

To spread information and knowledge and to promote collaboration in the area of Materials Research, Engineering and Technology amongst the members of MRS-S

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➤ MRS-S Activities: Past, Present and Future

The Materials Research Society of Singapore (MRS-S) organized five International and four National Conferences in Singapore since 2001. The biennial 'International Conference on Materials for Advanced Technologies (ICMAT)' series were held in 2001, 2003, 2005, 2007 and 2009.

The biennial National Conferences were held in 2004, 2006, 2008 and 2010.

MRS-S also sponsored/supported several other conferences, workshops, symposia and public lectures. To reach out to the public, MRS-S has organized number of public lectures by Nobel Laureates and also an Astronaut.

Medals & Bursaries: MRS-S instituted gold medals for the best outgoing students in Materials Science at the National University of Singapore (NUS) and Nanyang Technological University (NTU). It instituted the 'MRS Singapore Student Bursary Fund' at the NUS. MRS-S also instituted the 'MRS-S Book Prize' at the 'Republic Polytechnic' of Singapore. This yearly Book Prize will be awarded to the top final-year student graduating with the 'Diploma in Materials Science'. MRS-S recently instituted the medal for the best Ph.D. Thesis in the Physics Department of NUS.

Awards: Prof Shih Choon Fong, the founding President of MRS-S, has been chosen and received the 'Outstanding Service Award' of the NUS for the year 2011. He is now Founding President and Professor of Mechanical Engineering, King Abdullah University of Science and Technology, Saudi Arabia.

Prof. J.J. Vittal, MRS-S Executive committee member, has been chosen and received the 'Outstanding Researcher Award' of the NUS for the year 2011. He is at the Chemistry Dept. of the NUS.

Dr. Ramam Akkipeddi, MRS-S Executive committee member, has been chosen and received the 'STAR Employee Award' for the year 2011 given by A*STAR (Agency for Science, Technology and Research, Singapore). Dr. Akkipeddi is the Head of the SERC Nano-Fabrication, Processing and Characterization (SnFPC) group at the Institute of Materials Research and Engineering (IMRE).

Hearty Congratulations to the above three MRS-S Members.

The ICMAT 2011 will be held in Singapore during 26 June to 1 July, 2011. It will have 40 Symposia, comprising the areas of Nanoscience and Technology, Energy and Environment, Functional Materials, Bio/Soft Materials, Imaging, Crystal Growth and Crystal Technology and Interdisciplinary. There will be nine Plenary Talks and three Theme Lectures, and two Public Lectures (by Nobel laureates).

Incorporation of 4th Asian Nanoimprint Lithography Symposium (ASNIL), Nanoformulation 2011, Crystal Growth and Crystal Technology-5 and organization of 'Young Scientists Workshop' and Industry Workshops on 'Applied Surface Engineering', 'Microelectronic Process and Package Characterization and Reliability Analysis', and 'Teaching the Nano Scale: A Global Revolution in Science Education - an Education Forum and Open Discussion', are some of the new initiatives of the ICMAT 2011 conference. About 3000 delegates are expected.

Details of the various Symposia and other relevant information can be found at the website: <http://www.mrs.org.sg/icmat2011/>

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Highlights of Previous ICMAT Conferences

Year 2001: 1–6, July 2001; 16 Symposia; 10 Plenary Lectures; 4 Public Lectures by Nobel Laureates; 1400 delegates; 18 Best Poster Awards; 36 Exhibitors.

Year 2003: 7–12, Dec., 2003; 16 Symposia; 9 Plenary Lectures; 2 Public Lectures by Nobel Laureates; 1500 delegates; 19 Best Poster Awards; 29 Exhibitors.

Year 2005: 3–8, July 2005; 25 Symposia; 9 Plenary Lectures; 2 Theme Lectures; 3 Public Lectures by Nobel Laureates; 2200 Delegates; 28 Best Poster Awards; 43 Exhibitors.

Year 2007: 1–6, July 2007; 18+6 Symposia; 9 Plenary Lectures; 2 Theme Lectures; 2 Public Lectures by Nobel Laureates; 2300 Delegates; 25 Best Poster Awards; 41 Exhibitors.

Year 2009: 28 June.–3, July 2009; 23 Symposia, 9 Plenary and 3 Theme Lectures, 3 Public Lectures by Nobel Laureates; 2170 Participants; 37 Best Poster Awards; 43 Exhibitors.

Highlights of Previous National Conferences

Year 2004: 6 Aug., 2004; 20 Invited Talks; 130 Poster Papers; 4 Best Poster Awards.

Year 2006: 18–20, Jan., 2006; Includes the Symposium on ‘Physics and Mechanic of Advanced Materials’; 60 Invited Talks; 200 Poster Papers; 1 Public Lecture; 5 Best Poster Awards.

Year 2008: Feb., 25–27, 2008. Incorporated the MRS-I Mumbai (India)-Chapter Joint Indo-Singapore Meeting; 2 Keynote Talks, 60 Invited Talks; 211 Poster Papers; 10 Best Poster Awards.

Year 2010: March, 17–19, 2010. 1 Keynote Talk, 26 Invited Talks; 137 Poster Papers; 7 Best Poster Awards.

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Highlights of Recent Literature

(Contributed by the Editor)

Layer-by-Layer Removal of Graphene for Device Patterning

The patterning of graphene is useful in fabricating electronic devices, but existing methods do not allow control of the number of layers of graphene that are removed. Here, Dimiev *et al* [1] show that sputter-coating graphene and graphene-like materials with zinc and dissolving the latter with dilute acid removes one graphene layer and leaves the lower layers intact. The method works with the four different types of graphene and graphene-like materials: graphene oxide, chemically converted graphene, chemical vapor-deposited graphene, and micromechanically cleaved (“clear-tape”) graphene. On the basis of the data, the top graphene layer is damaged by the sputtering process, and the acid treatment removes the damaged layer of carbon. When used with predesigned zinc patterns, this method can be viewed as lithography that etches the sample with single-atomic-layer resolution.

Reference

1. A. Dimiev, D. V. Kosynkin, A. Sinitskii, A. Slesarev, Z. Sun and J. M. Tour, *Science*, **331** (6021), 1168–1172 (2011) (4 Mar., Issue).

The Bonding Electron Density in Aluminum

Aluminum (Al) metal is considered to approach an “ideal” metal or free electron gas. The valence electrons move freely, as if unaffected by the presence of the metal ions. Therefore, the electron redistribution due to chemical bonding is subtle and has proven extremely difficult to determine. Experimental measurements and *ab initio* calculations have yielded substantially different results.

Nakashima *et al* [1] applied quantitative convergent-beam electron diffraction to Al to provide an experimental determination of the bonding electron distribution. Calculation of the electron distribution based on density functional theory is shown

to be in close agreement. The results yield an accurate quantitative correlation between the anisotropic elastic properties of Al and the bonding electron and electrostatic potential distributions.

Reference

1. P. N. H. Nakashima, A. E. Smith, J. Etheridge and B. C. Muddle, *Science*, **331** (6024), 1583–1586 (2011) (25 Mar., Issue).

Magnetic and non-magnetic phases of a quantum spin liquid

A quantum spin-liquid phase is an intriguing possibility for a system of strongly interacting magnetic units in which the usual magnetically ordered ground state is avoided owing to strong quantum fluctuations. It was first predicted theoretically for a triangular-lattice model with antiferromagnetically coupled $S = 1/2$ spins. The layered molecular system κ -(BEDT-TTF)₂Cu₂(CN)₃ is a Mott insulator with an almost isotropic, triangular magnetic lattice of spin-1/2 BEDT-TTF dimers that provides a prime example of a spin liquid. Despite a high-temperature exchange coupling, J , of 250 K, no obvious signature of conventional magnetic ordering is seen down to 20 mK.

Here, Pratt *et al* [1] show, using muon spin rotation, that applying a small magnetic field to this system produces a quantum phase transition between the spin-liquid phase and an antiferromagnetic phase with a strongly suppressed moment. This can be described as Bose–Einstein condensation of spin excitations with an extremely small spin gap. At higher fields, a second transition is found that suggests a threshold for de-confinement of the spin excitations. These studies reveal the low-temperature magnetic phase diagram and enable the measurement of characteristic critical properties. The authors also compare the results closely with current theoretical models.

Reference

1. F. L. Pratt, P. J. Baker, S. J. Blundell, T. Lancaster, S. Ohira-Kawamura, C. Baines, Y. Shimizu, K. Kanoda, I. Watanabe and G. Saito, *Nature*, **471** (7340), 612–616 (2011) (31 Mar., Issue).

Spontaneous Ferroelectric Order in a Bent-Core Smectic Liquid Crystal of Fluid Orthorhombic Layers

Macroscopic polarization density, characteristic of ferroelectric phases, is stabilized by dipolar intermolecular interactions. These are weakened as materials become more fluid and of higher symmetry, limiting ferroelectricity to crystals and to smectic liquid crystal stackings of fluid layers.

Here, Reddy *et al* [1] report on the SmAP_F, the smectic of fluid polar orthorhombic layers that order into a three-dimensional (3D) ferroelectric state, the highest-symmetry layered ferroelectric possible and the highest-symmetry ferroelectric material found to date. Its bent-core molecular design employs a single flexible tail that stabilizes layers with untilted molecules and in-plane polar ordering, evident in monolayer-thick freely suspended films. Electro-optic response reveals the 3D- orthorhombic ferroelectric structure, stabilized by silane molecular terminations that promote parallel alignment of the molecular dipoles in adjacent layers.

Reference

1. R. A. Reddy, C. Zhu, R. Shao, E. Korblova, T. Gong, Y. Shen, E. Garcia, M. A. Glaser, J. E. MacLennan, D. M. Walba and N. A. Clark, *Science*, **332** (6025), 72–77 (2011) (1 Apr., Issue).

Heavily Doped Semiconductor Nanocrystal Quantum Dots

Doping of semiconductors by impurity atoms enabled their widespread technological application in microelectronics and optoelectronics. However, doping has proven elusive for strongly confined colloidal semiconductor nanocrystals because of the synthetic challenge of how to introduce single impurities, as well as a lack of fundamental understanding of this heavily doped limit under strong quantum confinement.

Mocatta *et al* [1] developed a method to dope semiconductor nanocrystals with metal impurities, enabling

control of the band gap and Fermi energy. A combination of optical measurements, scanning tunneling spectroscopy, and theory revealed the emergence of a confined impurity band and band-tailing. The method yields n- and p-doped semiconductor nanocrystals, which have potential applications in solar cells, thin-film transistors, and optoelectronic devices.

Reference

1. D. Mocatta, G. Cohen, J. Schattner, O. Millo, E. Rabani and U. Banin, *Science*, **332** (6025), 77–81 (2011) (1 Apr., Issue).

Intrinsically Colored and Luminescent Silk

Here, Tansil *et al* [1] demonstrated an in vivo uptake of dyes into domesticated silkworms, leading to the direct production of intrinsically colored silk by the silkworms. The colored silk has been achieved by adding appropriate dyes into silkworm feed with minimal interference to standard sericulture procedure, thus making this method applicable for large-scale production of colored silk by the silkworms.

A series of fluorescent dyes were successfully used as model compounds to investigate and understand their selective uptake into fibroin or sericin through fluorescence imaging and spectroscopic quantification. The authors state that, ‘when applied to other compounds with similar molecular properties, this process can potentially lead to functional silk for various biomedical applications including tissue engineering and bioelectronic, bio-optic, and biomicrofluidic devices’.

Reference

1. N. C. Tansil, Y. Li, C. P. Teng, S. Zhang, K. Y. Win, X. Chen, X. Y. Liu and M.-Y. Han, *Adv. Mater.*, **23** (12) 1463–1466 (2011).

High-Frequency, Scaled Graphene Transistors on Diamond-Like Carbon

Owing to its high carrier mobility and saturation velocity, graphene has attracted enormous attention in recent years. In particular, high-performance graphene transistors for radio-frequency (r.f.) applications are of great interest. Synthesis of large-scale graphene sheets of high quality and at low cost has been demonstrated using chemical vapour deposition (CVD) methods.

Here, Wu *et al* [1] report the systematic study of top-gated CVD-graphene r.f. transistors with gate lengths scaled down to 40 nm, the shortest gate length demonstrated on graphene r.f. devices. The CVD graphene was grown on copper film and transferred to a wafer of diamond-like carbon. Cut-off frequencies as high as 155 GHz have been obtained for the 40-nm transistors, and the cut-off frequency was found to scale as $1/(\text{gate length})$. Unlike conventional semiconductor devices where low-temperature performance is hampered by carrier freeze-out effects, the r.f. performance of the above graphene devices exhibits little temperature dependence down to 4.3 K, providing a much larger operation window than is available for conventional devices.

Reference

1. Y. Wu, Y.-M. Lin, A. A. Bol, K. A. Jenkins, F. Xia, D. B. Farmer, Y. Zhu and P. Avouris, *Nature*, **472** (7341), 74–78 (2011) (7 Apr., Issue).

Surface-Plasmon Holography with White-Light Illumination

The recently emerging three-dimensional (3D) displays in the electronic shops imitate depth illusion by overlapping two parallax 2D images through either polarized glasses that viewers are required to wear or lenticular lenses fixed directly on the display. Holography, on the other hand, provides real 3D imaging, although usually limiting colors to monochrome. The so-called rainbow holograms—mounted, for example, on credit cards—are also produced from parallax images that change color with viewing angle.

Here, Ozaki *et al* [1] report on a holographic technique based on surface plasmons that can reconstruct true 3D color images, where the colors are reconstructed by satisfying resonance conditions of surface plasmon polaritons for individual wavelengths. Such real 3D color images can be viewed from any angle, just like the original object.

Reference

1. M. Ozaki, J.-I. Kato and S. Kawata, *Science*, **332** (6026), 218–220 (2011) (8 April Issue).

Oriented 2D Covalent Organic Framework Thin Films on Single-Layer Graphene

Covalent organic frameworks (COFs), in which molecular building blocks form robust microporous networks, are usually synthesized as insoluble and unprocessable powders. Colson *et al* [1] have grown two-dimensional (2D) COF films on single-layer graphene (SLG) under operationally simple solvothermal conditions. The layered films stack normal to the SLG surface and show improved crystallinity compared with COF powders.

The authors used SLG surfaces supported on copper, silicon carbide, and transparent fused silica (SiO_2) substrates, enabling optical spectroscopy of COFs in the transmission mode. Three chemically distinct COF films grown on SLG exhibit similar vertical alignment and long-range order, and two of these are of interest for organic electronic devices for which thin-film formation is a prerequisite for characterizing their optoelectronic properties.

Reference

1. J. W. Colson, A. R. Woll, A. Mukherjee, M. P. Levendorf, E. L. Spitzer, V. B. Shields, M. G. Spencer, J. Park and W. R. Dichtel, *Science*, **332** (6026), 228–231 (2011) (8 April Issue).

Air-Stable Magnesium Nanocomposites Provide Rapid and High-Capacity Hydrogen Storage without using Heavy-Metal Catalysts

Jeon *et al* [1] have developed a new, simple method to synthesize air-stable crystalline Mg nanocrystals (NCs)/poly (methyl methacrylate) (PMMA) composites by encapsulation in a polymer with selective gas permeability, protecting the NCs from O_2 and H_2O . The Mg NCs/PMMA composites impressively showed no oxidation after two weeks of air exposure. Rapid uptake ($<30\text{min}$ at 200°C) of hydrogen was achieved with a high capacity ($\sim 6\text{ wt\%}$ in Mg, $\sim 4\%$ overall) in the absence of heavy-metal catalysts, demonstrating a volumetric capacity (55 g/l) greater than that of compressed H_2 gas.

Theoretical modelling of the experimental data with a Johnson–Mehl–Avrami model indicates that hydrogenation of Mg NCs proceeds through one dimensional (1D) growth, which can occur along line

defects in the Mg NCs. The authors state that, ‘this approach of synthesizing nanosized air-sensitive metal nanocrystals protected in a gas-selective polymer, provides new opportunities in low-cost high-capacity hydrogen storage media, batteries and fuel cells.

Reference

1. K.-J. Jeon, H. R. Moon, A. M. Ruminski, B. Jiang, C. Kisielowski, R. Bardhan and J. J. Urban, *Nature Mater.*, **10** (4), 286–290 (2011).

Optically Healable Supramolecular Polymers

Polymers with the ability to repair themselves after sustaining damage could extend the lifetimes of materials used in many applications. Most approaches to healable materials require heating the damaged area.

Here, Burnworth *et al* [1] present metallo-supramolecular polymers that can be mended through exposure to light. They consist of telechelic, rubbery, low-molecular-mass polymers with ligand end groups that are non-covalently linked through metal-ion binding. On exposure to ultraviolet light, the metal–ligand motifs are electronically excited and the absorbed energy is converted into heat. This causes temporary disengagement of the metal–ligand motifs and a concomitant reversible decrease in the polymers’ molecular mass and viscosity, thereby allowing quick and efficient defect healing. Light can be applied locally to a damage site, so objects can in principle be healed under load. The authors, ‘anticipate that this approach to healable materials, based on supramolecular polymers and a light–heat conversion step, can be applied to a wide range of supramolecular materials that use different chemistries’.

Reference

1. M. Burnworth, L. Tang, J. R. Kumpfer, A. J. Duncan, F. L. Beyer, G. L. Fiore, S. J. Rowan and C. Weder, *Nature*, **472** (7343), 334–337 (2011) (21 Apr., Issue).

High-Performance Electrocatalysts for Oxygen Reduction Derived from Polyaniline, Iron, and Cobalt

The prohibitive cost of platinum (Pt) for catalyzing the cathodic oxygen reduction reaction (ORR) has hampered the widespread use of polymer electrolyte fuel

cells. Here, Wu *et al* [1] describe a family of non-precious metal catalysts that approach the performance of Pt-based systems at a cost sustainable for high-power fuel cell applications, possibly including automotive power.

The approach uses polyaniline as a precursor to a carbon-nitrogen template for high-temperature synthesis of catalysts incorporating iron and cobalt. The most active materials in the group catalyze the ORR at potentials within ~60 millivolts of that delivered by state-of-the-art carbon-supported-Pt, combining their high activity with remarkable performance stability for non-precious metal catalysts (700 h at a fuel cell voltage of 0.4V) as well as excellent four-electron selectivity (hydrogen peroxide yield <1.0%).

Reference

1. G. Wu, K. L. More, C. M. Johnston and P. Zelenay, *Science*, **332** (6028), 443–447 (2011) (22 Apr., Issue).

Topological Phase Transition and Texture Inversion in a Tunable Topological Insulator

Topological insulators in three dimensions (3D) are nonmagnetic insulators with novel surface states that are a consequence of the nontrivial topology of electronic wave functions in the bulk of the materials. The recently discovered 3D or bulk topological insulators are expected to exhibit exotic quantum phenomena. It is believed that a trivial insulator can be twisted into a topological state by modulating the spin-orbit interaction or the crystal lattice, driving the system through a topological quantum phase transition.

By directly measuring the topological quantum numbers and invariants, Xu *et al* [1] report the observation of a phase transition in a tunable spin-orbit system, $\text{BiTl}(\text{S}_{1-\delta}\text{Se}_\delta)_2$, in which the topological state formation is visualized. In the topological state, vortex-like polarization states are observed to exhibit 3D vectorial textures, which collectively feature a chirality transition as the spin momentum–locked electrons on the surface go through the zero carrier density point. The authors state that, ‘such phase transition and texture inversion can be the physical basis for observing fractional charge ($\pm e/2$) and other fractional topological phenomena.

Reference

1. S.-Y. Xu, Y. Xia, L. A. Wray, S. Jia, F. Meier, J. H. Dil, J. Osterwalder, B. Slomski, A. Bansil, H. Lin, R. J. Cava and M. Z. Hasan, *Science*, **332** (6029), 560–564 (2011) (29 Apr., Issue).

Low-Power Switching of Phase-Change Materials with Carbon Nanotube Electrodes

Phase-change materials (PCMs) like, $\text{Ge}_2\text{Sb}_2\text{Te}_5$ (GST), are promising candidates for nonvolatile data storage and reconfigurable electronics, but high programming currents have presented a challenge to realize low-power operation.

Here, Xiong *et al* [1] report the realization of controlled PCM bits of GST with single-wall and small-diameter multi-wall carbon nanotubes. This configuration achieves programming currents of $0.5 \mu\text{A}$ (set) and $5 \mu\text{A}$ (reset), two orders of magnitude lower than present state-of-the-art devices. Pulsed measurements enable memory switching with very low energy consumption. Analysis of over 100 devices finds that the programming voltage and energy are highly scalable and could be below 1 volt and single femtojoules per bit, respectively.

Reference

1. F. Xiong, A. D. Liao, D. Estrada and E. Pop, *Science*, **332** (6029), 568–570 (2011) (29 Apr., Issue).

Low-Voltage, Low-Power, Organic Light-Emitting Transistors for Active Matrix Displays

Intrinsic non-uniformity in the polycrystalline-silicon backplane transistors of active matrix organic light-emitting diode displays severely limits display size. Organic semiconductors might provide an alternative, but their mobility remains too low to be useful in the conventional thin-film transistor design.

Here, McCarthy *et al* [1] demonstrate an organic channel light-emitting transistor operating at low voltage, with low power dissipation, and high aperture ratio, in the three primary colors. The high level of performance is enabled by a single-wall carbon nanotube network source electrode that permits integration of the drive transistor and the light emitter into an efficient single stacked device. The performance demonstrated

is comparable to that of polycrystalline-silicon backplane transistor-driven display pixels.

Reference

1. M. A. McCarthy, B. Liu, E. P. Donoghue, I. Kravchenko, D. Y. Kim, F. So and A. G. Rinzler, *Science*, **332** (6029), 570–573 (2011) (29 Apr., Issue).

Convergence of Electronic Bands for High Performance Bulk Thermoelectrics

Many different concepts have been used in the search for new materials with high thermoelectric efficiency, such as the use of nano-structuring to reduce phonon thermal conductivity, which has led to the investigation of a variety of complex material systems. It is well known that a high valley degeneracy (typically ≤ 6 for known thermoelectrics) in the electronic bands is conducive to high zT (thermoelectric figure of merit), and this in turn has stimulated attempts to engineer such degeneracy by adopting low-dimensional nanostructures.

Here, Pei *et al* [1] demonstrate that it is possible to direct the convergence of many valleys in a bulk material by tuning the doping and composition. By this route, they achieved a convergence of at least 12 valleys in Na-doped $\text{Pb}(\text{Te}_{1-x}\text{Se}_x)$ alloys, leading to an extraordinary zT value of 1.8 at about 850 K. The authors state that, ‘band engineering to converge the valence (or conduction) bands to achieve high valley degeneracy should be a general strategy in the search for, and improvement of bulk thermoelectric materials, because it simultaneously leads to a high Seebeck coefficient and high electrical conductivity’.

Reference

1. Y. Pei, X. Shi, A. LaLonde, H. Wang, L. Chen and G. J. Snyder, *Nature*, **473** (7345), 66–69 (2011) (5 May, Issue).

Beating Crystallization in Glass-Forming Metals by Millisecond Heating and Processing

The development of metal alloys that form glasses at modest cooling rates has stimulated broad scientific and technological interest. However, intervening crystallization of the liquid in even the most robust bulk metallic glass-formers is orders of magnitude faster

than in many common polymers and silicate glass-forming liquids. Crystallization limits experimental studies of the undercooled liquid and hampers efforts to plastically process metallic glasses.

Johnson *et al* [1] have developed a method to rapidly and uniformly heat a metallic glass at rates of 10^6 K/sec to temperatures spanning the undercooled liquid region. Liquid properties are subsequently measured on millisecond time scales at previously inaccessible temperatures under near-adiabatic conditions. Rapid thermoplastic forming of the undercooled liquid into complex net shapes is implemented under rheological conditions typically used in molding of plastics. By operating in the millisecond regime, the authors are able to “beat” the intervening crystallization and successfully process even marginal glass-forming alloys with very limited stability against crystallization that are not processable by conventional heating.

Reference

1. W. L. Johnson, G. Kaltenboeck, M. D. Demetriou, J. P. Schramm, X. Liu, K. Samwer, C. P. Kim and D. C. Hofmann, *Science*, **332** (6031), 828–833 (2011) (13 May, Issue).

Three-Dimensional Orientation Mapping in the Transmission Electron Microscope

Over the past decade, efforts have been made to develop nondestructive techniques for three-dimensional (3D) grain-orientation mapping in crystalline materials. 3D x-ray diffraction microscopy and differential-aperture x-ray microscopy can now be used to generate 3D orientation maps with a spatial resolution of 200 nm.

Here, Liu *et al* [1] describe a nondestructive technique that enables 3D orientation mapping in the transmission electron microscope of mono- and multiphase nano-crystalline materials with a spatial resolution reaching 1 nm. They demonstrate the technique by an experimental study of a nano-crystalline aluminum sample and use simulations to validate the principles involved.

Reference

1. H. H. Liu, S. Schmidt, H. F. Poulsen, A. Godfrey, Z. Q. Liu, J. A. Sharon and X. Huang, *Science*, **332** (6031), 833–834 (2011) (13 May, Issue).

Dimensionality Control of Electronic Phase Transitions in Nickel-Oxide Superlattices

The competition between collective quantum phases in materials with strongly correlated electrons depends sensitively on the dimensionality of the electron system, which is difficult to control by standard solid-state chemistry.

Here, Boris *et al* [1] have fabricated superlattices of the paramagnetic metal lanthanum nickelate (LaNiO_3) and the wide-gap insulator lanthanum aluminate (LaAlO_3) with atomically precise layer sequences. They used optical ellipsometry and low-energy muon spin rotation to show that superlattices with LaNiO_3 , as thin as two unit cells, undergo a sequence of collective metal-insulator and antiferromagnetic transitions as a function of decreasing temperature, whereas samples with thicker LaNiO_3 layers remain metallic and paramagnetic at all temperatures. The authors conclude that, ‘metal-oxide superlattices thus allow control of the dimensionality and collective phase behavior of correlated-electron systems’.

Reference

1. A. V. Boris, Y. Matiks, E. Benckiser, A. Frano, P. Popovich, V. Hinkov, P. Wochner, M. Castro-Colin, E. Detemple, V. K. Malik, C. Bernhard, T. Prokscha, A. Suter, Z. Salman, E. Morenzoni, G. Cristiani, H.-U. Habermeier and B. Keimer, *Science*, **332** (6032), 937–940 (2011) (20 May Issue).

Competition of Superconducting Phenomena and Kondo Screening at the Nanoscale

Magnetic and superconducting interactions couple electrons together to form complex states of matter. Here, Franke *et al* [1] show that, at the atomic scale, both types of interactions can coexist and compete to influence the ground state of a localized magnetic moment. Local spectroscopy at 4.5 K shows that the spin-1 system formed by manganese-phthalocyanine (MnPc) adsorbed on Pb(111) can lie in two different magnetic ground states. These are determined by the balance between Kondo screening and superconducting pair-breaking interactions. Both ground states alternate at nm-length scales to form a Moiré-like superstructure. The quantum phase transition connecting the two (singlet and doublet) ground

states is thus tuned by small changes in the molecule-lead interaction.

Reference

1. K. J. Franke, G. Schulze, and J. I. Pascual, *Science*, **332** (6032), 940–944 (2011) (20 May Issue).

Chlorinated Indium Tin Oxide Electrodes with High Work Function for Organic Device Compatibility

In organic light-emitting diodes (OLEDs), a stack of multiple organic layers facilitates charge flow from the low work function [~ 4.7 eV] of the transparent electrode (tin-doped indium oxide, ITO) to the deep energy levels (~ 6 eV) of the active light-emitting organic materials. Here, Helander *et al* [1] demonstrate a chlorinated ITO transparent electrode with a work function of >6.1 eV that provides a direct match to the energy levels of the active light-emitting materials in state-of-the-art OLEDs.

A highly simplified green OLED with a maximum external quantum efficiency (EQE) of 54% and power efficiency of 230 lumens/watt using out-coupling enhancement was demonstrated, as were EQE of 50% and power efficiency of 110 lumens/watt at 10,000 candelas/m².

Reference

1. M. G. Helander, Z. B. Wang, J. Qiu, M. T. Greiner, D. P. Puzzo, Z. W. Liu, and Z. H. Lu, *Science*, **332** (6032), 944–947 (2011) (20 May Issue).

Improved Measurement of the Shape of the Electron

The electron is predicted to be slightly aspheric, with a distortion characterized by the electric dipole moment (EDM), d_e . No experiment has ever detected this deviation. The standard model of particle physics predicts that d_e is far too small to detect, being some eleven orders of magnitude smaller than the current experimental sensitivity. However, many extensions to the standard model naturally predict much larger values of d_e that should be detectable. This makes the search for

the electron EDM a powerful way to search for new physics and constrain the possible extensions.

Here, Hudson *et al* [1] used cold polar molecules to measure the electron EDM at the highest level of precision reported so far, providing a constraint on any possible new interactions. They obtained $d_e = (-2.4 \pm 5.7_{stat} \pm 1.5_{syst}) \times 10^{-28} e$ cm, where e is the charge on the electron, which sets a new upper limit of $|d_e| < 10.5 \times 10^{-28} e$ cm with 90 per cent confidence. This result, consistent with zero, indicates that the electron is spherical at this improved level of precision. The authors state that, ‘our measurement of atto-electronvolt energy shifts in a molecule probes new physics at the tera-electronvolt energy scale’.

Reference

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Electrically Induced Ferromagnetism at Room Temperature in Cobalt-Doped Titanium Dioxide

The electric field effect in ferromagnetic semiconductors enables switching of the magnetization, which is a key technology for spintronic applications. Here, Yamada *et al* [1] demonstrated electric field-induced ferromagnetism at room temperature in a film of the magnetic oxide semiconductor, (Ti,Co)O₂, by means of electric double-layer gating with high-density electron accumulation ($>10^{14}$ per cm²). By applying a gate voltage of a few volts, a low-carrier paramagnetic state was transformed into a high-carrier ferromagnetic state, thereby revealing the considerable role of electron carriers in high-temperature ferromagnetism and demonstrating a route to room-temperature semiconductor spintronics.

Reference

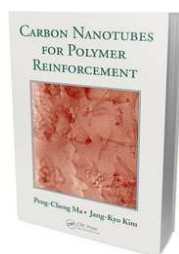
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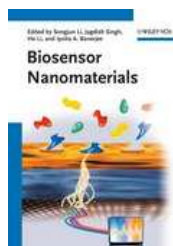
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Books

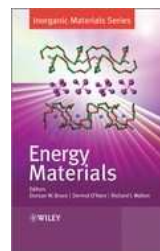
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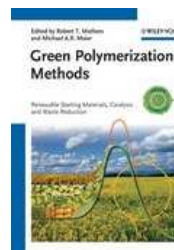
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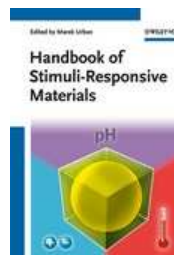
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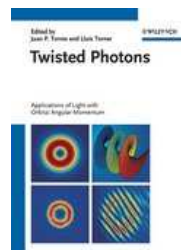
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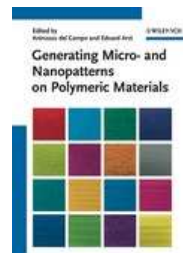
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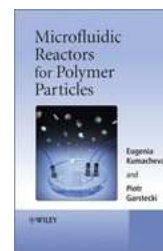
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Press, Cambridge, 2011. Hardcover: 488 pp. \$110, £65. ISBN 9780521516846.

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Review Articles

- ϵ -Fe₂O₃ : An Advanced Nanomaterial Exhibiting Giant Coercive Field, Millimeter-Wave Ferromagnetic Resonance, and Magnetoelectric Coupling. By J. Tucek, R. Zboril, A. Namai and S.-I. Ohkoshi, *Chem. Mater.*, **22** (24), 6483–6505 (2010).

Abstract

Nanosized iron oxides still attract significant attention within the scientific community, because of their application-promising properties. Among them, ϵ -Fe₂O₃ constitutes a remarkable phase, taking pride in a giant coercive field at room temperature, significant ferromagnetic resonance, and coupled magnetoelectric features that are not observed in any other simple metal oxide phase.

In this article, the authors reviewed the basic structural and magnetic characteristics of this extraordinary nanomaterial with an emphasis on questionable and unresolved issues raised during its intense research in the past years. They show how a combination of various experimental techniques brings essential and valuable information, with regard to understanding the physicochemical properties of the ϵ -polymorph of Fe₂O₃, which remained unexplored for a long period of time. In addition, they recapitulate a series of synthetic routes that lead to the formation of ϵ -Fe₂O₃, highlighting their advantages and drawbacks, and also demonstrate how the magnetic properties of ϵ -Fe₂O₃ can be tuned through the exploitation of various morphologies of ϵ -Fe₂O₃ nanosystems, the alignment of ϵ -Fe₂O₃ nanoobjects in a supporting matrix, and various degrees of cation substitution. Based on the current knowledge of the scientific community working in the field of ϵ -Fe₂O₃, the authors finally arrive at two main future challenges: (i) the search for optimal synthetic conditions to prepare single-phase ϵ -Fe₂O₃ with a high yield, desired size, morphology, and stability; and (ii) the search for a correct description of the magnetic behavior of ϵ -Fe₂O₃ at temperatures below the characteristic magnetic ordering temperature. 104 References.

- Synthesis of Environmentally Friendly Ceramic Materials via Solvothermal Reactions. By T. Sato, *J. Ceram. Soc. Japan*, **118** (No. 1384), 1105–1114 (2010).

Abstract

Solvothermal reactions are designated as the reactions which use high temperatures and/or high pressure solvents. It is possible to control the acid–base reaction rate, morphology and agglomeration of the products, i.e., well dispersed nanoparticles with high crystallinity can be obtained by solvothermal reactions. Therefore, solvothermal reactions are expected to be used to generate environmentally friendly functional ceramic materials. Actually, various functional ceramics, such as tetragonal zirconia, with excellent thermal stability and mechanical properties, visible light responsive photocatalyst for environmental clean-up, high performance UV-shielding materials, etc. have been fabricated by solvothermal reactions. Unique plate-like ceria microparticles and the new Sn(II) titanate based compound which are impossible to be formed via a normal solid state reaction have also been formed. 33 References.

- Oxides of Third Period Elements Revisited: Synthesis, Structure and Photoluminescence Properties of Silica, Magnesia, and Alumina. By T. Uchino, *J. Ceram. Soc. Japan*, **118** (No. 1384), 1115–1123 (2010).

Abstract

Silica (SiO₂), magnesia (MgO), and alumina (Al₂O₃) are principal oxides composed of third period elements. These oxides are prerequisite materials in the field of ceramic science and technology but are not regarded as functional materials in their pure forms.

In recent publications, however, it has been demonstrated that these refractive oxides can exhibit efficient ultraviolet/visible emissions by carefully controlling their microscopic structure and stoichiometry without adding any activator metals. Some intriguing properties, such as white light emission, random lasing, photoinduced reversible interconversion of color centers, have been achieved. The present approach will open up new routes and new strategic issues to produce highly functionalized materials consisting solely of third period elements. 79 References.

- Thin Film Processing of MoO₃ based Hybrid Materials. By I. Matsubara, *J. Ceram. Soc. Japan*, **118** (No. 1384), 1124–1130 (2010).

Abstract

Intercalative inorganic–organic hybrids with useful properties have attracted much attention owing to their potential applications in various kinds of devices. The development of thin film process is crucial to realize a novel device using the hybrid materials. Thin films of the intercalated organic/MoO₃ hybrids have been prepared by an ex-situ intercalation process. The host MoO₃ films were first deposited on substrates by using a CVD method followed by the intercalation of organic components into the MoO₃ films. The preparation of highly *b*-axis oriented MoO₃ films is essential to prepare the organic/MoO₃ films. The organic/MoO₃ films show semiconducting-like transport. The organic/MoO₃ films show a distinct response to VOCs (volatile organic compounds) by changing their electrical resistivity and exhibit higher sensitivities to aldehyde gases, whereas almost no response to toluene and xylene. The VOC sensing performance is closely related to the microstructure of the organic/MoO₃ thin films, which is able to be controlled by the growth conditions of the host MoO₃ thin films. 48 References.

- Anti-Reflecting and Photonic Nanostructures. By S. Chattopadhyay, Y. F. Huang, Y. J. Jen, A. Ganguly, K. H. Chen, L. C. Chen, *Mater. Sci. & Engg. R.*, **69** (1–3), 1–35 (2010).

Abstract

Optical reflection, or in other words the loss of reflection, from a surface becomes increasingly crucial in determining the extent of the light-matter interaction. The simplest example of using an anti-reflecting (AR) surface is possibly the solar cell that incorporates an AR coating to harvest sunlight more effectively. Researchers have now found ways to mimic biological structures, such as moth eyes or cicada wings, which have been used for the AR purpose by nature herself. These nanoscopic biomimetic structures lend valuable clues in fabricating and designing gradient refractive index materials that are efficient AR structures. The reflectance from a selected sub-wavelength or gradient index structures have come down to below 1% in the visible region of the spectrum and efforts are on to achieve broader bands of such enhanced AR regime. In

addition to the challenge of broader bands, the performance of AR structures is also limited by factors such as omni-directional properties and polarization of incident light.

This review presents selected state-of-the-art AR techniques, reported over the last half a century, and their guiding principles to predict a logical trend for future research in this field. 197 References.

- Polymers in Modern Ophthalmic Implants—Historical Background and Recent Advances. By D. Bozukova, C. Pagnouille, R. Jérôme and C. Jérôme, *Mater. Sci. & Engg. R.*, **69** (6), 63–83 (2010).

Abstract

Cataract surgery is the most frequently performed surgical intervention, pursued by replacement of the opacified natural lens by a polymeric intraocular lens (IOL).

This review, based on an exhaustive number of scientific references, provides a brief simplified discussion of the surgical advances for cataract treatment, and is mainly focused on the process of IOL discovery, engineering and development. The performances of the polymer materials, used for the IOLs fabrication are discussed in a comparative way, and their properties, such as handling during surgery, biocompatibility, rate of some post-surgical complications (e.g. Posterior Capsular Opacification) and optical properties, are considered. Special attention is paid on the basic scientific approaches for engineering and modification of the IOL surface and bulk properties. Polymer coating techniques like ‘grafting onto’ and ‘grafting from’ are discussed and exemplified by a variety of coating compositions and performances.

In another part of the review, modification techniques concerning optimization of the bulk properties of the polymer lens are also discussed, and synthetic approaches such as copolymerization and nanocomposite formation are considered. A perspective aspect of this discussion concerns improvement of the performance of the main polymer by the incorporation of *in situ* formed or preformed nanoparticles. The most attractive perspectives concerning the improvement of the IOL properties by chemical modification approaches are described. 226 References.

- Carbon Spheres. By A. A. Deshmukh, S. D. Mhlanga and N. J. Coville, *Mater. Sci. & Engg. R.*, **70** (1–2), 1–28 (2010).

Abstract

The discovery of fullerenes has opened up new studies in shaped carbon materials. In particular, the discovery that carbon atoms in fullerenes showed curved sp^2 bonding also led to the discovery of single walled carbon nanotubes and a re-investigation of carbon fibers and tubes. The area of shaped carbon materials has since been dominated by studies of carbon nanotubes. The discovery has, however, also impacted on the well known spherical carbons exemplified by carbon blacks. Over the last two decades this has led to a resurgence of interest in solid carbon spheres as well as core-shell spheres and hollow carbon spheres.

In this review, developments in the synthesis, doping and functionalization of spherical carbon materials (but not fullerenes) are highlighted. The chemical and physical properties as well as the uses of the carbon spheres are also described. 269 References.

- Ion Beam Doping of Semiconductor Nanowires. By C. Ronning, C. Borschel, S. Geburt and R. Niepelt, *Mater. Sci. & Engg. R.*, **70** (3–6), 30–43 (2010).

Abstract

This review summarizes recent studies on ion implantation doping of semiconductor nanowires and discusses both the advantages and disadvantages compared to other doping approaches in detail.

Furthermore, a guideline in both handling samples and performing ion-beam doping experiments for the nanosized objects and address the special needs of semiconductor nanowires in comparison to their bulk counterparts, is presented. The confined geometry leads to an enhanced sputtering yield, but also to an enhanced dynamic annealing effect; thus, a different structural impact of the ions, which can be even used for an alignment of the nanowires. The removal of the implantation damage is a crucial prerequisite for successful activation of implanted atoms and can be achieved via adequate annealing techniques, which are described in this review. The authors also reported on several successful experiments in order to modify the electrical and optical properties in a controlled manner

of silicon and compound semiconductor nanowires. 119 References.

- Engineering the Properties of Metal Nanostructures via Galvanic Replacement Reactions. By C. M. Cobley and Y. Xia, *Mater. Sci. & Engg. R.*, **70** (3–6), 44–62 (2010).

Abstract

In this review, the authors bring the reader up to date with recent advances in the use of galvanic replacement reactions to engineer highly tunable nanostructures for a variety of applications.

They begin by discussing the variety of templates that have been used for such reactions and how the structural details (e.g., shape, size, and defects, among others) have interesting effects on the ultimate product, beyond serving as a simple site for deposition. This is followed by a discussion of how one can manipulate the processes of alloying and de-alloying to produce novel structures and how the type of precursor affects the final properties. Finally, the interesting optical properties of these materials and some innovative applications in areas of biomedical engineering and catalysis are discussed, completing the overview of the state of the art in galvanic replacement. 130 References.

- Controlled Growth and Modification of Vertically-Aligned Carbon Nanotubes for Multifunctional Applications. By H. Chen, A. Roy, J.-B. Baek, L. Zhu, J. Qu and L. Dai, *Mater. Sci. & Engg. R.*, **70** (3–6), 63–91 (2010).

Abstract

Vertically-aligned carbon nanotubes (CNTs) possess many advantages for a wide range of multifunctional applications. Along with the controlled growth of aligned/micropatterned CNTs, surface modification of vertically-aligned CNTs are essential in order to meet specific requirements demanded for particular applications. While many innovative synthetic methods have been developed for controlled growth of vertically-aligned multiwalled and single-walled CNTs, various interesting physical and chemical approaches have

recently been devised for functionalization of the constituent carbon nanotubes in vertically-aligned CNT-arrays with their alignment being largely retained.

In this article, recent developments in the controlled growth and modification of vertically-aligned CNTs for multifunctional applications are reviewed. 278 References.

- Boron Nitride Nanotubes. By C. Zhi, Y. Bando, C. Tang and D. Golberg, *Mater Sci. & Engg. R.*, **70** (3–6), 92–111 (2010).

Abstract

This article presents an overview of the up-to-date developments in boron nitride nanotubes (BNNTs), including theory, fabrication, structure, physical properties, chemical functionalization and applications.

Soon after the discovery of carbon nanotubes, BNNTs were theoretically predicted, followed by their successful fabrication by arc-discharge in 1995. Subsequently, various methods were developed for the BNNT synthesis, although till now, the growth of highly pure single-walled BNNTs in large quantities remains a challenge. The physical property investigations reveal that BNNTs' exhibit a stable wide band gap, superb mechanical strength, high thermal conductivity, ultra-violet light emission, etc. All these properties build up the solid basis for their future technological applications. Chemical modification is also a decent approach to adjust the BNNTs properties. In recent years the yield of multi-walled BNNTs has reached the grams level, that can allow their detailed chemical functionalization studies. So far, many kinds of functionalizations through different weak interactions and covalent bonding were developed. These treatments improved BNNT dispersions in solvents and extended their fields of applications. Moreover, some application-related studies on multi-walled BNNTs, such as composites fabrication, hydrogen storage, biocompatibility, and mechanical, and electrical breakdown tests have also been started in recent years. 402 References.

- Nucleation and Growth of Epitaxial Silicide in Silicon Nanowires. By Y.-C. Chou, K.-C. Lu and K. N. Tu, *Mater Sci. & Engg. R.*, **70** (3–6), 112–125 (2010).

Abstract

Transition-metal silicides have been used in the silicide process to form gate and source/drain contacts in MOSFET devices. How to control silicide formation in shallow junction devices and the kinetics of single silicide phase formation between the Si and metal thin films have received extensive attention and study. As the trend of miniaturization of Si devices moves from 45 nm to smaller sizes, the formation of nanoscale metal silicides has attracted renewed interest in silicide formation. Nanostructures in Si nanowires have been studied for basic components in electronic and optoelectronics devices, especially for biosensors. Well-defined nanoscale building blocks such as ohmic contacts and gates on Si nanowires must be developed in order to be assembled into functional circuit components in future nanotechnology. It requires a systematic study of solid-state chemical reactions in the nanoscale to form these circuit components.

In this review, the authors compare silicide formation in thin films and in nanowires and focus on the nucleation and growth of epitaxial silicides. The difference of silicide formation between the thin film case and the nanowire case, especially the kinetics of nucleation and growth, is emphasized. 139 References.

- Magnetoresistance Oscillations in High-Mobility Two-Dimensional Semiconductors: A unified description with balance-equation model. By X. L. Lei, *Mater Sci. & Engg. R.*, **70** (3–6), 126–150 (2010).

Abstract

This article gives a brief introduction to the magnetoresistance oscillations in high-mobility two-dimensional semiconductors at low temperatures, which are induced by a microwave radiation, a dc current, a branch of acoustic phonons, or a combination of them, and a comprehensive review of a balance-equation model for nonlinear magnetotransport in systems with short thermalization time, which enables a unified description for all these magnetoresistance oscillations. 134 References.

- Trends in Semiconductor Defect Engineering at the Nanoscale. By E. G. Seebauer and K. W. Noh, *Mater Sci. & Engg. R.*, **70** (3–6), 151–168 (2010).

Abstract

Defect engineering involves manipulating the type, concentration, spatial distribution, or mobility of defects within a crystalline solid. Defect engineering in semiconductors has become much more sophisticated in recent years, driven by the need to control material properties at small length scales.

This article describes recent trends in defect engineering across several nano-oriented applications, beginning with Si-based integrated circuits and extending into non-Si microelectronics and especially into oxide semiconductors for sensors and photocatalysis. Special focus fixes upon physical mechanisms that have been little exploited up to now, but show significant promise as new means for controlling defect behavior, including low-energy ion bombardment, surface chemistry, and photostimulation. Systems-based methods for parameter estimation offer considerable promise for helping to understand the complex diffusion and reaction networks that characterize defect behavior in most prospective applications. 266 References.

- Formation and Structural Transition of Molecular Self-Assembly on Solid Surface Investigated by Scanning Tunneling Microscopy. By D. Wang, L. -J. Wan and C.-L. Bai, *Mater Sci. & Engg. R.*, **70** (3–6), 169–187 (2010).

Abstract

The spontaneous formation of ordered self-assembly on solid supports is not only an intriguing subject for fundamental surface science study, but also closely related to many emerging technologically important applications, especially in the field of nanotechnology. With the help of scanning tunneling microscopy (STM) at sub-molecular resolution, the detailed structural information within the self-assembled monolayers can be obtained, which allows us to have an insight into how the interplay between the intermolecular weak interactions and the substrate–molecule interactions governs the formation of molecular self-assembly.

In this review, the structural transition of self-assembly in response to the subtle differences in the molecular structures and/or the environment change is presented. The fundamental understanding about the

driving force controlling the assembly process promotes the development of various means to tune the structural transition of supramolecular assembly on solid surfaces and fabricate the sophisticated architectures. Finally, some future directions in the field are outlined. 154 References.

- Cage Molecules for Self-Assembly. By J. N. Hohman, S. A. Claridge, M. Kim and P. S. Weiss, *Mater Sci. & Engg. R.*, **70** (3–6), 188–208 (2010).

Abstract

Self-assembled monolayers using functionalized cage molecules offer distinct advantages because of their symmetry, lack of conformational flexibility, and well-defined chemistries. While these systems have not yet been studied to the extent that linear alkanethiols on Au{1 1 1} have been studied, early explorations indicate great promise and important differences. For simple cage molecules that bind upright on the substrate, tilt domain boundaries found in linear chain systems are completely eliminated. Cage molecules can be designed to have a great range of intermolecular interactions, which thereby define the stabilities of the assemblies. Weakly interacting monolayers, such as those of 1-adamantanethiol on Au{1 1 1} are labile relative to exchange reactions from solution, vapor, or contact, and thus can be used as sacrificial placeholders and diffusion barriers in soft lithography. Such molecules can be further functionalized to serve as molecular resists for chemical patterning. Cage molecules can also be designed with directional interactions, as for carboranethiols, where molecules with identical lattices have dramatically different chemical and physical properties, and film stabilities. Multifunctional cage molecules enable further directed surface reactions, higher order supramolecular assembly, and ultimately, precise three-dimensional assembly off the surface. 323 References.

- Principles and Applications of Micro and Nanoscale Wrinkles. By Y. Mei, S. Kiravittaya, S. Harazim and O. G. Schmidt, *Mater Sci. & Engg. R.*, **70** (3–6), 209–224 (2010).

Abstract

In this review, the authors summarize recent and interesting applications of micro and nanoscale wrinkles. Fluidic studies are comprehensively highlighted for various wrinkled nanochannels. Wrinkling as a mechanical characterization tool is also explained. As a new feature, wrinkles are employed to modify structures or physical properties of nanomaterials. It is promising to apply wrinkling for strain-engineering of graphene.

The authors believe that wrinkling offers entirely new research perspectives in micro and nanotechnologies as well as in material sciences and engineering. 75 References.

- Fabrication, Biological Effects, and Medical Applications of Calcium Phosphate Nanoceramics. By Y. Hong, H. Fan, B. Li, B. Guo, M. Liu and X. Zhang, *Mater Sci. & Engg. R.*, **70** (3–6), 225–242 (2010).

Abstract

Due to large grain sizes, the biological properties of the conventional calcium phosphate (Ca–P) bioceramics are limited to a great extent. Progresses in nanotechnological approaches now allow the fabrication of nanocrystalline Ca–P bioceramics.

In this article the authors first review current methodologies of the Ca–P nanocrystal syntheses and nanoceramic processes. In particular, they emphasize in this article the fabrication of porous Ca–P nanoceramics using a modified co-precipitation synthesis and its microwave sintering. Subsequently, the biological properties of the three-dimensional porous Ca–P nanoceramics, involving protein adsorption, cell adhesion, bone repair, osteoconductivity and osteoinductivity, are introduced in detail on the basis of the *in vitro* protein adsorption and cell adhesion, and *in vivo* intramuscular and bone implant experiments. Because of high specific surface area, nano-level surface topography, high surface defects and interconnecting macropores with abundant micropores, the Ca–P nanoceramics can well initiate and regulate a cascade of gene activities of cells, thereby resulting in higher *in vivo* osteoconductivity and osteoinductivity than the conventional ones. Finally, the degradability, potential risk, and anticancer activity of the nanoceramics

are discussed. In summary, because of the chemical and macro-/nanoscale structural similarities with bone, the Ca–P nanoceramics are hopeful of becoming a new generation of biomaterials for hard tissue repair. 195 References.

- Order and Disorder in the Heteroepitaxy of Semiconductor Nanostructures. By F. Ratto and F. Rosei, *Mater Sci. & Engg. R.*, **70** (3–6), 243–264 (2010).

Abstract

The heteroepitaxy of semiconductor pairs with a small lattice mismatch is a process of tremendous interest in materials science and technology. Epitaxial nanostructures are proposed as the building blocks of a variety of innovative applications. An ample variety of natural (bottom–up, parallel) and artificial (typically integrated top–down and bottom–up, sequential and/or parallel) methods have been reported to yield some extent of control over nanostructure positioning.

This review aims at highlighting some of the most relevant concepts developed over recent years. While a significant number of reviews on different aspects of the synthesis and characterization of individual nanostructures are found in the literature, the complexity of the issues mentioned above has never been addressed within a dedicated framework so far. 263 References.

- Nanoparticle-based Environmental Sensors. By L. Wang, W. Ma, L. Xu, W. Chen, Y. Zhu, C. Xu and N. A. Kotov, *Mater Sci. & Engg. R.*, **70** (3–6), 265–274 (2010).

Abstract

Environmental monitoring requires rapid and reliable analytical tools that can perform sample analysis with minimal sample handling. Nanoparticle (NP)-based environmental sensors have the potential to detect toxins, heavy metals, and organic pollutants in air, water, and soil, and are expected to play an increasingly important role in environmental monitoring. They can both improve detection and sensing of pollutants, and be used to develop new remediation technologies. Compared to traditional detection methods, NP sensors may have higher selectivity, sensitivity and stability and lower cost.

This review reports on the development of sensing principles based on NP, including synthesis of specific NP components, optical sensors, electrochemical biosensors and magnetic-relaxation sensors. Advantages over other environmental monitoring methods are discussed. 180 References.

- Surface Nano-Functionalization of Biomaterials. By X. Liu, P. K. Chu and C. Ding, *Mater Sci. & Engg. R.*, **70** (3–6), 275–302 (2010).

Abstract

After biomaterials are implanted into the human body, there are inevitable interactions between the biological environment and implant surfaces. Therefore, the surface of biomaterials has become one of the hottest research topics. Nanotechnology is a powerful tool in modern materials science and able to incorporate biomimicry on the nanoscale into materials engineering. Therefore, research on nanotechnology/nanostructured biomaterials has attracted much attention. A nano-functionalized surface has promising biological properties and clinical applications of biomaterials can be improved by producing a nanostructured surface.

Many surface modification techniques have been adopted to produce nano-functionalized biomaterials surface, and in this paper, the fabrication, characterization, and properties of biomaterials such as ceramics, metals, and polymers with nanostructured surfaces are reviewed. 183 References.

- In Situ TEM Investigation of Dynamical Changes of Nanostructures. By L. J. Chen and W. W. Wu, *Mater Sci. & Engg. R.*, **70** (3–6), 303–319 (2010).

Abstract

In situ investigation of the temperature induced phase transformation, structural and chemical evolution of nanocrystals is important for understanding the structure and stability of nanomaterials. Transmission electron microscopy (TEM), one of the most powerful tools for characterizing nanostructured materials, is essential for the development of nanotechnology. In situ TEM is a technique that allows a direct observation of dynamic properties in nanoscale. Recent development of ultra-high vacuum TEM (UHV-TEM) further enables the

investigation on atomic-scale materials systems in a clean environment. The appropriate utilization of the UHV-TEM will be beneficial in studying the fundamental mechanisms of dynamic reactions, formation of transient phase, solid-state amorphization, epitaxial growth, growth kinetics and evolution of defects.

In this review, the authors present the most recent progress in observing dynamic processes in nanoscale by in situ UHV-TEM. 84 References.

- Lateral Nanowire/Nanobelt based Nanogenerators, Piezotronics and Piezo-Phototronics. By Z. L. Wang, R. Yang, J. Zhou, Y. Qin, C. Xu, Y. Hu and S. Xu, *Mater Sci. & Engg. R.*, **70** (3–6), 320–329 (2010).

Abstract

Relying on the piezopotential created in ZnO under straining, nanogenerators, piezotronics and piezophototronics developed based on laterally bonded nanowires on a polymer substrate have been reviewed.

The principle of the nanogenerator is a transient flow of electrons in external load as driven by the piezopotential created by dynamic straining. By integrating the contribution made by millions of nanowires, the output voltage has been raised to 1.2 V. Consequently, self-powered nanodevices have been demonstrated. Alternatively, the piezopotential can act as a gate voltage that can tune/gate the transport process of the charge carriers in the nanowire, which is a gate-electrode free field effect transistor (FET). The device fabricated based on this principle is called the piezotronic device. Piezophototronic effect is about the tuning and controlling of electro-optical processes by strain induced piezopotential. The piezotronic, piezophotonic and piezophototronic devices are focused on low frequency applications in areas involving mechanical actions, such as MEMS/NEMS, nanorobotics, sensors, actuators and triggers. 48 References.

- Nanostructured Photon Management for High Performance Solar Cells. By J. Zhu, Z. Yu, S. Fan and Y. Cui, *Mater Sci. & Engg. R.*, **70** (3–6), 330–340 (2010).

Abstract

Advanced photon management, involving both absorption enhancement and reflection reduction, is critical to all photovoltaic devices. Here the authors discuss a novel solar cell structure with an efficient photon management design.

The centerpiece of the design is the nanocone structure, which is fabricated by a scalable low temperature process. With this design, devices with a very thin active layer can achieve near perfect absorption because of both efficient anti-reflection and absorption enhancement over a broadband of spectra and a wide range of angles of incidence. The device performance of this design is significantly superior to that of conventional devices. More excitingly, the design and process is, in principle, not limited to any specific materials; hence, it opens up exciting opportunities for a variety of photovoltaic devices to further improve the performance, reduce materials usage, and relieve the abundance limitation. 34 References.

- Fabrication and Electrical Properties of Graphene Nanoribbons. By J. Bai and Y. Huang, *Mater Sci. & Engg. R.*, **70** (3–6), 341–353 (2010).

Abstract

Graphene is a semimetal with a zero band gap, and therefore cannot be used for effective field-effect transistors (FETs) at room temperature. Theoretical study predicted an appreciable band gap opening with the formation of nanometer graphene nanoribbons (GNRs), providing opportunities for graphene based transistor application.

In this paper, the authors review recent developments in fabrication and electrical property studies of GNRs. They first study the theoretic prediction of electrical structures in ideal graphene nanoribbons which is closely related to the edge configurations. Different experimental efforts to fabricate GNRs are introduced and the electrical transport behaviors of fabricated GNR device are described. The authors then investigate the effect of edge disorder and charge impurities on real device performance, in which Anderson localization and Coulomb blockade effect are discussed to explain the observed transport behaviors. Other approaches such as symmetry broken to

induce band gap on bulk graphene are also described. 138 References.

- Graphene–Dielectric Integration for Graphene Transistors. By L. Liao and X. Duan, *Mater Sci. & Engg. R.*, **70** (3–6), 354–370 (2010).

Abstract

Graphene is emerging as an interesting electronic material for future electronics due to its exceptionally high carrier mobility and single-atomic thickness. Graphene–dielectric integration is of critical importance for the development of graphene transistors and a new generation of graphene based electronics. Deposition of dielectric materials onto graphene is of significant challenge due to the intrinsic material incompatibility between pristine graphene and dielectric oxide materials.

Here, the authors review various strategies being researched for graphene–dielectric integration. A physical assembly approach has recently been explored to integrate dielectric nanostructures with graphene without introducing any appreciable defects, and enabled top-gated graphene transistors with the highest carrier mobility reported to date. They conclude with a brief summary and perspective on future opportunities. 100 References.

- Phosphors in Phosphor-Converted White Light-Emitting Diodes: Recent Advances in Materials, Techniques and Properties. By S. Ye, F. Xiao, Y. X. Pan, Y. Y. Ma and Q. Y. Zhang, *Mater Sci. & Engg. R.*, **71** (1), 1–34 (2010).

Abstract

Phosphor-converted white light-emitting diodes (pc-WLEDs) are emerging as an indispensable solid-state light source for the next generation lighting industry and display systems due to their unique properties including but not limited to energy savings, environment-friendliness, small volume, and long persistence. Until now, major challenges in pc-WLEDs have been to achieve high luminous efficacy, high chromatic stability, brilliant color-rendering properties, and price competitiveness against fluorescent lamps, which rely critically on the phosphor properties. A comprehensive understanding of the nature and limitations

of phosphors and the factors dominating the general trends in pc-WLEDs is of fundamental importance for advancing technological applications.

This review aims to provide the most recent advances in the synthesis and application of phosphors for pc-WLEDs with emphasis specifically on: (a) principles to tune the excitation and emission spectra of phosphors: prediction according to crystal field theory, and structural chemistry characteristics (e.g., covalence of chemical bonds, electronegativity, and polarization effects of element); (b) pc-WLEDs with phosphors excited by blue-LED chips: phosphor characteristics, structure, and activated ions (i.e. Ce^{3+} and Eu^{2+}), including YAG: Ce, other garnets, non-garnets, sulfides, and (oxy)nitrides; (c) pc-WLEDs with phosphors excited by near ultraviolet LED chips: single-phased white-emitting phosphors (e.g., Eu^{2+} – Mn^{2+} activated phosphors), red-green-blue phosphors, energy transfer, and mechanisms involved; and (d) new clues for designing novel high-performance phosphors for pc-WLEDs based on available LED chips. Emphasis shall also be placed on the relationships among crystal structure, luminescence properties, and device performances. In addition, applications, challenges and future advances of pc-WLEDs are discussed. 377 References.

- Single-Walled Carbon Nanotubes in Biomedical Imaging. By Z. Liu, K. Yang and S.-T. Lee, *J. Mater. Chem.*, **21** (3), 586–598 (2011).

Abstract

This article reviews the latest developments in using single-walled carbon nanotubes (SWNTs) for biomedical imaging. SWNTs with a number of unique intrinsic optical properties have been widely used as contrast agents in Raman imaging, near-infrared (NIR) fluorescence imaging and photoacoustic imaging *in vitro* and *in vivo*.

More imaging functionalities including positron emission tomography (PET) and magnetic resonance (MR) imaging can be achieved by either utilizing external labels or the metal impurities of nanotube samples. Although there is still a long way to go before SWNTs are ready for clinical use, they are promising nanomaterials with great potential in multimodality biomedical imaging. 111 References.

- ZnO based Advanced Functional Nanostructures: Synthesis, Properties and Applications. By M. Ahmad and J. Zhu, *J. Mater. Chem.*, **21** (3), 599–614 (2011).

Abstract

ZnO nanostructures, due to their novel properties, are promising components in a wide range of nanoscale devices for future applications. This article provides a comprehensive review of the current research activities that focus on the synthesis, characterization and applications of ZnO based nanostructures.

The most commonly applied methodologies for the synthesis of ZnO nanostructures are briefly described. A range of remarkable characteristics is then presented, organized into sections describing the optical, electrical and mechanical properties. Finally, a brief analysis of the possible future trends for the application of this interesting semiconductor oxide for hydrogen storage and biosensors, are included. These studies constitute the basis for developing versatile applications of ZnO nanostructures. 244 References.

- Recent Developments in Fabrication and Applications of Colloid based Composite Particles. By M. Agrawal, S. Gupta and M. Stamm, *J. Mater. Chem.*, **21** (3), 615–627 (2011).

Abstract

In recent years, a variety of nano-(micro) scale organic–inorganic composite particles with well defined chemical composition, size and morphology have been fabricated and their applications in wide spectrum of cutting-edge technological areas have been explored.

This review is focused on recent developments towards various fabrication methodologies and applications of such colloid based composite particles. Strategies for preparation of nano and micro scale composite materials are presented by choosing as examples hard core based composite particles having core–shell and raspberry-like morphologies and soft core based composite microgels. Applications of these materials in wide range of potential areas are discussed including the fabrication of colloidal crystal arrays, hollow spheres, superhydrophobic surfaces, filler carriers and smart nanomaterials. 102 References.

- Graphene: Learning from Carbon Nanotubes. By L. Huang, B. Wu, G. Yu and Y. Liu, *J. Mater. Chem.*, **21** (4), 919–929 (2011).

Abstract

As a new member of the carbon family, graphene has many fascinating properties and potential applications with the greatest degree of similarity to its “brother” carbon nanotubes (CNTs). Research on graphene has developed rapidly in the past 6 years, partially due to its similarity to carbon nanotubes, which have been extensively studied for almost two decades.

The adaptation of CNT research strategies for the development of graphene preparation, functionalization and applications as well as the conversion and hybrid structures of carbon nanotubes and graphene are reviewed in this article. 108 References.

- Organic–Inorganic Hybrid Aerogels with High Mechanical Properties via Organotrialkoxysilane-Derived Sol–Gel Process. By K. Kanamori, *J. Ceram. Soc. Japan*, **119** (No. 1385), 16–22 (2011).

Abstract

A brief overview of siloxane-based low-density aerogels and aerogels-like xerogels is presented. Aerogels are highly porous solids composed of inorganic oxides, metals, cross-linked polymers and carbons, and are known to possess a number of excellent physical properties such as high visible-light transparency with low refractive index, low dielectric properties, and extremely-low thermal conductivity. Aerogels are therefore regarded as a promising candidate for applications such as superinsulators; however, a mass production and applications of aerogels have been significantly discouraged due to the lack of mechanical properties since the first invention in 1931.

This review introduces the substantial effort to improve the mechanical properties of aerogels with particularly highlighting the recent findings on elastic organic–inorganic hybrid aerogel monoliths obtained from methyltrimethoxysilane (MTMS) using the controlled sol–gel chemistry. 79 References.

- Recent Trends in Shape Forming from Colloidal Processing: A Review. By C. Tallon and

G. V. Franks, *J. Ceram. Soc. Japan*, **119** (No. 1387), 147–160 (2011).

Abstract

Shaping ceramic materials is a research area which has continuing innovation and excellence. Dry processing routes gave way to colloidal techniques enabling the preparation of more complex shapes for a wide and growing field of applications. Both dense and porous ceramics with improved properties can be produced. The development of colloidal processing led to the creation of the near-net-shaping concept, performed through slip-casting, gel-casting and freeze-casting. Even though these concepts have been used for the last few decades, different trends and combinations of these techniques are refreshing the processing strategies in recent years. New chemistries and concepts continue to emerge.

This paper is an overview of the recent trends in near-net-shaping routes, having a deeper look into gel-casting and freeze-casting, since both processes are used in the preparation of tailored and custom dense and porous ceramics. 102 References.

- Silicon Carbide Powder and Sintered Materials. By H. Tanaka, *J. Ceram. Soc. Japan*, **119** (No. 1387), 218–233 (2011).

Abstract

Silicon carbide (SiC) was first industrially synthesized in 1894 and has been used as refractories, abrasives and high temperature furnace parts. The basic fabrication and sintering technologies were almost established by about 1970. Recently, sintered SiC has become a key material as it has been widely used in advanced industries of semiconductors and high precision machines. New fabrication methods for modern SiC powders and sintering methods are being developed on the bases of traditional methods.

In this review, the original studies and recent developments have been given maximum possible emphasis, and in particular, basic points of view are introduced. 169 References.

- Study of the Friction, Adhesion and Mechanical Properties of Single Crystals, Ceramics and Ceramic Coatings by AFM. By J. J. Roa, G. Oncins,

J. Díaz, X. G. Capdevila, F. Sanz and M. Segarra, *J. Europ. Ceram. Soc.*, **31** (4), 429–449 (2011).

Abstract

This paper reviews commonly used methods of analyzing and interpreting friction, adhesion and nanoindentation with an AFM tip test data, with a particular emphasis of the testing of single crystals, metals, ceramics and ceramic coatings. Experimental results are reported on the friction, mechanical and adhesion properties of these materials.

The popularity of AFM testing is evidenced by the large quantity of papers that report such measurements in the last decade. Unfortunately, a lot of information about these topics is scarce in the literature. This paper is aimed to present the basic physical modelling employed and also some examples using each technique. 205 References.

- Crystal Chemistry of the Monazite Structure. By N. Clavier, R. Podor and N. Dacheux, *J. Europ. Ceram. Soc.*, **31** (6) 941–976 (2011).

Abstract

The AXO₄ monazite-type compounds form an extended family that is described in this review in terms of field of stability versus composition. All the substitution possibilities on the cationic and anionic sites leading to the monazite structure are reported. The phosphate, vanadate, chromate, arsenate, sulphate and silicate families are described and the unit-cell parameters of pure compounds and solid solutions are gathered. The stability limits of the monazite-type structure are discussed versus several models generally correlated with geometric criteria. The effects of physico-chemical parameters such as pressure, temperature and irradiation on the monazite-type structure stability are also discussed. The structural relationships between the monazite structure and the related structures (zircon, anhydrite, barite, AgMnO₄, scheelite and monoclinic BiPO₄, CaSeO₃, rhabdophane and SrNp(PO₄)₂) are described. 398 References.

- Polymer and Organic Nonvolatile Memory Devices. By P. Heremans, G. H. Gelinck, R. Muller, K.-J. Baeg, D.-Y. Kim and Y.-Y. Noh, *Chem. Mater.*, **23** (3), 341–358 (2011).

Abstract

Organic molecules and semiconductors have been proposed as active part of a large variety of nonvolatile memory devices, including resistors, diodes and transistors. In this review, the authors focus on electrically reprogrammable nonvolatile memories. They classify several possible devices according to their operation principle and critically review the role of the π -conjugated materials in the device operation. They also propose specifications for applications for organic nonvolatile memory, and review the state of the art with respect to these target specifications. Conclusions are drawn regarding further work on materials and device architectures. 129 References.

- Design of Organic Semiconductors from Molecular Electrostatics. By G. Heimel, I. Salzmann, S. Duhm and N. Koch, *Chem. Mater.*, **23** (3), 359–377 (2011).

Abstract

Progress in the field of organic electronics depends on the synthesis of new π -conjugated molecules to further improve the performance of, for example, organic light-emitting diodes, organic photovoltaic cells, and organic field-effect transistors. However, the interrelation between the properties of isolated molecules on one hand and close-packed thin films on the other hand is far from trivial.

Here, the authors review recent progress in the understanding of electrostatic phenomena, which originate in the collective action of the anisotropic charge distribution in typical conjugated molecules. Both the π -electron systems and polar end-group substitutions exposed at the surface of a molecular or polymeric film are seen to form dipole layers, which critically impact the device-relevant ionization energy and electron affinity of that film. After briefly revisiting electrostatic fundamentals and critically assessing related experimental methods, the energies of the frontier electronic states in organic thin films are shown to depend appreciably on the orientation of the constituent molecules with respect to device-relevant interfaces. For films of preferentially “standing” or “edge-on” molecules, this opens the possibility for electronic-structure engineering with intra-molecular polar bonds. On the basis of these findings, additional insights into the working principles of organic electronic devices are provided

and valuable guidelines for the synthesis of improved organic semiconductors are derived. 220 References.

- Discotic Liquid Crystals for Opto-Electronic Applications. By B. R. Kaafarani, *Chem. Mater.*, **23** (3), 378–396 (2011).

Abstract

Discotic liquid crystals (DLCs) have been exploited in opto-electronic devices for their advantageous properties including long-range self-assembling, self-healing, ease of processing, solubility in a variety of organic solvents, and high charge-carrier mobilities along the stacking axis.

An overview of DLCs and their charge-carrier mobilities, theoretical modeling, alignment, and device applications is addressed herein. The effects of alignment on charge-carrier properties of DLCs are discussed. Particular attention is devoted to processing techniques that achieve suitable alignment of DLCs for efficient electronic devices such as zone-casting, zone melting, Langmuir-Blodgett deposition, solution-casting on preoriented polytetrafluoroethylene (PTFE), surface treatment, IR irradiation, application of a magnetic field, use of sacrificial layers, use of blends, application of an electric field, and others. 223 References.

- Navigating the Color Palette of Solution-Processable Electrochromic Polymers. By C. M. Amb, A. L. Dyer and J. R. Reynolds, *Chem. Mater.*, **23** (3), 397–415 (2011).

Abstract

Solution-processable electrochromic (EC) polymers that can be switched from one distinct color state to a highly transmissive and near colorless state are required for applications in both EC windows and displays.

Using a tour around the color wheel, the authors describe the various EC polymer (ECP) compositions that now make a full palette of colors available demonstrating a set of structure-property relationships. Electrochemical and electrochromic characterization methodologies are described and their application to ECPs demonstrated. Processing and patterning methods including spray casting, screen-, flexo-, and ink

jet printing, along with photo- and soft lithography are described. Absorptive/transmissive (window type) and absorptive/reflective (display type) devices are described as platforms for practical applications. 131 References.

- Photoconducting Polymers for Photorefractive 3D Display Applications. By J. Thomas, C. W. Christenson, P.-A. Blanche, M. Yamamoto, R. A. Norwood and N. Peyghambarian, *Chem. Mater.*, **23** (3), 416–429 (2011).

Abstract

Photorefractive composites derived from photoconducting polymers offer the advantage of dynamically recording holograms without the need for processing of any kind. Thus, they are the material of choice for many cutting edge applications, such as updatable 3D displays and imaging through a scattering medium.

This article reviews the basic properties of photorefractive polymer systems and the inherent advantages that have attracted much attention. The chemistry and physics relevant for the design of the high-performance guest-host composite are discussed and recent advances emphasized. In particular, a charge transporting polymer with high mobility and history-independent response times is highlighted, as well as polymer systems useful for holographic displays and the material considerations necessary to develop high-speed, large-sensitivity composites. 115 References.

- Systematic Nanoengineering of Soft Matter Organic Electro-optic Materials. By L. R. Dalton, S. J. Benight, L. E. Johnson, D. B. Knorr, Jr., I. Kosilkin, B. E. Eichinger, B. H. Robinson, A. K.-Y. Jen and R. M. Overney, *Chem. Mater.*, **23** (3), 430–445 (2011).

Abstract

An overview of the development and utilization of organic electro-optic materials is presented with emphasis on the role played by quantum and statistical mechanical calculations in understanding critical structure/function relationships that have guided the improvement of such materials over the past two decades.

This review concentrates largely on three classes of organic electro-optic materials prepared by electric field poling of materials near their glass transition temperature: (1) chromophore/polymer composite materials, (2) dendrimers and polymers containing covalently incorporated chromophores, and (3) matrix-assisted-poling (MAP) materials where specific spatially anisotropic interactions enhance poling efficiency. In particular, the role of chromophore shape, restrictions on chromophore motion associated with covalent bonds, and lattice dimensionality effects are reviewed. The role of device design and auxiliary properties (optical loss, thermal stability, photochemical stability, processability) in influencing the utilization of organic electro-optic materials is also briefly reviewed. 146 References.

- Halogenated Materials as Organic Semiconductors. By M. L. Tang and Z. Bao, *Chem. Mater.*, **23** (3), 446–455 (2011).

Abstract

Organic semiconductors have great potential as the active material in low-cost, large area plastic electronics, whether as light-emitting diodes (LEDs), field-effect transistors (FETs) or solar cells. Organic semiconducting materials retain the processability associated with polymers while maintaining good optoelectronic properties, for example, high absorption coefficients for photons in the visible region, and field-effect mobilities comparable with that of amorphous silicon. The elucidation of important structure-property relationships is vital for the design of functional, high-performance organic semiconductors.

In this review, the authors summarize such relationships stemming from the halogenation of organic semiconductors. While it has been known in the past decade that fluorination lowers the energy levels in carbon based systems, induces stability and electron transport, less is known about the effect of the other halogens. Chlorination has recently been shown to be a viable route to *n*-type materials. The bandgap of conjugated compounds can also be decreased slightly by the addition of Cl, Br, and I to the aromatic core. The effect of the halogenated moieties on the packing of molecules is discussed. 80 References.

- Processable Low-Bandgap Polymers for Photovoltaic Applications. By P. -L. T. Boudreault, A. Najari and M. Leclerc, *Chem. Mater.*, **23** (3), 456–469 (2011).

Abstract

Over the last five years, organic photovoltaic devices have emerged as a new competitor to silicon-based solar cells. In particular, the bulk heterojunction architecture (BHJ), in which the photoactive layer consists of a bicontinuous blend of an electron donor and an electron acceptor, has allowed power conversion efficiencies around 8%.

The latest conjugated polymers used in such BHJ solar cells are presented in this review, mainly focusing on electron-donating (*p*-type) polymers based on thiophenes, 1,3,2-benzodithiazoles, pyrrolo[3,4-*c*]pyrrole-1,4-diones, benzo[1,2-*b*; 3,4-*b*]dithiophenes, and few other materials with more exotic structures. This review should be helpful to evaluate which are the most promising materials and where this research field is going in the years to come. 106 References.

- Molecule Solution-Processed Bulk Heterojunction Solar Cells. By B. Walker, C. Kim and T.-Q. Nguyen, *Chem. Mater.*, **23** (3), 470–482 (2011).

Abstract

Although most research in the field of organic bulk heterojunction solar cells has focused on combinations of a *p*-type conducting polymer as a donor and a fullerene-based acceptor, recent work has demonstrated the viability of solution-processed heterojunctions composed entirely of molecular solids. Molecular solids offer potential advantages over conjugated polymer systems in terms of easier purification, amenability to mass-scale production and better batch-to-batch reproducibility.

This article reviews the major classes of molecular donors that have been reported in the literature in the past several years and highlights some of key considerations in molecular heterojunction design compared to polymer-based bulk heterojunctions. 96 References.

- Metal-Ion-Responsive Fluorescent Probes for Two-Photon Excitation Microscopy. By S. Sumalekshmy and C. J. Fahrni, *Chem. Mater.*, **23** (3), 483–500 (2011).

Abstract

Metal-ion-responsive fluorescent probes are powerful tools for visualizing labile metal ion pools in live cells. To take full advantage of the benefits offered by two-photon excitation microscopy, including increased depth penetration, reduced phototoxicity, and intrinsic 3D capabilities, the photophysical properties of the probes must be optimized for nonlinear excitation.

This review summarizes the challenges associated with the design of two-photon excitable fluorescent probes and labels, and offers an overview of recent efforts in developing selective and sensitive reagents for the detection of metal ions in biological systems. 114 References.

- Recent Advances in Conjugated Polyelectrolytes for Emerging Optoelectronic Applications. By A. Duarte, K.-Y. Pu, B. Liu and G. C. Bazan, *Chem. Mater.*, **23** (3), 501–515 (2011).

Abstract

This review summarizes recent advances in the science and applications of conjugated polyelectrolytes (CPEs), with an emphasis on direct visual sensing, cellular imaging, and the fabrication of optoelectronic devices.

CPEs backbones that incorporate donor- acceptor units are useful for direct visual sensing, whereas CPEs with hyperbranched structures, or biocompatible long side chains, are particularly useful for cellular imaging. With specially designed counterions, CPEs also demonstrate unique function in device fabrication and operation, for example, in dye-sensitized solar cells (DSSCs), bulk heterojunction (BHJ) solar cells, polymer light-emitting diodes (PLEDs), polymer light-emitting electrochemical cells (PLECs), and organic thin film transistors (OFET). Additionally, new strategies to modify and optimize CPE properties for specific applications are provided. The work summarized herein not only illustrates relationships between molecular structures and function, but also highlights how the structural versatility of CPEs makes them a

unique category of multifunctional materials with the potential for fulfilling a variety of optical and electronic applications in solution, mixed media, and in the solid state. 90 References.

- Magneto-Optic Properties of Regioregular Polyalkylthiophenes. By P. Gangopadhyay, G. Koeckelberghs and A. Persoons, *Chem. Mater.*, **23** (3), 516–521 (2011).

Abstract

This paper reviews work on the magneto-optical properties of π -conjugated polymers, in particular regioregular poly(3-alkyl) thiophenes. The authors give an overview of the theoretical formalism that led to the first observation of Faraday rotation from thin films of poly(3-dodecyl) thiophene and experimental results, which include Faraday rotation studies from thin films composed of various polythiophene derivatives with varying degree of regioregularity. They also discuss possible correlations of Faraday rotation and the supramolecular organization within the thin films of these polymers. When appropriate, the authors point out possible applications or suggest directions for further research. Organic magneto-optic polymer materials could reduce production costs for various magneto-optic devices, as these materials are solution processable and amenable to roll-to-roll processing. 39 References.

- Application of Molecular Simulation Techniques to the Study of Factors Affecting the Thin-Film Morphology of Small-Molecule Organic Semiconductors. By P. Clancy, *Chem. Mater.*, **23** (3), 522–543 (2011).

Abstract

The author provides a short review of the status of using atomic- or molecular-scale simulations to look at the phenomena associated with growing thin films of small organic semiconductor materials, such as surface diffusion, thin film growth, Ehrlich-Schwobel step-edge barrier, etc. She offers a summary of the advantages and limitations of existing computational tools (Molecular Dynamics, kinetic Monte Carlo, ab initio methods, etc.) and hint at method development that may help to deepen our understanding of “functional

π -materials. She also provides a deeper focus on computational, as well as related experimental, studies of fundamental questions related to the thin-film growth of a representative member of this class of materials, namely, pentacene, on a variety of substrates from insulating oxides to metals, and shows results for some other organic semiconductor members of the class, wherever possible. 222 References.

- Tailored Organic Electro-optic Materials and Their Hybrid Systems for Device Applications. By J. Luo, S. Huang, Z. Shi, B. M. Polishak, X.-H. Zhou and A. K.-Y. Jen, *Chem. Mater.*, **23** (3), 544–553 (2011).

Abstract

Recent development of tailored organic electric-optic (OEO) materials and their applications in hybrid device systems has been reviewed.

Hybrid systems encompass the optical and/or electrical components that form intimate contact with OEO materials, such as metal oxide barrier layers, solution processable passive waveguides, silicon nanoslots, and photonic CMOS chips, etc. These systems offer unique advantages combining excellent properties and simple processing for advanced photonic device platforms. Examples include the demonstration of low- V_{π} and low-loss EO modulators in hybrid polymer sol-gel waveguides, CMOS-compatible hybrid polymer/silicon slotted waveguides, and EO polymer-clad silicon nitride ring resonator modulators. This review also provides a future prospect for the development of OEO materials and their hybrid systems. 32 References.

- Charge-Carrier Transporting Graphene-Type Molecules. By W. Pisula, X. Feng and K. Mullen, *Chem. Mater.*, **23** (3), 554–567 (2011).

Abstract

Graphene-type molecules, typically large polycyclic aromatic hydrocarbons (PAHs), have gained enormous interest because of their unique self-organization behavior and promising electronic properties for applications in organic electronics. This article reviews the thermotropic behavior and supramolecular organization of discotic PAHs in the bulk as well as their self-assembly on the surface at different length scales.

Applications of PAHs in field-effect transistors and solar cells are discussed in light of various different processing approaches from solution that ensure high order and an adequate molecular arrangement in the device configuration. 118 References.

- Molecular Design and Synthetic Approaches to Electron-Transporting Organic Transistor Semiconductors. By B. J. Jung, N. J. Tremblay, M.-L. Yeh and H. E. Katz, *Chem. Mater.*, **23** (3), 568–582 (2011).

Abstract

This review covers the various classes of molecular structures that may be used as the basis for the synthesis of organic semiconductors that favor electron transport in field-effect transistors and related electronic and optoelectronic devices. The types of compounds include tetracarboxylic diimides, heterocyclic oligomers, fullerenes, and metal complexes. Approaches to polymers are also mentioned. Although brief discussions of transistor operation and applications are included, the emphasis is on the rationale for choosing these structures, and synthetic routes to them. Performance of exemplary compounds in transistors is also discussed. 181 References.

- Small-Molecule, Nonfullerene Acceptors for Polymer Bulk Heterojunction Organic Photovoltaics. By J. E. Anthony, *Chem. Mater.*, **23** (3), 583–590 (2011).

Abstract

In the field of polymer bulk-heterojunction organic photovoltaics, fullerenes and fullerene derivatives clearly play the dominant role as acceptor materials. Recently, a number of research efforts have focused on the development of new small-molecule acceptors for this device configuration. Although few materials prepared to-date have demonstrated power conversion efficiencies close to those achieved with fullerenes, numerous design rules and some interesting new materials classes have been explored.

This short review will highlight the progress toward higher efficiency in nonfullerene small-molecule acceptors for organic solar cells. 41 References.

- Electronic Processes at Organic–Organic Interfaces: Insight from Modeling and Implications for Opto-electronic Devices. By D. Beljonne, J. Cornil, L. Muccioli, C. Zannoni, J.-L. Bredas and F. Castet, *Chem. Mater.*, **23** (3), 591–609 (2011).

Abstract

The authors report on the recent progress achieved in modeling the electronic processes that take place at interfaces between π -conjugated materials in organic opto-electronic devices.

First, they provide a critical overview of the current computational techniques used to assess the morphology of organic: organic heterojunctions; highlight the compromises that are necessary to handle large systems and multiple time scales while preserving the atomistic details required for subsequent computations of the electronic and optical properties. They then review some recent theoretical advances in describing the ground-state electronic structure at heterojunctions between donor and acceptor materials and highlight the role played by charge-transfer and long-range polarization effects. Finally, The authors discuss the modeling of the excited-state electronic structure at organic: organic interfaces, which is a key aspect in the understanding of the dynamics of photoinduced electron-transfer processes. 162 References.

- Electronic Energy Transfer and Quantum-Coherence in π -Conjugated Polymers. By I. Hwang and G. D. Scholes, *Chem. Mater.*, **23** (3), 610–620 (2011).

Abstract

Electronic energy transfer (EET) has been the subject of intense research because of its significant contribution to the photophysical properties of various material systems. For π -conjugated polymers, it has long been accepted that a classical hopping mechanism is dominant in the energy transfer dynamics because of a weak electronic coupling. However, recent research reveals that conjugated polymers, in fact, can have an electronic coupling strong enough to preserve quantum-coherence.

In this review, the authors summarize the main photophysical features of conjugated polymers. They

discuss how electronic excited states evolve on various time scales from femto-seconds to hundreds of pico-seconds in terms of exciton relaxation, localization, and electronic energy transfer. The Forster energy transfer model and modifications needed for describing energy transfer in conjugated polymers are described. They also discuss how chain conformation and its disorder influence EET and the time scale of the evolution of electronic excited states, and demonstrate how quantum coherence contributes to energy transfer dynamics. Recent research on exciton diffusion in various kinds of polymers is summarized. 141 References.

- Multifunctional Materials in High-Performance OLEDs: Challenges for Solid-State Lighting. By H. Sasabe and J. Kido, *Chem. Mater.*, **23** (3), 621–630 (2011).

Abstract

Recent advances in material chemistry have enabled white organic light-emitting device (OLED) efficacy beyond fluorescent tube efficacy up to 100 lm/W. In this short review, the authors explore recent developments of small molecule-based multifunctional materials in high-performance OLEDs, especially blue phosphorescent emitters, host materials, and electron-transporting materials. 102 References.

- Probing Hopping Conduction in Conjugated Molecular Wires Connected to Metal Electrodes. By L. Luo, S. H. Choi and C. D. Frisbie, *Chem. Mater.*, **23** (3), 631–630 (2011).

Abstract

Understanding electrical transport processes in molecules connected between metal electrodes is a central focus in the field of molecular electronics and is important for both potential applications and fundamental research purposes.

This short review summarizes recent progress in assembling and measuring strategies for long conjugated molecular wires within molecular junctions, and introduces several new in situ methods to prepare molecular wires connected to electrodes. Following a brief introduction to charge transport mechanisms,

particular examples of molecular wires in the recent literature are presented to discuss the influence of molecular length, temperature, and applied voltage on the transport properties with emphasis on the tunneling-to-hopping transition. The review concludes with an outlook on future hopping transport experiments in long conjugated molecular wires. 114 References.

- Emerging Applications of Carbon Nanotubes. By J. M. Schnorr and T. M. Swager, *Chem. Mater.*, **23** (3), 646–657 (2011).

Abstract

On the basis of their unique electrical and mechanical properties, carbon nanotubes (CNTs) have attracted great attention in recent years. A diverse array of methods has been developed to modify CNTs and to assemble them into devices. On the basis of these innovations, many applications that include the use of CNTs have been demonstrated. Transparent electrodes for organic light-emitting diodes (OLEDs), lithium-ion batteries, supercapacitors, and CNT-based electronic components such as field-effect transistors (FETs) have been demonstrated. Furthermore, CNTs have been employed in catalysis and sensing as well as filters and mechanical and biomedical applications.

This review highlights illustrative examples from these areas to give an overview of applications of CNTs. 165 References.

- Approaches to Solution-Processed Multilayer Organic Light-Emitting Diodes Based on Cross-Linking. By C. A. Zuniga, S. Barlow and S. R. Marder, *Chem. Mater.*, **23** (3), 658–681 (2011).

Abstract

The fabrication of multilayer organic light-emitting diodes (OLEDs) through solution processing presents challenges, especially regarding dissolution of the first layer during deposition of a second layer. One possible approach to this problem is to insolubilize the first layer using cross-linking. Cross-linking has also been used to control the morphological stability and aggregation phenomena of the active organic materials.

In this short review, the authors discuss the alternative chemically, thermally, and photochemically

promoted cross-linking chemistries that have been examined in the context of OLEDs including: the hydrolysis of silicon compounds to form siloxanes; the polymerization of styrene, acrylate, and oxetane groups; and the dimerization of trifluorovinyl ethers, benzocyclobutenes, and cinnamates. 68 References.

- One-Dimensional Nanostructures of π -Conjugated Molecular Systems: Assembly, Properties, and Applications from Photovoltaics, Sensors, and Nanophotonics to Nanoelectronics. By F. S. Kim, G. Ren and S. A. Jenekhe, *Chem. Mater.*, **23** (3), 682–732 (2011).

Abstract

This paper presents a comprehensive review of the literature on one-dimensional (1D) nanostructures (nanowires, nanoribbons, nanotubes, nanobelts, and nanofibers) of π -conjugated small molecules, oligomers, and polymers.

The diverse methods used in assembling the molecular building blocks into 1D functional nanostructures and nanodevices are discussed, including hard and soft template-assisted synthesis, electro-spinning, nanolithography, self-assembly in solution and at interfaces, physical vapor transport, and other strategies. Optical, charge transport, electronic, and photoconductive properties of nanowires and nanotubes of selected classes of π -conjugated molecular systems are discussed, highlighting unique features of the 1D nanostructures compared to 2D thin films. Overview of applications of these 1D organic nanostructures ranging from nanoscale light-emitting diodes, field-emission devices, organic photovoltaics, sensors/biosensors, spin-electronics, and nanophotonics to nanoelectronics is then given. The final section provides brief concluding comments on the status of the field and on areas of outstanding challenges and opportunities for future work. 592 References.

- π -Conjugated Polymers for Organic Electronics and Photovoltaic Cell Applications. By A. Facchetti, *Chem. Mater.*, **23** (3), 733–758 (2011).

Abstract

The optoelectronic properties of polymeric semiconductor materials can be utilized for the fabrication of

organic electronic and photonic devices. When key structural requirements are met, these materials exhibit unique properties such as solution processability, large charge transporting capabilities, and/or broad optical absorption.

In this review, recent developments in the area of π -conjugated polymeric semiconductors for organic thin-film (or field-effect) transistors (OTFTs or OFETs) and bulk-heterojunction photovoltaic (or solar) cell (BHJ-OPV or OSC) applications are summarized and analyzed. 155 References.

- Using the Dynamic Bond to Access Macroscopically Responsive Structurally Dynamic Polymers. By R. J. Wojtecki, M. A. Meador and S. J. Rowan, *Nature Mater.*, **10** (1), 14–27 (2011).

Abstract

New materials that have the ability to reversibly adapt to their environment and possess a wide range of responses ranging from self-healing to mechanical work are continually emerging. These adaptive systems have the potential to revolutionize technologies such as sensors and actuators, as well as numerous biomedical applications.

The authors describe the emergence of a new trend in the design of adaptive materials that involves the use of reversible chemistry (both non-covalent and covalent) to program a response that originates at the most fundamental (molecular) level. Materials that make use of this approach — structurally dynamic polymers — produce macroscopic responses from a change in the material's molecular architecture. That is, the rearrangement or reorganization of the polymer components, or polymeric aggregates. This design approach requires careful selection of the reversible/dynamic bond used in the construction of the material to control its environmental responsiveness. 111 References.

- Single Dopants in Semiconductors. By P. M. Koenraad and M. E. Flatté, *Nature Mater.*, **10** (2), 91–100 (2011).

Abstract

The sensitive dependence of a semiconductor's electronic, optical and magnetic properties on dopants has provided an extensive range of tunable phenomena to

explore and apply to devices. Recently it has become possible to move past the tunable properties of an ensemble of dopants to identify the effects of a solitary dopant on commercial device performance as well as locally on the fundamental properties of a semiconductor. New applications that require the discrete character of a single dopant, such as single-spin devices in the area of quantum information or single-dopant transistors, demand a further focus on the properties of a specific dopant.

This article describes the huge advances in the past decade towards observing, controllably creating and manipulating single dopants, as well as their application in novel devices which allow opening the new field of 'solotronics' (solitary dopant optoelectronics). 117 References.

- Functional Soft Materials from Metallopolymers and Metallosupramolecular Polymers. By G. R. Whittell, M. D. Hager, U. S. Schubert and I. Manners, *Nature Mater.*, **10** (3), 176–188 (2011).

Abstract

Synthetic polymers containing metal centres are emerging as an interesting and broad class of easily processable materials with properties and functions that complement those of state-of-the-art organic macromolecular materials. A diverse range of different metal centres can be harnessed to tune macromolecular properties, from transition- and main-group metals to lanthanides. Moreover, the linkages that bind the metal centres can vary almost continuously from strong, essentially covalent bonds that lead to irreversible or 'static' binding of the metal to weak and labile, non-covalent coordination interactions that allow for reversible, 'dynamic' or 'metallosupramolecular', binding.

Here, the authors review recent advances and challenges in the field and illustrate developments towards applications as emissive and photovoltaic materials; as optical limiters; in nanoelectronics, information storage, nanopatterning and sensing; as macromolecular catalysts and artificial enzymes; and as stimuli-responsive materials. They focus on materials in which the metal centres provide function; although they can also play a structural role, systems where this is solely their purpose have not been discussed. 125 References.

- Strain Effects in Low-Dimensional Transition Metal Oxides. By J. Cao and J. Wu, *Mater Sci. & Engg. R.*, **71** (2–4), 35–52 (2011).

Abstract

Transition metal oxides offer a wide spectrum of properties which provide the foundation for a broad range of potential applications. Many of these properties originate from intrinsic coupling between lattice deformation and nanoscale electronic and magnetic ordering. Lattice strain thus has a profound influence on the electrical, optical, and magnetic properties of these materials. Recent advances in materials processing have led to the synthesis of low-dimensional single-crystal transition metal oxides, namely, epitaxial ultra-thin films and free-standing nano/microwires. Unlike bulk materials, these systems allow external tuning of uniform strain in these materials to tailor their properties and functionalities.

This paper provides a comprehensive review of recent developments in studies of strain effects in transition metal oxide ultra-thin films and nano/microwires. The authors focus on the work of strain-controlled electromechanical response in piezoelectric oxides and strain-induced metal–insulator transitions as well as domain physics in strongly correlated electron oxides. Related nanoscale device applications such as strain sensing and power generation are highlighted as well. 206 References.

- Electromigration in Submicron Interconnect Features of Integrated Circuits. By H. Ceric and S. Selberherr, *Mater Sci. & Engg. R.*, **71** (5–6), 53–86 (2011).

Abstract

Electromigration (EM) is a complex multiphysics problem including electrical, thermal, and mechanical aspects. Since the first work on EM was published in 1907, extensive studies on EM have been conducted theoretically, experimentally, and by means of computer simulation. Today EM is the most significant threat for interconnect reliability in high performance integrated circuits.

The intention of this review is to present the most important aspects of theoretical and experimental EM

investigations together with a brief history of the development of the main concepts and methods. The authors present an overview of EM models from their origins in classical materials science methods up to the most recent developments for submicron interconnect features, as well as the application of ab initio and first principle methods. The main findings of experimental studies, important for any model development and application, are also presented. 161 References.

- Medium Chain Length Polyhydroxyalkanoates, Promising New Biomedical Materials for the Future. By R. Rai, T. Keshavarz, J. A. Roether, A. R. Boccaccini and I. Roy, *Mater Sci. & Engg. R.*, **72** (3), 29–47 (2011).

Abstract

Medium chain length polyhydroxyalkanoates, mcl-PHAs (C₆–C₁₄ carbon atoms), are polyesters of hydroxyalkanoates produced mainly by fluorescent *Pseudomonads* under unbalanced growth conditions. These mcl-PHAs, which can be produced using renewable resources are biocompatible, biodegradable and thermo-processable. They have low crystallinity, low glass transition temperature, low tensile strength and high elongation to break, making them elastomeric polymers. Mcl-PHAs and their copolymers are suitable for a range of biomedical applications where flexible biomaterials are required, and are more structurally diverse than short chain length PHAs and hence can be more readily tailored for specific applications. Composites have also been fabricated using mcl-PHAs and their copolymers, with single walled carbon nanotubes and poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) [P(3HB-co-3HHx)] combined with hydroxyapatite. Because of these attractive properties, Mcl-PHAs and their composites are being increasingly used for biomedical applications. However, studies remain limited mainly to P(3HO) and the copolymer P(3HB-co-3HHx), which are the only mcl-PHAs available in large quantities.

In this review, the authors have consolidated current knowledge on the properties and biomedical applications of these elastomeric mcl-PHAs, their copolymers and their composites. 142 References.

- Bionanoelectronics. By A. Noy, *Adv. Mater.*, **23** (7), 807–820 (2011).

Abstract

Every cell in a living organisms performs a complex array of functions using a vast arsenal of proteins, ion channels, pumps, motors, signaling molecules, and cargo carriers. With all the progress that humankind has made to date in the development of sophisticated machinery and computing capabilities, understanding and communicating with living systems on that level of complexity lags behind. A breakthrough in these capabilities could only come if a way is found to integrate biological components into artificial devices. The central obstacle for this vision of bionanoelectronics is the absence of a versatile interface that facilitates two-way communication between biological and electronic structures. 1D nanomaterials, such as nanotubes and nanowires, open up the possibility of constructing tight interfaces that could enable such bidirectional flow of information.

This review discusses the overall progress in building such interfaces on the level of individual proteins and whole cells and focuses on the latest efforts to create device platforms that integrate membrane proteins, channels, and pumps with nanowire bioelectronics. 104 References.

- Magnetic Materials and Devices for the 21st Century: Stronger, Lighter, and More Energy Efficient. By O. Gutfleisch, M. A. Willard, E. Brück, C. H. Chen, S. G. Sankar and J. P. Liu, *Adv. Mater.*, **23** (7), 807–820 (2011).

Abstract

A new energy paradigm, consisting of greater reliance on renewable energy sources and increased concern for energy efficiency in the total energy lifecycle, has accelerated research into energy-related technologies. Due to their ubiquity, magnetic materials play an important role in improving the efficiency and performance of devices in electric power generation, conditioning, conversion, transportation, and other energy-use sectors of the economy.

This review focuses on the state-of-the-art hard and soft magnets and magnetocaloric materials, with

an emphasis on their optimization for energy applications. Specifically, the impact of hard magnets on electric motor and transportation technologies, of soft magnetic materials on electricity generation and conversion technologies, and of magnetocaloric materials for refrigeration technologies, are discussed. The synthesis, characterization, and property evaluation of the materials, with an emphasis on structure–property relationships, are discussed in the context of their respective markets, as well as their potential impact on energy efficiency. Finally, considering future bottlenecks in raw materials, options for the recycling of rare-earth intermetallics for hard magnets are discussed. 134 References.

- Recent Progresses on Materials for Electrophosphorescent Organic Light-Emitting Devices. By L. Xiao, Z. Chen, B. Qu, J. Luo, S. Kong, Q. Gong and J. Kido, *Adv. Mater.*, **23** (8), 926–952 (2011).

Abstract

Although organic light-emitting devices have been commercialized as flat panel displays since 1997, only singlet excitons were emitted. Full use of singlet and triplet excitons, electrophosphorescence, has attracted increasing attentions after the premier work made by Forrest, Thompson, and co-workers. In fact, red electrophosphorescent dye has already been used in sub-display of commercial mobile phones since 2003. Highly efficient green phosphorescent dye is now undergoing of commercialization. Very recently, blue phosphorescence approaching the theoretical efficiency has also been achieved, which may overcome the final obstacle against the commercialization of full color display and white light sources from phosphorescent materials. Combining light out-coupling structures with highly efficient phosphors, white emission with an efficiency matching that of fluorescent tubes (90 lm/W) has now been realized. It is possible to tune the color to the true white region by changing to a deep blue emitter and corresponding wide gap host and transporting material for the blue phosphor.

In this article, recent progresses in red, green, blue, and white electrophosphorescent materials for OLEDs are reviewed, with special emphasis on blue electrophosphorescent materials. 228 References.

- Strategies for Post-Synthesis Alignment and Immobilization of Carbon Nanotubes. By T. Druzhinina, S. Hoepfner and U. S. Schubert, *Adv. Mater.*, **23** (8), 953–970 (2011).

Abstract

Carbon nanotubes (CNTs) have developed into a standard material used as a building block for nanotechnological developments. Based on the unique properties that make CNTs useful for many different applications in nanotechnology, optics, electronics, and material science, there has been a rapid development of this research area and many different applications have emerged in the past few years. Frequently, the alignment and immobilization of CNTs play an important role for many applications and different strategies, in particular post-synthesis approaches, can be applied.

Recent developments of different techniques to immobilize and align carbon nanotubes are discussed and classified into three main categories: chemical immobilization and alignment, physical immobilization and alignment, and the use of external fields for these purposes. Many of the techniques involve multiple steps and may also cross these rather crudely defined boundaries. As such, the techniques are classified according to their most important or unique step. 169 References.

- Bimetallic Nanocrystals: Liquid-Phase Synthesis and Catalytic Applications. By D. Wang and Y. Li, *Adv. Mater.*, **23** (9), 1044–1060 (2011).

Abstract

Bimetallic nanocrystals (NCs) with core/shell, heterostructure, or intermetallic and alloyed structures are emerging as more important materials than monometallic NCs. They are expected to display not only a combination of the properties associated with two distinct metals, but also new properties and capabilities due to a synergy between the two metals. More importantly, bimetallic NCs usually show composition-dependent surface structure and atomic segregation behavior, and therefore more interesting applied potentials in various fields including electronics, engineering, and catalysis. Compared with monometallic NCs, preparation of bimetallic NCs is much more complicated and difficult to be achieved. In

recent years, researchers from many groups have made great efforts in this area. This review highlights the recent progress in the chemical synthesis of bimetallic NCs. The control over morphology, size, composition, and structure of bimetallic NCs as well as the exploration of their properties and applications are discussed. 111 References.

- Recent Progress in Multiferroic Magnetolectric Composites: from Bulk to Thin Films. By J. Ma, J. Hu, Z. Li and C.-W. Nan, *Adv. Mater.*, **23** (9), 1062–1087 (2011).

Abstract

Multiferroic magnetolectric composite systems such as ferromagnetic-ferroelectric heterostructures have recently attracted an ever-increasing interest and provoked a great number of research activities, driven by profound physics from coupling between ferroelectric and magnetic orders, as well as potential applications in novel multifunctional devices, such as sensors, transducers, memories, and spintronics.

In this review, the authors try to summarize what remarkable progress in multiferroic magnetolectric composite systems has been achieved in most recent few years, with emphasis on thin films; and to describe unsolved issues and new device applications which can be controlled both electrically and magnetically. 233 References.

- Dry Autoclaving for the Nanofabrication of Sulfides, Selenides, Borides, Phosphides, Nitrides, Carbides, and Oxides. By V. G. Pol, S. V. Pol and A. Gedanken, *Adv. Mater.*, **23** (10), 1179–1190 (2011).

Abstract

This review compiles various nanostructures fabricated by a distinct “dry autoclaving” approach, where the chemical reactions are carried out without solvents; above the dissociation temperature of the chemical precursor(s) at elevated temperature in a closed reactor. The diversity to fabricate carbides (SiC, Mo₂C, WC), oxides (VOx-C, ZnO, Eu₂O₃, Fe₃O₄, MoO₂), hexaborides (LaB₆, CeB₆, NbB₆, SmB₆, EuB₆, GdB₆), nitrides (TiN, NbN, TaN), phosphides (PtP₂, WP), sulfides (ZnS, FeS/C, SnS/C, WS₂, WS₂/C), and

selenides ($Zn_{1-x}Mn_xSe/C$, $Cd_{1-x}Mn_xSe/C$), with various shapes and sizes is accounted with plausible applications. This unique single-step, solvent-free synthetic process opens up a new route in the growing nanomaterials science, owing to its considerable advantages on the existing approaches. 116 References.

- Dynamic Aspects of Films Prepared by a Sequential Deposition of Species: Perspectives for Smart and Responsive Materials. By P. Lavalle, J.-C. Voegel, D. Vautier, B. Senger, P. Schaaf and V. Ball, *Adv. Mater.*, **23** (10), 1191–1221 (2011).

Abstract

The deposition of surface coatings using a step-by-step approach from mutually interacting species allows the fabrication of so called “multilayered films”. These coatings are very versatile and easy to produce in environmentally friendly conditions, mostly from aqueous solution. They find more and more applications in many hot topic areas, such as in biomaterials and nano-electronics but also in stimuli-responsive films.

The authors aim to review the most recent developments in such stimuli-responsive coatings based on layer-by-layer (LBL) depositions in relationship to the properties of these coatings. The most investigated stimuli are based on changes in ionic strength, temperature, exposure to light, and mechanical forces. The possibility to induce a transition from linear to exponential growth in thickness and to change the charge compensation from “intrinsic” to “extrinsic” by controlling parameters such as temperature, pH, and ionic strength are the ways to confer their responsiveness to the films. Chemical post-modifications also allow to significantly modify the film properties. 405 References.

- Thermoforming of Film-based Biomedical Microdevices. By R. Truckenmüller, S. Giselbrecht, N. Rivron, E. Gottwald, V. Saile, A. van den Berg, M. Wessling and C. van Blitterswijk, *Adv. Mater.*, **23** (11), 1311–1329 (2011).

Abstract

For roughly ten years now, a new class of polymer micromoulding processes comes more and more into

the focus both of the microtechnology and the biomedical engineering community. These processes can be subsumed under the term “microthermoforming”. In microthermoforming, thin polymer films are heated to a softened, but still solid state and formed to thin-walled microdevices by three-dimensional stretching. The high material coherence during forming is in contrast to common polymer microreplication processes where the material is processed in a liquid or flowing state. It enables the preservation of premodifications of the film material.

In this article, the authors review the still young state-of-the-art of microthermoforming technology as well as its first applications. So far, the applications are mainly in the biomedical field. They benefit from the fact that thermoformed microdevices have unique properties resulting from their special, unusual morphology. The focus of this article is on the impact of the new class of micromoulding processes and the processed film materials on the characteristics of the moulded microdevices and on their applications. 73 References.

- Smectic Liquid Crystal Defects for Self-Assembling of Building Blocks and their Lithographic Applications. By Y. H. Kim, D. K. Yoon, H. S. Jeong, O. D. Lavrentovich and H.-T. Jung, *Adv. Funct. Mater.*, **21** (4), 610–627 (2011).

Abstract

Recently, it has been reported that liquid crystal (LC) defects can be used to create highly periodic templates by controlling the surface anchoring and the elastic properties of LC molecules. The self-assembled defect ordering of the LC materials takes advantage of the ability to achieve fast stabilization of molecular ordering and structure due to the reversible and non-covalent interactions of the LC molecules.

In this article, the defect structures of liquid crystalline materials will be demonstrated by the surface anchoring and elastic properties. A particular focus is on the focal conic domains (FCDs) that are commonly observed in SmA liquid crystals and their lamellar lyotropic counterparts, which form periodic defect ordered structures. In addition, methodologies for creating lithographic templates from the defect order will

be described. Finally, the review closes with a discussion of toric focal conic domain arrays that have been fabricated in this manner and used for various applications. 95 References.

- Carbide-Derived Carbons – From Porous Networks to Nanotubes and Graphene. By V. Presser, M. Heon and Y. Gogotsi, *Adv. Funct. Mater.*, **21** (5), 810–833 (2011).

Abstract

Carbide-derived carbons (CDCs) are a large family of carbon materials derived from carbide precursors that are transformed into pure carbon via physical (e.g., thermal decomposition) or chemical (e.g., halogenation) processes. Structurally, CDC ranges from amorphous carbon to graphite, carbon nanotubes or graphene. For halogenated carbides, a high level of control over the resulting amorphous porous carbon structure is possible by changing the synthesis conditions and carbide precursor. The large number of resulting carbon structures and their tunability enables a wide range of applications, from tribological coatings for ceramics, or selective sorbents, to gas and electrical energy storage. In particular, the application of CDC in supercapacitors has recently attracted much attention.

This review summarizes key aspects of CDC synthesis, properties, and applications. It is shown that the CDC structure and properties are sensitive to changes of the synthesis parameters. Understanding of processing–structure–properties relationships facilitates tuning of the carbon material to the requirements of a certain application. 237 References.

- Materials Chemistry of Fullerene (C₆₀) Derivatives. By A. M. López, A. M. -Alonso and M. Prato, *J. Mater. Chem.*, **21** (5), 1305–1318 (2011).

Abstract

Despite the increasing interest of the scientific community in carbon nanotubes and graphene, fullerene C₆₀ still plays an important role in the family of nanocarbons. A quarter of a century of research on fullerenes has been dedicated to understanding the way to produce stable, well-characterized and highly soluble fullerene derivatives, which retain the original

properties of C₆₀. The applications in a wide number of fields, especially on new materials design, have enriched the literature with fascinating examples where fullerenes are directly involved.

The authors report a brief summary of recent achievements in some exciting applications of fullerene derivatives. 157 References.

- A Review of Powder Modifications in Conventional Glass-Ionomer Dental Cements. By A. Moshaverinia, N. Roohpour, W. W. L. Chee and S. R. Schricker, *J. Mater. Chem.*, **21** (5), 1319–1328 (2011).

Abstract

Glass-ionomer dental cements (GICs) have proven to be useful in several areas of dentistry such as restorative dentistry. Glass-ionomers are aqueous cements formed by the reaction of an acidic polymer and a basic glass in the presence of water. The oral environment presents many challenges to the longevity of restorative materials. Glass-ionomer cements have many properties that are clinically useful and promote longevity. Importantly, GICs adhere to moist tooth structure without any pretreatment, and provide a prolonged period of fluoride release, which inhibits recurrent tooth decay (caries). These properties together with acceptable aesthetics and biocompatibility make these materials popular and desirable for medical and dental applications. However, glass-ionomer dental cements have limitations that prevent broader clinical adaptation such as poor mechanical properties and moisture sensitivity. Many significant changes and modifications to the chemistry of the acidic polymers and basic glasses and to the formulation of the cements have been made to address these limitations.

In this review, advances in the development of the basic glasses and other reinforcing agents are discussed. An overview of the chemistry of glass-ionomer cements is discussed followed by an in-depth discussion of the chemistry of novel basic glasses and reinforcing additives. 94 References.

- Chalcogenoarene Semiconductors: New Ideas from Old Materials. By L. Zhang, S. M. Fakhouri, F. Liu, J. C. Timmons, N. A. Ran and A. L. Briseno, *J. Mater. Chem.*, **21** (5), 1329–1337 (2011).

Abstract

There are certain aspects of the electronic and packing behavior of planar aromatic molecules containing exocyclic chalcogen atoms (*i.e.*, sulfur, selenium, tellurium) which need considerable re-enlightenment. This class of semiconductors was once regarded as next-generation π -donors for applications in charge-transfer complexes. With the advent of new device technologies such as light-emitting diodes, solar cells, and organic transistors, the interest in charge-transfer complexes eventually tapered off. However, significant progress in the use of this class of materials in modern organic devices has been reported over the last five years.

In this article, the authors review the exocyclic arenes with chalcogen atoms in *peri*-positions, summarize synthetic routes to these compounds and take a close look at their basic properties. Particular emphasis is placed upon their packing arrangements and the effect of exocyclic chalcogen atoms on the crystal packing motifs. Selected example applications from this class of materials in different fields are highlighted. As a final note, the authors provide a prediction for their use in mainstream applications such as energy and fundamental charge transport/generation. 76 References.

- Alkoxy-Substituted Poly(Arylene-Ethynylene)-Alt-Poly(Arylene-Vinylene)s: Synthesis, Electroluminescence and Photovoltaic Applications. By D. A. M. Egbe, H. Neugebauer and N. S. Sariciftci, *J. Mater. Chem.*, **21** (5), 1338–1349 (2011).

Abstract

Poly (arylene-ethynylene)-*alt*-poly(arylene-vinylene)s (PAE-PAVs) combine the intrinsic features of both poly (arylene-ethynylene) (PAE) and poly(arylene-vinylene) (PAV) in a single polymeric backbone. They exhibit enhanced electron affinity, as compared to parent poly (*p*-phenylene-vinylene) (PPV), making electron injection easier, placing them as potential candidates for low turn-on voltage organic light emitting diodes (OLEDs). Depending on the chemical structures, PAE-PAVs have been efficiently used either as donor materials in polymer-PCBM

(phenyl-C₆₁-butyric acid methylester) or polymer-Vinazene (2-vinyl-4,5-dicyanoimidazole) bulk heterojunction solar cells, or as acceptor materials in polymer-polymer bilayer and blend solar cells.

This article reviews the synthesis and properties (electroluminescence and photovoltaic) of π -conjugated alkoxy-substituted PAE-PAVs designed by the authors, and which were obtained either by Horner–Wadsworth–Emmons olefination reaction of luminophoric dialdehydes with bisphosphonate esters, or Knoevenagel reaction of the same dialdehydes with dinitriles. 71 References.

- Exotic Materials for Bio-Organic Electronics. By M. Irimia-Vladu, N. S. Sariciftci and S. Bauer, *J. Mater. Chem.*, **21** (5), 1350–1361 (2011).

Abstract

‘Exotic materials have become the focus of recent developments in organic electronics that envision biocompatibility, biodegradability, and sustainability for low-cost, large-volume electronic components.

In this brief review, the authors discuss firstly the use of paper, leather, silk, hard gelatine, and biodegradable plastics as substrates for electronic devices, and secondly smoothing agents, such as polydimethylsiloxane and aurin. Thirdly, they describe DNA and nucleobases as examples of exotic dielectrics with low dielectric losses and leakage currents as well as sufficiently high dielectric breakdown strength. Fourthly, natural, nature-inspired, and common-commodity semiconductors are presented that broaden the materials base for organic semiconductors and may inspire further work to identify semiconductors that are stable in the face of changing environmental conditions yet degradable at the end of their product lifetime. Sustainability in organic electronics, energy storage, and emerging concepts are also reviewed briefly. Research on “exotic” organic materials may ultimately result in environmentally safe “green electronic” products. 56 References.

- From Molecular Mechanochemistry to Stress-Responsive Materials. By A. L. Black, J. M. Lenhardt and S. L. Craig, *J. Mater. Chem.*, **21** (6), 1655–1663 (2011).

Abstract

Current activity in, and future prospects for, the incorporation of mechanochemically active functional groups ('mechanophores') into polymers is reviewed.

This area of research is treated in the context of two categories. The first category is the development of new chemistry in the service of material science, through the design and synthesis of mechanophores to provide stress-sensing and/or stress-responsive elements in materials. The second category is the reverse—the development of new material architectures that efficiently transmit macroscopic forces to targeted molecules in order to generate chemical reactivity that is inaccessible by other means. 83 References.

- Carbon Nanospheres: Synthesis, Physicochemical Properties and Applications. By A. Nieto-Márquez, R. Romero, A. Romero and J. L. Valverde, *J. Mater. Chem.*, **21** (6), 1664–1672 (2011).

Abstract

The discovery of carbon nanostructures, essentially carbon nanotubes (CNT) and carbon nanofibres (CNF) has led to a big effort devoted to their synthesis, characterization, surface modification and use. Indeed, these structures have encountered application in a wide range of technological fields, such as adsorption, catalysis, hydrogen storage or electronics. Apart from the filamentous arrangement of graphene sheets conducting to CNT or CNF, carbon can bond in other different ways to create structures with dissimilar properties. The pairing of pentagonal and heptagonal carbon rings can result in the formation of carbon nanospheres (CNS). This novel nanostructure has only now started to attract significant research activity. In its spherical arrangement, the graphite sheets are not closed shells but rather waving flakes that follow the curvature of the sphere, creating many open edges at the surface. Contrary to the chemically inert C_{60} , the unclosed graphitic flakes provide reactive "dangling bonds" that are proposed to enhance surface reactions, establishing CNS as good candidates for catalytic and adsorption applications.

Despite the embryonic stage of the field and the existing data being too scattered, this work is aimed to

provide a comprehensive review of the existing literature related to CNS, exploring the different preparation routes employed, the critical characterization results as well as the applications studied so far. 105 References.

- Two-Dimensional Nanoparticle Organization using Block Copolymer Thin Films as Templates. By M. J. Pavan and R. Shenhar, *J. Mater. Chem.*, **21** (7), 2028–2040 (2011).

Abstract

The creation of ordered nanoparticle assemblies is one of the main prerequisites for the utilization of nanoparticles in advanced device applications. However, while considerable progress has been made in the precision synthesis of high quality, uniform nanoparticles of different compositions, sizes and shapes, our ability to organize them into ordered structures still faces major challenges.

This Article focuses on a facile approach developed in recent years for the fabrication of two-dimensionally organized nanoparticle assemblies, which is based on patterning as a simple and straightforward assembly mechanism and on block copolymer films as easily created templates. 62 References.

- Recent Advances in Making Nano-Sized TiO_2 Visible-Light Active through Rare-Earth Metal Doping. By S. Bingham and W. A. Daoud, *J. Mater. Chem.*, **21** (7), 2041–2050 (2011).

Abstract

Doping with metals and non-metals is a popular technique that facilitates visible light activity of titanium dioxide. More recently, rare-earth metals have shown tremendous potential as dopants not only in red-shifting the absorption but also in improving the photocatalysis of TiO_2 .

This article discusses recent developments in making TiO_2 visible-light active through single and co-doping with rare earth metals. An emphasis is placed on wet chemical techniques and their associated effects on the phase, adsorption, surface area, and photocatalytic activity of TiO_2 . New techniques, such as electrospinning, magnetron sputtering, co-precipitation, and complexation, as well as the use of nanotubes and physical support are also discussed. 52 References.

- Efficient Photocatalytic Degradation of Organics Diluted in Water and Air using TiO₂ Designed with Zeolites and Mesoporous Silica Materials. By Y. Kuwahara and H. Yamashita, *J. Mater. Chem.*, **21** (8), 2407–2016 (2011).

Abstract

Titanium dioxide (TiO₂) is a promising photocatalyst for degradation of organic compounds ideally under environmentally benign conditions. This paper reviews recent developments in designing TiO₂-sorbent hybrid photocatalysts, especially those supported on ordered nano-porous silica materials including zeolites and mesoporous silicas, with the objective of fabricating efficient photodegradation systems toward organic compounds diluted in water and air.

This review also describes the basic features of zeolites and mesoporous silica, adsorption kinetics on their surfaces, and the principles of surface modification techniques, and highlights that the hydrophobic nature of support materials can offer significant enhancement in photodegradation. Additionally, the several emerging synthetic approaches for related zeolitic materials from siliceous industrial wastes, which indicate the realization of energy-saving and recycling-oriented manufacturing processes in this field, are discussed. 54 References.

- The Impact of Carbon Materials on the Hydrogen Storage Properties of Light Metal Hydrides. By P. Adelhelm and P. E. de Jongh, *J. Mater. Chem.*, **21** (8), 2417–2027 (2011).

Abstract

The safe and efficient storage of hydrogen is still one of the remaining challenges towards fuel cell powered cars. Metal hydrides are a promising class of materials as they allow the storage of large amounts of hydrogen in a small volume at room temperature and low pressures. However, usually the kinetics of hydrogen release and uptake and the thermodynamic properties do not satisfy the requirements for practical applications. Therefore current research focuses on catalysis and the thermodynamic tailoring of metal hydride systems. Surprisingly, carbon materials used as additive or support are very effective to improve the hydrogen storage properties of metal hydrides allowing fast

kinetics and even a change in the thermodynamic properties. Even though the underlying mechanisms are not always well understood, the beneficial effect is probably related to the peculiar structure of the carbon materials.

This article gives an introduction to the different carbon materials, an overview of the preparation strategies to synthesize carbon/hydride nanocomposites, and highlights the beneficial effect of carbon by discussing two important hydrides: MgH₂ and NaAlH₄. 105 References.

- Lateral Interactions at Functional Monolayers. By S.-H. Hsu, D. N. Reinhoudt, J. Huskens and A. H. Velders, *J. Mater. Chem.*, **21** (8), 2428–2444 (2011).

Abstract

This article gives an overview of the recent literature regarding lateral molecular interactions in monolayers. The first part (Section 3) focuses on systems of self-assembled monolayers on metal surfaces, discussing the covalent and noncovalent interactions of the terminal functionality or between the molecular chains of the molecules. The second part (Section 4) highlights the intermolecular interactions of monolayers on silicon and metal oxide surfaces. The third part (Section 5) presents examples of lateral interactions on receptor surfaces. A focus in all parts is on examples of lateral interactions in monolayers in which electron or energy transfer occurs. 91 References.

- Composites of Functional Polymeric Hydrogels and Porous Membranes. By Q. Yang, N. Adrus, F. Tomicki and M. Ulbricht, *J. Mater. Chem.*, **21** (9), 2783–2811 (2011).

Abstract

Polymeric hydrogels are a most interesting class of “soft matter” with several established and many more possible applications as functional materials. In this review, the authors focus on the combination of polymeric hydrogels and porous membranes which leads to composites with promising functionality, for example, mass separations, sensing and analytics, (bio)catalysis, biomedical engineering and micro-system technologies.

The combination of a rigid porous membrane with a soft functional hydrogel by a suited preparation technique enables that the functionality of the hydrogel can be applied in a unique way. The most important preparation strategies for hydrogel composite membranes, i.e., pore-filling, various surface-grafting methods and combinations thereof, are discussed. The structural diversity of the hydrogels is based on the use of a wide range of synthetic monomers, but biopolymers or their derivatives can also be applied. The interplay of the membrane pore structure, the structure of the hydrogel and the distribution of the hydrogel in the pore space can lead to different types of composite membranes with completely different potential applications. The focus is on promising examples for the various types of functional composite membranes, i.e., macroporous membrane adsorbers, anti-fouling filtration membranes, hydrogel-based ultrafiltration membranes, other separation membranes with pore-filling hydrogel as selective material, stimuli-responsive membranes and porous membrane valves and gates, as well as bio-compatible or bioactive membranes. 233 References.

- Stimuli-Responsive, Mechanically-Adaptive Polymer Nanocomposites. By L. Hsu, C. Weder and S. J. Rowan, *J. Mater. Chem.*, **21** (9), 2812–2822 (2011).

Abstract

Stimuli-responsive nanocomposites composed of functional nanoparticles that are embedded within polymer matrices have begun to attract much attention as a new generation of mechanically-adaptive materials. These systems exhibit properties that exploit the influence of the filler beyond static mechanical reinforcement. The underlying mechanisms of these new nanomaterials typically involve an external stimulus that impacts the composite material, altering its bulk mechanics.

In this article, the key components currently being utilized to create polymeric nanocomposites with morphing mechanical properties are discussed, along with potential applications that provide the motivation for the development and investigation of such materials. 60 References.

- Core-Shell Structural Iron Oxide Hybrid Nanoparticles: from Controlled Synthesis to Biomedical

Applications. By L. Zhou, J. Yuan and Y. Wei, *J. Mater. Chem.*, **21** (9), 2823–2840 (2011).

Abstract

Superparamagnetic iron oxide nanoparticles have received great research attention due to their wide spectrum of potential applications. Core-shell structures with iron oxide nanoparticles as the core and with covalently grafted organic polymers as the shell, which has specific functions, such as biocompatibility, fluorescence, and biological activity have been synthesised. These nanostructured compounds could find numerous biomedical applications.

This article provides a review on the synthetic methodologies for building such magnetic core-shell structures, and on their applications in targeted drug delivery, enhanced magnetic resonance imaging (MRI), enzyme immobilization, hyperthermia and biosensors. Promising future directions of this active research field are also discussed. 136 References.

- Graphene: Preparation and Structural Perfection. By M. Inagaki, Y. A. Kim and M. Endo, *J. Mater. Chem.*, **21** (10), 3280–3294 (2011).

Abstract

Three basic processes for the production of monolayer graphene are reviewed: cleavage of graphite crystals, exfoliation of graphite intercalation compounds and chemical vapor deposition. The relationship of the structural perfection of the obtained thin flakes to the preparation method is discussed. 196 References.

- Solution-Chemistry Approach to Graphene Nanostructures. By X. Yan and L.-S. Li, *J. Mater. Chem.*, **21** (10), 3295–3300 (2011).

Abstract

Graphene has many novel optical and electrical properties desirable for applications in future electro-optical devices. Graphene nanostructures are especially attractive for their wide range of tunable properties. Here, the authors describe the recent progress and challenges in the solution-chemistry approach to graphene nanostructures. This approach could not only lead to new materials with various well-defined properties, but also

enable their production in large quantities. 154 References.

- Graphene Filled Polymer Nanocomposites. By R. Verdejo, M. M. Bernal, L. J. Romasanta and M. A. Lopez-Manchado, *J. Mater. Chem.*, **21** (10), 3301–3310 (2011).

Abstract

Graphene has attracted the attention of a growing number of scientists from several disciplines due to its remarkable physical properties and chemical functionalisation capabilities. This article presents an overview of graphene/polymer nanocomposites discussing preparation, properties and potential applications. The challenges and outlook of these emerging polymer nanocomposites are also discussed. 87 References.

- Assembly of Chemically Modified Graphene: Methods and Applications. By Y. Xu and G. Shi, *J. Mater. Chem.*, **21** (10), 3311–3323 (2011).

Abstract

Chemically modified graphenes (CMGs) are unique building blocks for “bottom up” nanotechnology because of their single-atom thickness, two-dimensional conjugated structure, and exceptional physical and chemical properties. Various hierarchical structures and functional nanocomposites based on CMGs have been prepared by self-assembly.

Here, the authors reviewed the recent advances in the assembly of CMGs in solution or at interfaces, and demonstrate the wide application of the resulting materials. 119 References.

- A Review of Chemical Vapour Deposition of Graphene on Copper. By C. Mattevi, H. Kim and M. Chhowalla, *J. Mater. Chem.*, **21** (10), 3324–3334 (2011).

Abstract

The discovery of uniform deposition of high-quality single layered graphene on copper has generated significant interest. That interest has been translated into rapid progress in terms of large area deposition of thin

films *via* transfer onto plastic and glass substrates. The opto-electronic properties of the graphene thin films reveal that they are of very high quality with transmittance and conductance values of >90% and 30 Ω /sq, both are comparable to the current state-of-the-art indium tin oxide transparent conductor.

In this Article, the authors provide a detailed and up to date description of the literature on the subject as well as highlighting challenges that must be overcome for the utilization of graphene deposited on copper substrates by chemical vapour deposition. 98 References.

- Chemical Doping of Grapheme. By H. Liu, Y. Liu and D. Zhu, *J. Mater. Chem.*, **21** (10), 3335–3345 (2011).

Abstract

Recently, a lot of effort has been focused on improving the performance and exploring the electric properties of graphene. This article presents a summary of chemical doping of graphene aimed at tuning the electronic properties of graphene. p-Type and n-type doping of graphene achieved through surface transfer doping or substitutional doping and their applications based on doping are reviewed. Chemical doping for band gap tuning in graphene is also presented. It will be beneficial to designing high performance electronic devices based on chemically doped graphene. 153 References.

- Ultrahigh Density Data Storage based on Organic Materials with SPM Techniques. By Y. Ma, Y. Wen and Y. Song, *J. Mater. Chem.*, **21** (11), 3522–3533 (2011).

Abstract

With the ever-increasing demand of expansive storage capacity and the continuous miniaturization of optoelectronic device, ultrahigh density data storage has attracted intensive research interest. In this article, recent progress on the developments of ultrahigh density data storage based on organic materials is summarized and discussed. The article especially focuses on materials for data recording using scanning tunneling microscopy (STM), atom force microscopy (AFM), and scanning near-field microscopy (SNOM). The focus is placed on the rational design and synthesis of new organic recording media to realize and improve

nanoscale data storage. In addition, an outlook in this field is also discussed. 96 References.

- The Oxidation of Aniline to Produce “Polyaniline”: A Process Yielding Many Different Nanoscale Structures. By H. D. Tran, J. M. D’Arcy, Y. Wang, P. J. Beltramo, V. A. Strong and R. B. Kaner, *J. Mater. Chem.*, **21** (11), 3534–3550 (2011).

Abstract

The number of different nano- and micro-scale structures produced from the chemical oxidation of aniline into “polyaniline” is rivaled by few other organic materials. Nanoscale structures such as fibers, tubes, aligned wires, flowers, spheres and hollow spheres, plates, and even those resembling anatomical organs, insects, and sea animals have been observed for the products produced when aniline is oxidized.

This article examines these different structures and the small and subtle changes in reaction parameters that result in their formation. These changes can often result in drastic differences in the polymer’s nanoscale morphology. Because a nanomaterial’s properties are highly dependent on the type of morphology produced, understanding polyaniline’s propensity for forming these structures is crucial towards tailoring the material for different applications as well as improving its synthetic reproducibility. The different approaches to commonly observed polyaniline nanostructures are presented in this article along with some of the highly debated aspects of these processes. The article ends with an approach towards resolving some of these contentious issues and a perspective on where things are headed in the years to come. 150 References.

- What Controls Triplet Exciton Transfer in Organic Semiconductors? By A. Köhler and H. Bässler, *J. Mater. Chem.*, **21** (12), 4003–4011 (2011).

Abstract

Dexter-type triplet transfer is a phenomenon that is ubiquitous in the field of molecular electronics, and that takes place at the interface of chemistry, physics and biology. It may be considered as a correlated transfer of two charges, and thus, models originally developed for charge transfer may be applied to describe

triplet transfer. In dilute fluid solutions, triplet transfer from a donor to an acceptor is well-understood and it has been described in terms of Marcus theory, *i.e.* taking into account distortions in the molecule and its surroundings. In amorphous thin films, that are used for organic semiconductor applications, the effects of energetic disorder prevail, and they need to be considered for an appropriate description of triplet energy transfer.

Here, an overview on recent experimental and theoretical work concerning a unified description of triplet energy transfer, is presented. 57 References.

- Gold-Platinum Nanoparticles: Alloying and Phase Segregation. By B. N. Wanjala, J. Luo, B. Fang, D. Mott and C.-J. Zhong, *J. Mater. Chem.*, **21** (12), 4012–4020 (2011).

Abstract

The ability to control nanoscale alloying and phase segregation properties is important for the exploration of multimetallic nanoparticles for the design of advanced functional materials and catalysts. This review highlights recent insights into the nanoscale phase properties of gold-platinum (AuPt) nanoparticles, which serves as an example to shine a light on the importance of changes in physical and chemical properties in which nanoscale multimetallic materials may differ from their bulk counterparts. In contrast to the wide miscibility gap well known for the bulk gold-platinum system, the bimetallic nanoparticles have been demonstrated to exist in phases ranging from alloy, partial alloy, to phase segregation depending on the preparation conditions, the bimetallic composition, and the supporting materials. For AuPt nanoparticles supported on carbon materials, the nanoscale alloying or phase segregation is shown to be controllable by thermal treatment temperatures, which is not only evidenced by detailed analysis of the phase and surface properties, but also supported by theoretical modeling based on thermodynamic and density functional theory.

The understanding of the nanoscale phase properties can be correlated with the electrocatalytic activities for fuel cell reactions such as methanol oxidation reaction and oxygen reduction reaction. Implications of the new insights to designing and nanoengineering

the phase properties of multimetallic nanoparticles and catalysts are also briefly discussed. 32 References.

- Thin Film Metal Hydrides for Hydrogen Storage Applications. By A. Baldi and B. Dam, *J. Mater. Chem.*, **21** (12), 4021–4026 (2011).

Abstract

Thin film technology is a powerful exploratory technique in the search for advanced hydrogen-storage systems. Thin films of metal hydrides allow one to perform high-throughput screening of large materials libraries, discover new metastable phases inaccessible by bulk preparation methods, and model the finite-size effects occurring at the nanoscale. 41 References.

- Nanostructured Catalysts in Fuel Cells. By Y. Qiao and C. M. Li, *J. Mater. Chem.*, **21** (12), 4027–4036 (2011).

Abstract

Fuel cells are promising green power sources with theoretically zero pollution and broad applications. One of the most important challenges for fuel cells is to have more cost-effective catalysts with high catalytic activity. Nanoscience has stimulated extensive interest in nanostructured catalysts to significantly improve the energy density, power density and operation reliability while greatly reducing the manufacturing expense. In particular, nanostructured materials play a critical role in the catalysis of various innovative fuel cells, which not only possess high specific surface area and good conductivity for low polarization, but also provide unique nanoporous structures and functional chemical properties for highly intrinsic electroactivity and excellent utilization.

The recent advances in nanostructured catalysts and supports are reviewed in this article. The relationships between the nanostructures and electrocatalytic performance and the catalysis mechanisms are discussed. 110 References.

- Enhancement of the Thermoelectric Properties in Nanoscale and Nanostructured Materials. By J. R. Szczech, J. M. Higgins and S. Jin, *J. Mater. Chem.*, **21** (12), 4037–4055 (2011).

Abstract

Thermoelectric materials can be used for solid state power generation and heating/cooling applications. The figure of merit of thermoelectric materials, ZT, which determines their efficiency in a thermoelectric device, remains low for most conventional bulk materials. Nanoscale and nanostructured thermoelectric materials are promising for increasing ZT relative to the bulk.

This review introduces the theory behind thermoelectric materials and details the predicted and demonstrated enhancements of ZT in nanoscale and nanostructured thermoelectric materials. The authors discuss thin films and superlattices, nanowires and nanotubes, and nanocomposites, providing a ZT comparison among various families of nanocomposite materials. They provide some perspectives regarding the origin of enhanced ZT in nanoscale and nanostructured materials and suggest some promising and fruitful research directions for achieving high ZT materials for practical applications. 149 References.

- Activation of Carbide-Derived Carbons: A Route to Materials with Enhanced Gas and Energy Storage Properties. By M. Sevilla and R. Mokaya, *J. Mater. Chem.*, **21** (13), 4727–4732 (2011).

Abstract

Thermal halogenation of a wide range of metal carbides provides a simple route to a class of so-called carbide-derived carbon (CDC) materials. The porosity of the CDCs, which is mainly in the microporous regime, may be modulated by the choice of metal carbide precursor and halogenation temperature. However, although the pore size of CDCs can be fine-tuned by the choice of synthesis process, the maximum surface area achieved is only up to $2500 \text{ m}^2 \text{ g}^{-1}$, which limits their use in gas storage or in electrochemical capacitor applications that require larger surface areas.

This article is focused on what has and can be done to enhance the textural properties of CDCs via further post-synthesis treatments and the ramifications of such modifications on their gas/energy storage capacity. The main developments in physical and chemical activation of CDCs and consequences on gas and energy storage are summarized. 56 References.

- Multilayer Edge Molecular Electronics Devices: A Review. By P. Tyagi, *J. Mater. Chem.*, **21** (13), 4733–4742 (2011).

Abstract

Molecular electronics devices have potential to miniaturize the computational devices down to few nm and can be highly versatile. The realization of any molecular electronics device critically depends on the methods of connecting functional molecule(s) to electrical leads. This review mainly focuses on the recently developed versatile multilayer edge molecular electronics device (MEMED) approach.

To produce MEMEDs molecular conduction channels are bridged across the ultrathin insulator, along the exposed vertical edges of a tunnel junction. MEMED can be produced by widely available microfabrication tools. The tunnel junction used in a MEMED can have any combination of metallic electrodes, and can be characterized before establishing molecular conduction channels. Besides the application in computational devices, MEMED design can also be used for biosensing by enabling the interaction between MEMED's active molecular channels with the target bio-analytes. 75 References.

- Advanced Hydrogen Storage Alloys for Ni/MH Rechargeable Batteries. By Y. Liu, H. Pan, M. Gao and Q. Wang, *J. Mater. Chem.*, **21** (13), 4743–4755 (2011).

Abstract

Hydrogen storage alloys are of particular interest as a novel group in functional materials owing to their potential and practical applications in Ni/MH rechargeable batteries. This review is devoted to the specific alloy families developed for high-energy and high-power Ni/MH batteries in the last decades, especially for EV, HEV and PHEV applications.

The scope of the work encompasses principles of Ni/MH batteries, electrochemical hydrogen storage thermodynamics and kinetics, prerequisites for hydrogen storage electrode alloys and recent advances in hydrogen storage electrode alloys. Rare earth AB₅-type alloys, Ti- and Zr-based AB₂-type alloys, Mg-based amorphous/nanocrystalline alloys, rare earth-Mg–Ni-based alloys and Ti–V-based alloys

are highlighted. Additionally, the challenges met in developing advanced hydrogen storage alloys for Ni/MH rechargeable batteries are pointed out and some research directions are suggested. 185 References.

- Chemistry and High Temperature Superconductivity. By J. P. Attfield, *J. Mater. Chem.*, **21** (13), 4756–4764 (2011).

Abstract

Seven distinct families of superconductors with critical temperatures at ambient pressure that equal or surpass the historic 23K limit for Nb₃Ge have been discovered in the last 25 years. Each family is reviewed briefly and their common chemical features are discussed.

High temperature superconductors are distinguished by having a high ($\geq 50\%$) content of nonmetallic elements and fall into two broad classes. 'Metal–nonmetal' superconductors require a specific combination of elements such as Cu–O and Fe–As which give rise to the highest known T_c 's, probably through a magnetic pairing mechanism. 'Nonmetal-bonded' materials contain covalently bonded nonmetal anion networks and are BCS-like superconductors. Fitting an extreme value function to the distribution of T_c values for the known high- T_c families suggests that the probability of a newly discovered superconductor family having maximum $T_c > 100$ K is ~ 0.1 to 1%, decreasing to ~ 0.02 to 0.2% for room temperature superconductivity. 45 References.

- Novel Rare-Earth-Free Tunable-Color-Emitting BCNO Phosphors. By W.-N. Wang, T. Ogi, Y. Kaihatsu, F. Iskandar and K. Okuyama, *J. Mater. Chem.*, **21** (14), 5183–5189 (2011).

Abstract

The authors present a facile synthesis of novel, rare-earth (RE)-ion-free boron carbon oxynitride (BCNO) phosphors. The preparation method, chemical composition, luminescent properties and emission mechanisms, as well as current trends in BCNO phosphors are reviewed.

The novel BCNO phosphors were synthesized from inexpensive and environmentally friendly raw materials by a straightforward route using liquid precursors at low temperatures under atmospheric pressure. The newly developed BCNO phosphors

demonstrated tunable color emission, high quantum efficiency, and long-duration afterglow. The color emission of these phosphors can be tuned across almost the entire visible light spectrum by varying the molar ratios of the raw materials. 48 References.

- Bio-Imaging, Detection and Analysis by using Nanostructures as SERS Substrates. By W. Xie, P. Qiu and C. Mao, *J. Mater. Chem.*, **21** (14), 5190–5202 (2011).

Abstract

Surface-enhanced Raman scattering (SERS) is a phenomenon that occurs on nanoscale-roughed metallic surface. The magnitude of the Raman scattering signal can be greatly enhanced when the scatterer is placed in the very close vicinity of the surface, which enables this phenomenon to be a highly sensitive analytical technique. SERS inherits the general strongpoint of conventional Raman spectroscopy and overcomes the inherently small cross section problem of a Raman scattering. It is a sensitive and nondestructive spectroscopic method for biological samples, and can be exploited either for the delivery of molecular structural information or for the detection of trace levels of analytes. Therefore, SERS has long been regarded as a powerful tool in biomedical research. Metallic nanostructure plays a key role in all the biomedical applications of SERS because the enhanced Raman signal can only be obtained on the surface of a finely divided substrate.

This review focuses on progress made in the use of SERS as an analytical technique in bio-imaging, analysis and detection. Recent progress in the fabrication of SERS active nanostructures is also highlighted. 167 References.

- Towards Printable Organic Thin Film Transistor based Flash Memory Devices. By W. L. Leong, N. Mathews, B. Tan, S. Vaidyanathan, F. Dötz and S. Mhaisalkar, *J. Mater. Chem.*, **21** (14), 5203–5214 (2011).

Abstract

The implementation of plastic electronic solutions to large area displays, disposable sensor arrays, radio-frequency identification tags (RFIDs), and various smart packaging devices necessitate the development

of organic memories that are solution-processable and readily integrated with the transistors for digital logic.

This article highlights recent research progress made towards organic memory transistors based on charge trapping and focuses on the principles and materials (namely, nanoparticles and polymer electrets) for these devices. The challenges and prospects of charge trapping memories are also discussed. 66 References.

- One-Dimensional Coordination Polymers: Complexity and Diversity in Structures, Properties, and Applications. By W. L. Leong and J. J. Vittal, *Chem. Rev.*, **111** (2), 688–764 (2011).

Abstract

Crystal engineering of coordination polymers, which involves self-assembly of organic ligands with appropriate functional groups and metal ions with specific directionality and functionality, is one of the facile routes to produce materials of technological importance. The non-molecular compounds in which the basic building blocks containing metal ions and organic ligands assemble infinitely leading to one-, two-, and three-dimensional networks, are commonly known as coordination polymers or metal-organic frameworks (MOFs). Of these one-dimensional coordination polymer (1D CP), being the simplest topological type of coordination array, is found to be ubiquitous in nature. The relative simplicity of the 1D chains and their ease of formation by self-assembly allow us to incorporate functional properties at the metal centers or in the backbone of the organic linkers very easily to develop strategies for engineering multifunctional polymeric materials.

This review focuses on the recent progress made on the linear and zigzag 1D CPs, emphasizing on unusual packing and interesting properties with selected examples from the literature. 473 References.

- Block Copolymer based Composition and Morphology Control in Nanostructured Hybrid Materials for Energy Conversion and Storage: Solar Cells, Batteries, and Fuel Cells. By M. C. Orilall and U. Wiesner, *Chem. Soc. Rev.*, **40** (2), 520–535 (2011).

Abstract

This review highlights block copolymers as an emerging and powerful yet affordable tool to structure-direct nano-materials with precise control over structural dimensions, composition and spatial arrangement of materials in composites for uses in photovoltaics, batteries and fuel cells. In each case, insights are provided into the various underlying fundamental chemical, thermodynamic and kinetic formation principles enabling general and relatively inexpensive wet-polymer chemistry methodologies for the efficient creation of multiscale functional materials. Examples include nanostructured ceramics, ceramic–carbon composites, ceramic–carbon–metal composites and metals with morphologies ranging from hexagonally arranged cylinders to three-dimensional bi-continuous cubic networks. 68 References.

- Progress on lanthanide-based organic–inorganic hybrid phosphors. By L. D. Carlos, R. A. S. Ferreira, V. de Zea Bermudez, B. Julián-López and P. Escribano, *Chem. Soc. Rev.*, **40** (2), 536–549 (2011).

Abstract

Research on organic–inorganic hybrid materials containing trivalent lanthanide ions (Ln^{3+}) is a very active field that has rapidly shifted in the last couple of years to the development of eco-friendly, versatile and multifunctional systems, stimulated by the challenging requirements of technological applications spanning domains as diverse as optics, environment, energy, and biomedicine. This article offers a general overview of the myriad of advanced Ln^{3+} -based organic–inorganic hybrid materials recently synthesised, which may be viewed as a major innovation in areas of phosphors, lighting, integrated optics and optical telecommunications, solar cells, and biomedicine. 61 References.

- Recent Development and Application of $\text{Li}_4\text{Ti}_5\text{O}_{12}$ as Anode Material of Lithium Ion Battery. By T.-F. Yi, L.-J. Jiang, J. Shu, C. -B. Yue, R.-S. Zhu and H.-B. Qiao, *J. Phys. Chem. Solids*, **71** (9), 1236–1242 (2010).

Abstract

Lithium-ion batteries with both high power and high energy density are one of the promising power sources

for electric devices, especially for electric vehicles (EV) and other portable electric devices. One of the challenges is to improve the safety and electrochemical performance of lithium ion batteries anode materials. $\text{Li}_4\text{Ti}_5\text{O}_{12}$ (LTO) has been accepted as a novel anode material of power lithium ion battery instead of carbon because it can release lithium ions repeatedly for recharging and quickly for high current. However, $\text{Li}_4\text{Ti}_5\text{O}_{12}$ has an insulating character due to the electronic structure characterized by empty Ti 3d-states, and this might result in the insufficient applications of LTO at high current discharge rate before any materials modifications.

This review focuses first on the present status of LTO including the synthesized method, doping, surface modification, application and theoretical calculation, then on its near future development. 85 References.

- Nanomaterials: Applications in Cancer Imaging and Therapy. By J. A. Barreto, W. O'Malley, M. Kubeil, B. Graham, H. Stephan and L. Spiccia, *Adv. Mater.*, **23** (12) H18–H40 (2011).

Abstract

The application of nanomaterials (NMs) in biomedicine is increasing rapidly and offers excellent prospects for the development of new non-invasive strategies for the diagnosis and treatment of cancer. In this review, the authors provide a brief description of cancer pathology and the characteristics that are important for tumor-targeted NM design, followed by an overview of the different types of NMs explored to date, covering synthetic aspects and approaches explored for their application in uni-modal and multi-modal imaging, diagnosis and therapy.

Significant synthetic advances now allow for the preparation of NMs with highly controlled geometry, surface charge, physicochemical properties, and the decoration of their surfaces with polymers and bioactive molecules in order to improve biocompatibility and to achieve active targeting. This is stimulating the development of a diverse range of nanometer-sized objects that can recognize cancer tissue, enabling visualization of tumors, delivery of anti-cancer drugs and/or the destruction of tumors by different therapeutic techniques. 396 References.

- Hyaluronic Acid Hydrogels for Biomedical Applications. By J. A. Burdick and G. D. Prestwich, *Adv. Mater.*, **23** (12) H41–H56 (2011).

Abstract

Hyaluronic acid (HA), an immunoneutral polysaccharide that is ubiquitous in the human body, is crucial for many cellular and tissue functions and has been in clinical use for over thirty years. When chemically modified, HA can be transformed into many physical forms—viscoelastic solutions, soft or stiff hydrogels, electrospun fibers, non-woven meshes, macroporous and fibrillar sponges, flexible sheets, and nanoparticulate fluids—for use in a range of preclinical and clinical settings. Many of these forms are derived from the chemical crosslinking of pendant reactive groups by addition/condensation chemistry or by radical polymerization. Clinical products for cell therapy and regenerative medicine require crosslinking chemistry that is compatible with the encapsulation of cells and injection into tissues. Moreover, an injectable clinical biomaterial must meet marketing, regulatory, and financial constraints to provide affordable products that can be approved, deployed to the clinic, and used by physicians. Many HA-derived hydrogels meet these criteria, and can deliver cells and therapeutic agents for tissue repair and regeneration.

This review covers both basic concepts and recent advances in the development of HA-based hydrogels for biomedical applications. 137 References.

- Biomimetic Smart Interface Materials for Biological Applications. By T. Sun and G. Qing, *Adv. Mater.*, **23** (12) H57–H77 (2011).

Abstract

Controlling the surface chemical and physical properties of materials and modulating the interfacial behaviors of biological entities, e.g., cells and biomolecules, are central tasks in the study of biomaterials. In this context, smart polymer interface materials have recently attracted much interest in bio-related applications and have broad prospects due to the excellent controllability of their surface properties by external stimuli. Among such materials, poly (*N*-isopropylacrylamide) and its copolymer films are

especially attractive due to their reversible hydrogen-bonding-mediated reversible phase transition, which mimics natural biological processes. This platform is promising for tuning surface properties or to introduce novel biofunctionalities via copolymerization with various functional units and/or combination with other materials.

Important progress in this field in recent years is highlighted. 148 References.

- Emerging Transparent Electrodes based on Thin Films of Carbon Nanotubes, Graphene, and Metallic Nanostructures. By D. S. Hecht, L. Hu and G. Irvin, *Adv. Mater.*, **23** (13) 1482–1513 (2011).

Abstract

Transparent electrodes are a necessary component in many modern devices such as touch screens, LCDs, OLEDs, and solar cells, all of which are growing in demand. Traditionally, this role has been well served by doped metal oxides, the most common of which is indium tin oxide, or ITO. Recently, advances in nano-materials research have opened the door for other transparent conductive materials, each with unique properties. These include carbon nanotubes (CNTs), graphene, metal nanowires, and printable metal grids.

This review will explore the materials properties of transparent conductors, covering traditional metal oxides and conductive polymers initially, but with a focus on current developments in nano-material coatings. Electronic, optical, and mechanical properties of each material will be discussed, as well as suitability for various applications. 299 References.

- Single Molecule Electronic Devices. By H. Song, M. A. Reed and T. Lee, *Adv. Mater.*, **23** (13) 1583–1608 (2011).

Abstract

Single molecule electronic devices in which individual molecules are utilized as active electronic components constitute a promising approach for the ultimate miniaturization and integration of electronic devices in nanotechnology through the bottom-up strategy. Thus, the ability to understand, control, and exploit charge transport at the level of single molecules has become a long-standing desire of scientists and engineers from

different disciplines for various potential device applications. Indeed, a study on charge transport through single molecules attached to metallic electrodes is a very challenging task, but rapid advances have been made in recent years.

This review focuses on experimental aspects of electronic devices made with single molecules, with a primary focus on the characterization and manipulation of charge transport in this regime. 210 References.

- Assemblies of Functional Peptides and Their Applications in Building Blocks for Biosensors. By R. de la Rica, C. Pejoux and H. Matsui, *Adv. Funct. Mater.*, **22** (6) 1018–1026 (2011).

Abstract

This article highlights the authors' recent applications of functional peptide nanotubes, self-assembled from short peptides with recognition elements, as building blocks to develop sensors.

Peptide nanotubes with high aspect ratios are excellent building blocks for a directed assembly into device configurations, and their combined structures with nanometric diameters and micrometric lengths enables to bridge the “nanoworld” and the “microworld”. When the peptide-nanotube-based biosensors, which incorporate molecular recognition units, apply alternating current probes to detect impedance signals, the peptide nanotubes behave as excellent building blocks of the transducer for the detection of target analytes such as pathogens, cells, and heavy metal ions with high specificity. In some sensor configurations, the electric signal can be amplified by coupling them with ion-specific mineralization via molecular recognition of peptides. In general the detection limit of peptide nanotube chips sensors is very low and the dynamic range of detection can be widened by improved device designs. 38 References.

- Self-Assembled Nanometer-Scale Magnetic Networks on Surfaces: Fundamental Interactions and Functional Properties. By C. Carbone, S. Gardonio, P. Moras, S. Lounis, M. Heide, G. Bihlmayer, N. Atodiresei, P. H. Dederichs, S. Blügel, S. Vlaic, A. Lehnert, S. Ouazi, S. Rusponi, H. Brune, J. Honolka, A. Enders, K. Kern, S. Stepanow, C. Krull, T. Balashov,

A. Mugarza and P. Gambardella, *Adv. Funct. Mater.*, **22** (7) 1212–1228 (2011).

Abstract

Nanomagnets of controlled size, organized into regular patterns open new perspectives in the fields of nanoelectronics, spintronics, and quantum computation. Self-assembling processes on various types of substrates allow designing fine-structured architectures and tuning of their magnetic properties.

Here, starting from a description of fundamental magnetic interactions at the nanoscale, the authors review recent experimental approaches to fabricate zero-, one-, and two-dimensional magnetic particle arrays with dimensions reduced to the atomic limit and unprecedented areal density. They describe systems composed of individual magnetic atoms, metal-organic networks, metal wires, and bimetallic particles, as well as strategies to control their magnetic moment, anisotropy, and temperature-dependent magnetic behavior. The investigation of self-assembled sub-nanometer magnetic particles leads to significant progress in the design of fundamental and functional aspects, mutual interactions among the magnetic units, and their coupling with the environment. 81 References.

- Surface-Confined Self-Assembly of Di-carbonitrile Polyphenyls. By S. Klyatskaya, F. Klappenberger, U. Schlickum, D. Kühne, M. Marschall, J. Reichert, R. Decker, W. Krenner, G. Zoppellaro, H. Brune, J. V. Barth and M. Ruben, *Adv. Funct. Mater.*, **22** (7) 1230–1240 (2011).

Abstract

This Article reports on the controlled formation and structure-functionality aspects of vacuum-deposited self-assembled organic and metal-organic networks at metal surfaces using ditopic linear and nonlinear molecular bricks, namely di-carbonitrile polyphenyls.

Surface confined supramolecular organization of linear aromatic molecules leads to a fascinating variety of open networks. Moreover, cobalt-directed assembly of the same linear linkers reveals highly regular, open honeycomb networks with tunable pore sizes representing versatile templates for the organization

of molecular guests or metal clusters and the control of supramolecular dynamers. In addition, the 2D (two dimensional) nanopore organic networks act as arrays of quantum corrals exhibiting confinement of the surface-electronic states of the metallic substrate. A reduction of the linker symmetry leads to the formation of disordered, glassy coordination networks, which represent a structural model for amorphous materials. 60 References.

- Selective and Responsive Nanoreactors. By K. Renggli, P. Baumann, K. Langowska, O. Onaca, N. Bruns and W. Meier, *Adv. Funct. Mater.*, **22** (7) 1241–1259 (2011).

Abstract

Chemical reactions can be confined to nanoscale compartments by encapsulating catalysts in hollow nano-objects. Such reaction compartments effectively become nanoreactors when substrate and product are exchanged between bulk solution and cavity. A key issue, thereby, is control of shell permeability. Nanoreactors exhibit selectivity and responsiveness if their shells discriminate among molecules and if access can be modulated by external triggers.

Here, the authors review natural nanoreactors that include protein-based bacterial microcompartments, protein cages, and viruses. Artificial nanoreactors based on dendrimers, layer-by-layer capsules, and amphiphilic block copolymer polymersomes are also discussed. Selectivity in these nanoreactors is either due to intrinsic reactor-shell semipermeability or can be engineered using smart polymers to gate the reactors. Moreover, a rich repertoire of pores and channels are already provided in nature, e.g., in protein-based nanoreactors or in transmembrane channel proteins. The latter can be reconstituted in polymersomes, resulting in gated vesicles. Nanoreactors hold promise for applications ranging from selective and size-constrained organic synthesis to biomedical advances (e.g., artificial organelles, biosensing) and as analytical tools to study reaction mechanisms. 202 References.

- Self-Assembly and Shape Morphology of Liquid Crystalline Gold Metamaterials. By M. Draper, I. M. Saez, S. J. Cowling, P. Gai, B. Heinrich,

B. Donnio, D. Guillon and J. W. Goodby, *Adv. Funct. Mater.*, **22** (7) 1260–1278 (2011).

Abstract

Gold nanoparticles offer the possibility of creating metamaterials; however, such nanoparticles are not particularly stable. Conversely, liquid crystals offer the possibility of creating self-organizing and self-assembling materials, which can be designed to be relatively stable. Potentially, combining these two concepts could provide materials that can be induced to assemble in a controlled way and that would have unique optical properties.

This article describes some of the groundwork made in the preparation of stable liquid-crystalline metamaterials and the investigation of their structures and physical properties. In particular, spherically substituted materials are found to be deformed into tactoids with anisotropic properties, most notably their dielectric anisotropies. 68 References.

- Non-conventional Processing and Post-processing Methods for the Nanostructuring of Conjugated Materials for Organic Electronics. By G. De Luca, W. Pisula, D. Credgington, E. Treossi, O. Fenwick, G. M. Lazzarini, R. Dabirian, E. Orgiu, A. Liscio, V. Palermo, K. Müllen, F. Cacialli and P. Samorì, *Adv. Funct. Mater.*, **22** (7) 1279–1295 (2011).

Abstract

In the search for new ways to combine the appealing simplicity of solution processing methods and the need for a high performance of the active layer of organic (opto) electronic devices, the possibilities given by the joint use of well-established casting techniques and post-treatment procedures are explored, as well as new and unconventional deposition protocols to tailor self-assembled architectures with a high degree of order at different length scales, from the sub-nanometer up to the macroscopic scale. In fact, even the same organic molecule can give rise to different molecular architectures which, in turn, may offer the possibility to exploit a large variety of new functionalities of the deposited materials, paving the way towards the fabrication of multifunctional organic-based devices. 68 References.

- Self-Assembly at Different Length Scales: Polyphilic Star-Branched Liquid Crystals and Miktoarm Star Copolymers. By G. Ungar, C. Tschierske, V. Abetz, R. Holyst, M. A. Bates, F. Liu, M. Prehm, R. Kieffer, X. Zeng, M. Walker, B. Glettner and A. Zywockinski, *Adv. Funct. Mater.*, **22** (7) 1296–1323 (2011).

Abstract

The diversity of phase morphologies observed recently in star-branched liquid-crystalline and polymeric compounds containing at least three immiscible segments is reviewed.

Bolaamphiphiles and facial amphiphiles with rod-like aromatic cores, two end-groups, and one (T-shape) or two (X-shape) chains attached laterally to the core, form numerous honeycomblike liquid-crystal phases, as well as a variety of novel lamellar and 3D-ordered mesophases. Molecular self-organization is described in bulk phases and in thin films on solid and liquid surfaces, as well as in Langmuir–Blodgett films. The remarkably reversible formation of mono- and trilayer films is highlighted. In the bulk, T-shaped “rod-coil” molecules without appended end-groups form predominantly lamellar phases if the core is a straight rod, but the bent-core variety forms hexagonal honeycombs. Furthermore, self-assembly of “Janus”-type molecules, is discussed. Also covered is the diversity of morphologies observed in miktoarm star terpolymers, i.e., polymers with three different and incompatible arms of well defined lengths. Similarities and differences are highlighted between the liquid-crystal morphologies on the 3–15 nm scale and the polymer morphologies on the scale of 10–100 nm. A separate section is dedicated to computer simulations of such systems, particularly those using dissipative particle and molecular dynamics. Of special interest are the recently synthesised X-shaped tetraphilic molecules, where two different and incompatible side-chains are attached at opposite sides of the rodlike core. The tendency for their phase separation produces liquid-crystal honeycombs with cells of different compositions that can be represented as a plane paved with

different colored tiles. The independent variation of chain length and “color” creates the potential for developing a considerable range of complex new 2D and 3D soft nanostructures. Analogous X-shaped rod-coil compounds with unequal side groups are also of considerable interest, forming tubular lyotropic structures capable of confining strings of guest molecules. 182 References.

- The Challenge of Unconventional Superconductivity. By M. R. Norman, *Science*, **332** (6026), 196–200 (2011).

Abstract

During the past few decades, several new classes of superconductors have been discovered that do not appear to be related to traditional superconductors. The source of the superconductivity of these materials is likely different from the electron-ion interactions that are at the heart of conventional superconductivity. Developing a rigorous theory for any of these classes of materials has proven to be a difficult challenge and will remain one of the major problems in physics in the decades to come. 66 References.

- The Electron-Pairing Mechanism of Iron-based Superconductors. By F. Wang and D.-H. Lee, *Science*, **332** (6026), 200–204 (2011).

Abstract

The past three years have witnessed the discovery of a series of novel high-temperature superconductors. Trailing behind the cuprates, these iron-based compounds are the second-highest-temperature superconducting material family known to date. Despite the marked differences in the chemical composition, these materials share many properties with the cuprates and offer the hope of finally unveiling the secret of high-temperature superconductivity.

The main theme of this review is the electron-pairing mechanism responsible for their superconductivity, and discuss the progress in this young field and point out the open issues. 63 References.

Forthcoming Conferences

18th International Conference on Solid State Ionics, July 3–8, 2011, Warsaw, Poland

Topics

Theory, modelling and kinetics-Techniques-Oxide Ion Conductors-Mixed Conductors-New Materials-Fuel Cells-Electrocatalysis-Sensors-Proton Conductors-Nanoionics-Glasses-Lithium Batteries-Polymer Electrolytes-Energy Storage-Ionic Liquids.

Workshop for young scientist will be organized at Faculty of Physics, Warsaw University of Tech.

Workshop for young scientist will be organized at the Faculty of Physics, Warsaw University of Tech., Warsaw.

Confirmed Invited Speakers

Maria Forsyth (Australia), Clare Grey (USA/UK), Saiful Islam (UK), Rainer Waser (Germany), Harumi Yokokawa (Japan) and Christian Masquelier (Amiens, France).

Website: <http://ssi-18.net/>

19th Annual International Conference on Composites or Nano Engineering (ICCE-19), July 24–30, 2011, Shanghai, China

Major Topics of ICCE-19

Aging, Flammability; Bio-Composites; Mathematical Modeling ; Chemistry of Materials; Coatings and Wear; Metal Matrix Composites; Ceramics Composites; Micromechanics; Packaging Barrier; Electronic/Magnetic Metamaterials; Particulate Composites; Engineering Science and Structures; Powder Metallurgy; Textile Composites; Functionally Graded Materials; Impact Engineering; Vibration; Infrastructures; Composites; Computational Materials; Durability; Natural Fibers; Processing; Biology; Physics of Materials.

Major Symposia of ICCE-19

Metals Research; Nano Bio Materials; Nano Devices and Actuators; Inorganic Nanowires; Nano-Fabrication; NanoLithography; Nanosensor; Magnetic Materials; Thin Films; Surface-Coating; Processing/Characterization; Durability of Composites.

Deadline for Submission of Short Paper: March,24,2011;

Deadline for Full Length Paper: July,17,2011

Website: <http://www.icce-nano.org/>

The 6th Conference of the Asian Consortium on Computational Materials Science (ACCMS-6), 6–9 Sept., 2011, Singapore

The 6th Conference of the Asian Consortium on Computational Materials Science (ACCMS-6), will be held in Singapore, from 6 to 9 September 2011. The conference is jointly organized by the National University of Singapore, Institute of Advanced Studies at the Nanyang Technological University, and Materials Research Society of Singapore.

The ACCMS was established in 2000 in order to nurture and promote research and development activities in computational materials in Asian countries. The biennial ACCMS conference has become an international event for exchanging and archiving knowledge on the development of advanced computational methodology and its strong link to material science and engineering applications. The previous ACCMS conferences were successfully held

in India (Bangalore 2001), Russia (Novosibirsk, 2004), China (Beijing, 2005), Korea (Seoul, 2007) and Vietnam (Hanoi, 2009).

Computational Materials Science (CMS) has emerged as a distinct multidisciplinary branch of science and computer modeling and simulation is playing an increasingly important role in materials science research. ACCMS-6 will provide a platform for computational materials scientists in Asian and world to present their recent results on research and development in CMS. The scope of the conference ranges from fundamental computational methodology (density functional theory and beyond, quantum mechanical based interatomic potentials, molecular dynamic and Monte-Carlo simulation of thermodynamic and kinetic properties at large length and time scales, phase field method of micro-structural simulation, etc.) to its industrial applications of different materials properties.

All computational materials scientists, including graduate students, from Asia as well as in other parts of the world are invited to participate in this conference. In addition to the three-day conference (7-9 September) which consists of plenary sessions, invited talks, contributed talks and poster presentation, pre-conference short courses will be held on 6 September to introduce new computational methods and/or emerging computational trends to beginners and those who may be interested in exploring new methods in their research.

Website: <http://www.mrs.org.sg/accms6/>

For further information, please contact, Prof. Yuan Ping Feng, Co-Chair of ACCMS-6

Tel: (65) 6516 2960; *E-mail:* phyfyp@nus.edu.sg

or Miss Eileen So, Secretariat of ACCMS-6, *DID:* (65) 6874 1176; *HP:* (65) 8223 9845

Email: accms6@mrs.org.sg

The 7th International Conference on Porous Metals and Metallic Foams [MetFoam2011], Sep., 18–21, 2011, Busan, Korea

The conference will cover the following topics (but will not be limited to):

- Physics of foaming, pore nucleation, pore growth and coalescence, foam stabilization
- Techniques for making foams and other cellular metals, effect of processing parameters on the structure and properties
- Morphological and microstructural characterization at different size scales
- Property profiles in relation with porous structure
- Modelling of structure, structure development and relates properties
- Secondary operations (joining, coating, machining, shaping, etc.)
- Challenging applications and case studies including component design criteria
- Porous biomaterials and nanoporous structures

Key dates: Submission of Abstract: April 15, 2011; red Notification to Authors: April 30, 2011; Early Registration: May 31, 2011; Submission of Manuscript: September 18, 2011. For details, see the Website: www.metfoam2011.org

The 7th International Symposium on ‘Novel Materials and their Synthesis’, 11–14, October 2011, Shanghai, China

For further information, please contact, Prof. Yuping Wu, Chemistry Dept.,
New energy and Mater. Lab., Fudan Univ., Shanghai, 200 433, China.

E-mail: wuyup@fudan.edu.cn

**International Conference on Advanced Electromaterials (ICAE 2011)
Nov., 7 to 10, 2011, Jeju, Korea**

The ICAE 2011 is intended to provide an open forum to all participants with an opportunity to present the latest important findings in research activities and to discuss and share them with experts and renowned scholars from all over the world. It consists of 14 symposia in the field of electrical and electronic materials such as semiconductors, electronic ceramics, high voltage technology and insulating materials, sensors, displays, nano-materials and devices, and energy materials. In these symposiums, stimulating lectures and presentations by distinguished speakers from all over the world are planned for the ICAE 2011. In addition to the professional exchange of ideas, it will be a place to meet friends who share common research objectives and to have chances for further co-work that may result in mutual achievements. Jeju, the venue of the ICAE 2011 is a beautiful volcanic resort island. Symposium Title and the Organizer:

- (1) Nanostructured Materials for Sensor Applications (SE)
Organizer: Dr. Seok-Jin Yoon (KIST, Korea, sjyoon@kist.re.kr)
- (2) Advanced Materials for Energy Conversion: fuel cell and solar cell (EC)
Organizer: Dr. Tae-Hoon Lim (KIST, Korea, thlim@kist.re.kr)
- (3) Energy Storage Materials (ES)
Organizer: Dr. Hyun-Soo Kim (KERI, Korea, hskim@keri.re.kr)
- (4) Nanostructured Materials for Energy Devices (ED)
Organizer: Dr. Eun Dong Kim (KERI, Korea, edkim@keri.re.kr)
- (5) Emerging Nano-based Device Technologies (ND)
Organizer: Dr. Kamran Eshraghian (Chungbuk Nat'l Univ., Korea, k.eshraghian@elabs.com.au)
- (6) Ferroelectric, Piezoelectric Materials and Device Applications (FM)
Organizer: Prof. Jae-Shin Lee (University of Ulsan, Korea, jslee@ulsan.ac.kr)
- (7) Superconducting and Magnetic Materials and Devices (SM)
Organizer: Prof. Sang-Heon Lee (Sunmoon Univ., Korea, shlee@sunmoon.ac.kr)
- (8) Thin Film Processing and Devices (TF)
Organizer: Prof. Soon-Gil Yoon (Chungnam Nat'l Univ., Korea, sgyoon@cnu.ac.kr)
- (9) Advanced Insulating Materials and Condition Monitoring Diagnosis for HVPower Apparatus (HV)
Organizer: Dr. Sang-Jin Kim (KEPCO KDN, Korea, sjkim@kdn.com)
- (10) LED & OLED Lighting Technology (LT)
Organizer: Sung-Jin Park (University of Illinois at Urbana-Champaign, USA, sjinpark@illinois.edu)
- (11) Nanoscale Interface Devices and Materials for Organic Electronics (OE)
Organizer: Prof. Hoon-Kyu Shin (POSTECH, Korea, shinhk@postech.ac.kr)
- (12) Flexible and Printable Electronic Materials and Devices (FE)
Organizer: Dr. Byoung-Gon Yu (ETRI, Korea, bgyu@etri.re.kr)
- (13) Advanced Technology for LEDs (LE)
Organizer: Prof. Ja-Soon Jang (Yeungnam Univ., Korea, jsjang@ynu.ac.kr)
- (14) Thermal Management Materials, Devices, Packages, and Processing Technologies (TM)
Organizer: Dr. Hyo-Tae Kim (KICET, Korea, hytek@kicet.re.kr)

Important Dates

Abstract Submission: May 15, 2011; Acceptance

Notice: June 30, 2011; Early Registration: July 15, 2011; Manuscript

Submission: November 7, 2011

Homepage: www.icae.kr

Conference Chairman: Dae-Hee Paek (Wonkwang University)

Conference Secretariat: For registration & inquires: ICAE2011 Secretariat: *Tel:* +82-70-8222-3371;

Mobile: +82-10-9156-3571; *Fax:* +82-2-3412-8723; *E-mail:* secretariat@icae.kr

Materials Education & Research in Singapore

There are two Universities and several Research Institutes in Singapore involved in teaching, research and development in the broad area of Materials Science, Engineering and Technology. These are listed below along with the Websites and provide information on the available courses and opportunities for undergraduate, graduate and post doctoral research. They also entertain queries regarding openings for Research Scientists and Faculty positions.

National University of Singapore: www.nus.edu.sg

Nanyang Technological University: www.ntu.edu.sg

Institute of Materials Research and Engineering (IMRE): www.imre.a-star.edu.sg

Institute of Microelectronics (IME): www.ime.a-star.edu.sg

Data Storage Institute: www.dsi.a-star.edu.sg

Institute of Chemical & Engineering Sciences: www.ices.a-star.edu.sg

Institute of High Performance Computing: www.ihpc.a-star.edu.sg

Singapore Institute of Manufacturing Technology: www.SIMTech.a-star.edu.sg

Institute of Bioengineering and Nanotechnology (IBN): www.ibn.a-star.edu.sg

INVITATION**MRS-S members are welcome to
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- To suggest topics and prospective author(s) for ‘thematic’ articles pertaining to the areas of materials science, engineering and technology. These will be of general interest to the students, teachers as well as active researchers. These can be 10–15 pages (A4-size, single spaced) with figures, tables and select references.
- To contribute reports on the recently held conferences and information on the forthcoming conferences.
- To contribute ‘Highlights from Recent Literature’ in the areas of materials science, engineering and technology. These must pertain to the past two years, and be of general interest to non-specialists, students, teachers as well as active researchers. Each ‘Highlight’ must not exceed 250–300 words, including reference(s). Contributing author(s) and e-mail address(es) will be included under each ‘Highlight’.
- To contribute information about the recent awards and distinctions conferred on the MRS-S members.
- To contribute ‘Letters to the Editor’. They may be edited for brevity, clarity and available space, and the author(s) will be informed.

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Dr. G.V. Subba Rao

E-mail: phyvsg@nus.edu.sg

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