Materials Views

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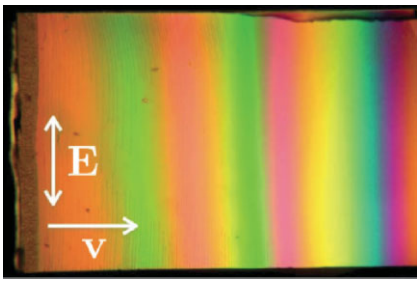
Masks to Fit Any Occasion

Soft lithography, the printing method of choice in such fields as biotechnology and plastic electronics, is a well-developed and accepted small-scale printing system. Nonetheless, it still has disadvantages; among these is the difficulty with which it is applied to non-planar structures. Now, Audrey Bowen and Professor Ralph Nuzzo of the University of Illinois have developed new soft-lithography methods, expanding this method into numerous non-planar substrates. Their work is based on the creation of new, highly flexible polymer photomasks. Current polymer-based lithography masks are difficult to use on complex 3D geometries, as the strain that they are put under can cause serious deformation of the lithographic patterns, corrupting the intended printing effect. These new masks, on the other hand, are cleverly patterned to compensate for these distortions. They are still themselves planar but can be stretched to fit many 3D shapes, as demonstrated by the authors. To showcase their new printing technique, they pattern a complex electrode mesh onto a glass hemisphere. /am

R. G. Nuzzo et al., *Adv. Funct. Mater.* DOI: 10.1002/adfm.200900978

Titania Nanoparticles

Colloidal particles are key building blocks in materials with nano- to micrometer-scale structure. Due to their electronic, optical, and photocatalytic properties, structures assembled from colloidal suspensions of titania particles hold great promise for creating functional nanomaterials. In new work published this month by E. M. Furst et al., a method of simultaneous field- and flow-directed assembly of anisotropic titania nanoparticle films from a colloidal suspension is presented. Titania particles are oriented by an alternating electric field as they advect towards a drying front due to evaporation of the solvent. At high field frequencies ($\nu > \approx 25$ kHz) and field strengths ($E > 300$ V cm^{-1}), the particles orient with their major axis along the field direction. As the front recedes, a uniform film with a thickness of 1–10 mm is deposited on the substrate. When the frequency is lowered, the particle orientation undergoes a parallel-random-perpendicular transition with respect to the field direction. The orientation dependence on field frequency and strength is explained by the polarizability of ellipsoidal particles using an interfacial polarization model. This field-directed assembly of anisotropic particles is a powerful means of tailoring nanoparticle film properties. /sl



E. M. Furst et al., *Adv. Funct. Mater.* DOI: 10.1002/adfm.200900908

A Toxic Topic

Quantum dots have potential in biomedical applications but concerns persist about their safety. Most toxicology data is derived from in vitro studies and may not reflect in vivo responses. In new work by Warren C. W. Chan et al., an initial systematic animal toxicity study of CdSe-ZnS core–shell quantum dots in healthy Sprague-Dawley rats is presented. Biodistribution, animal survival, animal mass, hematology, clinical biochemistry, and organ histology are characterized at different concentrations over short-term (<7 days) and long-term (>80 days) periods. The results show that the quantum-dot formulations do not cause appreciable toxicity even after their breakdown in vivo over time. Further studies are still required but the results will eventually lead to conclusions regarding the issue of quantum-dot toxicity. /sl

W. C. W. Chan et al., *Small* DOI: 10.1002/smll.200900626

In Brief

Enhanced Chemotherapy Efficacy

Mesoporous silica nanoparticles can simultaneously deliver doxorubicin – a model apoptosis-inducing anticancer drug – and siRNA – a suppressor of pump resistance and cellular antiapoptotic defense – into multidrug-resistant cancer cells for efficient cancer therapy. /ks

H. He et al., *Small* DOI: 10.1002/smll.200900621

Initiator Efficiency in Radical Polymerization

A method for measuring initiator efficiency in radical polymerization using electrospray ionization mass spectrometry (ESI-MS) is presented. The method rests on the evaluation of relative MS peak intensities of the polymer that has been initiated by a mixture of initiators, of which one serves as an internal reference. The method is quickly and easily performed and is reproducible and robust. /ct

P. Vana et al., *Macromol. Chem. Phys.*, DOI:10.1002/macp.200900237

Stereospecific Living Polymerization of Hydrocarbon Monomers

Highly active syndiospecific living polymerization of higher 1-alkenes are realized by the use of fluorenylamidodimethyltitanium combined with trialkylaluminum-free modified methylaluminoxane. /ct

T. Shiono et al., *Macromol. Rapid Commun.* DOI: 10.1002/marc.200900413

Clickable Coatings

Copper is inherently toxic and cannot be present in materials used in biology and nanomedicine. The work developed at the Radboud University Nijmejen reports a copper-free click procedure for the synthesis of polymeric coatings for the immobilization of functional molecules. /cn

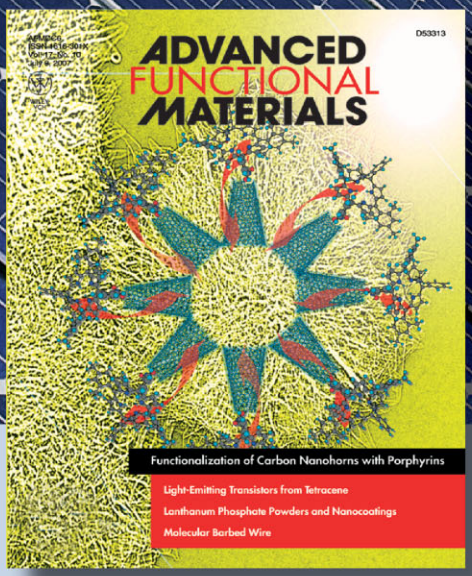
J. C. M. van Hest et al., *Adv. Funct. Mater.* DOI: 10.1002/adfm200900743

DNA Microarrays

Label-free, signal-amplifying DNA microarrays are created by combining the molecular-beacon concept and a multifunctional conjugated poly(oxadiazole) derivative. The effects of relevant molecular design parameters on the sensitivity and selectivity of the microarrays are evaluated. /sos

J. Kim et al., *Adv. Funct. Mater.* DOI: 10.1002/adfm.200901175

Solar Cells



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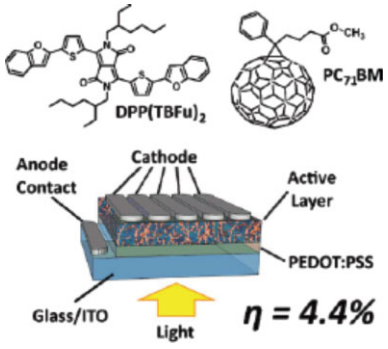
Resistive Switching in Nanogap Systems

Resistive-switching materials have been extensively studied as candidates for future nonvolatile memories. By making nanogap systems on SiO_2 substrates using different materials ranging from metals, semiconductors, and metallic non-metals through various methods, a team from Rice University (US) show that resistive switching can always be realized. In particular, the nanogap switching system is further reduced in size by electrical breakdown in a single-walled carbon nanotube on a SiO_2



substrate. The switching in all the nanogap systems share the same characteristics and are largely independent of the material composition of the electrodes. The defects (possibly Si filament formations through direct Si–Si bonds) in the SiO_2 substrate at the gap region are found to be the cause of the switching. It calls for caution when studying resistive switching in nanosystems on oxide substrates, since oxide breakdown extrinsic to the nanosystem can mimic resistive switching. Meanwhile, the switching is found to have promising memory properties. /sl

J. M. Tour et al., *Small* DOI: 10.1002/smll.200901100

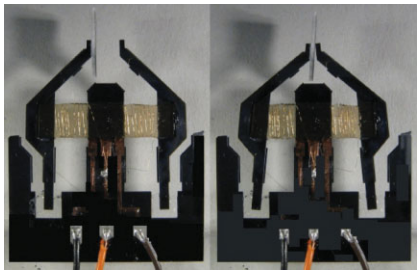
Cyclodextrin Gels for Sustained Antibiotic Delivery

Cyclodextrin molecules (CDm) are well-known cyclic oligosaccharides with the ability to form complexes with specific drug molecules via non-covalent interactions in their hydrophobic cavities. This characteristic makes them invaluable in the fields of pharmaceutics and drug delivery. The most common pharmaceutical applications of CDm and their chemical derivatives are to enhance the aqueous solubility of the complexed species, to improve the aqueous stability, photostability, and bioavailability of complexed drugs, and eventually to reduce side effects. The water solubility of cyclodextrins can limit their applications in drug-delivery systems. T. T. Reddy et al. now present the results of crosslinking β-cyclodextrin with biocompatible crosslinkers and the complexation ability of crosslinked gels with various antibiotic drug molecules, leading to the release of the drugs in a sustained manner. In vitro experiments of antibacterial activities of drug-loaded gels against *Staphylococcus aureus* show more than a month of continuous zones of inhibition, reflecting their potential as a novel biocompatible delivery platform or for the coating of biomedical devices. /ct

T. T. Reddy et al., *Macromol. Biosci.* DOI: 10.1002/mabi.200900204

Thermally Controlled Microgrippers

Microactuators are an essential component in microsystems and microdevices, and in applications such as pumps, valves, or switches. The properties of these materials (strain, speed, density, power) are of great interest for industrial, medical, and domestic uses. In new work this month, A. Sánchez-Ferrer et al. have synthesized liquid-crystalline polymers containing photoreactive groups in order to obtain liquid-crystalline elastomers (LCEs). Their synthetic strategy results in thin elastomeric films, which can be integrated into silicon-based microsystems. Analysis of their thermally controlled model microactuator at different voltage rates indicates



that it is suitable for slow, sensitive positioning and gripping movements. On applying electrical power, the nematic-to-isotropic transition induces changes in the LCE film length, causing strains of up to 150% and the capacity to move up to 400 times its own mass! /lb

A. Sánchez-Ferrer et al., *Macro. Chem. Phys.* DOI: 10.1002/macp.200900308

Highly Read Articles

Recent Progress in Polymer Solar Cells: Manipulation of Polymer:Fullerene Morphology and the Formation of Efficient Inverted Polymer Solar Cells
Y. Yang et al.
Adv. Mater. **2009**, *21*, 1434

General Theoretical Considerations on Nanowire Solar Cell Designs
A. Fontcuberta i Morral et al.
Phys. Status Solidi A **2009**, *206*, 173

Functionalized Graphene Sheet - Poly(vinylidene fluoride) Conductive Nanocomposites
Emmanuel P. Giannelis et al.
J. Polym. Sci., Part B: Polym. Phys. **2009**, *47*, 888

Porous Polymers: Enabling Solutions for Energy Applications
M. Antonietti et al.
Macromol. Rapid Commun. **2009**, *30*, 221

Single-Walled Carbon Nanotube/Trititanate Nanotube Composite Fibers
G. G. Wallace et al.
Adv. Eng. Mater. **2009**, *11*, B55

Has Click Chemistry Lead to a Paradigm Shift in Polymer Material Design?
C. Barner-Kowollik et al.
Macromol. Chem. Phys. **2009**, *210*, 987

Polymer Photovoltaic Cells Based on Solution-Processable Graphene and P3HT
Y. Chen et al.
Adv. Funct. Mater. **2009**, *19*, 894

Correlation of Pre-Breakdown Sites and Bulk Defects in Multicrystalline Silicon Solar Cells
D. Lausch et al.
Phys. Status Solidi RRL **2009**, *3*, 70

The Mechanism of the Oxidative Polymerization of Aniline and the Formation of Supramolecular Polyaniline Structures
J. Stejskal et al.
Polym. Int. **2008**, *57*, 1295

Core/Shell Semiconductor Nanocrystals
P. Reiss et al.
Small **2009**, *5*, 154

Degradable Star Polymers with High "Click" Functionality
G. G. Qiao et al.
J. Polym. Sci., Part A: Polym. Chem. **2009**, *47*, 1485

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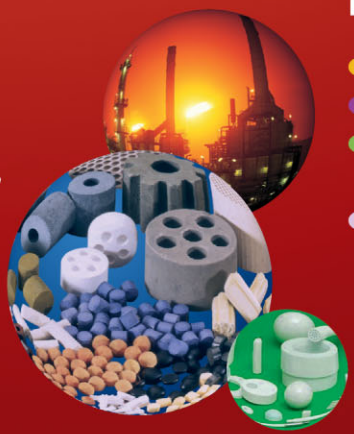

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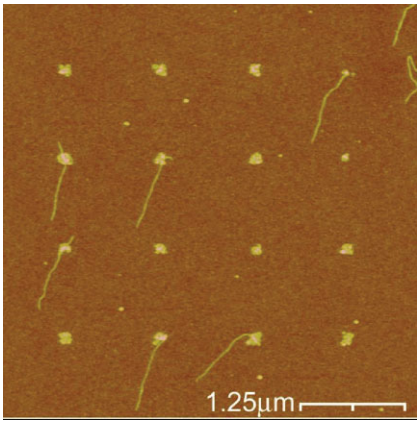
Single Virus Arrays

The development of general biocompatible processes for the organization of unmodified biological systems in order to exploit the numerous highly specific interactions commonly found in nature (including DNA, antibodies, and protein complexes) is highly



desirable. To this end, E. Delamarche and co-workers demonstrate single virus arrays by using direct printing of unmodified anti-M13 bacteriophage antibodies onto silicon with nanometer resolution, widely variable feature pitch, and flow alignment of the viruses. Such functional, addressable arrays may find interesting applications, including microarray technology and bottom-up nanoassemblies. /sos

E. Delamarche et al., *Adv. Mater.* DOI: 10.1002/adma.200902086

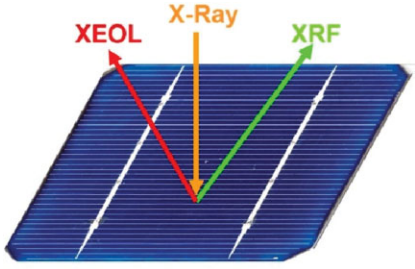
Lord of the Ring Oscillators

A polyanionic electrolyte is used as the gate insulator in top-gate p-channel polymer thin-film transistors. The high capacitance and quick polarization of the polyanionic electrolyte allows digital transistor circuits to be operated at clock frequencies in the range of 0.1–1 kHz. The seven-stage ring oscillators operate at supply voltages as low as 0.9 V, and signal propagation delays of 300 ms per stage are reported. Such characteristics enable powering of printed batteries, organic solar cells, and electromagnetic induction. Semiconductor materials with even higher charge-carrier mobilities are likely to improve the speed of the transistor circuits, bringing clock frequencies of around 10 kHz within reach. /sos

M. Berggren et al., *Adv. Mater.* DOI: 10.1002/adma.200901850

Looking into Silicon with XEOL

The art of preparing crystalline Si has advanced to a level where the last few impurities (1 ppb or less) are best chased using contactless, high-sensitivity synchrotron-based methods. Synchrotron radiation can penetrate the material and deliver information about carrier lifetimes and recombination inside a Si-based device. So far, X-ray-beam-induced current has been used to identify regions of low minority carrier lifetime but the method comes at the cost of modifying the sample by attaching electrical contacts. Researchers from the Fraunhofer Institute for Solar Energy Systems in Freiburg (Germany) and the ESRF in Grenoble (France) have developed a method that combines contactless measurement with bulk



information yield. They show that it is possible to perform X-ray-excited optical luminescence (XEOL) on crystalline silicon despite the fact that its indirect bandgap causes low luminescence efficiency. In order to establish this new approach, XEOL data from two samples with high and low minority carrier lifetime is compared to conventional luminescence and X-ray fluorescence. /sb

P. Gundel et al., *Phys. Status Solidi RRL* DOI: 10.1002/pssr.200903263

In Brief

Antireflective and Antifogging Surfaces

Inspired by the antireflective structures on the corneas of some nocturnal insects, B. Yang and co-workers have developed a versatile and time-efficient method to fabricate silica cone arrays for high-performance antireflective and antifogging surfaces. /ks

B. Yang et al., *Adv. Mater.* DOI: 10.1002/adma.200901335

Organic Solar Cells on Precision Fabric

In a step towards roll-to-roll production of flexible solar cells, organic devices with precision fabric working as both the substrate and electrode material are demonstrated. /sb

F. A. Castro et al., *Phys. Status Solidi RRL*, DOI: 10.1002/pssr.200903276

Materials for Fuel Cells

The possibility of using a potential electrolyte material for fuel cells, $BaIn_{0.3}Ti_{0.7}O_{2.85}$, is validated by the testing of its chemical, mechanical, and electrochemical compatibilities with three classical cathode materials, and shows acceptable mechanical and electrical properties when combined with $La_{0.58}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$/cn

A. Le Gal La Salle et al., *Fuel Cells* DOI: 10.1002/fuce.200900072

Transformations in Zirconia

Zirconia ceramics are an attractive material for use in energy and biomedical applications. However, many of its attractive properties are compromised after prolonged exposure to water vapor at intermediate temperatures in a process known as low-temperature degradation. It is now shown that many of these problems can be mitigated by the appropriate choice of alloying and process control. /sl

L. Gremillard et al., *J. Am. Ceram. Soc.* DOI: 10.1111/j.1551-2916.2009.03278.x

Synthetic Helical Polymers

There is growing interest in the design and synthesis of artificial helical polymers and oligomers. This short review highlights the recent advances in the synthesis, structure, and functions of double helical polymers and oligomers, including the important role of supramolecular chemistry in the design and synthesis of double helices. /sl

Y. Furusho et al., *J. Polym. Sci. A: Polym. Chem.* DOI: 10.1002/pola.23596

Copolymers for Gene Therapy

Poly(L-succinimide)-*graft*-polyethylenimines are prepared as non-viral vectors for gene transfection. Branched polyethylenimine ($\bar{M}_W$=800, PEI800) was grafted to poly(L-succinimide) in a one-step reaction with no catalyst. /ct

X. Z. Zhang et al., *Macromol. Biosci.* DOI:10.1002/mabi.200900187

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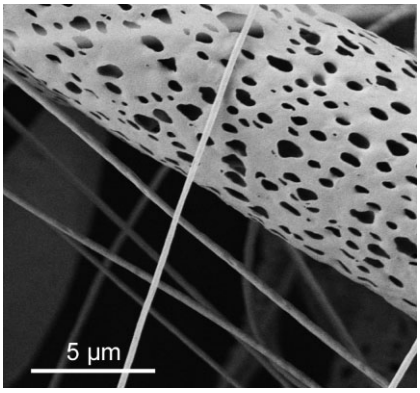
Simple Electrospinning in One Step

Electrospinning has been established as a versatile method to produce diverse non-woven materials. Meshes with uniform fiber diameters of 10 µm down to a few nanometers can be obtained. Particularly, tissue-engineering strategies frequently apply electrospun non-wovens because the fiber dimensions are in the size range of fibers in biological systems (i.e., extracellular matrix of cells). However, reported first-generation electrospun



scaffolds suffer from poor cellular infiltration. Most studies introduce additional steps and processes to address this problem. In this study by H. Börner et al., one-step electrospinning is presented to obtain bimodal fiber meshes with diameters differing by one order of magnitude. The nano- and microfiber meshes combine the benefits of nanofibers (cell adhesion, proliferation) with those of microfibers (open structure, large pore size) and are therefore interesting as scaffolds for cellular infiltration, as shown by initial cell studies. /ct

H. Börner et al., *Macromol. Rapid Commun.* DOI:10.1002/marc.200900431

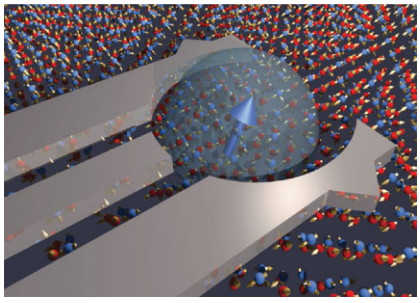
Polyoxometalate/ Polymer Hybrid Materials

Polyoxometalates (POMs) consist of three or more transition metal oxyanions linked by oxygen atoms to form discrete clusters. Their diverse electronic, structural, and magnetic properties open up a range of suitable applications in catalysis, decontamination, medical anti-viral and anti-tumor applications, and in magnetic storage devices. By incorporating these structures into polymer matrices, hybrid materials that feature the high functionality of the POMs with the ductility and processability of their polymeric supports can be made. The fabrication and properties of these exciting new materials are summarized in this minireview by W. Qi and L. Wu in *Polymer International.* /pc

W. Qi, L. Wu, *Polym. Int.* DOI: 10.1002/pi.2654

Nuclear Spins in Nanostructures

The Feature Article by Coish and Baugh reviews recent theoretical and experimental advances towards understanding the effects of nuclear spins in confined nanostructures. These systems, which include quantum dots, defect centers, and molecular magnets, are particularly interesting for their importance in quantum information processing devices, which aim to coherently manipulate single electron spins with high precision. On one hand, interactions between confined electron spins



and a nuclear-spin environment provide a decoherence source for the electron, and on the other, a strong effective magnetic field that can be used to execute local coherent rotations. A sequence of spectacular new results provides an understanding of spin-bath decoherence, nuclear spin diffusion, and preparation of the nuclear state through dynamic polarization and more general manipulation of the nuclear-spin density matrix through "state narrowing". /rsr

W. A. Coish et al., *Phys. Status Solidi B* DOI: 10.1002/pssb.200945229

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