Highlights of Recent Literature

(*Contributed by the Editor*)

Observation of Molecular Orbital Gating.

The control of charge transport in an active electronic device depends intimately on the modulation of the internal charge density by an external node. For example, a field-effect transistor relies on the gated electrostatic modulation of the channel charge produced by changing the relative position of the conduction and valence bands with respect to the electrodes. In molecular-scale devices, a longstanding challenge has been to create a true three-terminal device that operates in this manner (that is, by modifying orbital energy).

Here, Song *et al.* [1] report the observation of such a solid-state molecular device, in which transport current is directly modulated by an external gate voltage. Resonance-enhanced coupling to the nearest molecular orbital is revealed by electron tunnelling spectroscopy, demonstrating direct molecular orbital gating in an electronic device. The authors state that, 'Our findings demonstrate that true molecular transistors can be created, and so enhance the prospects for molecularly engineered electronic devices'.

Reference

1. H. Song, Y. Kim, Y. H. Jang, H. Jeong, M. A. Reed and T. Lee, *Nature*, **462**, 1039-1043 (2009) (Dec., 24 Issue).

Foldable Printed Circuit Boards on Paper Substrates.

Siegel *et al.* [1] describe several low-cost methods for fabricating flexible electronic circuits on paper. The circuits comprise, i) metallic wires (e.g., tin or zinc) that are deposited on the substrate by evaporation, sputtering, or airbrushing, and ii) discrete surface-mountable electronic components that are fastened with conductive adhesive directly to the wires. These electronic circuits - like conventional printed circuit boards -can be produced with electronic components that connect on both sides of the substrate.

Unlike printed circuit boards made from fiberglass, ceramics, or polyimides, however, paper can be folded and creased (repeatedly), shaped to form three-dimensional structures, trimmed using scissors, used to wick fluids (e.g., for microfluidic applications) and disposed of by incineration. Paper-based electronic circuits are thin and lightweight; they should be useful for applications in consumer electronics and packaging, for disposable systems for uses in the military and homeland security, for applications in medical sensing or low-cost portable diagnostics, for paper-based microelectromechanical systems, and for applications involving textiles.

Reference

1. A. C. Siegel, S. T. Phillips, M. D. Dickey, N. Lu, Z. Suo and G. M. Whitesides, *Adv. Funct. Mater.*, **20** (1), 28-35 (2010).

A Tricyclic Aromatic Isomer of Hexasilabenzene.

Benzene represents the showcase of Hückel aromaticity. The silicon analog, hexasilabenzene, has consequently been targeted for decades. Presently, Abersfelder *et al.* [1] report the synthesis and characterization of an intensely green isomer of Si_6R_6 (R being 2,4,6-triisopropylphenyl) with a tricyclic structure in the solid state featuring silicon atoms with two, one, and no substituents outside the ring framework.

The highly dispersed^{29} Si NMR shifts in solution ranging from +125 to -90 ppm indicate an inhomogeneous electron distribution due to the dismutation of formal oxidation numbers as compared with that of benzene.

Theoretical analysis reveals nonetheless the cyclic delocalization of six mobile electrons of the π-, σ-, and non-bonding type across the central four-membered ring. For this alternative form of aromaticity, in principle applicable to many Hückel aromatic species, the authors propose the term dismutational aromaticity.

Reference

1. K. Abersfelder, A. J. P. White, H. S. Rzepa and D. Scheschkewitz, *Science*, **327** (No. 5965), 564 - 566 (2010) (Jan., 29 Issue).

Broken rotational symmetry in the pseudogap phase of a high-T $_c$ superconductor.

The nature of the pseudogap phase is a central problem in the effort to understand the high-transition-temperature (high-T_c) copper oxide superconductors. A fundamental question is what symmetries are broken when the pseudogap phase sets in, which occurs when the temperature decreases below a value T*. There is evidence from measurements of both polarized neutron diffraction and the polar Kerr effect that time-reversal symmetry is broken, but at temperatures that differ significantly from one another. Broken rotational symmetry was detected from both resistivity measurements and inelastic neutron scattering at low doping, and from scanning tunnelling spectroscopy at low temperature, but showed no clear relation to T*.

Daou *et al.* [1] report the observation of a large in-plane anisotropy of the Nernst effect in $YBa_2Cu_3O_y$ that sets in precisely at T* throughout the doping phase diagram. They show that the CuO chains of the orthorhombic lattice are not responsible for this anisotropy, which is therefore an intrinsic property of the CuO_2 planes. The authors conclude that the pseudogap phase is an electronic state that strongly breaks four-fold rotational symmetry. This narrows the range of possible states considerably, pointing to stripe or nematic order.

Reference

1. R. Daou, J. Chang, D. LeBoeuf, O. C.-Choinière, F. Laliberté, N. D.-Leyraud, B. J. Ramshaw, R. Liang, D. A. Bonn, W. N. Hardy and L. Taillefer, *Nature*, **463** (No.7280), 519-522 (2010) (Jan., 28 Issue).

100-GHz Transistors from Wafer-Scale Epitaxial Graphene.

The high carrier mobility of graphene has been exploited in field-effect transistors that operate at high frequencies. Lin *et al.* [1] fabricated the transistors on epitaxial graphene synthesized on the silicon face of a silicon carbide wafer, and achieved a cut-off frequency of 100 GHz for a gate length of 240 nm. They found that the high-frequency performance of these epitaxial graphene transistors exceeds that of state-of-the-art silicon transistors of the same gate length, thereby demonstrating the high potential of graphene for electronics applications.

Reference

1. Y.-M. Lin, C. Dimitrakopoulos, K. A. Jenkins, D. B. Farmer, H.-Y. Chiu, A. Grill and Ph. Avouris, *Science*, **327** (No. 5966), 662 (2010) (Feb., 5 Issue).

Water Freezes Differently on Positively and Negatively Charged Surfaces of Pyroelectric Materials.

Although ice melts and water freezes under equilibrium conditions at 0°C, water can be supercooled under homogeneous conditions in a clean environment down to –40°C without freezing. The influence of the electric field on the freezing temperature of supercooled water (electrofreezing) is of topical importance in the living and inanimate worlds.

Ehre *et al.* [1] report that positively charged surfaces of pyroelectric $LiTaO_3$ crystals and $SrTiO_3$thin films promote ice nucleation, whereas the same surfaces when negatively charged reduce the freezing temperature. Accordingly, droplets of water cooled down on a negatively charged $LiTaO_3$ surface and remaining liquid at –11°C, freeze immediately when this surface is heated to -8°C, as a result of the replacement of the negative surface charge by a positive one. Furthermore, powder x-ray diffraction studies demonstrated that the freezing on the positively charged surface starts at the solid/water interface, whereas on a negatively charged surface, ice nucleation starts at the air/water interface.

Reference

1. D. Ehre, E. Lavert, M. Lahav and I. Lubomirsky, *Science*, **327** (No. 5966), 672-675 (2010) (Feb., 5 Issue).

Above -room-temperature ferroelectricity in a single-component molecular crystal.

Ferroelectrics are electro-active materials that can store and switch their polarity (ferroelectricity), sense temperature changes (pyroelectricity), interchange electric and mechanical functions (piezoelectricity), and manipulate light (through optical nonlinearities and

the electro-optic effect): all of these functions have practical applications. Topological switching of π-conjugation in organic molecules, such as the keto-enol transformation, has long been anticipated as a means of realizing these phenomena in molecular assemblies and crystals. Croconic acid, an ingredient of black dyes, was recently found to have a hydrogen-bonded polar structure in a crystalline state.

Here, Horiuchi *et al.* [1] demonstrate that application of an electric field can coherently align the molecular polarities in crystalline croconic acid, as indicated by an increase of optical second harmonic generation, and produce a well-defined polarization hysteresis at room temperature. To make this simple pentagonal molecule ferroelectric, the authors switched the π-bond topology using synchronized proton transfer instead of rigid-body rotation. Of the organic ferroelectrics, this molecular crystal exhibits the highest spontaneous polarization ($\sim$20 μC.cm^{-2}) in spite of its small molecular size, which is in accord with first-principles electronic-structure calculations. The authors state that, 'such high polarization, which persists up to 400 K, may find application in active capacitor and nonlinear optics elements in future organic electronics'.

Reference

1. S. Horiuchi, Y. Tokunaga, G. Giovannetti, S. Picozzi, H. Itoh, R. Shimano, R. Kumai and Y. Tokura, *Nature*, **463** (No.7282), 789-792 (2010) (11 Feb., Issue).

Multiple Functional Groups of Varying Ratios in Metal-Organic Frameworks.

Here, Deng *et al.* [1] show that metal-organic frameworks (MOFs) can incorporate a large number of different functionalities on linking groups in a way that mixes the linker, rather than forming separate domains. The authors made complex MOFs from 1,4-benzenedicarboxylate (denoted by "A" in this work) and its derivatives $-NH_2$, $-Br$,$-(Cl)_2$, $-NO_2$, $-(CH_3)_2$, $-C_4H_4$, $-(OC_3H_5)_2$, and $-(OC_7H_7)_2$ (denoted by "B" to "I," respectively) to synthesize 18 multivariate (MTV) MOF-5 type structures that contain up to eight distinct functionalities in one phase. The backbone (zinc oxide and phenylene units) of these structures is ordered, but the distribution of functional groups is disordered.

The complex arrangements of several functional groups within the pores can lead to properties that are not simply linear sums of those of the pure components. For example, a member of this series, MTV-MOF-5-EHI, exhibits up to 400% better selectivity for carbon dioxide over carbon monoxide compared with its best same-link counterparts.

Reference

1. H. Deng, C. J. Doonan, H. Furukawa, R. B. Ferreira, J. Towne, C. B. Knobler, B. Wang and O. M. Yaghi, *Science*, **327** (No.5967), 846-850 (2010) (12 Feb., Issue).

$NaVO_2(IO_3)_2(H_2O)$: A Unique Layered Material Produces A Very Strong SHG Response.

The synthesis, crystal structure, and characterizations of a new noncentrosymmetric sodium vanadyl iodate, $NaVO_2(IO_3)_2(H_2O)$, are reported by Yang *et al.* [1]. The compound crystallizes in the polar monoclinic space group $P2_1$ (No. 4) with a = 9.114(1) Å, b = 5.2146(5) Å, c = 9.216(1) Å, and β = 111.298(8)°. It displays a unique layered structure composed of 1-D right-handed helical chains of $[(VO_2)(IO_3)_2]^-$ anions along the b-axis that are bridged by sodium(I) ions. The polarity in the structure is imparted by the alignment of the stereochemically active lone pairs of the iodate anions along the b-axis. On the basis of the powder second-harmonic generation (SHG) measurements, $NaVO_2(IO_3)_2(H_2O)$ belongs to the phase-matchable class with a very large SHG response of approximately 20 $\times$ KH_2PO_4 (KDP) or about 800 $\times$ α-quartz, which is in good agreement with the results from the theoretical calculations.

Reference

1. B.-P. Yang, C.-L. Hu, X. Xu, C.-F. Sun, J.-H. Zhang and J.-G. Mao, *Chem. Mater.*, **22** (4), 1545–1550 (2010).

Simultaneous phase and size control of upconversion nanocrystals through lanthanide doping.

Doping is a widely applied technological process in materials science that involves incorporating atoms or ions of appropriate elements into host lattices to yield

hybrid materials with desirable properties and functions. For nanocrystalline materials, doping is of fundamental importance in stabilizing a specific crystallographic phase, modifying electronic properties, modulating magnetism as well as tuning emission properties.

Here, Wang *et al.* [1] describe a material system in which doping influences the growth process to give simultaneous control over the crystallographic phase, size and optical emission properties of the resulting nanocrystals. They show that $NaYF_4$ nanocrystals can be rationally tuned in size (down to 10 nm), phase (cubic or hexagonal) and upconversion emission colour (green to blue) through use of trivalent lanthanide dopant ions introduced at precisely defined concentrations. They used first-principles calculations to confirm that the influence of lanthanide doping on crystal phase and size arises from a strong dependence on the size and dipole polarizability of the substitutional dopant ion. According to the authors, the 'results suggest that the doping-induced structural and size transition, demonstrated here in $NaYF_4$ upconversion nanocrystals, could be extended to other lanthanide-doped nanocrystal systems for applications ranging from luminescent biological labels to volumetric three-dimensional displays.

Reference

1. F. Wang, Y. Han, C. S. Lim, Y. Lu, J. Wang, J. Xu, H. Chen, C. Zhang, M. Hong and X. Liu, *Nature*, **463** (No.7284), 1061-1065 (2010) (25 Feb., Issue).

Ferroelectric Control of Spin Polarization.

A current drawback of spintronics is the large power that is usually required for magnetic writing, in contrast with nanoelectronics, which relies on "zero-current," gate-controlled operations. Efforts have been made to control the spin-relaxation rate, the Curie temperature or the magnetic anisotropy with a gate voltage, but these effects are usually small and volatile. Garcia *et al.* [1] used ferroelectric tunnel junctions with ferromagnetic electrodes to demonstrate local, large, and nonvolatile control of carrier spin polarization by electrically switching ferroelectric polarization. The results represent a giant type of interfacial magnetoelectric coupling and suggest a low-power approach for spin-based information control.

Reference

1. V. Garcia, M. Bibes, L. Bocher, S. Valencia, F. Kronast, A. Crassous, X. Moya, S. E.-Vedrenne, A. Gloter, D. Imhoff, C. Deranlot, N. D. Mathur, S. Fusil, K. Bouzehouane and A. Barthélémy, *Science*, **327** (No.5969), 1106-1110 (2010) (26 Feb., Issue).

Superconductivity in alkali-metal-doped picene.

Efforts to identify and develop new superconducting materials continue apace, motivated by both fundamental science and the prospects for application. For example, several new superconducting material systems have been developed in the recent past, including calcium-intercalated graphite compounds, boron-doped diamond and—most prominently—iron arsenides such as $La(O_{1-x}F_x)FeAs$. In the case of organic superconductors, however, no new material system with a high superconducting transition temperature (T_c) has been discovered in the past decade.

Here, Mitsuhashi *et al.* [1] report that intercalating an alkali metal into picene ($C_{22}H_{14}$), a wide-bandgap semiconducting solid hydrocarbon, which crystallizes in a layer structure produces metallic behaviour and superconductivity. Solid potassium-intercalated picene ($K_x$picene) shows T_c values of 7K and 18K, depending on the metal content, x=2.9 or 3.3. The drop of magnetization in $K_x$picene solids at the T_c is sharp (<2K), similar to the behaviour of Ca-intercalated graphite. The T_c of 18K is comparable to that of K-intercalated C_{60}. The authors state that, 'this discovery of superconductivity in $K_x$picene shows that organic hydrocarbons are promising candidates for improved T_c values'.

Reference

1. R. Mitsuhashi, Y. Suzuki, Y. Yamanari, H. Mitamura, T. Kambe, N. Ikeda, H. Okamoto, A. Fujiwara, M. Yamaji, N. Kawasaki, Y. Maniwa and Y. Kubozono, *Nature*, **464**, 76-79 (2010) (4 Mar., Issue).

Tunable polymer multi-shape memory effect.

Shape memory polymers are materials that can memorize temporary shapes and revert to their permanent shape upon exposure to an external stimulus such as heat, light, moisture or magnetic field. Such properties have enabled a variety of applications including

deployable space structures, biomedical devices, adaptive optical devices, smart dry adhesives and fasteners. The ultimate potential for a shape memory polymer, however, is limited by the number of temporary shapes it can memorize in each shape memory cycle and the ability to tune the shape memory transition temperature(s) for the targeted applications. Currently known shape memory polymers are capable of memorizing one or two temporary shapes, corresponding to dual- and triple-shape memory effects (also counting the permanent shape), respectively. At the molecular level, the maximum number of temporary shapes a shape memory polymer can memorize correlates directly to the number of discrete reversible phase transitions (shape memory transitions) in the polymer. Intuitively, one might deduce that multi-shape memory effects are achievable simply by introducing additional reversible phase transitions. The task of synthesizing a polymer with more than two distinctive and strongly bonded reversible phases, however, is extremely challenging. Tuning shape memory effects, on the other hand, is often achieved through tailoring the shape memory transition temperatures, which requires alteration in the material composition.

Here, Xie shows that the perfluorosulphonic acid ionomer (PFSA) (Nafion), which has only one broad reversible phase transition, exhibits dual-, triple-, and at least quadruple-shape memory effects, all highly tunable without any change to the material composition.

Reference

1. T. Xie, *Nature* **464**, 267-270 (2010) (11 March Issue).

Design of Polymethine Dyes with Large Third-Order Optical Nonlinearities and Loss Figures of Merit.

All-optical switching applications require materials with large third-order nonlinearities and low nonlinear optical losses. Hales *et al.* [1] present a design approach that involves enhancing the real part of the third-order polarizability (γ) of cyanine-like molecules through incorporation of polarizable chalcogen atoms into terminal groups, while controlling the molecular length to obtain favorable one- and two-photon absorption resonances that lead to suitably low optical loss and appreciable dispersion enhancement of the real part of (γ).

The authors implemented this strategy in a soluble bis(selenopyrylium) heptamethine dye that exhibits a real part of (γ) that is exceptionally large throughout the wavelength range used for telecommunications, and an imaginary part of (γ), a measure of nonlinear loss, that is smaller by two orders of magnitude. This combination is critical in enabling low-power, high-contrast optical switching.

Reference

1. J. M. Hales, J. Matichak, S. Barlow, S. Ohira, K. Yesudas, J. –L. Brédas, J. W. Perry and S. R. Marder, *Science*, **327** (5972), 1485-1488 (2010) (19 March Issue).

Ferrous Polycrystalline Shape-Memory Alloy Showing Huge Superelasticity.

Shape-memory alloys, such as Ni-Ti and Cu-Zn-Al, show a large reversible strain of more than several percent due to superelasticity. In particular, the Ni-Ti–based alloy, which exhibits some ductility and excellent superelastic strain, is the only superelastic material available for practical applications at present.

Tanaka *et al.* [1] herein describe a ferrous polycrystalline, high-strength, shape-memory alloy exhibiting a superelastic strain of more than 13%, with a tensile strength above 1 GPa, which is almost twice the maximum superelastic strain obtained in the Ni-Ti alloys. Furthermore, this ferrous alloy has a very large damping capacity and exhibits a large reversible change in magnetization during loading and unloading. The authors state that, ‘this ferrous shape-memory alloy has great potential as a high-damping and sensor material’.

Reference

1. Y. Tanaka, Y. Himuro, R. Kainuma, Y. Sutou, T. Omori and K. Ishida, *Science*, **327** (5972), 1488-1490 (2010) (19 March Issue).

Recent Books and Review Articles in the Area of Materials Science, Engineering and Technology

(*Contributed by the Editor*)

Books

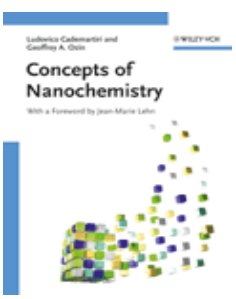
- *High-Speed Electronics and Optoelectronics. Devices and Circuits.* By Sheila Prasad, Hermann Schumacher, and Anand Gopinath. Cambridge University Press, New York, 2009. Hardback: 440 pp., illus. $90. ISBN 9780521862837.

- *Optoelectronic Devices. Design, Modeling, and Simulation.* By Xun Li. Cambridge University Press, New York, 2009. Hardback: 373 pp., illus. $115. ISBN 9780521875103.

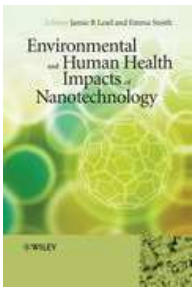
- *Solar Energy Engineering. Processes and Systems.* By Soteris A. Kalogirou. Academic (Elsevier), Burlington, MA, 2009. Hardback: 776 pp., illus. $125. ISBN 9780123745019.

- *Fundamentals of High-Frequency CMOS Analog Integrated Circuits.* By Duran Leblebici and Yusuf Leblebici. Cambridge University Press, New York, 2009. Hardback: 316 pp., illus. $85. ISBN 9780521513401.

- *Concepts in Nanochemistry.* By Cademartiri, Ludovico and Ozin, Geoffrey A. Wiley-VCH, Weinheim, 2009. Softcover. 262 Pages. 39.- EUR. ISBN 978-3-527-32597-9. Hardcover. 262 Pages. 89.- EUR. ISBN 978-3-527-32626-6.



- *Environmental and Human Health Impacts of Nanotechnology.* Edited by Lead, Jamie R. and Smith, Emma. Wiley-VCH, Weinheim, 2009. Hardcover. 456 Pages. 129.- EUR. ISBN 978-1-4051-7634-7.



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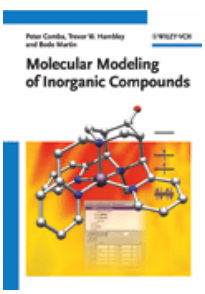

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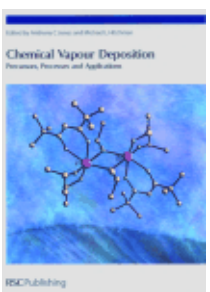

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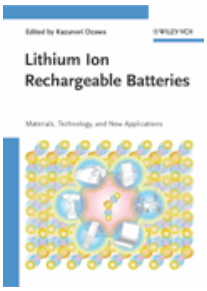

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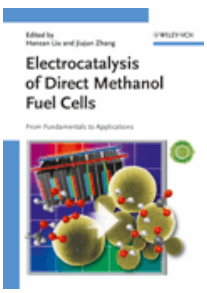

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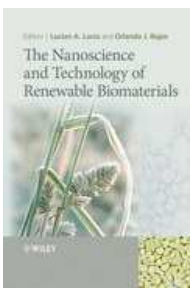

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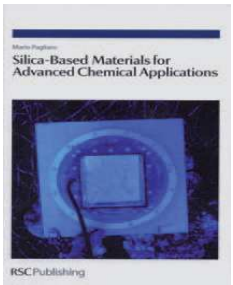

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- *Chasing Molecules. -Poisonous Products, Human Health, and the Promise of Green Chemistry.* By Elizabeth Grossman. Shearwater (Island), Washington, DC, 2009. Hardback: 281 pp. $26.95. ISBN 9781597263702.

- *Fundamentals of Modern VLSI Devices.* By Yuan Taur and Tak H. Ning. 2nd Ed., Cambridge University Press, New York, 2009. Hardback: 670 pp., illus. $90. ISBN 9780521832946.

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- *Thin Film Shape Memory Alloys. Fundamentals and Device Applications.* Edited by Shuichi Miyazaki, Yong Qing Fu, and Wei Min Huang. Cambridge University Press, New York, 2009. Hardback: 485 pp., illus. $145. ISBN 9780521885768.

- *Transport in Laser Microfabrication. Fundamentals and Applications.* By Costas P. Grigoropoulos. Cambridge University Press, New York, 2009. Hardback: 412 pp., illus. $108. ISBN 9780521821728.

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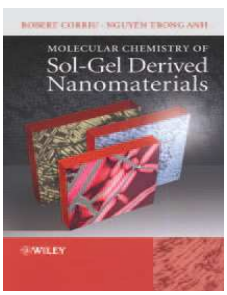

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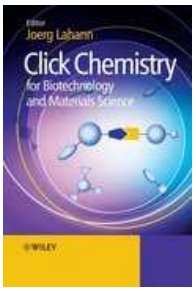

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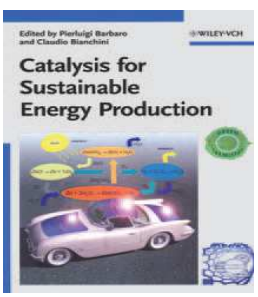

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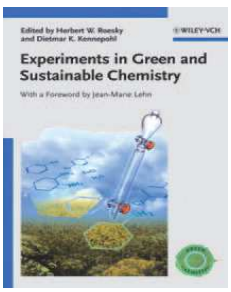

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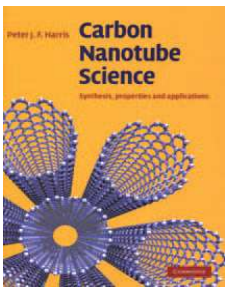

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Review Articles

- Carbon nanotube-based organic light emitting diodes. By M. Bansal, R. Srivastava, C. Lal, M. N. Kamalasanan and L. S. Tanwar, Nanoscale, **1**, 317-330 (2009).

Abstract

Carbon nanotubes (CNTs), revolutionary and fascinating from the materials point of view and exceedingly sensational from a research point of view, are standing today at the threshold between inorganic electronics and organic electronics and posing a serious challenge to the big daddies of these two domains in electronics, namely, silicon and indium tin oxide (ITO). In the field of inorganic electronics, CNTs offer advantages such as high current carrying capacity, ballistic transport, absence of dangling bonds, etc. and on the other hand, in the field of organic electronics, they offer advantages such as high conductivity, high carrier mobility, optical transparency (in the visible and IR spectral ranges), flexibility, robustness, environmental resistance, etc., and hence, CNTs are seriously being considered as contenders to silicon and ITO.

This review traces the origin of CNTs in the field of organic electronics (with emphasis on organic light emitting diodes) and moves on to cover the latest advances in the field of CNT -based organic light emitting diodes. Topics that are covered within, include applications of multi-wall nanotubes and single-wall nanotubes in organic light emitting diodes. Applications of CNTs as hole-transport layers, as electron-transport layers, as transparent electrodes, etc. in

organic light emitting diodes (OLEDs) are discussed and the daunting challenges facing this progressive field today are brought into the limelight. 100 References.

- Deposition in supercritical fluids: from silver to semiconductors. By J. Yang, T. Hasell, D. C. Smith and S. M. Howdle, J. Mater. Chem., **19** (45), 8560-8570 (2009)

Abstract

There is great interest in developing new routes to novel functional materials, particularly for heterogeneous nanocomposites of metals or semiconductors with polymeric hosts. Supercritical fluids have become important media for the synthesis of such nanocomposites largely because of their unique properties, but also through their perceived environmental benefits over conventional routes. In this article, the authors focus on the deposition of silver and semiconductor nanoparticles into polymer substrates by use of supercritical fluids. These processes develop nanocomposites with distinct characteristics for optical and biomedical applications. The preparation and characterization of silver and semiconductor nanoparticles is described and a brief discussion is extended to some other novel deposition systems in supercritical fluids. 118 References.

- A review of integration strategies for solid oxide fuel cells. By X. Zhang, S. H. Chan, G. Li, H. K. Ho, J. Li and Z. Feng, J. Power Sources, **195** (3), 685-702 (2010).

Abstract

Due to increasing oil and gas demand, the depletion of fossil resources, serious global warming, efficient energy systems and new energy conversion processes are urgently needed. Fuel cells and hybrid systems have emerged as advanced thermodynamic systems with great promise in achieving high energy/power efficiency with reduced environmental loads. In particular, due to the synergistic effect of using integrated solid oxide fuel cell (SOFC) and classical thermodynamic cycle technologies, the efficiency of the integrated system can be significantly improved. This paper reviews different concepts/strategies for SOFC-based integration systems, which are timely transformational energy-related technologies available to overcome the threats posed by climate change and energy security. 151 References.

- Recent developments in cathode materials for lithium ion batteries. By J.W. Fergus, J. Power Sources, **195** (4), 939-954 (2010).

Abstract

One of the challenges for improving the performance of lithium ion batteries (LIBs) to meet increasingly demanding requirements for energy storage is the development of suitable cathode materials. Cathode materials must be able to accept and release lithium ions repeatedly (for recharging) and quickly (for high current). Transition metal oxides based on the α-$NaFeO_2$, spinel and olivine structures have shown promise, but improvements are needed to reduce cost and extend effective lifetime. In this paper, recent developments in cathode materials for LIBs are reviewed. This includes comparison of the performance characteristics of the promising cathode materials and approaches for improving their performances. 443 References.

- A review on air cathodes for zinc–air fuel cells. By V. Neburchilov, H. Wang, J. J. Martin and W. Qu, J. Power Sources, **195** (5), 1271-1291(2010).

Abstract

This paper reviews the compositions, design and methods of fabrication of air cathodes for alkali zinc–air fuel cells (ZAFCs), one of the few successfully commercialized fuel cells. The more promising compositions for air cathodes are based on individual oxides, or mixtures of such, with a spinel, perovskite, or pyrochlore structure: MnO_2, Ag, Co_3O_4, La_2O_3, $LaNiO_3$, $NiCo_2O_4$, $LaMnO_3$, $LaNiO_3$, etc. These compositions provide the optimal balance of ORR (oxygen reduction reaction) -activity and chemical stability in an alkali electrolyte. The sol–gel and reverse micelle methods supply the most uniform distribution of the catalyst on carbon and the highest catalyst BET surface area. It is shown that the design of the air cathode, including types of carbon black, binding agents,

current collectors, Teflon membranes, thermal treatment of the GDL, and catalyst layers, has a strong effect on performance. 151 References.

- ZnO Nanostructures for Dye-Sensitized Solar Cells. By Q. Zhang, C. S. Dandeneau, X. Zhou and G. Cao, Adv. Mater., **21** (41), 4087 - 4108 (2009).

Abstract

This Review focuses on recent developments in the use of ZnO nanostructures for dye-sensitized solar cell (DSC) applications. It is shown that carefully designed and fabricated nanostructured ZnO films are advantageous for use as a DSC photoelectrode as they offer larger surface areas than bulk film material, direct electron pathways, or effective light-scattering centers, and, when combined with TiO_2, produce a core-shell structure that reduces the combination rate. The limitations of ZnO-based DSCs are also discussed and several possible methods are proposed so as to expand the knowledge of ZnO to TiO_2, motivating further improvement in the power-conversion efficiency of DSCs. 227 References.

- Interface Engineering of Inorganic Thin-Film Solar Cells - Materials-Science Challenges for Advanced Physical Concepts. By W. Jaegermann, A. Klein and T. Mayer, Adv. Mater., **21** (42), 4196 – 4206 (2009).

Abstract

The challenges and research needs for the interface engineering of thin-film solar cells using inorganic-compound semiconductors are discussed in this paper from a materials-science point of view. It is, in principle, easily possible to define optimized device structures from physical considerations. However, to realize these structures, many materials' limitations must be overcome by complex processing strategies. In this paper, interface properties and growth morphology are discussed using cadmium telluride (CdTe) solar cells as an example. The need for a better fundamental understanding of cause-effect relationships for improving thin-film solar cells is emphasized. 76 References.

- Synthesis of Inorganic Nanotubes. By C.N.R. Rao and A. Govindaraj, Adv. Mater., **21** (42), 4208 – 4223 (2009).

Abstract

Nanotubes constitute an exciting class of one-dimensional nanomaterials of which carbon nanotubes are recognized widely as materials of importance. The possibility of having inorganic nanotubes was recognized early in the 1990s, accompanied by the report of nanotubes of MoS_2 and WS_2. Since then, nanotubes of several inorganic materials have been prepared and characterized. While nanotubes of metal chalcogenides and oxides form a high proportion of the inorganic nanotubes investigated hither to, nanotubes of many other materials have also been prepared and characterized. Several synthetic strategies including both physical and chemical methods have been employed, of which the use of templates, precursors, and hydro- or solvothermal methods are prominent. In this article, the authors present a brief account of the present status of the synthesis of nanotubes of elemental materials as well as binary and complex metal oxides, chalcogenides, pnictides and carbides. 239 References.

- Photoluminescence-Based Sensing With Porous Silicon Films, Microparticles, and Nanoparticles. By M. J. Sailor and E. C. Wu, Adv. Funct. Mater., **19** (20), 3195 - 3208 (2009).

Abstract

In this paper, chemical sensors made from porous Si are reviewed, with an emphasis on systems that harness photoluminescence and related energy- and charge-transfer mechanisms available to porous Si-derived nanocrystallites. Quenching of luminescence by molecular adsorbates involves the harvesting of energy from a delocalized nanostructure that can be much larger than the molecule being sensed, providing a means to amplify the sensory event. The interaction of chemical species on the surface of porous Si can exert a pronounced influence on this process, and examples of some of the key chemical reactions that modify either the surface or the bulk properties of porous Si are presented. Sensors based on micron-scale and smaller porous Si particles are also discussed. Miniaturization to this size regime enables new applications, including imaging of cancerous tissues, indirect detection of reactive oxygen species (ROS), and controlled drug release. Examples of environmental

and in vivo sensing systems enabled by porous Si are provided. 197 References.

- Inspiration and application in the evolution of biomaterials. By N. Huebsch and D.J. Mooney, Nature, **462**, 426-432 (2009) (26 Nov., Issue).

Abstract

Biomaterials, traditionally defined as materials used in medical devices, have been used since antiquity, but recently their degree of sophistication has increased significantly. Biomaterials made today are routinely information rich and incorporate biologically active components derived from nature. In the future, biomaterials will assume an even greater role in medicine and will find use in a wide variety of non-medical applications through biologically inspired design and incorporation of dynamic behavior. 50 References.

- The Quest for Nanoscale Magnets: The example of [Mn_{12}] Single Molecule Magnets. By G. Rogez, B. Donnio, E. Terazzi, J.-L. Gallani, J. -P. Kappler, J.-P. Bucher and M. Drillon, Adv. Mater., **21** (43), 4323-4333 (2009).

Abstract

Recent advances on the organization and characterization of [Mn_{12}] single molecule magnets (SMMs) on a two dimensional (2D) surface or in three dimensions (3D) are reviewed. By using nonconventional techniques such as X-ray magnetic circular dichroism (XMCD) and scanning tunneling microscopy (STM), it is shown that [Mn_{12}]-based SMMs deposited on a surface lose their SMM behavior, even though the molecules seem to be structurally undamaged. A new approach is reported to get high-density information-storage devices, based on the 3D assembling of SMMs in a liquid crystalline phase. The 3D nanostructure exhibits the anisotropic character of the SMMs, thus opening the way to address micrometric volumes by two photon absorption using the pump-probe technique. The authors present recent developments such as μ-SQUID, magneto-optical Kerr effect (MOKE), or magneto-optical circular dichroism (MOCD), which enable the characterization of SMM nanostructures with exceptional sensitivity. Further, the spin-polarized version of the STM under ultrahigh vacuum is shown to be the key tool for addressing not only single molecule magnets, but also magnetic nano-objects. 113 References.

- Advancements in the Search for Superhard Ultra-Incompressible Metal Borides. By J. B. Levine, S. H. Tolbert and R. B. Kaner, Adv. Funct. Mater., **19** (22), 3519-3533 (2009).

Abstract

Dense transition metal borides have recently been identified as superhard materials that offer the possibility of ambient pressure synthesis compared to the conventional high pressure- high temperature approach. This review article begins with a discussion of the relevant physical properties for this class of compounds, followed by a summary of the synthesis and properties of several transition metal borides. A strong emphasis is placed on correlating mechanical properties with electronic and atomic structure of these materials in an effort to better predict new superhard compounds. It concludes with a perspective of future research directions, highlighting some recent results and presenting several new ideas that remain to be tested. 118 References.

- High refractive index polymers: fundamental research and practical applications. By J.-G Liu and M. Ueda, J. Mater. Chem., 19 (47), 8907 - 8919 (2009).

Abstract

Rapid developments in advanced photonic devices have led to the increasing exploration of high refractive index (high-n) materials, particularly high-refractive-index polymers (HRIP). High refractive indices have been achieved either by introducing substituents with high molar refractions to make intrinsic HRIPs or by combining high-n nanoparticles with polymer matrixes to make HRIP nanocomposites. For intrinsic HRIPs, aromatic rings, sulfur-containing groups, halogens except fluorine and organometallic moieties are often utilized to increase their refractive indices. However, their upper n limitation is usually below 1.80. Incorporation of high-n nanoparticles into polymers seems to be a more promising strategy to achieve a refractive

index higher than 1.80; however, the obtained organic–inorganic hybrid materials sometimes suffer from poor storage stability, higher optical loss and poor processability. Besides the refractive index, optical dispersion (Abbe number), birefringence and optical transparency are often involved in designing HRIPs for practical optical fabrications. Therefore, research of HRIPs is becoming an interdisciplinary subject. This article reviews recent developments in optical HRIPs and their typical applications in high-tech fields. 95 References.

- Cubic silsesquioxanes for use in solution processable organic light emitting diodes (OLED). By K. L. Chan, P. Sonar and A. Sellinger, J. Mater. Chem., 19 (48), 9103-9120 (2009).

Abstract

Commercial products using organic light emitting diode (OLED) display technology have begun to appear in cell phones, mp3 players and even televisions. One key area that has allowed and will allow for this technology to continue its ascension into the flat panel display and lighting markets is materials R&D. From this perspective, recent progress in cubic silsesquioxane (SSQ) based materials may provide some new advantageous properties well suited for OLEDs. In this review article the authors provide an overview of recent progress in the synthesis, characterization and implementation of SSQ-based materials with properties well suited for application in solution processable organic/polymer electronics, specifically OLEDs. 84 References.

- Liquid-Phase Exfoliation of Nanotubes and Graphene. By J. N. Coleman, Adv. Funct. Mater., **19** (23), 3680-3695 (2009).

Abstract

Many applications of carbon nanotubes require the exfoliation of the nanotubes to give individual tubes in the liquid phase. This requires the dispersion, exfoliation, and stabilization of nanotubes in a variety of liquids. In this paper recent work in this area is reviewed, focusing on results from the author's group. It begins by reviewing stabilization mechanisms before exploring research into the exfoliation of nanotubes in solvents, by using surfactants or biomolecules and by covalent attachment of molecules. The concentration dependence of the degree of exfoliation in each case is highlighted. In addition, research into the dispersion mechanism for each dispersant type is discussed. Most importantly, dispersion quality metrics for all dispersants are compared. From this analysis, it is concluded that functionalized nanotubes can be exfoliated to the greatest degree. Finally, the extension of this work to the liquid phase exfoliation of graphite to give graphene is reviewed. 138 References.

- Bulk Metallic Glasses with Functional Physical Properties. By W. H. Wang, Adv. Mater., **21** (45), 4524-4544 (2009).

Abstract

In this review, Wang reports on the formation of a variety of novel, metallic, glassy materials that might well have applications as functional materials. The metallic glasses, with excellent glass-forming ability, display many fascinating properties and features such as excellent wave-absorption ability, exceptionally low glass-transition temperatures (~35-60 °C) approaching room temperature, ultralow elastic moduli comparable to that of human bone, high elasticity and high strength, superplasticity and polymer-like thermoplastic formability near room temperature, an excellent magnetocaloric effect, hard magnetism and tunable magnetic properties, heavy-fermion behavior, superhydrophobicity and superoleophobicity, and polyamorphism, all of which are of interest not only for basic research but also for technological applications.

A strategy based on elastic-moduli correlations for fabrication of bulk metallic glasses (BMGs) with controllable properties is presented. The work has implications in the search for novel metallic glasses with unique functional properties, for advancing our understanding of the nature and formation of glasses, and for extending the applications of the materials. 148 References.

- Recent Progress in Exploring Magnetocaloric Materials. By B. G. Shen, J. R. Sun, F. X. Hu, H. W. Zhang and Z. H. Cheng, Adv. Mater., **21** (45), 4545-4564 (2009).

Abstract

The magnetic refrigeration technique based on the magnetocaloric effect (MCE) has attracted increasing interest because of its high efficiency and environmental friendliness. In this article, recent progress in exploring effective MCE materials is reviewed with emphasis on the MCE in the $LaFe_{13-x}Si_x$-based alloys discovered by us. These alloys show large entropy changes over a wide temperature range near room temperature. The effects of magnetic rare-earth doping, interstitial atoms and high pressure on the MCE have been systematically studied. Special issues, such as appropriate approaches to determining the MCE associated with the first-order magnetic transition, the depression of magnetic and thermal hysteresis, and the key factors determining the magnetic exchange in alloys of this kind, are discussed. The applicability of giant MCE materials to magnetic refrigeration near ambient temperature is evaluated. A brief review of other materials with significant MCE is also presented. 113 References.

- Synthesis, Structure, and Properties of Single-Walled Carbon Nanotubes. By W. Zhou, X. Bai, E. Wang and S. Xie, Adv. Mater., **21** (45), 4565-4583 (2009).

Abstract

Great interest in single-walled carbon nanotubes (SWCNTs) derives from their remarkable electrical, thermal, optical, and mechanical properties together with their lower density, which promise extensive and unique applications. Much progress has been achieved in the fundamental and applied investigations of SWCNTs over the past decade. At the same time, many obstacles still remain, hampering further development in this field.

To clarify the emerging problems and to provide a comprehensive understanding of the field, the authors review the recent progress of research on the synthesis, structure, and properties of SWCNTs, in particular the SWCNT non-woven film, SWCNT rings, boron-nitrogen (B-N) co-doped SWCNTs (BCN-SWNTs), and individual SWCNTs. Some long-standing problems and topics warranting further investigations in the near future are addressed.191 References.

- Research and Prospects of Iron-Based Superconductors. By Z.-A. Ren and Z.-X. Zhao, Adv. Mater., **21** (45), 4584-4592 (2009).

Abstract

The discovery of a new superconductor, $LaFeAsO_{1-x}F_x$ with a superconducting critical temperature, T_c, of 26 K in 2008, has quickly renewed interest in the exploration of iron-based superconductors. More than 70 new superconductors have been discovered within several months, with the highest T_c of up to 55 K being observed in the $SmFeAsO_{1-x}$ compound. High T_c superconductors have previously only been observed in cuprates; these new iron-based superconductors have been added as second members of the high-T_c family. The crystal structure of these compounds contains an almost 2D Fe-As layer formed by $FeAs_4$ tetrahedrons, which can be separated by an oxide or metal layer that provides extra electrons to the Fe-As layer, and the itinerant iron 3d electrons form an antiferromagnetic (AFM) ordered state in the undoped parent compounds at around 100-200 K. Superconductivity can be induced by carrier doping, which destroys the AFM ground state.

In this review, the most recent findings on and basic experimental facts about this class of high-T_c materials are presented, including the various superconducting structures, the synthesis methods, the physical properties of the parent compounds, the doping methods that could produce superconductivity, pressure effects, and the prospects for this new iron-based high-T_c family.130 References.

- Research on Advanced Materials for Li-ion Batteries. By H. Li, Z. Wang, L. Chen and X. Huang, Adv. Mater., **21** (45), 4593-4607 (2009).

Abstract

In order to address power and energy demands of mobile electronics and electric cars, Li-ion technology

is urgently being optimized by using alternative materials. This article presents a review of our recent progress dedicated to the anode and cathode materials that have the potential to fulfill the crucial factors of cost, safety, lifetime, durability, power density, and energy density. Nanostructured inorganic compounds have been extensively investigated. Size effects revealed in the storage of lithium through micropores (hard carbon spheres), alloys (Si, SnSb), and conversion reactions (Cr_2O_3, MnO) are studied. The formation of nano/micro core-shell, dispersed composite, and surface pinning structures can improve their cycling performance. Surface coating on $LiCoO_2$ and $LiMn_2O_4$ was found to be an effective way to enhance their thermal and chemical stability and the mechanisms are discussed. Theoretical simulations and experiments on $LiFePO_4$ reveal that alkali metal ions and nitrogen doping into the $LiFePO_4$ lattice are possible approaches to increase its electronic conductivity and does not block transport of lithium ion along the 1D channel.162 References.

- Block Copolymer Nanolithography: Translation of Molecular Level Control to Nanoscale Patterns. By J. Bang, U. Jeong, D. Y. Ryu, T. P. Russell and C. J. Hawker, Adv. Mater., **21** (47), 4769-4792 (2009).

Abstract

The self-asembly of block copolymers is a promising platform for the 'bottom-up' fabrication of nanostructured materials and devices. This review covers some of the advances made in this field from the laboratory setting to applications where block copolymers are in use. 260 References.

- Structure, Microstructure, Composition and Properties of Lanthanum Lithium Titanates and some Substituted Analogues. By S. García-Martín, U. Amador, A. Morata-Orrantia, J. Rodríguez-Carvajal, M. Á. Alario-Franco, Z. Anorg. Allgem. Chem., 635 (15) 2363-2373 (2009).

Abstract

The very high value of ionic conductivity at room temperature reported for $La_{0.51}Li_{0.34}TiO_{2.94}$ some years ago did originate a great deal of interest in the study of materials of general formula, $La_{2/3-x}Li_{3x}TiO_3$ (LaLiTiO) and related systems. These oxides have shown to be potential solid electrolytes for lithium secondary batteries, but other aspects, apart from the conducting properties, such as their dielectric behaviour and crystal structure, have been the main focus of important studies in the area of inorganic solid-state chemistry. LaLiTiO-related compounds have the perovskite-type structure (ABO_3) with A-cation ordering. However, essential details of their crystal structure, as for instance the location of the lithium atoms, are still under discussion and are the subject of current work.

The authors show, in this short review of mainly their our own work, that the complex microstructure of these materials, which has been studied in detail by transmission electron microscopy, is the cause of the difficulties on the precise determination of their crystal structure. They have developed a new approach for crystal structure refinement, which takes into account the microstructural effects, obtaining significantly better results than conventional methods of refinement. The microstructure of these oxides also affects their conducting and dielectric properties. Therefore, different parameters such as composition and microstructure must be considered to understand and, eventually, optimise, as was done by the authors, the conducting properties of LaLiTiO-related systems. 51 References.

- A review of recent progress in coatings, surface modifications and alloy developments for solid oxide fuel cell ferritic stainless steel interconnects. By N. Shaigan, W. Qu, D. G. Ivey and W. Chen, J. Power Sources, **195** (6), 1529-1542 (2010).

Abstract

Ferritic stainless steels have become the standard material for solid oxide fuel cell (SOFC) interconnect applications. The use of commercially available ferritic stainless steels, not specifically designed for interconnect application, however, presents serious issues leading to premature degradation of the fuel cell stack, particularly on the cathode side. These problems include rapidly increasing contact resistance and volatilization of Cr from the oxide scales, resulting in cathode chromium poisoning and cell malfunction. To overcome these issues, a variety of conductive/protective coatings, surface treatments and modifications as well as alloy development have been suggested and studied over the past several years.

This paper critically reviews the attempts performed thus far to mitigate the issues associated with the use of ferritic stainless steels on the cathode side. Different approaches are categorized and summarized and examples for each case are provided. Finally, directions and recommendations for the future studies are presented. 143 References.

- Advanced materials and processes for polymer solar cell devices. By M. Helgesen, R. Søndergaard and F. C. Krebs, J. Mater. Chem., 20 (1), 36-60 (2010).

Abstract

The rapidly expanding field of polymer and organic solar cells is reviewed in the context of materials, processes and devices that significantly deviate from the standard approach which involves rigid glass substrates, indium-tin-oxide electrodes, spincoated layers of conjugated polymer/fullerene mixtures and evaporated metal electrodes in a flat multilayer geometry. It is likely that significant advances can be found by pursuing many of these novel ideas further and the purpose of this review is to highlight these reports and hopefully spark new interest in materials and methods that may be performing less than the current state-of-the-art in their present form but that may have the potential to outperform these pending a larger investment in effort. 212 References.

- Current international research into cellulose nanofibres and nanocomposites. By S. J. Eichhorn, A. Dufresne, M. Aranguren, N. E. Marcovich, J. R. Capadona, S. J. Rowan, C. Weder, W. Thielemans, M. Roman, S. Renneckar, W. Gindl, S. Veigel, J. Keckes, H. Yano, K. Abe, M. Nogi, A. N. Nakagaito, A. Mangalam, J. Simonsen, A. S. Benight, A. Bismarck, L. A. Berglund and T. Peijs, J. Mater. Sci., 45 (1), 1-33 (2010).

Abstract

This paper provides an overview of recent progress made in the area of cellulose nanofibre-based nanocomposites. An introduction into the methods used to isolate cellulose nanofibres (nanowhiskers, nanofibrils) is given, with details of their structure. Following this, the article is split into sections dealing with processing and characterization of cellulose nanocomposites and new developments in the area, with particular emphasis on applications. The types of cellulose nanofibres covered are those extracted from plants by acid hydrolysis (nanowhiskers), mechanical treatment and those that occur naturally (tunicate nanowhiskers) or under culturing conditions (bacterial cellulose nanofibrils). Research highlighted in the article are the use of cellulose nanowhiskers for shape memory nanocomposites, analysis of the interfacial properties of cellulose nanowhisker and nanofibril-based composites using Raman spectroscopy, switchable interfaces that mimic sea cucumbers, polymerization from the surface of cellulose nanowhiskers by atom transfer radical polymerization and ring opening polymerization, and methods to analyze the dispersion of nanowhiskers.

The applications and new advances covered in this review are the use of cellulose nanofibres to reinforce adhesives, to make optically transparent paper for electronic displays, to create DNA-hybrid materials, to generate hierarchical composites and for use in foams, aerogels and starch nanocomposites, and the use of all-cellulose nanocomposites for enhanced coupling between matrix and fibre. A comprehensive coverage of the literature is given and some suggestions on where the field is likely to advance in the future are discussed. 280 References.

- Current Trends in Shrinking the Channel Length of Organic Transistors Down to the Nanoscale. By Y. Cao, M. L. Steigerwald, C. Nuckolls and X. Guo, Adv. Mater., **22** (1), 20-32 (2010).

Abstract

In this review article, the authors highlighted current trends in shrinking the channel length of organic field effect transistors (OFETs) down to the nanoscale in three systems where sophisticated device fabrication has been integrated into the development of different electrodes with nanoscale gaps. The design principle is the combination of molecular design freedom and flexible molecular self-assembly with state-of-the-art device fabrication to realize organic field effect nano-transistors where molecular materials themselves behave as pivotal elements. Three different types of nanoscale electrodes are used for OFETs: metals, single-walled carbon nanotubes (SWCNTs), and

graphenes. These electrodes are made by e-beam lithography as well as other complementary methods (shadow deposition, underetching, nanoimprinting, rubber stamping, and microcontact printing). 106 References.

- Dendritic Polyglycerols for Biomedical Applications. By M. Calderón , M. A. Quadir, S. K. Sharma and R. Haag, Adv. Mater., **22** (2), 90-218 (2010).

Abstract

The application of nanotechnology in medicine and pharmaceuticals is a rapidly advancing field that is quickly gaining acceptance and recognition as an independent area of research called "nanomedicine". Urgent needs in this field, however, are biocompatible and bioactive materials for antifouling surfaces and nanoparticles for drug delivery. Therefore, extensive attention has been given to the design and development of new macromolecular structures. Among the various polymeric architectures, dendritic ("tree-like") polymers have experienced an exponential development due to their highly branched, multifunctional, and well-defined structures.

This review describes the diverse syntheses and biomedical applications of dendritic polyglycerols (PGs). These polymers exhibit good chemical stability and inertness under biological conditions and are highly biocompatible. Oligoglycerols and their fatty acid esters are FDA-approved and are already being used in a variety of consumer applications, e.g., cosmetics and toiletries, food industries, cleaning and softening agents, pharmaceuticals, polymers and polymer additives, printing photographing materials, and electronics. Herein, the authors present the current status of dendritic PGs as functional dendritic architectures with particular focus on their application in nanomedicine, in drug, dye, and gene delivery, as well as in regenerative medicine in the form of non-fouling surfaces and matrix materials. 223 References.

- Epitaxial Growth and Properties of Doped Transition Metal and Complex Oxide Films. By S.A. Chambers, Adv. Mater., **22** (2), 219-248 (2010).

Abstract

The detailed science and technology of crystalline oxide film growth using vacuum methods is reviewed and discussed with an eye toward gaining fundamental insights into the relationships between growth process and parameters, film and interface structure and composition, and electronic, magnetic and photochemical properties. The topic is approached first from a comparative point of view based on the most widely used growth methods, and then on the basis of specific material systems that have generated very high levels of interest. Emphasis is placed on the wide diversity of structural, electronic, optical and magnetic properties exhibited by oxides, and the fascinating results that this diversity of properties can produce when combined with the degrees of freedom afforded by heteroepitaxy. 374 References.

- Preparation of Inorganic Materials Using Ionic Liquids. By Z. Ma, J. Yu and S. Dai, Adv. Mater., **22** (2), 261-285 (2010).

Abstract

Conventional synthesis of inorganic materials relies heavily on water and organic solvents. Alternatively, the synthesis of inorganic materials using, or in the presence of, ionic liquids represents a burgeoning direction in materials chemistry. Use of ionic liquids in solvent extraction and organic catalysis has been extensively studied, but their use in inorganic synthesis has just begun. Ionic liquids are a family of non-conventional molten salts that can act as templates and precursors to inorganic materials, as well as solvents. They offer many advantages, such as negligible vapor pressures, wide liquidus ranges, good thermal stability, tunable solubility for both organic and inorganic molecules, and much synthetic flexibility.

In this review, the use of ionic liquids in the preparation of several categories of inorganic and hybrid materials (i.e., metal structures, non-metal elements, silicas, organosilicas, metal oxides, metal chalcogenides, metal salts, open-framework structures, ionic liquid-functionalized materials, and supported ionic liquids) is summarized. The status quo of the research field is assessed, and some future perspectives are furnished. 422 References.

- Nanogap Electrodes. By T.Li, W. Hu and D. Zhu,

Adv. Mater., **22** (2), 286-300 (2010).

Abstract

Nanogap electrodes (namely, a pair of electrodes with a nanometer gap) are fundamental building blocks for the fabrication of nanometer-sized devices and circuits. They are also important tools for the examination of material properties at the nanometer scale, even at the molecular scale. In this review, the techniques for the fabrication of nanogap electrodes, the preparation of assembled devices based on the nanogap electrodes, and the potential application of these nanodevices for analysis of material properties are introduced. The history, the research status, and the prospects of nanogap electrodes are also discussed. 183 References.

- Defect-Mediated Polarization Switching in Ferroelectrics and Related Materials: From Mesoscopic Mechanisms to Atomistic Control. By S. V. Kalinin, B. J. Rodriguez, A. Y. Borisevich, A. P. Baddorf, N. Balke, H. J. Chang L.-Q. Chen, S. Choudhury, S. Jesse, P. Maksymovych, M. P. Nikiforov and S. J. Pennycook, Adv. Mater., **22**(3), 314-322 (2010).

Abstract

The plethora of lattice and electronic behaviors in ferroelectric and multiferroic materials and heterostructures opens vistas into novel physical phenomena including magnetoelectric coupling and ferroelectric tunneling. The development of new classes of electronic, energy-storage, and information-technology devices depends critically on understanding and controlling field-induced polarization switching. Polarization reversal is controlled by defects that determine activation energy, critical switching bias, and the selection between thermodynamically equivalent polarization states in multiaxial ferroelectrics. Understanding and controlling defect functionality in ferroelectric materials is as critical to the future of oxide electronics and solid-state electrochemistry as defects in semiconductors are for semiconductor electronics.

In this article, recent advances in understanding the defect-mediated switching mechanisms, enabled by recent advances in electron and scanning probe microscopy, are discussed. The synergy between local probes and structural methods offers a pathway to decipher deterministic polarization switching mechanisms on the level of a single atomically defined defect. 52 References.

- Estimating the Maximum Attainable Efficiency in Dye-Sensitized Solar Cells. By H.J. Snaith, Adv. Funct. Mater., **20**(1), 13-19 (2010).

Abstract

For an ideal solar cell, a maximum solar-to-electrical power conversion efficiency of just over 30% is achievable by harvesting UV to near IR photons up to 1.1 eV. Dye-sensitized solar cells (DSCs) are, however, not ideal. Here, the electrical and optical losses in the dye-sensitized system are reviewed, and the main losses in potential from the conversion of an absorbed photon at the optical bandgap of the sensitizer to the open-circuit voltage generated by the solar cell are specifically highlighted. In the first instance, the maximum power conversion efficiency attainable as a function of optical bandgap of the sensitizer and the loss-in-potential from the optical bandgap to the open-circuit voltage is estimated. For the best performing DSCs with current technology, the loss-in-potential is 0.75 eV, which leads to a maximum power-conversion efficiency of 13.4% with an optical bandgap of 1.48 eV (840 nm absorption onset). Means by which the loss-in-potential could be reduced to 0.4 eV are discussed; a maximum efficiency of 20.25% with an optical bandgap of 1.31 eV (940 nm) is possible if this is achieved. 38 References.

Forthcoming Conferences

POLYCHAR 18: World Forum for Advanced Materials, April, 7 – 10, 2010, Siegen, Germany

POLYCHAR is a series of conferences taking place annually in different countries. http://www.unt.edu/POLYCHAR/

POLYCHAR18 aims to bring together established polymer scientists from academia and industry, young researchers and students. Synthesis, Characterization and Application of polymeric materials and biorelated polymers will be discussed in 2 parallel sessions including plenary (keynote) lectures, invited lectures, regular oral contributions and dedicated poster sessions. There will be a Short Course on 6, April 2010.

Topics

The technical program will include symposia with main (key note) lectures, invited and contributed lectures and dedicated poster sessions on the following topics:

- **Structure, Morphology and Properties of Polymers:** characterization, testing, simulation/ modelling
- **Synthesis and Modification of Polymer Systems**
- **Polymeric Materials and Application:** stimuli responsive systems, devices, processing
- **Biorelated Polymers** bio, medical; sustainable approaches (including recyling)

Awards

The prestigious Paul J. Flory research award and further prizes for young scientists and poster presenters will be awarded during the Conference.
Conference chairman and chairman of the Organising committee: Werner Mormann

Important Dates

Pre-registration : August 30, 2009
Abstract submission : October 30, 2009
Abstract acceptance : December 15, 2009
Registration fee payment: January 15, 2010
Submission of Abstracts and Online Registration
For instructions on preparation and submission of abstracts, online registration, technical program and further information please visit the conference website: http://polychar18.uni-siegen.de
Website: http://www.uni-siegen.de/fb8/polychar18
Publication: Manuscripts of contributions will be published in Macromolecular Symposia after peer review.

12th Asian Conference on Solid State Ionics & 15th Chinese Conference on Solid State Ionics, May, 2-6, 2010, Wuhan, China

Solid State Ionics is a growing inter-disciplinary branch of science and technology. It is concerned with ionic motion in a wide spectrum of materials covering inorganic solids, ceramic, glasses, polymers, composites and nano-scale materials with applications in solid state devices such as solid state and polymer batteries, fuel cells, electrochromic displays, solar cells and sensors.

The ACSSI is the 12th in a series of Meetings held every two years since 1988, with the purpose of providing a forum for the presentation and discussion of the latest advanced research from Asia and other countries in the areas of solid state ionic materials, devices and related topics.

The CCSSI is the 15th biennial conference organized by the Chinese Society for Solid State Ionics, with the purpose of providing a forum for the presentation and discussion of the latest advanced research in the field of Solid State Ionic from China and other countries.

Specific areas to be covered are:

- Synthesis, and characterization of ionically conducting materials
- Ionically transport mechanisms and theoretical modeling
- Cathode/anode materials and interfaces
- Electronically conducting polymers, polymer devices
- Nanoionic materials, nanocomposites, structures and devices
- Ion conducting biological systems and biomaterials
- Application technologies of batteries, fuel cells, sensors, solar cells, supercapacitors, molecular electronic devices *et al.*.

Abstracts

Those who wish to participate should submit a one-page abstract not exceeding 300 words in MS Word format via the conference website at https://www.easychair.org/login.cgi?conf=acssi12 or as an e-mail attachment to acssi12@whut.edu.cn before **1st January 2010**. At least one author of each abstract should register for the conference.

Papers

Manuscripts should also be submitted electronically in MS word format via the conference website at https://www.easychair.org/login.cgi?conf=acssi12 or as an e-mail attachment to acssi12@whut.edu.cn before **15th March 2010**. Guidelines for preparing full papers can be found at the conference website: http://acssi12.whut.edu.cn. All accepted papers will be published as conference proceedings (ISTP) by Wuhan University of Technology Press, Wuhan, China.

Important dates/deadlines:

Abstracts due: 1st January 2010
Notice of acceptance: 31st January 2010
Manuscripts due: 15th March 2010
Early registration: 15th March 2010

Conference website: http://acssi12.whut.edu.cn.

Contact Address:
Dr. Zhiyong Yu, Coordinator, ACSSI12, School of Materials Science and Engineering Wuhan University of Technology, Luoshi Road122#, Wuhan, 430070, P. R. China. Tel: 86-27-87864492: 86-27-87864681; Fax: 86-27-87651779. E-mail: acssi12@whut.edu.cn

Recent Advances in Graphene and Related Materials, Aug., 1-6, 2010, Singapore

Graphene, a single aromatic sheet of sp^2 bonded carbon, exhibits novel electronic properties such as ballistic transport, massless Dirac fermions, Berry's phase, high conductivity, and localization suppression. There are intense efforts to apply graphene materials in electronic, optoelectronic, capacitor and sensing applications. This is driven by the desire to discover new performance threshold in this novel material. Over the last few years, graphene has emerged as the most important new material for electronic condensed material research. It can be said that graphene research is providing the impetus for the post-CMOS all- carbon-electronics revolution. In the realm of chemistry, graphene and its derivatives can be used as useful templates for synthesis and functionalization. This conference will focus on the rapidly progressing science and technology of this novel two-dimensional system.

Oral sessions will include a series of Invited and Keynote talks reviewing state-of-the-art preparation methods of large-area, continuous graphene, by either chemical or physical means. Various sessions will also dedicate to topics on characterization methods, modeling of the band structure of graphene, new functionalities offered by nanoscale graphene devices, chemistry and applications of graphene derivatives or graphene composites. Related materials such as diamond and carbon nanotubes will also be covered, especially when the chemistry and physics converged with that of graphene.

The timeliness of holding this conference in Singapore: Graphene is undoubtedly the hottest topic in condensed matter research today. It is timely to organize the conference in Singapore because there is very strong core expertise and focus strength in graphene and related materials research in Singapore, spread across the two local universities and research institutes, involving no less than 100 dedicated researchers.

Conference Chair: Prof. Kian Ping Loh, Dept. of Chemistry, National University of Singapore, Singapore.
E-mail: chmlohkp@nus.edu.sg

Conference Website:http://www.engconfintl.org/10ah.html

IUMRS-ICEM 2010, Aug., 22-27, 2010, Giyang, Korea

International Union of Materials Research Societies - International Conference on Electronic Materials 2010 will be held at KINTEX (Korea International Exhibition Center), Goyang, Gyeonggi-do, Korea, from August 22(Sun)-27(Fri), 2010. It is being organized by the Materials Research Society of Korea (MRS-K).
Organizing Committee
General Chair: Prof. Hyeong Joon Kim (Seoul National University) e-mail: thinfilm@snu.ac.kr
Secretariat: Prof. Woo-Gwang Jung (Kookmin University) e-mail: wgjung@kookmin.ac.kr
Program Committee Chair: Prof. Hyungsun Kim (Inha University) e-mail: kimhs@inha.ac.kr
Organizing Committee Chair: Prof. Taik Nam Kim (Paichai University) e-mail: tnkim@pcu.ac.kr
Administrator: Ms. Ji Young Kim (MRS-K) e-mail: mrsk@mrs-k.or.kr

Important Dates (tentative): Abstract Submission Due: Mar.,15, 2010; Notification to Authors: Apr., 30, 2010 ; Final Announcement with Program: June, 15, 2010; Advance Registration: June, 30, 2010.

International Conference on Superconductivity and Magnetism (ICSM2010) Aug., 25-30, 2010, Antalya, Turkey

Members of the international scientific and engineering communities interested in recent developments in superconductivity, magnetism, magnetic materials and related technologies are cordially invited to attend the Conference and contribute to its technical sessions. The ICSM2010 will provide a platform, where solid state physicists,

chemists and material scientists, engineers and other professionals meet together for mutual benefits and collaboration.

There will also be an Educational Courses during 20-25, Apr., 2010 (prior to the Conference).
Major Topics: Superconducting Materials and Basic Properties; Magnetism and Magnetic Materials; Large Scale Applications, Science and Technology; Electronics Applications, Science and Technology.

Important Dates: Abstract Submission Deadline: Dec.,1, 2009; Abstract Acceptance: Jan.,15, 2010; Online Registration Open: Dec., 15, 2009; Online Hotel Reservation Open: Jan.,15, 2010; Early Registration Deadline: Feb., 15, 2010; Pre-registration Deadline: Apr.,15, 2010; Manuscript Submission Deadline: Mar.,15, 2010
Website: www.icsm2010.org

6th International Symposium on Novel Materials and their Synthesis
11-14, Oct., 2010, Wuhan, China

Contact person: Prof. Yu-Ping Wu, Dept. of Chemistry, Fydan Univ., Shanghai, China. E-mail:nms@fudan.edu.cn;wuyuping99@yahoo.com

15th International Metallurgy & Materials Congress (IMMC15),
11-13, Nov., 2010, Istanbul, Turkey

The 15th International Metallurgy & Materials Congress (IMMC15) is going to be held by UCEAT Chamber of Metallurgical Engineers in Istanbul, Turkey, between 11-13 Nov., 2010.
Starting from the first congress hold in 1975, this traditional congress together with the trade fair is the largest event of Turkey and the region in this field. The program will be composed of oral and poster sessions covering all aspects of metallurgy, materials science and engineering.

Informative notes: Invited Talks:

- Micro-Nano Scale: Basic Science to Practical Systems and Commercial Applications, Meyya Meyyappan, J Li, C Nguyen, J Lee, NASA Ames Research Center, USA.
- Recent Development of High Mechanical Bio-functional Metallic Biomaterials, Mitsuo Niinomi, T Akahori, M Nakai, H Tsutsumi, Dept. of Biomaterials Science, Institute for Materials Research, Tohoku University, Japan.
- Study of Precipitation in Next Generation HSLA Steels, Peter Hodgson,
- S Mukherjee, I B Timokhina, Institute for Technology Research and Innovation, Deakin University, Australia.
- Heat Treatment: State-of-the Art, Future Trends, George E. Totten, Dept. of Mechanical Engineering, Texas A&M University, USA.

The following events will also take place simultaneously:

- ANKIROS 2010, 10th International Iron-Steel and Foundry Technology, Machinery and Products Trade Fair
- ANNOFER 2010, 9th International Non-Ferrous Metals Technology, Machinery and Products Trade Fair
- TURKCAST 2010, 4th Foundry Products Trade Fair organised by Hannover-Messe Ankiros Fair Organisation, and
- 5th International Ankiros Foundry Congress organised by Foundrymen's Association of Turkey

For detailed information please visit: http://www.metalurji.org.tr/congress
Chairman of the Organization Committee: Prof. Dr. C. Hakan Gür.

INVITATION

MRS-S members are welcome to contribute to 'MRS-S OUTLOOK'

- 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.

Information on the above aspects may be communicated to the Editor:

Dr. G.V. Subba Rao
E-mail: phyvsg@nus.edu.sg

The Editorial Board of 'MRS-S OUTLOOK' reserves the right to include or not any of the submitted contributions.

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