ADVANCED FUNCTIONAL MATERIALS

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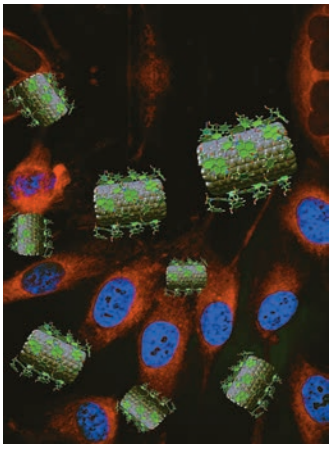
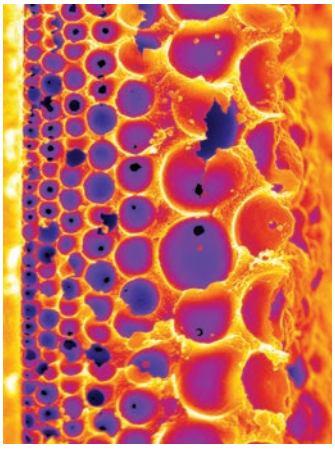


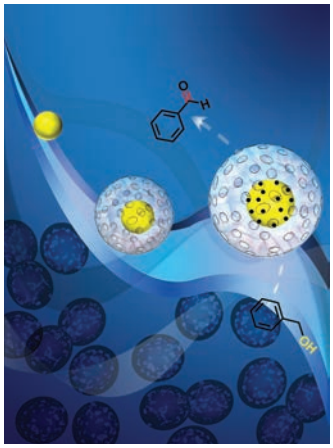
Carbon Nanotubes

The self-assembly of naphthalenediimide (NDI) based nanotubular receptors onto the surface of carbon nanotubes is demonstrated and the resulting supramolecular complex, denoted NDI@SWNT, is studied. On page 503, Sofia I. Pascu and co-workers report that amino-acid tagged NDIs act as tailor-made high-performance dispersing agents for single-walled carbon nanotubes (SWNTs), with the ability to recognize and coat the entire surface of nanotubes without disruptions to the aromatic network. The resulting composites are traceable in vitro and these supramolecular materials translocate into cancer cells as intact objects.

Porous Materials

Original, complex macroporous architectures made of metal or conducting polymers can be obtained by using the Langmuir–Blodgett technique for the elaboration of colloidal superstructures as templates. As reported by Serge Ravaine, Alexander Kuhn, and co-workers on page 538, porosity gradients are synthesized with control of the pore size at the single pore layer level. The obtained materials present features that provide a pathway to interesting applications ranging from electrochemistry to catalysis and photonics.





Nanoreactors

Mesoporous yolk–shell structured nanoreactors with metal nanoparticle cores and inorganic-organic hybrid shells are successfully synthesized using a simple soft templating method, as reported on page 591 by Gao Qing (Max) Lu, Shi Zhang Qiao, and co-workers. Taking advantage of the unique structures, the obtained nanoreactors with Au, Pt, and Pd nanoparticle catalysts achieve high conversion and selectivity for selective alcohol oxidation reactions.

CONTENTS

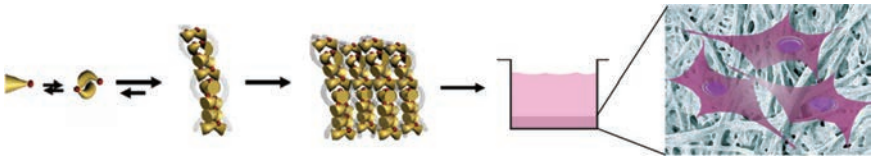
FEATURE ARTICLE

Tissue Engineering

E. C. Wu, S. Zhang,
C. A. E. Hauser* 456–468

Self-Assembling Peptides as Cell-Interactive Scaffolds

Self-assembling peptide hydrogels have great potential as cell scaffolds for a wide range of biological applications due to the ease of tuning their nanostructure and their innate biocompatibility. The recent progress made in functionalizing and improving the bioactivity of these materials to direct cell behavior is reviewed.

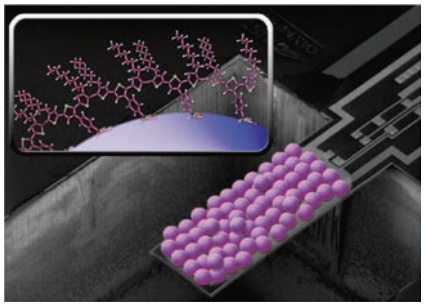


FULL PAPERS

Sensors

M. Kimura,* R. Sakai, S. Sato,
T. Fukawa, T. Ikehara, R. Maeda,
T. Mihara.....469–476

Sensing of Vaporous Organic Compounds by TiO_2 Porous Films Covered with Polythiophene Layers

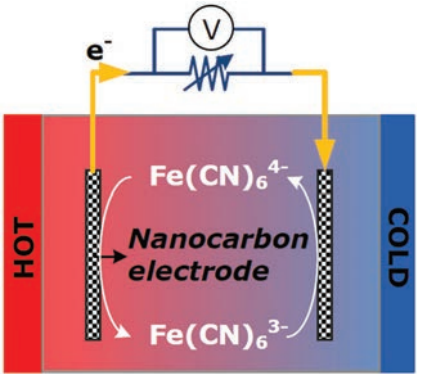


The surface of TiO_2 porous films is modified by terthiophene monomers and the adsorbed monomers are polymerized at the surface of TiO_2 nanoparticles. The TiO_2 porous films covered with polythiophene layers work as highly sensitive sensing interfaces to provide two output signals for weight and resistance changes during exposure to vapors of volatile organic compounds.

Thermocells

T. J. Kang, S. Fang, M. E. Kozlov,
C. S. Haines, N. Li, Y. H. Kim,*
Y. Chen, R. H. Baughman* 477–489

Electrical Power From Nanotube and Graphene Electrochemical Thermal Energy Harvesters

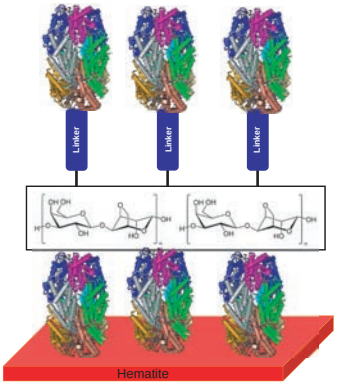


Nanocarbon-based thermocells involving aqueous potassium ferro/ferricyanide electrolyte are investigated as an alternative to conventional thermoelectrics for thermal energy harvesting. The nanocarbon thermocell may become an attractive alternative for harvesting low-grade heat, given its simple design, direct thermal to electric energy conversion, continuous operation, low expected maintenance, and zero carbon emission.

Thin-Film Electrodes

D. K. Bora, E. A. Rozhkova,
K. Schrantz, P. P. Wyss, A. Braun,*
T. Graule, E. C. Constable 490–502

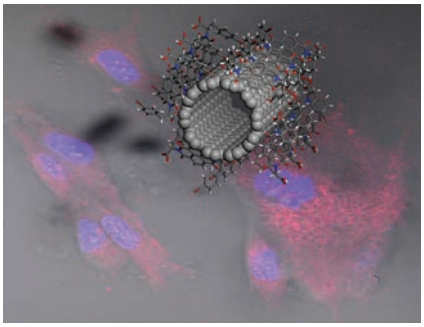
Functionalization of Nanostructured Hematite Thin-Film Electrodes with the Light-Harvesting Membrane Protein C-Phycocyanin Yields an Enhanced Photocurrent



A hybrid integrated system constituting a hematite nanoparticulate film and a light-harvesting protein (C-phycocyanin) is developed. The system shows a two-fold increase in the photocurrent in comparison to the pristine hematite film. The system also shows enhanced efficiency in the visible region due to the light-harvesting action of the protein.

FULL PAPERS

The recognition and coating of single-walled carbon nanotubes (SWNTs) by an amino acid-derivatized naphthalenediimide, NDI, is demonstrated using circular dichroism, UV–vis, and fluorescence spectroscopies and probed in the solid state by high-resolution transmission electron microscopy, scanning electron microscopy, energy dispersive X-ray spectroscopy, and atomic force microscopy. The translocation in cancerous and healthy cells of the resulting fluorescence NDI@SWNT nanohybrid can be imaged by laser scanning confocal microscopies and its integrity in vitro is probed by fluorescence lifetime imaging (FLIM) techniques.

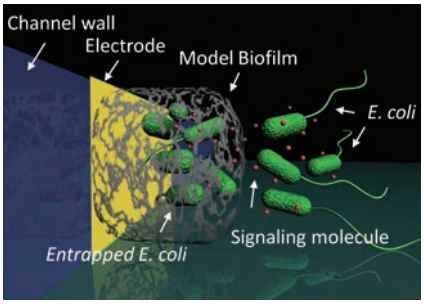


Carbon Nanotubes

Z. Hu, G. D. Pantoş, N. Kuganathan, R. L. Arrowsmith, R. M. J. Jacobs, G. Kociok-Köhn, J. O'Byrne, K. Jurkschat, P. Burgos, R. M. Tyrrell, S. W. Botchway, J. K. M. Sanders, S. I. Pascu* 503–518

Interactions Between Amino Acid-Tagged Naphthalenediimide and Single Walled Carbon Nanotubes for the Design and Construction of New Bioimaging Probes

The functionality of stimuli-responsive polysaccharide alginate is demonstrated by biofabricating 3D cell-gel biocomposites, mimicking the formation of biofilms, for interrogating phenotypes of *E. coli* bacterial populations. By using device-imposed electrical signals, the bacterial population density and distribution can be spatiotemporally controlled. This approach can be exploited for investigating biofilm development and bacterial intra- and interspecies signaling in controlled patterns.



Biocomposites

Y. Cheng, C.-Y. Tsao, H.-C. Wu, X. Luo, J. L. Terrell, J. Betz, G. F. Payne, W. E. Bentley, G. W. Rubloff* 519–528

Electroaddressing Functionalized Polysaccharides as Model Biofilms for Interrogating Cell Signaling

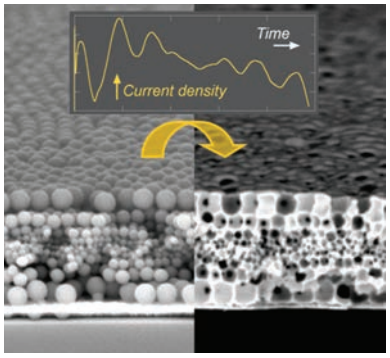
An evolution-based design strategy results in a peptide-based hydrogel capable of shear-thin delivery from a simple syringe. Gels with an optimal sequence, namely LK13, should find utility in the direct encapsulation and delivery of cells for tissue regenerative therapy.

Hydrogels

I. M. Geisler, J. P. Schneider* 529–537

Evolution-Based Design of an Injectable Hydrogel

Complex macroporous architectures made of gold or polypyrrole are obtained by using the Langmuir–Blodgett technique to assemble colloidal superstructures as templates. Porosity gradients can be synthesized with control of the pore size at the single-pore-layer level. The obtained materials present interesting features that open up potential applications ranging from electrochemistry to photonics.



Porous Materials

M. Heim, S. Reculusa, S. Ravaine,* A. Kuhn*.....538–545

Engineering of Complex Macroporous Materials Through Controlled Electrodeposition in Colloidal Superstructures

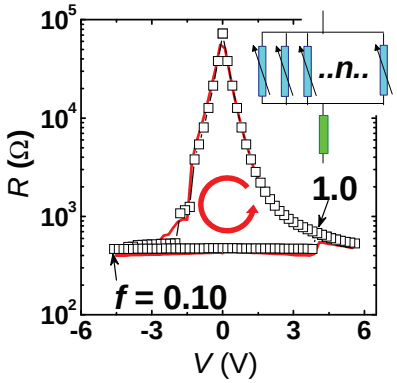
CONTENTS

FULL PAPERS

Memory Devices

A. B. K. Chen, B. J. Choi, X. Yang, I.-W. Chen* 546–554

A Parallel Circuit Model for Multi-State Resistive-Switching Random Access Memory

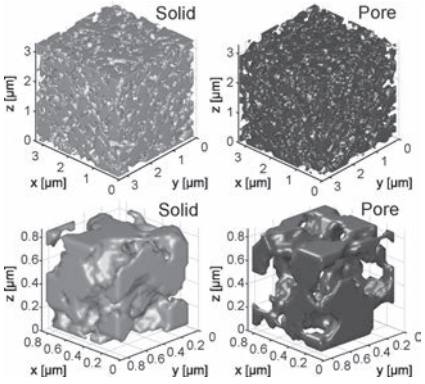


Multi-state resistance-switching thin film memory is modeled for the first time using a parallel circuit model, which successfully accounts for all the resistance-switching features as function of voltage and time, thus providing a unifying framework to predict fast data write/rewrite and memory retention.

Fuel Cells

W. K. Epting, J. Gelb, S. Litster*.....555–560

Resolving the Three-Dimensional Microstructure of Polymer Electrolyte Fuel Cell Electrodes using Nanometer-Scale X-ray Computed Tomography

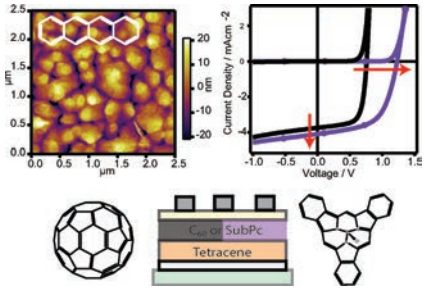


The porous electrode of a polymer electrolyte fuel cell is imaged using X-ray computed tomography with a resolution of 50 nm, achieved using Zernike phase contrast. The three-dimensional reconstructions are validated against transmission electron microscopy and mercury intrusion porosimetry.

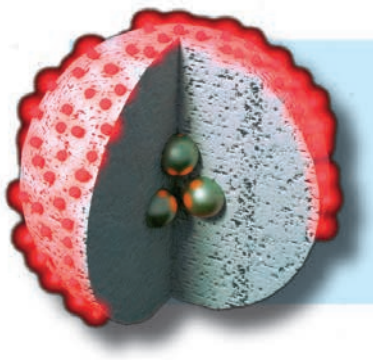
Solar Cells

N. Beaumont, S. W. Cho, P. Sullivan, D. Newby, K. E. Smith, T. S. Jones* 561–566

Boron Subphthalocyanine Chloride as an Electron Acceptor for High-Voltage Fullerene-Free Organic Photovoltaics



High-efficiency fullerene-free single heterojunction organic photovoltaic (OPV) devices are achieved via the replacement of C_{60} with the typical "donor" material boron subphthalocyanine chloride (SubPc). Devices containing SubPc achieve a 60% increase in open-circuit voltage, one of the largest to date for single heterojunction devices, allowing for an increase in cell efficiency from 1.8% to 2.9%.



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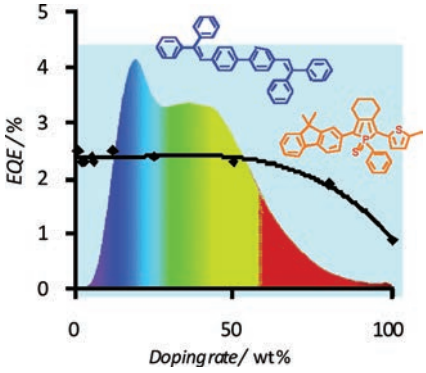
FULL PAPERS

The design of advanced organophosphorus dopants for a blue matrix, 4,4'-bis(2,2'-diphenylvinyl)biphenyl), affording organic light-emitting diodes presenting no change in the external quantum yield caused by an increase in the doping rate is reported. Moreover, white-emission is obtained for high doping rates varying over a large range, giving access to easily reproducible white organic light-emitting diodes.

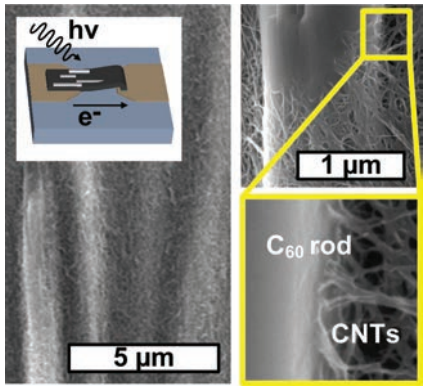


Organic Light-Emitting Diodes

D. Joly, D. Tondelier, V. Deborde, W. Delaunay, A. Thomas, K. Bhanuprakash, B. Geffroy, M. Hissler,* R. Réau* 567–576

White Organic Light-Emitting Diodes Based on Quench-Resistant Fluorescent Organophosphorus Dopants

Aligned carbon nanotube (CNT) films cause rapid, directional crystallization of C_{60} rods from solution, resulting in hybrid structures where the C_{60} rods incorporate CNTs during growth and are oriented parallel to the direction of the CNTs. The hybrid sheets are integrated electrically and employed as UV detectors with high photoconductive gain (responsivity as high as 10^5 A W^{-1} at low biases (±0.5 V)).

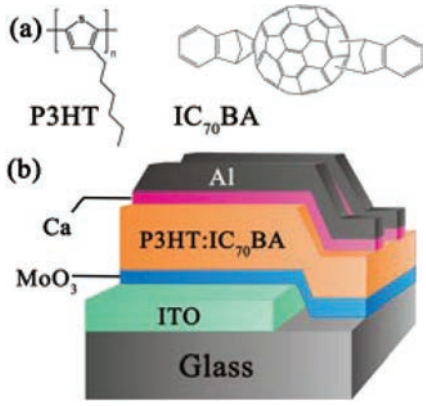


Carbon Nanotubes

E. R. Meshot, K. D. Patel, S. Tawfick, K. A. Juggernauth, M. Bedewy, E. A. Verploegen, M. F. L. De Volder, A. J. Hart* 577–584

Photoconductive Hybrid Films via Directional Self-Assembly of C_{60} on Aligned Carbon Nanotubes

The power conversion efficiency of polymer solar cells (PSCs) based on poly(3-hexylthiophene) (P3HT) as a donor and an indene-C_{70} bisadduct ($IC_{70}BA$) as an acceptor with MoO_3-modified indium tin oxide as a positive electrode reaches 6.68% at the optimized ratio of P3HT/$IC_{70}BA$ = 1:1 (w/w). The photovoltaic performance of the PSCs is optimized by controlling spin-coating time (solvent annealing time) and thermal annealing.

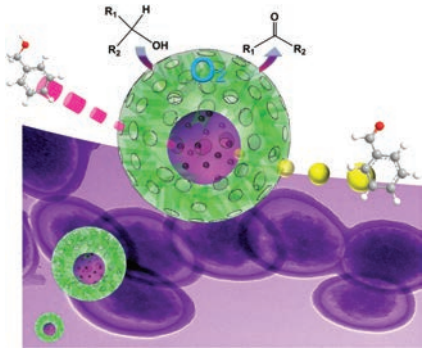


Solar Cells

X. Fan, C. H. Cui, G. J. Fang,* J. Z. Wang, S. Z. Li, F. Cheng, H. Long, Y. F. Li* 585–590

Efficient Polymer Solar Cells Based on Poly(3-hexylthiophene):Indene-C_{70} Bisadduct with a MoO_3 Buffer Layer

Yolk–shell-structured metal (Au, Pt, Pd) catalysts with periodic mesoporous organosilica (PMO) shells and tunable void space and shell thickness are synthesized by a simple soft templating method. The Pd-loaded hybrid yolk–shell PMO catalysts exhibit high catalytic activities (≈100% conversions) and selectivity (≈99%) in various selective oxidation reaction of alcohol in aqueous conditions.



Nanoparticles

J. Liu, H. Q. Yang, F. Kleitz, Z. G. Chen, T. Yang, E. Strounina, G. Q. (M.) Lu,* S. Z. Qiao* 591–599

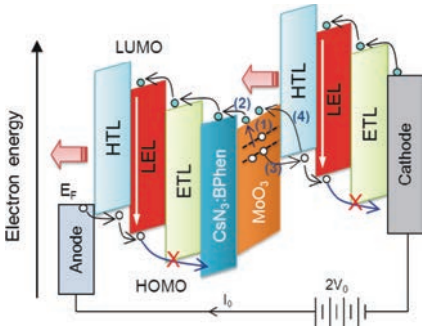
Yolk–Shell Hybrid Materials with a Periodic Mesoporous Organosilica Shell: Ideal Nanoreactors for Selective Alcohol Oxidation

FULL PAPERS

Organic Light-Emitting Diodes

J.-P. Yang, Y. Xiao, Y.-H. Deng,
S. Duhm, N. Ueno, S.-T. Lee, Y.-Q. Li,*
J.-X. Tang*.....600–608

Electric-Field-Assisted Charge Generation and Separation Process in Transition Metal Oxide-Based Interconnectors for Tandem Organic Light-Emitting Diodes

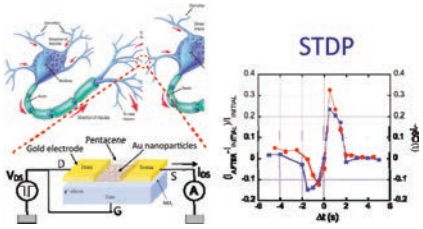


The impacts of constituent materials on the functional effectiveness of transition metal oxide-based interconnectors in tandem organic light-emitting diodes are addressed. Spontaneous electron transfer occurs in a vacuum-deposited MoO_3 layer from various defect states to the conduction band via thermal diffusion. The external electric field induces charge separation through tunneling of generated electrons and holes from MoO_3 into the neighboring electron- and hole-transporting layers.

Hybrid Materials

F. Alibart, S. Pleutin, O. Bichler,
C. Gamrat, T. Serrano-Gotarredona,
B. Linares-Barranco,
D. Vuillaume*.....609–616

A Memristive Nanoparticle/Organic Hybrid Synapstor for Neuroinspired Computing

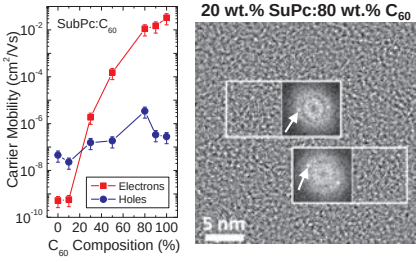


A synapstor (synapse-transistor), called NOMFET (nanoparticle organic memory field-effect transistor) is designed and fabricated to mimic the spike-timing dependent plasticity (STDP) of a biological synapse. STDP is a fundamental mechanism of learning in the brain. The STDP behavior means that the synaptic response (here the device conductance) depends on the time correlation between pre- and postsynaptic spikes received by the synapstor.

Solar Cells

R. Pandey, A. A. Gunawan,
K. A. Mkhoyan, R. J. Holmes*....617–624

Efficient Organic Photovoltaic Cells Based on Nanocrystalline Mixtures of Boron Subphthalocyanine Chloride and C_{60}

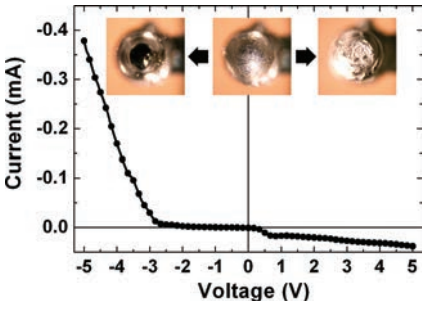


Efficient organic photovoltaic cells based on nanocrystalline mixtures of boron subphthalocyanine chloride and C_{60} are characterized in terms of device performance, electrical transport, and film morphology. Device performance and hole mobility in uniform mixtures of boron subphthalocyanine chloride (SubPc) and C_{60} are optimized at a composition of 80 wt% C_{60}. This C_{60}-rich optimum results from the formation of nanocrystalline domains of SubPc at 80 wt% C_{60}.

Soft-Matter Diodes

J.-H. So, H.-J. Koo, M. D. Dickey,*
O. D. Velev*.....625–631

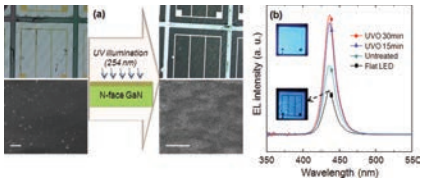
Ionic Current Rectification in Soft-Matter Diodes with Liquid-Metal Electrodes



A soft-matter diode composed of hydrogel and a gallium-based liquid metal is reported. The thickness of an insulating oxide skin on the liquid metal electrode depends on the direction of the bias and can be harnessed to produce ionic current rectification. The rectification behavior is a function of the environment in the hydrogel including the local pH and the ionic conductivity. Such principles could be used in new generations of soft and biocompatible devices.

FULL PAPERS

Nanostructured vertical light-emitting diodes with a dramatic improvement in light extraction efficiency are reported, assisted by successful growth of densely aligned ZnO nanorods on GaN regardless of the surface polarity. The structural transformation on the surface, at the nanolevel by the UV/ozone treatments, contributes significantly to the initial nucleation due to interdiffusion of Zn into GaN. This enables the densely aligned ZnO nanorods to be grown on the N-face of n-GaN.

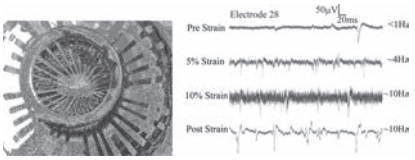


Light-Emitting Diodes

B.-U. Ye, B. J. Kim, Y. H. Song, J. H. Son, H. k. Yu, M. H. Kim, J.-L. Lee,* J. M. Baik*.....632–639

Enhancing Light Emission of Nanostructured Vertical Light-Emitting Diodes by Minimizing Total Internal Reflection

Spontaneous and evoked neural activity of a hippocampal tissue slice are recorded using a high-resolution stretchable microelectrode array (SMEA). The SMEA is capable of recording and stimulating neural activity at large biaxial strains and completely recovers after relaxation.

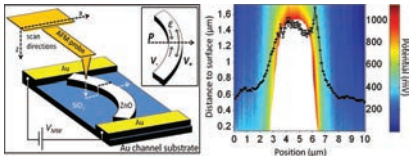


Biomedical Applications

O. Graudejus,* B. Morrison III, C. Goletiani, Z. Yu, S. Wagner....640–651

Encapsulating Elastically Stretchable Neural Interfaces: Yield, Resolution, and Recording/Stimulation of Neural Activity

Direct measurement of the piezoelectric voltage generated by a single ZnO microwire under bending strain is achieved with a novel three-dimensional Kelvin probe microscopy (3DKPM) technique, which eliminates measurement artifacts associated with discontinuous sample topography (e.g., at edges of micro-/nanowires). 3DKPM is applied to observe piezoelectric–semiconductor property coupling in ZnO and detect peak piezoelectric voltage of at least 600 mV from a single microwire.



Nanowires

D. J. Bayerl, X. D. Wang*.....652–660

Three-Dimensional Kelvin Probe Microscopy for Characterizing In-Plane Piezoelectric Potential of Laterally Deflected ZnO Micro-/Nanowires