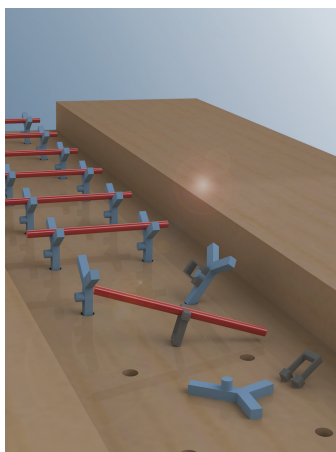


# ADVANCED FUNCTIONAL MATERIALS

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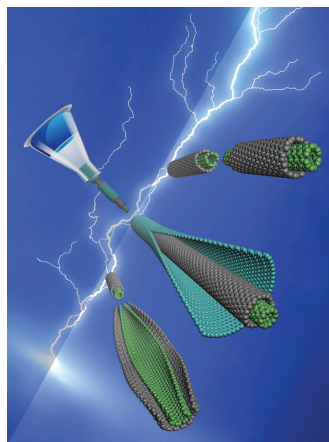
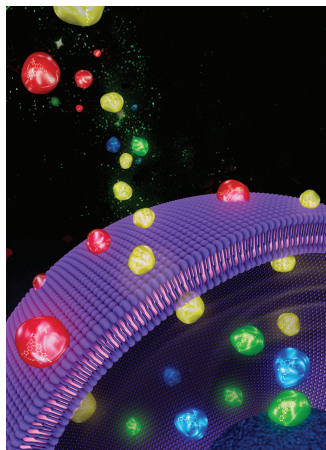


## Robotics

Remotely actuated microdevices powered by magnetic fields have gained attention where a physical presence is required inside remote or enclosed microscale environments. On page 4397, E. Diller and M. Sitti demonstrate a millimeter-scale robotic gripper capable of locomotion for precise transport, orientation, and programmable 3D assembly of microparts. The cover image illustrates a team of mobile microgrippers building a series of 3D linkage assemblies from a variety of materials in a remote fluidic channel.

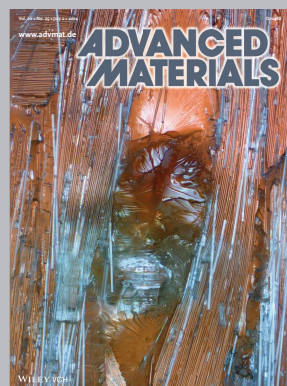
## Organic Nanoparticles

Four tetrahydro[5]helicene-based fluorescent dyes with three primary emission colors (blue-green-red) and the corresponding multicolor organic nanoparticles are described on page 4405 by H.-Y. Lu, S. Wang, C.-F. Chen, and co-workers. These organic nanoparticles exhibit intense emission colors, low cytotoxicity, and good photostability. In particular, the stained regions of the nanoparticles from membrane to cytoplasm for HeLa cells show obvious structure-dependent properties.



## Nanotubes

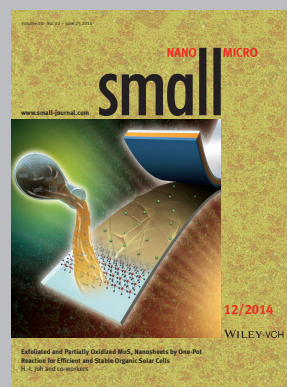
On page 4497, Z. Chen, J. W. Connell, Y. Lin, and co-workers demonstrate a method to disperse and chemically modify the morphology of BNNTs via sonication in aqueous ammonia solutions. While BNNTs have always been considered chemically inert, the ammonia-modified BNNTs are significantly corroded and exhibit end-cap removal, tip sharpening, wall thinning, length shortening, and longitudinal unzipping. This could lead to an effective purification technique for BNNTs by removing amorphous BN fragments from production.



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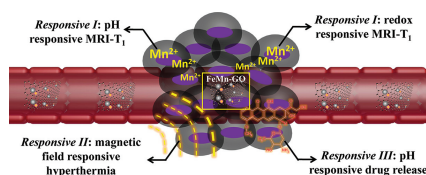
[www.small-journal.com](http://www.small-journal.com)

## FULL PAPERS

## Cancer Therapy

Y. Chen, P. Xu, Z. Shu, M. Wu, L. Wang,  
S. Zhang, Y. Zheng, H. Chen,\* J. Wang,  
Y. Li,\* J. Shi\* ..... 4386–4396

### Multifunctional Graphene Oxide-based Triple Stimuli-Responsive Nanotheranostics

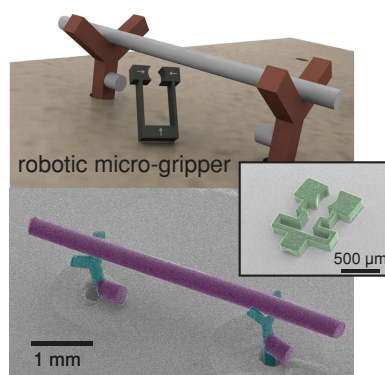


A triple-functional biocompatible stimuli-responsive nanosystem based on the functionalized nanographene oxides is developed by a novel and efficient double redox strategy. This elaborately designed nanographene oxide-based nanoplateform exhibits the unique triple stimuli-responsiveness for biomedical engineering, including pH-responsive drug release to inhibit the metastasis and reverse the multidrug resistance of cancer cells, pH-/redox-responsive magnetic resonance imaging and magnetic field-responsive hyperthermia of cancer.

## Robotics

E. Diller, M. Sitti\* ..... 4397–4404

### Three-Dimensional Programmable Assembly by Untethered Magnetic Robotic Micro-Grippers

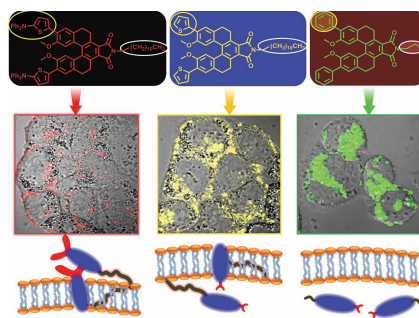


A robotic micro-gripper is made from a flexible patterned magnetic composite material. By remotely controlling the magnetization direction of each micro-gripper arm, grasping motion is combined with locomotion for precise transport, orientation, and programmable three-dimensional assembly of micro-parts in remote environments.

## Organic Nanoparticles

M. Li, L.-H. Feng, H.-Y. Lu,\* S. Wang,\*  
C.-F. Chen\* ..... 4405–4412

### Tetrahydro[5]helicene-Based Nanoparticles for Structure-Dependent Cell Fluorescent Imaging

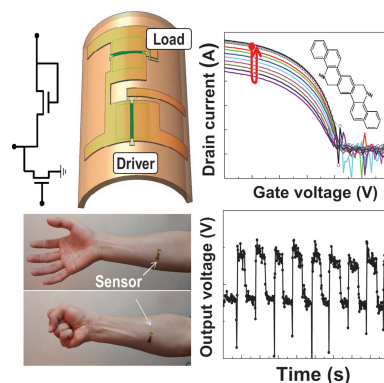


A new kind of tetrahydro[5]helicene based fluorescent dyes with three-primary emission colors (blue-green-red) are synthesized, and the multicolor organic nanoparticles are then prepared. The nanoparticles exhibit low cytotoxicity, excellent photostability, and high quantum yields. Interestingly, the stained regions of these nanoparticles from membrane to cytoplasm for HeLa cells show obvious structure-dependent properties.

## Flexible Electronics

S. H. Nam, P. J. Jeon, S. W. Min,  
Y. T. Lee, E. Y. Park, S. Im\*... 4413–4419

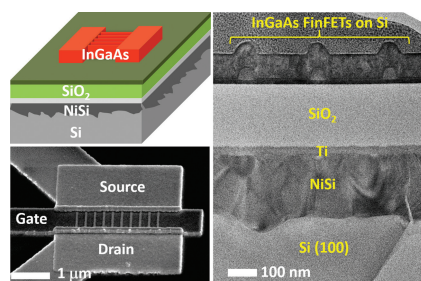
### Highly Sensitive Non-Classical Strain Gauge Using Organic Heptazole Thin-Film Transistor Circuit on a Flexible Substrate



An ultrasensitive organic strain gauge as an inverter-type thin-film transistor (TFT) circuit, which uses heptazole-based organic TFTs, is reported. On a plastic substrate, this non-classical organic strain gauge sensitively measures 2.48% tensile strain by bending, which leads to a minimum radius of 1 mm. Both strain sensitivity and sensing speed of the strain gauge are good enough to be used as a muscle motion sensor attached on a human arm.

# FULL PAPERS

**A new hybrid integration/wafer bonding approach using Nickel silicide** allows integration of III–V materials to Si substrates in a fab-compatible process. With this approach, high mobility InGaAs FinFETs on Si are realized for the first time. These advances highlight the potential of Nickel silicide bonding for heterogeneous integration of high speed electronic and optoelectronic systems for data processing and communications.

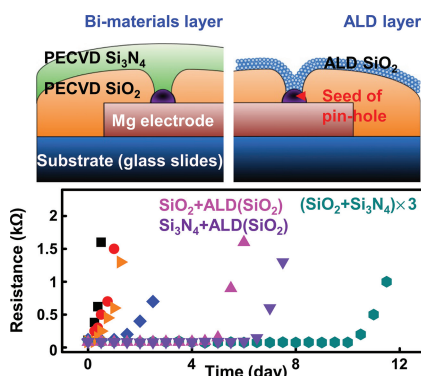


## Hybrid Integration

X. Dai, B.-M. Nguyen, Y. Hwang, C. Soci, S. A. Dayeh\* .....4420–4426

## Novel Heterogeneous Integration Technology of III–V Layers and InGaAs FinFETs to Silicon

**Studies of the kinetics of hydrolysis of thin films of silicon oxides and nitrides and the use of these materials as encapsulants** are presented for applications in water soluble, transient electronic devices. Dissolution rates of various oxides and nitrides depend on the pH and ionic concentration, the temperature of the solution, and the film properties. Encapsulation with these materials prevents water permeation for up to 10 days.

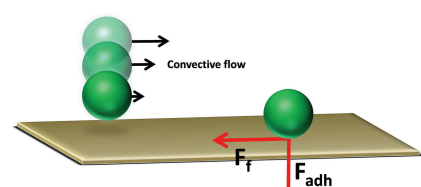


## Microelectronics

S.-K. Kang, S.-W. Hwang, H. Cheng, S. Yu, B. H. Kim, J.-H. Kim, Y. Huang, J. A. Rogers\* .....4427–4434

## Dissolution Behaviors and Applications of Silicon Oxides and Nitrides in Transient Electronics

**Bacterial friction forces** are involved in the adhesion and immobilization of bacteria to polymer-brush coated surfaces from a flowing carrier fluid. Friction forces are governed by an interplay of the normally oriented adhesion forces and the properties of the surface and are required to cause immobilization of adhering bacteria once they have approached the surface and established contact.

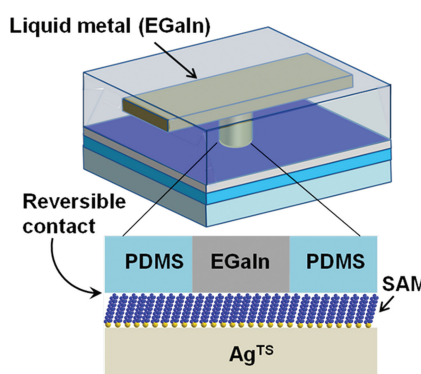


## Biofilms

J. J. T. M. Swartjes, D. H. Veeregowda, H. C. van der Mei,\* H. J. Busscher, P. K. Sharma .....4435–4441

## Normally Oriented Adhesion versus Friction Forces in Bacterial Adhesion to Polymer-Brush Functionalized Surfaces Under Fluid Flow

**Molecular electronic devices** normally require patterning of the bottom-electrodes resulting in electrode edges at which self-assembled monolayers (SAMs) cannot pack well. Here, a method that is compatible with ultra-flat template-stripped electrodes without the need for patterning of the bottom-electrode is reported. This method generates SAM-based junctions in good yields and reproducibility between top-electrodes and operators with good electrical stability.



## Molecular Electronics

A. Wan, L. Jiang, C. S. Suchand Sangeeth, C. A. Nijhuis\* .....4442–4456

## Reversible Soft Top-Contacts to Yield Molecular Junctions with Precise and Reproducible Electrical Characteristics

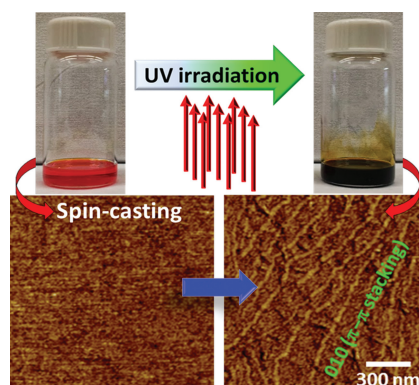


## FULL PAPERS

## Semiconductors

M. Chang, J. Lee, N. Kleinhenz, B. Fu,  
E. Reichmanis\* ..... 4457–4465

**Photoinduced Anisotropic  
Supramolecular Assembly and  
Enhanced Charge Transport of Poly(3-  
hexylthiophene) Thin Films**

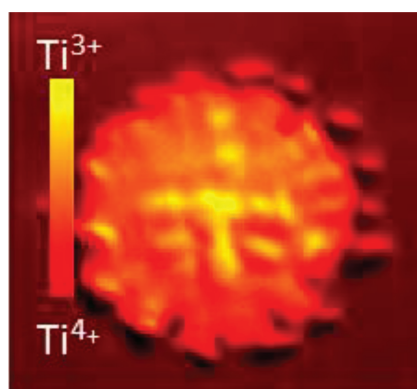


The photoinduced anisotropic supramolecular assembly of P3HT chains in solution is demonstrated. Low intensity UV irradiation enhances intra- and intermolecular ordering of the polymer chains in solution with no discernible polymer degradation, and thereby, results in dramatically enhanced molecular ordering and concomitantly, enhanced charge transport characteristics of corresponding films.

## Resistive Switching

C. Lenser,\* M. Patt, S. Menzel, A. Köhl,  
C. Wiemann, C. M. Schneider, R. Waser,  
R. Dittmann ..... 4466–4472

**Insights into Nanoscale Electrochemical  
Reduction in a Memristive Oxide: the  
Role of Three-Phase Boundaries**

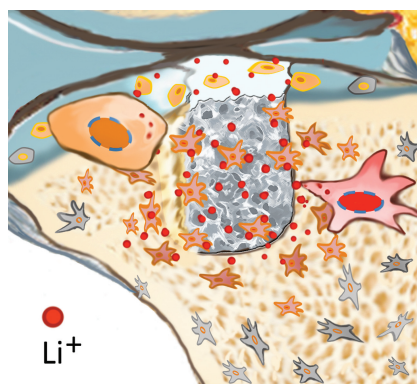


The three-phase boundary between electrode, oxide and ambient is shown to play a crucial role for the electroreduction in resistively switchable devices fabricated from Fe-doped SrTiO<sub>3</sub>. Nanoscale chemical mapping by X-ray photoemission electron microscopy, combined with simulated temperature profiles of the filaments, provide evidence that localized Joule heating at the electrode edge is essential for the formation of conducting filaments.

## Tissue Engineering

Y. Wu, S. Zhu, C. Wu,\* P. Lu, C. Hu,  
S. Xiong, J. Chang, B. C. Heng, Y. Xiao,  
H. W. Ouyang\* ..... 4473–4483

**A Bi-Lineage Conductive Scaffold for  
Osteochondral Defect Regeneration**

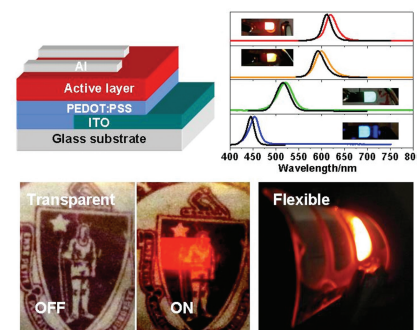


Lithium-containing mesoporous bioactive glass (Li-MBG) scaffolds offer two functions for regeneration of both cartilage and subchondral bone for osteochondral defects via enhancing the osteogenic differentiation of bone mesenchymal stem cells through activation of the Wnt/ $\beta$ -catenin signalling pathway and protect cartilage tissues from the inflammatory osteoarthritis environment through activation of autophagy.

## Semiconductors

G. Qian, Y. Lin, G. Wantz, A. R. Davis,  
K. R. Carter, J. J. Watkins\* .... 4484–4490

**Saturated and Multi-Colored  
Electroluminescence from Quantum  
Dots Based Light Emitting  
Electrochemical Cells**

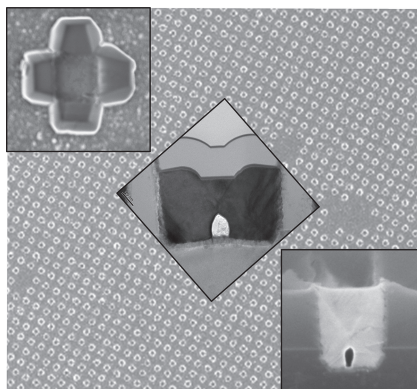


Quantum dot based light emitting electrochemical cells are prepared by blending of quantum dots, polyvinylcarbazole and an ionic liquid. Saturated red, orange, green, blue, and white electroluminescences are demonstrated and the performance of these simple, single-layered devices is comparable to that of multilayer LED devices. Transparent and flexible devices are also demonstrated and enable a broad range of application.



## FULL PAPERS

**Thermodynamically stable, stress-free, and low-defectivity GaN** is integrated on CMOS Si (100) substrates. A new mask-free local-area epitaxy is introduced, resolving the issue of lattice and thermal mismatch between GaN and Si. A novel U-shaped nano-groove pattern is proposed, enabling polarization-free cubic phase GaN. InGaN/GaN multi-quantum-well structures on such polarization-free GaN/Si templates offer an ideal roadmap for (integrated) photonic devices.

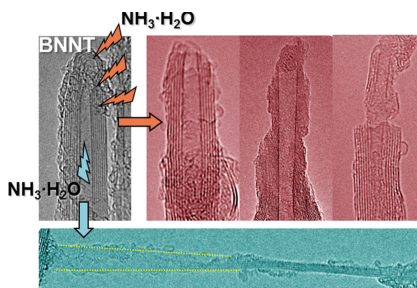


## Gallium Nitride

C. Bayram,\* J. A. Ott, K.-T. Shiu, C.-W. Cheng, Y. Zhu, J. Kim, M. Razeghi, D. K. Sadana .....4492–4496

## Cubic Phase GaN on Nano-grooved Si (100) via Maskless Selective Area Epitaxy

**Boron nitride nanotubes (BNNTs)**, often considered chemically inert, are shown to be significantly corroded during functionalization and dispersion by sonication in aqueous ammonia solutions. The observed corrosion effects include end-cap removal, tip sharpening, wall thinning, length shortening, and longitudinal unzipping, which highly resembles various oxidative treatments of carbon nanotubes.

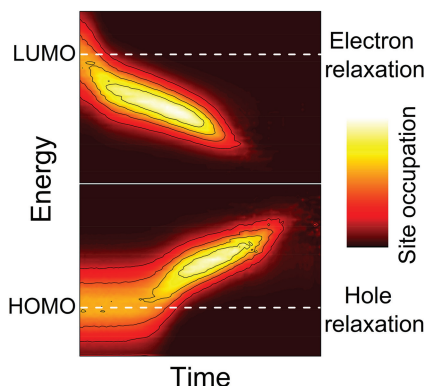


## Nanotubes

Y. Liao, Z. Chen,\* J. W. Connell,\* C. C. Fay, C. Park, J.-W. Kim, Y. Lin\* .....4497–4506

## Chemical Sharpening, Shortening, and Unzipping of Boron Nitride Nanotubes

**Ultra-fast electric field probing and Monte Carlo simulations** show that photogenerated charge carriers in organic bulk heterojunction solar cells are very far from equilibrium. Their motion is boosted by relaxation, orders of magnitude faster than expected on the basis of near-equilibrium mobilities, and extremely dispersive. The charge extraction time distribution in operating solar cells can be experimentally determined.



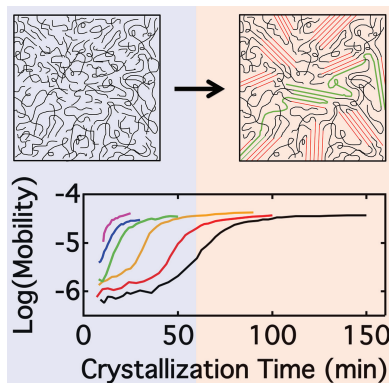
## Solar Cells

A. Melianas,\* V. Pranculis, A. Devižis, V. Gulbinas, O. Inganäs, M. Kemerink\* .....4507–4514

## Dispersion-Dominated Photocurrent in Polymer:Fullerene Solar Cells



**Recrystallization kinetics and its relationship to charge transport in poly(3-ethylhexylthiophene) (P3EHT) thin films** are investigated using a combination of grazing incidence X-ray diffraction, optical absorption, and field-effect transistor measurements. These results show that thin film crystallization kinetics is limited by polymer chain reorganization and that charge percolation depends strongly on the edge-to-edge distance between aggregates.



## Organic Semiconductors

D. T. Duong, V. Ho, Z. Shang, S. Möllinger, S. C. B. Mannsfeld, J. Dacuna, M. F. Toney, R. Segalman, A. Salleo\* .....4515–4521

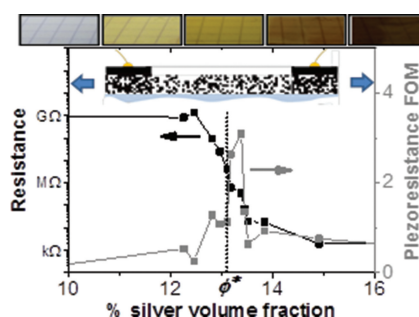
## Mechanism of Crystallization and Implications for Charge Transport in Poly(3-ethylhexylthiophene) Thin Films

## FULL PAPERS

## Piezoelectrics

T. D. Gupta, T. Gacoin,\*  
A. C. H. Rowe\* ..... 4522–4527

### Piezoresistive Properties of Ag/Silica Nano-Composite Thin Films Close to the Percolation Threshold

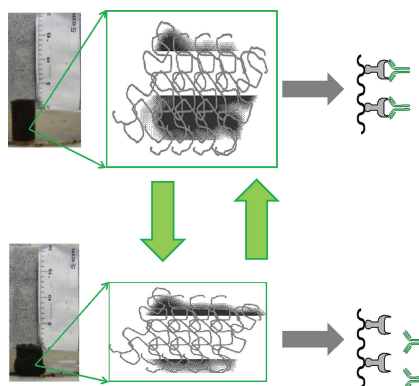


The piezoresistance of sol-gel composite coatings with a tunable silver nanoparticle volume fraction is investigated. While the gage factor sharply peaks at the percolation threshold ( $\phi^*$ ), so too do the intrinsic resistance fluctuations. By defining a figure-of-merit to account for this, it is shown that conductive composite sensors should be used slightly to the metallic side of  $\phi^*$ .

## Antibodies

T. Barroso, T. Casimiro, A. M. Ferrara,  
F. Mattioli, A. Aguiar-Ricardo,\*  
A. C. A. Roque\* ..... 4528–4541

### Hybrid Monoliths for Magnetically-Driven Protein Separations

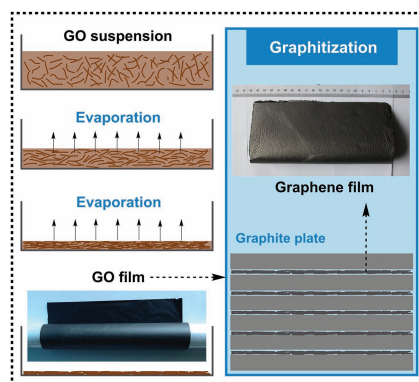


The concept of “magnetically-assisted elution” of antibodies is explored for the first time in this work by employing hybrid composites as the bioseparation matrix. Hybrid composites are deformed during the protein recovery step due to the presence of an external magnet. This greatly accelerated protein elution and increased the yield of protein recovery.

## Flexible Electronics

B. Shen, W. T. Zhai,\*  
W. G. Zheng\* ..... 4542–4548

### Ultrathin Flexible Graphene Film: An Excellent Thermal Conducting Material with Efficient EMI Shielding

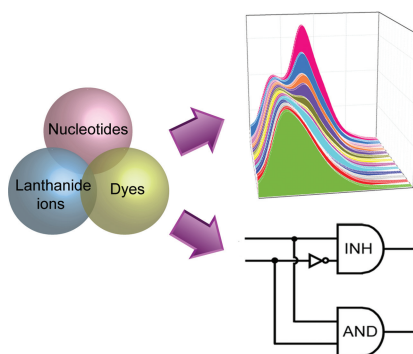


The graphitization of graphene oxide films can lead to the formation of graphite-like graphene films, which not only display a remarkable combination of excellent electromagnetic interface (EMI) shielding effectiveness and high in-plane thermal conductivity, but also show excellent mechanical flexibility, indicating a novel promising candidate for excellent thermal conducting materials with efficient EMI shielding.

## Energy Transfer

F. Pu, L. Wu, E. Ju, X. Ran, J. Ren,\*  
X. Qu\* ..... 4549–4555

### Artificial Light-Harvesting Material Based on Self-Assembly of Coordination Polymer Nanoparticles



A novel light-harvesting material based on coordination polymer nanoparticles (CPNs) is presented. Fluorescence resonance energy transfer (FRET) occurs between donor and acceptor molecules encapsulated in the CPNs, and the acceptor emission signal is amplified significantly. Photocurrent generation can be realized upon irradiation with visible light. The creation of FRET system provides a platform to mimic dual-channel logic gates.