F. Ren,\* J.-H. Zhang, D.-D. Li, E. Zhao, Z. J. Zhao, Z.-K. Xu, J. Ji\* ..... 7470–7477

**Humidity-Triggered Self-Healing of Microporous Polyelectrolyte Multilayer Coatings for Hydrophobic Drug Delivery**

## Hollow Crystals

C. Dai, A. Zhang, M. Liu, X. Guo,\* C. S. Song\* ..... 7479–7487

**Hollow ZSM-5 with Silicon-Rich Surface, Double Shells, and Functionalized Interior with Metallic Nanoparticles and Carbon Nanotubes**

## Li-Rich Cathodes

D. Ye, G. Zeng, K. Nogita, K. Ozawa, M. Hankel, D. J. Searles, L. Wang\* ..... 7488–7496

**Understanding the Origin of  $\text{Li}_2\text{MnO}_3$  Activation in Li-Rich Cathode Materials for Lithium-Ion Batteries**

## Biodetoxification

Z. Wu, J. Li, B. E.-F. de Ávila, T. Li, W. Gao, Q. He, L. Zhang,\* J. Wang\* ..... 7497–7501

**Water-Powered Cell-Mimicking Janus Micromotor**

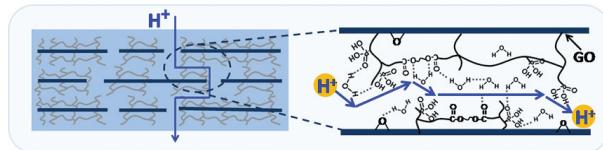


## FULL PAPERS

## Functionalized Graphene

G. He, C. Chang, M. Xu, S. Hu, L. Li, J. Zhao, Z. Li, Z. Li, Y. Yin, M. Gang, H. Wu, X. Yang, M. D. Guiver, Z. Jiang\* ..... 7502–7511

**A novel approach to construct tunable nanochannels** via direct assembly of graphene oxide/polymer core–shell nanosheets is developed. Through molecular-level engineering of the nanosheets, ordered and continuous nanochannels with well-tailored chemical structures can be created. The resulting membrane exhibits a proton conductivity of  $32 \text{ mS cm}^{-1}$  at 51% RH, surpassing state-of-the-art Nafion membrane and all previously reported GO-based materials.

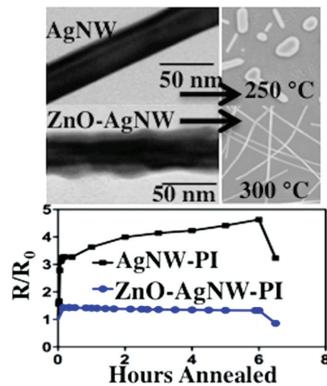


## Tunable Nanochannels along Graphene Oxide/Polymer Core–Shell Nanosheets to Enhance Proton Conductivity

## Silver Nanowires

D. Chen, J. Liang, C. Liu, G. Saldanha, F. Zhao, K. Tong, J. Liu, Q. Pei\* ..... 7512–7520

## Thermally Stable Silver Nanowire–Polyimide Transparent Electrode Based on Atomic Layer Deposition of Zinc Oxide on Silver Nanowires

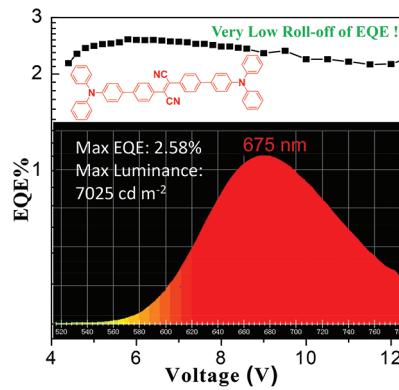


**Silver nanowires are made thermally stable** with a thin layer of ZnO deposited using atomic layer deposition. This ZnO layer prevents the melting and coalescence of AgNWs observed at annealing temperatures above 180 °C, while maintaining a porous network structure. When transparent, colorless polyimide is infiltrated between the nanowires, the resulting freestanding films are able to withstand 300 °C annealing for over 6 h, showing little to no degradation in electrical or optical properties.

## Organic LEDs

X. Han, Q. Bai, L. Yao, H. Liu, Y. Gao, J. Li, L. Liu, Y. Liu, X. Li, P. Lu,\* B. Yang ..... 7521–7529

## Highly Efficient Solid-State Near-Infrared Emitting Material Based on Triphenylamine and Diphenylfumaronitrile with an EQE of 2.58% in Nondoped Organic Light-Emitting Diode

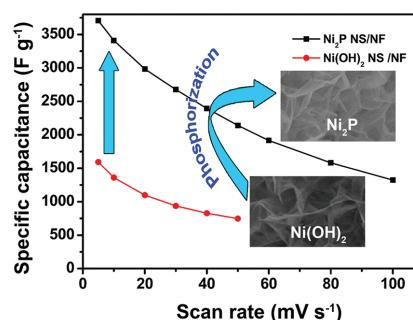


**The development of near-infrared (NIR) emitting material** is of increasing interest. TPATCN with a strong NIR emission and a film efficiency of 33% is obtained. It benefits from a large dipole moment of CT state and a certain degree of orbital overlap of LE state. The maximum EQE of nondoped device reaches 2.58%, which is among the highest values of NIR OLEDs.

## Pseudocapacitors

K. Zhou, W. Zhou,\* L. Yang, J. Lu, S. Cheng, W. Mai, Z. Tang, L. Li, S. Chen\* ..... 7530–7538

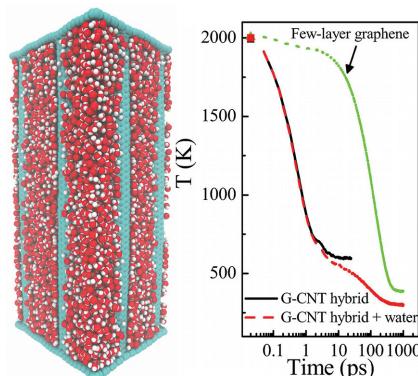
## Ultrahigh-Performance Pseudocapacitor Electrodes Based on Transition Metal Phosphide Nanosheets Array via Phosphorization: A General and Effective Approach



**Ultrahigh-performance pseudocapacitor electrodes** are prepared with a general and effective phosphorization strategy to enhance supercapacitor performance of various transition metals oxide or hydroxide. The Ni foam supported  $\text{Ni}_2\text{P}$  nanosheets array electrode shows a remarkable specific capacitance of more than  $3000 \text{ F g}^{-1}$ , much larger than the corresponding  $\text{Ni}(\text{OH})_2$  nanosheets array before phosphorization.

## FULL PAPER

An improvement for the *c*-axis heat transfer of few layer graphene by a covalently bonded graphene–carbon nanotube (G-CNT) hybrid is demonstrated. The G-CNT exhibits a thermal resistance that is three orders of magnitude lower than state-of-the-art thermal interface materials. The G-CNT can be immersed in a circulating liquid for the ultrafast cooling of hot surfaces such as integrated circuits.



## Thermal Interfaces

J. Chen,\* J. H. Walther,\*  
P. Koumoutsakos\*.....7539–7545

## Covalently Bonded Graphene–Carbon Nanotube Hybrid for High-Performance Thermal Interfaces

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