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### ➤ MRS-S Activities: Past, Present and Future

The Materials Research Society of Singapore (MRS-S) organized six 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, 2009 and 2011.

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.

The ICMAT 2011 was held in Singapore during 26, June to 1, July, 2011. It was a grand success in terms of the total participants, total Symposia, total Exhibitors and new Initiatives.

A brief report on the Conference is included in this Issue.

The second Trilateral Conference on 'Advances in Nanoscience-Energy, Water & Healthcare' will be held at Donghua University in Shanghai, China in Nov., 2011. It is being organized by Chinese MRS in association with the MRS-S and MRS-I (India) with Prof. Zhu Meifang as Chair.

The first Trilateral Conference with the above Topic was held in Aug., 2010 in Singapore, and was organized by MRS-S in association with the Chinese MRS and MRS-I (India).

### ➤ 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.

**Year 2011:** 26 June - 1 July 2011; 40 Symposia; 9 Plenary and 3 Theme Lectures; 2 Public Lectures by Nobel Laureates; 3139 Papers; 3212 Participants from 64 countries; 48 Best Poster Awards; 68 Exhibitors.

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Saudi Arabia

## 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.

## Highlights of MRS-S Trilateral Conference on ‘Advances in Nanoscience- Energy, Water & Healthcare’ held in Singapore

**Year 2010:** Aug., 11–13, 2010. Incorporated the Chinese MRS and MRS-I (India); 1 Keynote Talk; 34 Invited Talks; 98 Poster Papers; 5 Best Poster Awards.

MRS-S OUTLOOK (ISSN 1793-3609) is published quarterly by the Materials Research Society of Singapore (MRS-S), c/o Institute of Materials Research & Engineering, 3, Research Link, Singapore 117 602.

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## Highlights of Recent Literature

(Contributed by the Editor)

### A Graphene-based Broadband Optical Modulator

Integrated optical modulators with high modulation speed, small footprint and large optical bandwidth are poised to be the enabling devices for on-chip optical interconnects. Semiconductor modulators have therefore been heavily researched over the past few years. However, the device footprint of silicon-based modulators is of the order of mm, owing to its weak electro-optical properties. Germanium and compound semiconductors, on the other hand, face the major challenge of integration with existing silicon electronics and photonics platforms.

Here, Liu *et al.*<sup>1</sup> experimentally demonstrate a broadband, high-speed, waveguide-integrated electroabsorption modulator based on monolayer graphene. By electrically tuning the Fermi level of the graphene sheet, they demonstrate modulation of the guided light at frequencies over 1 GHz, together with a broad operation spectrum that ranges from 1.35 to 1.6  $\mu\text{m}$  under ambient conditions. The high modulation efficiency of graphene results in an active device area of merely 25  $\mu\text{m}^2$ , which is among the smallest to date. The authors state that ‘this graphene-based optical modulation mechanism, with combined advantages of compact footprint, low operation voltage and ultra-fast modulation speed across a broad range of wavelengths, can enable novel architectures for on-chip optical communications’.

#### Reference

1. M. Liu, X. Yin, E. Ulin-Avila, B. Geng, T. Zentgraf, L. Ju, F. Wang and X. Zhang, *Nature*, **474** (7349), 64–67 (2011) (2 June, Issue).

### A Material with Electrically Tunable Strength and Flow Stress

The selection of a structural material requires a compromise between strength and ductility. The material

properties will then be set by the choice of alloy composition and microstructure during synthesis and processing, although the requirements may change during service life. Materials design strategies that allow for a recoverable tuning of the mechanical properties would thus be desirable, either in response to external control signals or in the form of a spontaneous adaptation, for instance in self-healing.

Here, Jin and Weissmüller<sup>1</sup> have designed a material that has a hybrid nanostructure consisting of a strong metal backbone that is interpenetrated by an electrolyte as the second component, namely, nanoporous gold containing a solution of 1 M  $\text{HClO}_4$ . By polarizing the internal interface via an applied electric potential, they accomplish fast and repeatable tuning of yield strength, flow stress, and ductility. The authors state that, ‘the concept allows the user to select, for instance, a soft and ductile state for processing and a high-strength state for service as a structural material’.

#### Reference

1. H.-J. Jin and J. Weissmüller, *Science*, **332** (6034), 1179–1182 (2011) (3 June, Issue).

### Scaling up Digital Circuit Computation with DNA Strand Displacement Cascades

To construct sophisticated biochemical circuits from scratch, one needs to understand how simple the building blocks can be and how robustly such circuits can scale up. Using a simple DNA reaction mechanism based on a reversible strand displacement process, Qian and Winfree<sup>1</sup> experimentally demonstrated several digital logic circuits, culminating in a four-bit square-root circuit that comprises 130 DNA strands. These multilayer circuits include thresholding and catalysis within every logical operation to perform digital signal restoration, which enables fast and reliable function in large circuits with roughly constant switching time and linear signal propagation delays. The design naturally incorporates other crucial elements for

large-scale circuitry, such as general debugging tools, parallel circuit preparation, and an abstraction hierarchy supported by an automated circuit compiler.

#### Reference

1. L. Qian and E. Winfree, *Science*, **332** (6034), 1196–1201 (2011) (3 June, Issue).

#### DNA-based Computing of Strategic Assignment Problems

DNA-based computing is a novel technique to tackle computationally difficult problems, in which computing time grows exponentially corresponding to problematic size. A strategic assignment problem is a typical nondeterministic polynomial problem, which is often associated with strategy applications.

Here, a new approach dealing with strategic assignment problems is proposed by Shu *et al.*<sup>1</sup> based on manipulating DNA strands, which is believed to be better than the conventional silicon-based computing in solving the same problem.

#### Reference

1. J.–J. Shu, Q.–W. Wang and K.–Y. Yong, *Phys. Rev. Lett.*, **106**, 188702–1 to –4 (2011).

#### Wafer-Scale Graphene Integrated Circuit

A wafer-scale graphene circuit was demonstrated by Lin *et al.*<sup>1</sup> in which all circuit components, including graphene field-effect transistor and inductors, were monolithically integrated on a single silicon carbide wafer. The integrated circuit operates as a broadband radio-frequency mixer at frequencies up to 10 GHz. These graphene circuits exhibit outstanding thermal stability with little reduction in performance (less than 1 db) between 300 and 400 K. The authors state that, ‘these results open up possibilities of achieving practical graphene technology with more complex functionality and performance’.

#### Reference

1. Y.–M. Lin, A. Valdes-Garcia, S.–J. Han, D. B. Farmer, I. Meric, Y. Sun, Y. Wu, C. Dimitrakopoulos, A. Grill, P. Avouris and K. A. Jenkins, *Science*, **332** (6035), 1294–1297 (2011) (10 June Issue).

#### Modular and Predictable Assembly of Porous Organic Molecular Crystals

Nanoporous molecular frameworks are important in applications such as separation, storage and catalysis. Empirical rules exist for their assembly but it is still challenging to place and segregate functionality in three-dimensional porous solids in a predictable way.

Here, Jones *et al.*<sup>1</sup> show that highly porous crystalline solids can be produced by mixing different organic cage modules that self-assemble by means of chiral recognition. The structures of the resulting materials can be predicted computationally, allowing *in silico* materials design strategies. The constituent pore modules are synthesized in high yields on gram scales in a one-step reaction. The authors show that the method is valid for four different cage modules and can in principle be generalized in a computationally predictable manner based on a lock-and-key assembly between modules.

#### Reference

1. J. T. A. Jones, T. Hasell, X. Wu, J. Bacsá, K. E. Jelfs, M. Schmidtman, S. Y. Chong, D. J. Adams, A. Trewin, F. Schiffman, F. Cora, B. Slater, A. Steiner, G. M. Day and A. I. Cooper, *Nature*, **474** (7351), 367–371 (2011) (16 June, Issue).

#### Long-Range Topological Order in Metallic Glass

Glass lacks the long-range periodic order that characterizes a crystal. In the Ce<sub>75</sub>Al<sub>25</sub> metallic glass (MG), however, Zeng *et al.*<sup>1</sup> discovered a long-range topological order corresponding to a single crystal of indefinite length.

Structural examinations confirm that the MG is truly amorphous, isotropic, and unstrained, yet under 25 Gp hydrostatic pressures, every segment of a cm-length MG ribbon devitrifies independently into a face-centered cubic (fcc) crystal with the identical orientation. By using molecular dynamics simulations and synchrotron x-ray techniques, the authors elucidated that the mismatch between the large-size Ce and small-size Al atoms frustrates the crystallization and causes amorphization, but a long-range fcc topological order still exists. Pressure induces electronic transition in Ce, which eliminates the mismatch and manifests the topological order by the formation of a single crystal.

**Reference**

1. Qiaoshi Zeng, Hongwei Sheng, Yang Ding, Lin Wang, Wenge Yang, Jian-Zhong Jiang, Wendy L. Mao, and Ho-Kwang Mao, *Science*, **332** (6036), 1404–1406 (2011) (17 June Issue).

**Carbon-based Supercapacitors Produced by Activation of Graphene**

Supercapacitors, also called ultracapacitors or electrochemical capacitors, store electrical charge on high-surface-area conducting materials. Their widespread use is limited by their low energy storage density and relatively high effective series resistance.

Using chemical activation of exfoliated graphite oxide, Zhu *et al.*<sup>1</sup> synthesized a porous carbon with a Brunauer-Emmett-Teller surface area of up to 3100 m<sup>2</sup>/g, a high electrical conductivity, and a low oxygen and hydrogen content. This sp<sup>2</sup>-bonded carbon has a continuous three-dimensional network of highly curved, atom-thick walls that form primarily 0.6- to 5-nm-width pores. Two-electrode supercapacitor cells constructed with this carbon yielded high values of gravimetric capacitance and energy density with organic and ionic liquid electrolytes. The authors state that, ‘the processes used to make this carbon are readily scalable to industrial levels’.

**Reference**

1. Y. Zhu, S. Murali, M. D. Stoller, K. J. Ganesh, W. Cai, P. J. Ferreira, A. Pirkle, R. M. Wallace, K. A. Cychoz, M. Thommes, D. Su, E. A. Stach, and R. S. Ruoff, *Science*, **332** (6037), 1537–1541 (2011) (24 June Issue).

**Superelastic Effect in Polycrystalline Ferrous Alloys**

In superelastic alloys, large deformation can revert to a memorized shape after removing the stress. However, the stress increases with increasing temperature, which limits the practical use over a wide temperature range.

Polycrystalline Fe-Mn-Al-Ni shape memory alloys show a small temperature dependence of the superelastic stress because of a small transformation entropy change brought about by a magnetic contribution to the Gibbs energies. For one alloy composition, namely, Fe<sub>43.5</sub>Mn<sub>34</sub>Al<sub>15</sub>Ni<sub>7.5</sub>, Omori *et al.*<sup>1</sup> find that the

superelastic stress varies by 0.53 MPa/°C over a temperature range from –196 to 240 °C.

**Reference**

1. T. Omori, K. Ando, M. Okano, X. Xu, Y. Tanaka, I. Ohnuma, R. Kainuma and K. Ishida, *Science*, **333** (6038), 68–71 (2011) (1 July Issue).

**Solvated Electrons in High-Temperature Melts and Glasses of the Room-Temperature Stable Electride, [Ca<sub>24</sub>Al<sub>28</sub>O<sub>64</sub>]<sup>4+</sup>·4e<sup>–</sup>**

Solvated electrons in alkali metal-ammonia solutions have attracted attention as a prototype electronic conductor and chemical reducing agent for over a century. However, solvated electrons have not been realized in a high-temperature melt or glass of an oxide system to date.

Here, Kim *et al.*<sup>1</sup> demonstrate the formation of persistent solvated electrons in both a high-temperature melt and its glass by using the thermally stable electride, [Ca<sub>24</sub>Al<sub>28</sub>O<sub>64</sub>]<sup>4+</sup>·4e<sup>–</sup> (C12A7:e<sup>–</sup>) and controlling the partial pressure of oxygen. The electrical and structural properties of the resulting melt and glass differ from those of the conventional C12A7:O<sup>2–</sup> oxide, exhibiting metallic and hopping conduction, respectively, and a glass transition temperature that is ~160 K lower than that of C12A7:O<sup>2–</sup> glass. Solvated electrons reside in cage structures in C12A7:e<sup>–</sup> and form a diamagnetic paired state.

**Reference**

1. S. W. Kim, T. Shimoyama, and H. Hosono, *Science*, **333** (6038), 71–74 (2011) (1 July Issue).

**Thermal Spin Current from a Ferromagnet to Silicon by Seebeck Spin Tunnelling**

Recently it was reported that heat flow within a ferromagnet can produce a flow of spin angular momentum—a spin current—and an associated voltage. This spin Seebeck effect has been observed in metallic, insulating and semiconductor ferromagnets with temperature gradients across them. Here, Le Breton *et al.*<sup>1</sup> describe and report the demonstration

of Seebeck spin tunnelling—a distinctly different thermal spin flow, of purely interfacial nature—generated in a tunnel contact between electrodes of different temperatures when at least one of the electrodes is a ferromagnet. The Seebeck spin current is governed by the energy derivative of the tunnel spin polarization. By exploiting this in ferromagnet–oxide–silicon tunnel junctions, the authors observe thermal transfer of spins from the ferromagnet to the silicon without a net tunnel charge current. The induced spin accumulation scales linearly with heating power and changes sign when the temperature differential is reversed. The authors state that, ‘the results highlight the engineering of heat transport in spintronic devices and facilitate the functional use of heat’.

#### Reference

1. J.-C. Le Breton, S. Sharma, H. Saito, S. Yuasa and R. Jansen, *Nature*, **475** (7354), 82–85 (2011) (7 July Issue).

### Observation of Transient Structural-Transformation Dynamics in a Cu<sub>2</sub>S Nanorod

The study of first-order structural transformations has been of great interest to scientists in many disciplines. Expectations from phase-transition theory are that the system fluctuates between two equilibrium structures near the transition point and that the region of transition broadens in small crystals.

Here, Zheng *et al.*<sup>1</sup> report the direct observation of structural fluctuations within a single nanocrystal of Cuprous sulphide (Cu<sub>2</sub>S) using transmission electron microscopy. They observed trajectories of structural transformations in individual nanocrystals with atomic resolution, which reveal details of the fluctuation dynamics, including nucleation, phase propagation, and pinning of structural domains by defects. The authors state that, ‘such observations provide crucial insight for the understanding of microscopic pathways of phase transitions’.

#### Reference

1. H. Zheng, J. B. Rivest, T. A. Miller, B. Sadtler, A. Lindenberg, M. F. Toney, L.-W. Wang, C. Kisielowski

and A. P. Alivisatos, *Science*, **333** (6039), 206–209 (2011) (8 July Issue).

### Inkjet Printing of Single-Crystal Films

The use of single crystals has been fundamental to the development of semiconductor microelectronics and solid-state science. ‘Printed electronics’ is being explored for the manufacture of large-area and flexible electronic devices by the patterned application of functional inks containing soluble or dispersed semiconducting materials.

Here, Minemawari *et al.*<sup>1</sup> developed a method that combines the technique of antisolvent crystallization with inkjet printing to produce organic semiconducting thin films of high crystallinity. Specifically, they showed that mixing fine droplets of an antisolvent and a solution of an active semiconducting component within a confined area on an amorphous substrate can trigger the controlled formation of exceptionally uniform single-crystal or polycrystalline thin films that grow at the liquid–air interfaces. Using this approach, they have printed single crystals of the organic semiconductor, 2,7-dioctyl[1]benzothieno[3,2-b][1]benzothiophene (C<sub>8</sub>-BTBT), yielding thin-film transistors with average carrier mobilities as high as 16.4 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup>. The authors state that, ‘this printing technique constitutes a major step towards the use of high-performance single-crystal semiconductor devices for large-area and flexible electronics applications’.

#### Reference

1. H. Minemawari, T. Yamada, H. Matsui, J. Tsutsumi, S. Haas, R. Chiba, R. Kumai and T. Hasegawa, *Nature*, **475** (7356), 364–367 (2011) (21 July Issue).

### A Single Molecule of Water Encapsulated in Fullerene C<sub>60</sub>

Water normally exists in hydrogen-bonded environments, but a single molecule of H<sub>2</sub>O without any hydrogen bonds can be completely isolated within the confined subnano space inside fullerene, C<sub>60</sub>.

Here, Kurotobi and Murata<sup>1</sup> isolated bulk quantities of such a molecule by first synthesizing an open-cage C<sub>60</sub> derivative whose opening can be enlarged

in situ at 120°C that quantitatively encapsulated one water molecule under the high-pressure conditions. The relatively simple method was developed to close the cage and encapsulate water. The structure of  $\text{H}_2\text{O}@C_{60}$  was determined by single-crystal x-ray analysis, along with its physical and spectroscopic properties.

### Reference

1. K. Kurotobi and Y. Murata, *Science*, **333** (6042), 613–616 (2011) (29 July Issue).

### High-Performance Flat-Panel Solar Thermoelectric Generators with High Thermal Concentration.

The conversion of sunlight into electricity has been dominated by photovoltaic and solar thermal power generation. Photovoltaic cells are deployed widely, mostly as flat panels, whereas solar thermal electricity generation relying on optical concentrators and mechanical heat engines is only seen in large-scale power plants.

Here, Kraemer *et al.*<sup>1</sup> demonstrate a promising flat-panel solar thermal to electric power conversion technology based on the Seebeck effect and high thermal concentration, thus enabling wider applications. The developed solar thermoelectric generators (STEGs) achieved a peak efficiency of 4.6% under AM1.5G ( $1\text{kWm}^{-2}$ ) conditions. The efficiency is 7–8 times higher than the previously reported best value for a flat-panel STEG, and is enabled by the use of high-performance nano-structured thermoelectric materials (n/p-type  $\text{Bi}_2\text{Te}_3$ ) and spectrally-selective solar absorbers in an innovative design that exploits high thermal concentration in an evacuated environment. The authors state that, the ‘work opens up a promising new approach which has the potential to achieve cost-effective conversion of solar energy into electricity’.

### Reference

1. D. Kraemer, B. Poudel, H.–P. Feng, J. C. Caylor, B. Yu, X. Yan, Y. Ma, X. Wang, D. Wang, A. Muto, K. McEnaney, M. Chiesa, Z. Ren and G. Chen, *Nature Mater.*, **10** (7), 532–538 (2011).

### Link between Spin Fluctuations and Electron Pairing in Copper Oxide Superconductors

Although it is generally accepted that superconductivity is unconventional in the high-transition-temperature copper oxides, the relative importance of phenomena such as spin and charge (stripe) order, superconductivity fluctuations, proximity to a Mott insulator, a pseudogap phase and quantum criticality are still a matter of debate. In electron-doped copper oxides, the absence of an anomalous pseudogap phase in the under-doped region of the phase diagram and weaker electron correlations suggest that Mott physics and other unidentified competing orders are less relevant and that antiferromagnetic spin fluctuations are the dominant feature.

Here, Jin *et al.*<sup>1</sup> report a study of magnetotransport in thin films of the electron-doped copper oxide,  $(\text{La}_{2-x}\text{Ce}_x)\text{CuO}_4$ . They show that a scattering rate that is linearly dependent on temperature—a key feature of the anomalous normal state properties of the copper oxides—is correlated with the electron pairing. They also show that an envelope of such scattering surrounds the superconducting phase, surviving to zero temperature when superconductivity is suppressed by magnetic fields. Comparison with similar behaviour found in organic superconductors strongly suggests that the linear dependence on temperature of the resistivity in the electron-doped copper oxides is caused by spin-fluctuation scattering.

### Reference

1. K. Jin, N. P. Butch, K. Kirshenbaum, J. Paglione and R. L. Greene, *Nature*, **476** (7358), 73–75 (2011) (4 August Issue).

### Spectroscopic Observation of Dual Catalytic Sites During Oxidation of CO on a Au/TiO<sub>2</sub> Catalyst

The prevailing view of CO oxidation on gold-titanium oxide (Au/TiO<sub>2</sub>) catalysts is that the reaction occurs on metal sites at the Au/TiO<sub>2</sub> interface. Here, Green *et al.*<sup>1</sup> observed dual catalytic sites at the perimeter of 3-nm Au particles supported on TiO<sub>2</sub> during CO oxidation. Infrared-kinetic measurements indicate that O–O bond scission is activated by the formation of a (CO–O<sub>2</sub>) complex at dual Ti–Au sites at

the Au/TiO<sub>2</sub> interface. Density functional theory calculations, which provide the activation barriers for the formation and bond scission of the (CO—O<sub>2</sub>) complex, confirm this model as well as the measured apparent activation energy of 0.16 eV. The observation of sequential delivery and reaction of CO first from TiO<sub>2</sub> sites and then from Au sites indicates that catalytic activity occurs at the perimeter of Au nanoparticles.

#### Reference

1. I. X. Green, W. Tang, M. Neurock and J. T. Yates, Jr., *Science*, **333** (6043), 736–739 (2011) (5 August Issue).

### Perpendicular Switching of a Single Ferromagnetic Layer Induced by In-Plane Current Injection

Materials with large coercivity and perpendicular magnetic anisotropy represent the mainstay of data storage media, owing to their ability to retain a stable magnetization state over long periods of time and their amenability to miniaturization. However, the same anisotropy properties that make a material attractive for storage also make it hard to write to.

Here, Miron *et al.*<sup>1</sup> demonstrate switching of a perpendicularly magnetized cobalt dot driven by in-plane current injection at room temperature. Their device is composed of a thin cobalt layer with strong perpendicular anisotropy and Rashba interaction induced by asymmetric platinum and AlO<sub>x</sub> interface layers. The effective switching field is orthogonal to the direction of the magnetization and to the Rashba field. The authors' measurements indicate that the switching efficiency increases with the magnetic anisotropy of the cobalt layer and the oxidation of the Al-layer, which is uppermost, suggesting that the Rashba interaction has a key role in the reversal mechanism. To prove the potential of in-plane current switching for spintronic applications, the authors constructed a reprogrammable magnetic switch that can be integrated into non-volatile memory and logic architectures. This device is simple, scalable and compatible with present-day magnetic recording technology.

#### Reference

1. I. M. Miron, K. Garello, G. Gaudin, P.-J. Zermatten, M. V. Costache, S. Auffret, S. Bandiera, B. Rodmacq,

A. Schuhl and P. Gambardella, *Nature*, **476** (7359), 189–193 (2011) (11 Aug., Issue).

### A Synthetic Nickel Electrocatalyst with a Turnover Frequency Above 100,000 s<sup>-1</sup> for H<sub>2</sub> Production

Reduction of acids to molecular hydrogen as a means of storing energy is catalyzed by platinum, but its low abundance and high cost are problematic. Precisely controlled delivery of protons is critical in hydrogenase enzymes in nature that catalyze hydrogen (H<sub>2</sub>) production using earth-abundant metals (iron and nickel).

Here, Helm *et al.*<sup>1</sup> report that a synthetic nickel complex, [Ni(P<sub>2</sub><sup>Ph</sup>N<sup>Ph</sup>)<sub>2</sub>](BF<sub>4</sub>)<sub>2</sub>, (P<sub>2</sub><sup>Ph</sup>N<sup>Ph</sup> = 1,3,6-triphenyl-1-aza-3,6-diphosphacycloheptane), catalyzes the production of H<sub>2</sub> using protonated-dimethylformamide as the proton source, with turnover frequencies of 33,000 s<sup>-1</sup> in dry acetonitrile and 106,000 s<sup>-1</sup> in the presence of 1.2 M of water, at a potential of -1.13 V (vs ferrocenium/ferrocene couple). The authors state that, 'the mechanistic implications of these remarkably fast catalysts point to a key role of pendant amines that function as proton relays'.

#### Reference

1. M. L. Helm, M. P. Stewart, R. M. Bullock, M. R. Du Bois and D. L. Du Bois, *Science*, **333** (6044), 863–866 (2011) (12 Aug., Issue).

### Visualizing Individual Nitrogen Dopants in Monolayer Graphene

In monolayer graphene, substitutional doping during growth can be used to alter its electronic properties. Zhao *et al.*<sup>1</sup> used scanning tunneling microscopy, Raman spectroscopy, x-ray spectroscopy, and first principles calculations to characterize individual nitrogen dopants in monolayer graphene grown on a copper substrate. Individual nitrogen atoms were incorporated as graphitic dopants, and a fraction of the extra electron on each nitrogen atom was delocalized into the graphene lattice. The electronic structure of nitrogen-doped graphene was strongly modified only within a few lattice spacings of the site of the nitrogen dopant. The authors state that, 'these findings show

that chemical doping is a promising route to achieving high-quality graphene films with a large carrier concentration.'

## Reference

1. L. Zhao, R. He, K. T. Rim, T. Schiros, K. S. Kim, H. Zhou, C. Gutiérrez, S. P. Chockalingam, C. J. Arguello, L. Pálová, D. Nordlund, M. S. Hybertsen, D. R. Reichman, T. F. Heinz, P. Kim, A. Pinczuk, G. W. Flynn and A. N. Pasupathy, *Science*, **333** (6045), 999–1003 (2011) (19 Aug., Issue).

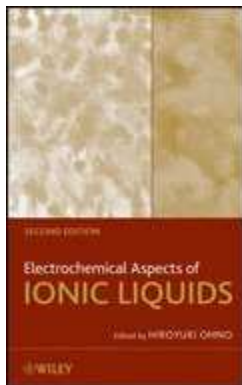
## Recent Books and Review Articles in the Area of Materials Science, Engineering and Technology

(Contributed by the Editor)

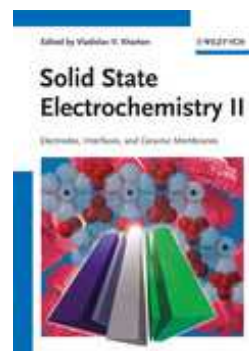
### Books

*Quantum Computing — A Gentle Introduction.* By Eleanor Rieffel and Wolfgang Polak. MIT Press, Cambridge, MA, 2011. Hardback. 388 pp. \$45, £33.95. ISBN 9780262015066.

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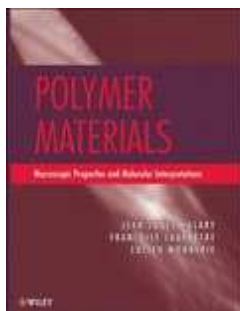
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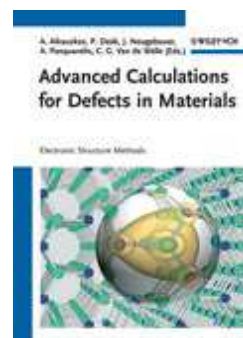
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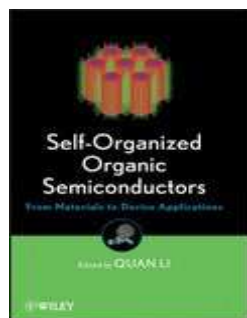
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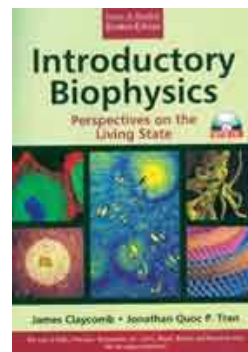
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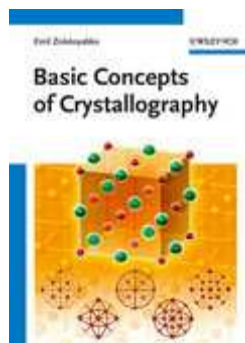


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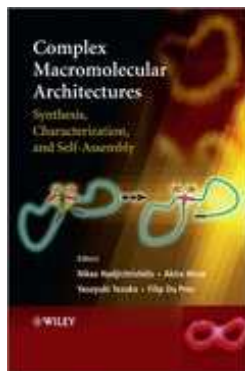
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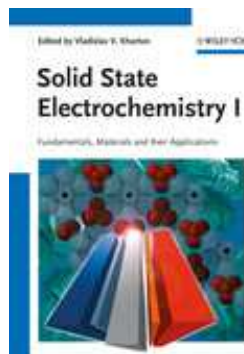
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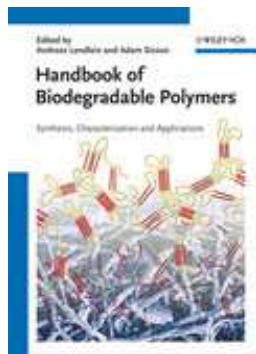
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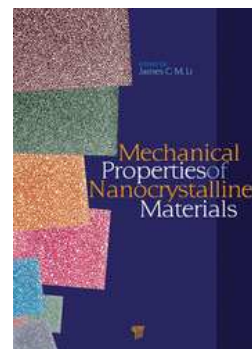
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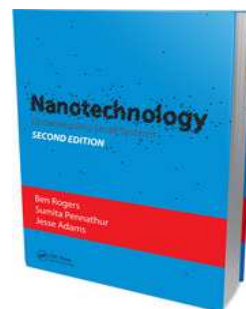
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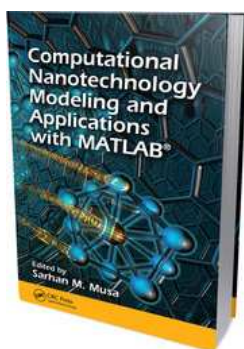


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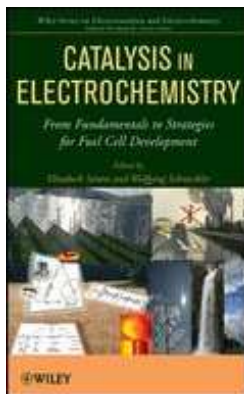
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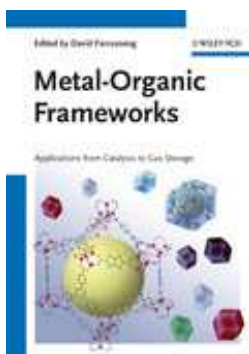
***Catalysis in Electrochemistry — From Fundamental Aspects to Strategies for Fuel Cell Development.***

Edited by Santos, Elizabeth/Schmickler, Wolfgang. Wiley-VCH, Weinheim.2011. Hardcover. 536 pp.. Euro 119. ISBN-10: 0-470-40690-9. ISBN-13: 978-0-470-40690-8, John Wiley & Sons.

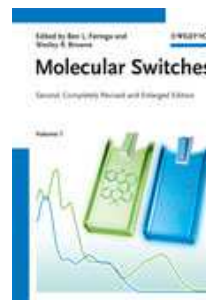


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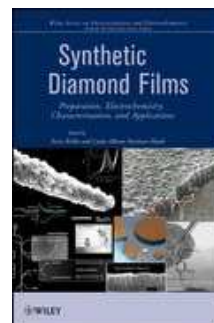


***Molecular Switches Second completely revised and enlarged Edition.*** Edited by Feringa, Ben L. /Browne, Wesley R. Wiley-VCH, Weinheim.2011. Hardcover. 792 pp. Euro 249. ISBN-10: 3-527-31365-6. ISBN-13: 978-3-527-31365-5, Wiley-VCH, Weinheim.



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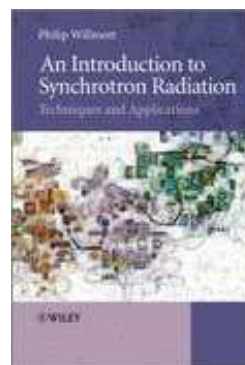
***Processing and Finishing of Polymeric Materials Two Volume Set.***

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*Applications of Biotechnology in Cardiovascular Therapeutics.* By Kewal K. Jain. Humana (Springer), New York, 2011. Hardcover. 378 pp. \$209. ISBN 9781617792397.

*An Introduction to Synchrotron Radiation — Techniques and Applications.* By Willmott, Philip. Wiley-VCH, Weinheim. 2011. Softcover. 368 pp. Euro 57.90. Hardcover. 368 pp. Euro 129. ISBN-10: 0-470-74578-9. ISBN-13: 978-0-470-74578-6, John Wiley & Sons. Hardcover: ISBN 978-0-470-74579-3.



## Review Articles

Palladium-based electrocatalysts for hydrogen oxidation and oxygen reduction reactions.

By M. Shao, *J. Power Sources*, **196** (5), 2433–2444 (2011).

### Abstract

Fuel cells, especially low temperature fuel cells are clean energy devices that are expected to help address the energy and environmental problems that have become prevalent in our society. Platinum-based electrocatalysts are usually used as the electrocatalysts for both the anode (hydrogen oxidation) and cathode (oxygen reduction) reactions. The high cost and limited resources of this precious metal hinder the commercialization of fuel cells. Recent efforts have focused on the discovery of palladium-based electrocatalysts with little or no platinum for hydrogen oxidation reaction (HOR) and oxygen reduction reaction (ORR).

This paper overviews the recent progress of electrocatalysis of palladium-based materials including both extended surfaces and nanostructured ones for HOR and ORR. The properties of CO and methanol tolerances of palladium-based electrocatalysts are also summarized. 142 References.

Dependence of open-circuit potential and power density on electrolyte thickness in solid oxide fuel cells with mixed conducting electrolytes. By K. L. Duncan, K.–T. Lee and

E. D. Wachsman, *J. Power Sources*, **196** (5), 2445–2451 (2011).

### Abstract

A continuum-level electrochemical model previously developed by the authors is used to investigate the dependence of open-circuit voltage (OCV), and maximum power density on electrolyte thickness for solid oxide fuel cells (SOFCs) with mixed conducting electrolytes. Experimental results confirm the models predictions that OCV decreases monotonically with decreasing electrolyte thickness due to increased permeation flux. The model was further extended to show that there exists an optimal electrolyte thickness at which maximum power density occurs for mixed conducting electrolytes. As expected, for electrolyte thickness greater than optimal, losses from ohmic overpotential reduce the cell output. However, when the electrolyte thickness is lower than optimal, losses from an increasing electronic “leakage” current reduces the cell output. 25 References.

Materials processing for lithium-ion batteries.

By J. Li, C. Daniel and D. Wood, *J. Power Sources*, **196** (5), 2452–2460 (2011).

### Abstract

Extensive efforts have been undertaken to develop and optimize new materials for lithium-ion batteries (LIBs)

to address power and energy demands of mobile electronics and electric vehicles. However, the introduction of large-format LIBs is hampered by high cost, safety concerns, and deficiencies in energy density and calendar life. Advanced materials-processing techniques can contribute solutions to such issues.

From that perspective, this work summarizes the materials-processing techniques used to fabricate the cathodes, anodes, and separators used in lithium-ion batteries. 197 References.

Carbon materials in composite bipolar plates for polymer electrolyte membrane fuel cells: A review of the main challenges to improve electrical performance. By R. A. Antunes, M. C. L. de Oliveira, G. Ett and V. Ett, *J. Power Sources*, **196** (6), 2945–2961 (2011).

#### Abstract

The technology of polymer electrolyte membrane (PEM) fuel cells is dependent on the performance of bipolar plates. There is a strong relationship between the material used in the manufacturing of the bipolar plate and its final properties. Graphite–polymer composite bipolar plates are well-established commercial products. Several other carbon based fillers are tested. Carbon nanotubes, carbon fibers, carbon black, graphite nanoplatelets and expanded graphite are examples of such materials. Structural characteristics of these particles such as morphology and size have decisive influence on the final properties of bipolar plates. Furthermore, the volumetric fraction of the filler is of prime importance. There is plenty of information on individual aspects of specific composite bipolar plates in the literature. Notwithstanding, the analysis of structure–property relationship of these materials in a comprehensive source is not found.

In this paper, relevant topics on the structural aspects of carbon based fillers and how they influence the final electrical performance of composite bipolar plates are discussed. It is intended that this document contribute to the development of new and maximized products to the PEM fuel cell industry. 130 References.

Structure and performance of  $\text{LiFePO}_4$  cathode materials: A review. By W.–J. Zhang, *J. Power Sources*, **196** (6), 2962–2970 (2011).

#### Abstract

$\text{LiFePO}_4$  has been considered a promising battery material in electric vehicles. However, there are still a number of technical challenges to overcome before its wide-spread applications.

In this article, the structure and electrochemical performance of  $\text{LiFePO}_4$  are reviewed in light of the major technical requirements for EV batteries. The rate capability, capacity density, cyclic life and low-temperature performance of various  $\text{LiFePO}_4$  materials are described. The major factors affecting these properties are discussed, which include particle size, doping, carbon coating, conductive carbon loading and synthesis techniques. Important future research for science and engineering is suggested. 162 References.

Computational design and optimization of fuel cells and fuel cell systems: A review.

By M. Secanell, J. Wishart and P. Dobson, *J. Power Sources*, **196** (8), 3690–3704 (2011).

#### Abstract

The design of fuel cells is a challenging endeavour due to the multitude of physical phenomena that need to be simultaneously optimized in order to achieve proper fuel cell operation. Fuel cell design is a multi-objective, multi-variable problem. In order to design fuel cells by computational design, a mathematical formulation of the design problem needs to be developed. The problem can then be solved using numerical optimization algorithms and a computational fuel cell model. In the past decade, the fuel cell community has gained momentum in the area of numerical design.

In this article, research aimed at using numerical optimization to design fuel cells and fuel cell systems is reviewed. The review discusses the strengths, limitations, advantages, and disadvantages of optimization formulations and numerical optimization algorithms, and insight obtained from previous studies. 117 References.

Overview of electrode materials in microbial fuel cells. By M. Zhou, M. Chi, J. Luo, H. He and T. Jin, *J. Power Sources*, **196** (10), 4427–4435 (2011).

#### Abstract

Electrode materials play an important role in the performance (e.g., power output) and cost of microbial fuel cells (MFCs), which use bacteria as the catalysts to oxidize organic (inorganic) matter and convert chemical energy into electricity.

In this paper, the recent progress of anode/cathode materials and filling materials as three-dimensional electrodes for MFCs has been systematically reviewed, resulting in comprehensive insights into the characteristics, options, modifications, and evaluations of the electrode materials and their effects on different actual wastewater treatment. Some existing problems of electrode materials in current MFCs are summarized, and outlooks for future development are also suggested. 87 References.

Lithium–oxygen batteries—Limiting factors that affect performance. By R. Padbury and X. Zhang, *J. Power Sources*, **196** (10), 4436–4444 (2011).

#### Abstract

Lithium–oxygen batteries have recently received attention due to their extremely high theoretical energy densities, which far exceed that of any other existing energy storage technology. This is due to the use of a pure lithium metal as anode and the fact that the cathode oxidant, oxygen, is stored externally since it can be readily obtained from the surrounding air. Before the lithium–oxygen batteries can be realized as high performance, commercially viable products, there are still many challenges to overcome, from designing their cathode structure, to optimizing their electrolyte compositions and elucidating the complex chemical reactions that occur during charge and discharge. The scientific obstacles that are related to the performance of the lithium–oxygen batteries open up an exciting opportunity for researchers from many different backgrounds to utilize their unique knowledge and skills

to bridge the knowledge gaps that exist in current research projects.

This article is a summary of the most significant limiting factors that affect the performance of the lithium–oxygen batteries from the perspective of the authors. The article indicates the relationships that form between various limiting factors and highlights the complex yet, captivating nature of the research within this field. 57 References.

An overview of graphene in energy production and storage applications. By D. A. C. Brownson, D. K. Kampouris and C. E. Banks, *J. Power Sources*, **196** (11), 4873–4885 (2011).

#### Abstract

Energy production and storage are both critical research domains where increasing demands for the improved performance of energy devices and the requirement for greener energy resources constitute immense research interest. Graphene has incurred intense interest since its freestanding form was isolated in 2004, and with the vast array of unique and highly desirable electrochemical properties it offers, comes the most promising prospects when implementation within areas of energy research is sought. We present a review of the current literature concerning the electrochemical application of graphene in energy storage/generation devices, starting with its use as a supercapacitor through to applications in batteries and fuel cells, depicting graphene's utilisation in this technologically important field. 77 References.

Electrospinning materials for energy-related applications and devices. By Z. Dong, S. J. Kennedy and Y. Wu, *J. Power Sources*, **196** (11), 4886–4904 (2011).

#### Abstract

The tasks of harvesting, transmitting, and storing the energy required to meet global demands are some of the most pressing needs we will face in the near future. Scientists are seeking new technologies to generate

renewable and clean energy resources. Nanofibrous materials with high surface areas and porosities have attracted significant attention in recent years and are considered to be promising candidates to address these critical issues. Nanofibers can be produced by many techniques. Of these, electrospinning is a particularly low cost and versatile method. This paper highlights research into the use of electrospinning to create materials suited for four major energy-related applications: (1) fuel cells, (2) dye-sensitized solar cells, (3) Li-ion batteries, and (4) supercapacitors. In addition, electrospun nanofibers used in other areas, such as thermoelectrical and piezoelectric materials, are also discussed. Specific attention is given to the material properties that have been achieved through electrospinning and what limitations of existing processes offer opportunities for future research. 211 References.

Recent trends and developments in polymer electrolyte membrane fuel cell modeling. By A. A. Shah, K. H. Luo, T. R. Ralph and F. C. Walsh, *Electrochim. Acta*, **56** (11), 3731–3757 (2011).

#### Abstract

Modelling and simulation are well-established tools for investigating the physical processes inside a polymer electrolyte membrane (PEM) fuel cell. The early literature paid great attention to steady-state transport phenomena in the main components, which continues to be a focus of ongoing activities. There is, on the other hand, a growing interest in modelling other aspects of fuel cell operation, such as transient performance and degradation phenomena. There has also been a growth in the number of molecular and pore-level studies of transport phenomena in fuel cell components, enabled by developments in simulation techniques and enhancements in computer hardware. Such approaches are capable of representing important small-scale phenomena more faithfully than traditional macroscopic models.

This review summarizes recent activity in PEM fuel cell modelling, with a focus on detailed physical models, and considers its potential significance. An industrial perspective is also provided, highlighting the

current use of modelling in the test and design cycles, and outlining future requirements. 323 References.

Intermetallic hydrides: A review with *ab initio* aspects. By S. F. Matar, *Progr. Solid State Chem.*, **38** (1–4), 1–37 (2010).

#### Abstract

The review aims to provide a coverage of different classes of intermetallic systems, which have the ability of absorbing hydrogen in different amounts, like binary and ternary Laves phases and Haucke-type intermetallics. Such intermetallic hydrides are attractive for applied research as potential candidates for on-board vehicular use (engines, batteries, etc.).

Focus is made here on the fundamental features regarding the physical and chemical properties obtained from the first-principles – *ab initio*, for a better understanding of the role played by inserted hydrogen. Beside establishing the equation of state, the binding energetics, the electronic band structure, the magneto-volume effects, the hyperfine field etc., the author endeavors answering the relevant question raised by solid state chemistry: “where are the electrons?”. This is approached through different schemes calling for a description of the chemical bonding, of the electron localization as well as the charge density mappings and the numerical Bader charge analysis scaling the ionic-covalence of hydrogen within the lattice. For the sake of a complete scope, the author extends the studies to characteristics regarding the valence state changes in cerium based hydrided phases and the magnetism (spin-only, spin-orbit coupling, magnetic order of the ground state) in hydrogen modified ternary uranium intermetallics. 104 References.

Hole and electron attractor model: An explanation of clustered states in manganites.

By R. Cortés-Gil, J. M. Alonso, J. M. Rojo, A. Hernando, M. Vallet-Regí, M. L. Ruiz-González and J. M. González-Calbet, *Progr. Solid State Chem.*, **38** (1–4), 38–45 (2010).

#### Abstract

A previously proposed model, based on the attractor role of doping cations, is extended to account for the electric and magnetic behavior on  $\text{La}_{1-x}\text{Ca}_x\text{MnO}_3$  manganites in the whole compositional range ( $0 < x < 1$ ). From this model, the spontaneous magnetization value is predicted quantitatively over the entire compositional range of the solid solution. By further including as basic parameters the tolerance factor and the band-width, the model is expanded to give an overall description of other  $\text{Ln}_{1-x}\text{T}_x\text{MnO}_3$  systems (Ln = lanthanide, T = alkaline-earth metal) with special emphasis in explaining the asymmetry and complexity of the magnetic phase diagrams. Those basic parameters are accounted for, in turn, by compositional variations,  $x$ , as well as by effects due to the different size of substitutional atoms. The model also sheds some light on the current issue of explaining the phase segregation and allowing the prediction of the spontaneous magnetization values in  $\text{Ln}_{1-x}\text{T}_x\text{MnO}_3$  systems. 72 References.

Piezoelectric films for high frequency ultrasonic transducers in biomedical applications. By Q. Zhou, S. Lau, D. Wu and K. K. Shung, *Progr. Mater. Sci.*, **56** (2), 139–174 (2011).

#### Abstract

Piezoelectric films have recently attracted considerable attention in the development of various sensor and actuator devices such as nonvolatile memories, tunable microwave circuits and ultrasound transducers.

In this paper, an overview of the state of art in piezoelectric films for high frequency transducer applications is presented. Firstly, the basic principles of piezoelectric materials and design considerations

for ultrasound transducers are introduced. Following this, the current status of the piezoelectric films and recent progress in the development of high frequency ultrasonic transducers are discussed. Then, details for preparation and structure of the materials derived from piezoelectric thick film technologies are described. Both chemical and physical methods are included in the discussion, namely, the sol–gel approach, aerosol technology and hydrothermal method. The electric and piezoelectric properties of the piezoelectric films, which are very important for transducer applications, such as permittivity and electromechanical coupling factor, are also addressed. Finally, the recent developments in the high frequency transducers and arrays with piezoelectric ZnO and PZT thick film using MEMS technology are presented. In addition, current problems and further direction of the piezoelectric films for very high frequency ultrasound application (up to GHz) are also discussed. 163 References.

ZnS nanostructures: From synthesis to applications. By X. Fang, T. Zhai, U. K. Gautam, L. Li, L. Wu, Y. Bando and D. Golberg, *Progr. Mater. Sci.*, **56** (2), 175–287 (2011).

#### Abstract

Zinc sulfide (ZnS) is one of the first semiconductors discovered. It has traditionally shown remarkable versatility and promise for novel fundamental properties and diverse applications. The nanoscale morphologies of ZnS have been proven to be one of the richest among all inorganic semiconductors.

In this article, the authors provide a comprehensive review of the state-of-the-art research activities related to ZnS nanostructures. They begin with a historical background of ZnS, description of its structure, chemical and electronic properties, and its unique advantages in specific potential applications. This is followed by in-detail discussions on the recent progress in the synthesis, analysis of novel properties and potential applications, with the focus on the critical experiments determining the electrical, chemical and physical parameters of the nanostructures, and the interplay between synthetic conditions and nanoscale

morphologies. Finally, the authors highlight the recent achievements regarding the improvement of ZnS novel properties and finding prospective applications, such as field emitters, field effect transistors (FETs), p-type conductors, catalyzators, UV-light sensors, chemical sensors (including gas sensors), biosensors, and nano-generators. Overall this review presents a systematic investigation of the ‘synthesis-property-application’ triangle for the diverse ZnS nanostructures. 469 References.

Proton exchange membranes for fuel cells operated at medium temperatures: Materials and experimental techniques.

By A.–C. Dupuis, *Progr. Mater. Sci.*, **56** (3), 289–327 (2011).

#### Abstract

This paper gives an overview of the different materials currently thought to be potential proton exchange membrane materials for fuel cells operated at medium temperatures (100–200°C). This includes perfluorosulfonic acid (PFSA) membranes like Nafion. The most frequently used experimental techniques to study the morphology of these membrane materials and their proton conduction mechanisms and water transport are reviewed.

The aim of this review is two-fold: to help scientists and science managers not yet in this field to easily gain an overview of the state-of-the-art membrane materials and the experimental techniques used to study them; and to give insight to scientists already carrying out research on membrane materials on how to extend their research either on other materials or with other experimental techniques. 263 References.

Atomic-level structure and structure–property relationship in metallic glasses.

By Y. Q. Cheng and E. Ma, *Progr. Mater. Sci.*, **56** (4), 379–473 (2011).

#### Abstract

The structure of metallic glasses (MGs) has been a long-standing mystery. On the one hand, MGs are

amorphous materials with no long-range structural order; on the other hand, topological and chemical short-to-medium range order is expected to be pronounced in these alloys, due to their high atomic packing density and the varying chemical affinity between the constituent elements. The unique internal structure of MGs underlies their interesting properties, which render MGs potentially useful for various applications. While more and more glass-forming alloys have been developed in recent years, fundamental knowledge on the structural aspect of MGs remains seriously lacking. For example, how atoms pack on the short-to-medium range, how the structure differs in different MGs and changes with composition, temperature, and processing history, and more importantly, how the structure influences the properties of MGs, are still unresolved questions.

In this paper, the authors review the tremendous efforts over the past 50 years devoted to unraveling the atomic-level structure of MGs and the structural origin of their unique behaviors. Emphasis was placed on the progress made in recent years, including advances in structural characterization and analysis of prototypical MGs, general structural models and fundamental principles, and the correlations of thermodynamic, kinetic, and mechanical properties with the MG structures. Some widely observed property–property correlations in MGs are also examined from the structural perspective. The insights summarized are shown to shed light on many intriguing behaviors of the MG-forming alloys and expected to impact the development of MGs. Outstanding questions in this important research area are also outlined. 475 References.

Functional Materials for Rechargeable Batteries. By F. Cheng, J. Liang, Z. Tao and J. Chen, *Adv. Mater.*, **23** (15), 1695–1715 (2011).

#### Abstract

There is an ever-growing demand for rechargeable batteries with reversible and efficient electrochemical energy storage and conversion. Rechargeable batteries cover applications in many fields, which include portable electronic consumer devices, electric vehicles,

and large-scale electricity storage in smart or intelligent grids. The performance of rechargeable batteries depends essentially on the thermodynamics and kinetics of the electrochemical reactions involved in the components (i.e., the anode, cathode, electrolyte, and separator) of the cells. During the past decade, extensive efforts have been dedicated to developing advanced batteries with large capacity, high energy and power density, high safety, long cycle life, fast response, and low cost. Here, recent progress in functional materials applied in the currently prevailing rechargeable lithium-ion, nickel-metal hydride, lead acid, vanadium redox flow, and sodium-sulfur batteries is reviewed. The focus is on research activities toward the ionic, atomic, or molecular diffusion and transport; electron transfer; surface/interface structure optimization; the regulation of the electrochemical reactions; and the key materials and devices for rechargeable batteries. 257 References.

**Nanostructured Organic and Hybrid Solar Cells.** By J. Weickert, R. B. Dunbar, H. C. Hesse, W. Wiedemann and L. Schmidt-Mende, *Adv. Mater.*, **23** (16), 1810–1828 (2011).

#### **Abstract**

This Report highlights recent developments in nanostructured organic and hybrid solar cells. The authors discuss novel approaches to control the film morphology in fully organic solar cells and the design of nanostructured hybrid solar cells. The motivation and recent results concerning fabrication and effects on device physics are emphasized. The aim of this review is not to give a summary of all recent results in organic and hybrid solar cells, but rather to focus on the fabrication, device physics, and light trapping properties of nanostructured organic and hybrid devices. 192 References.

**Hybrid Organic–Inorganic Light-Emitting Diodes.** By M. Sessolo and H. J. Bolink, *Adv. Mater.*, **23** (16), 1829–1845 (2011).

#### **Abstract**

The demonstration of colour tunability and high efficiency has brought organic light-emitting diodes (OLEDs) into the displays and lighting market. However, high production costs due to expensive deposition techniques and the use of reactive materials still limit their market entry, highlighting the need for novel concepts. This has driven the research towards the integration of both organic and inorganic materials into devices that benefit from their respective peculiar properties. The most representative example of this tendency is the application of metal oxides in organic optoelectronics. Metal oxides combine properties such as high transparency, good electrical conductivities, tuneable morphology, and the possibility of deposition on large areas with low-cost techniques. The use of metal oxides as charge injection interfaces in OLEDs has also been investigated. Hybrid organic–inorganic light-emitting diodes (HyLEDs) are inverted OLEDs that employ air-stable metal oxides as the charge injection contacts. They are emerging as a potential competitor to standard OLEDs, thanks to their intrinsic air stable electrodes and solution processability, which could result in low-cost, large area, light-emitting devices.

This article reviews the short history of this class of devices from its first solid state example published in 2006 to the present achievements. The data presented shed light on the electronic mechanism behind the functioning of HyLEDs and give guidelines for their further optimization. 156 References.

**Tailored Assembly of Carbon Nanotubes and Graphene.** By S. H. Lee, D. H. Lee, W. J. Lee and S. O. Kim, *Adv. Funct. Mater.*, **21** (8), 1338–1354 (2011).

#### **Abstract**

This Article reviews recent progress in the tailored assembly of carbon nanotubes (CNTs) and graphene into three-dimensional architectures with particular

emphasis on the authors' research employing self-assembly principles. CNTs and graphene can be assembled into macroporous films, hollow spherical capsules, or hollow nanotubes, via directed assembly from solvent dispersion.

This approach is cost-effective and beneficial for large-scale assembly, but pre-requests stable dispersion in a solvent medium. Directed growth from a nanopatterned catalyst array is another promising approach, which enables the control of morphology and properties of graphitic materials as well as their assembly. In addition, the aforementioned two approaches can be synergistically integrated to generate a carbon hybrid assembly consisting of vertical CNTs grown on flexible graphene films. Tailored assembly relying on scalable self-assembly principles offer viable routes that are scalable for mass production towards the ultimate utilization of graphitic carbon materials in nanoelectronics, displays, sensors, energy storage/conversion devices, and so on, including future flexible devices. 263 References.

Soft porous crystal meets TCNQ: charge transfer-type porous coordination polymers.  
By S. Shimomura and S. Kitagawa, *J. Mater Chem.*, **21** (15), 5537–5546 (2011).

#### Abstract

The significant progress of porous coordination polymers (or metal–organic frameworks) has been attracting the attention of a lot of scientists in various disciplines and encouraging their entry into this field. The synergy of diverse scientific senses brings further spread of the chemistry of porous coordination polymers. In this review, we introduced the recent developments in PCPs resulting from the hybridization with TCNQ chemistry. Electronic and structural diversities of TCNQ provide novel and advanced porous properties, when it is hybridized with a flexible nature of porous coordination polymers. 112 References.

Mesoporous silica nanoparticle based nano drug delivery systems: synthesis, controlled drug release and delivery, pharmacokinetics and biocompatibility. By Q. He and J. Shi, *J. Mater Chem.*, **21** (16), 5845–5855 (2011).

#### Abstract

The biomedical applications of mesoporous silica nanoparticles (MSNs) as efficient drug delivery carriers have attracted great attention in the last decade. The structure, morphology, size, and surface properties of MSNs have been found to be facilely tunable for the purposes of drug loading, controlled drug release and delivery, and multi-functionalization. Meanwhile, the biosafety and *in vivo* drug efficiency of MSN-based nano drug delivery systems (nano-DDSs), involving biocompatibility (including cytotoxicity, blood and tissue compatibility) and pharmacokinetics (including biodistribution, biodegradation, retention, excretion, blood circulation) are also drawing increasing attention because of their clinical application prospects.

Herein, the authors review the most recent research progresses on the synthesis, controlled drug release and delivery, pharmacokinetics and biocompatibility of MSNs. 108 References.

Adaptive DNA-based materials for switching, sensing, and logic devices.  
By M. J. Campolongo, J. S. Kahn, W. Cheng, D. Yang, T. Gupton-Campolongo and D. Luo, *J. Mater Chem.*, **21** (17), 6113–6121 (2011).

#### Abstract

DNA-based materials that can adapt to their surroundings are of great interest for the development of next-generation switching, sensing, and logic devices. Through elaborate sequence design and chemical functionalization, numerous adaptive DNA-based materials have been developed that can reversibly switch conformations, act as dynamic sensors, perform logic operations, and even trigger macroscopic phase responses. 108 References.

Templated-assisted one-dimensional silica nanotubes: synthesis and applications.

By X. Yang, H. Tang, K. Cao, H. Song, W. Sheng and Q. Wu, *J. Mater Chem.*, **21** (17), 6122–6135 (2011).

#### Abstract

Silica (SiO<sub>2</sub>) is one of the most frequently used inorganic materials. This review covers the research progress in the synthesis of one-dimensional silica nanotubes as well as the newest aspects of silica nanotubes in applications where their structural attributes are exploited.

The synthetic methods for well-defined silica nanotubes and a variety of specific silica nanotubes including hollow silica nanotubes, mesoporous silica nanotubes, chiral or helical silica nanotubes are summarized. One-dimensional tubular silica nanomaterials display structures that differ from those of other kinds of nanostructured silica materials and provide unique features such as very uniform diameter, open at both ends. In addition, sol–gel process and silane chemistry offer the reliable and robust surface modification or functionalization of silica nanotubes. Attractively, end functionalization of silica nanotubes may be able to control drug release, resulting in their wide applications in controlled drug and gene delivery; also their distinctive inner and outer surfaces can be differentially functionalized making silica nanotubes ideal multifunctional nanostructure candidates for biomedical applications in various areas such as biosensing, bioseparation and biocatalysis. 125 References.

Metamaterials: constitutive parameters, performance, and chemical methods for realization. By H. Chen, *J. Mater Chem.*, **21** (18), 6452–6463 (2011).

#### Abstract

Electromagnetic metamaterials are artificial materials composed of subwavelength structures to provide unusual effective macroscopic behavior not found in nature. These materials are characterized by constitutive relations which contain a maximum of 36 complex constitutive parameters. With different combinations

of positive and negative parameters in the constitutive tensors, striking phenomena and novel applications were discovered.

In this Article, the author briefly reviews the experimental progress in the metamaterial, focusing on their constitutive parameters and material performance, *e.g.* the bandwidth, the loss, and the electrical size with respect to the operating wavelength, *etc.* The two fabrication approaches: the structure approach that is widely used to construct periodic metamaterial structures, and the chemical approach that is very promising in constructing nano-scaled metamaterial with randomized patterns, are discussed. The practical potential of this field and the possible challenging future work are pointed out in the conclusion. 125 References.

Applications of pair distribution function methods to contemporary problems in materials chemistry. By C. A. Young and A. L. Goodwin, *J. Mater Chem.*, **21** (18), 6464–6476 (2011).

#### Abstract

Over the past five years, the use of pair distribution function (PDF) methods to study local structure has become increasingly prominent in the mainstream materials chemistry literature. Because the technique is sensitive not only to the average (long-range) material structure but also to any local distortions away from the average structure, PDF measurements provide a valuable means of studying local structure in a way that is inherently consistent with traditional crystallographic refinement.

In this article, the authors review the ways in which PDF methods are being used to determine local structure–property relationships in a range of materials of particular currency within the materials chemistry community. 121 References.

Hierarchically structured photoelectrodes for dye-sensitized solar cells. By Q. Zhang and G. Cao, *J. Mater Chem.*, **21** (19), 6769–6774 (2011).

#### Abstract

This article highlights several significant achievements in dye-sensitized solar cells using hierarchically structured photoelectrodes that consist of spherical or one-dimensional assemblies of ZnO or TiO<sub>2</sub> nanocrystallites. It shows that, besides providing a large surface area for dye adsorption, more importantly, the hierarchically structured photoelectrodes may improve the solar cell's performance by imparting extra functions, such as (1) generating light scattering owing to the size of assemblies being comparable to the wavelengths of the incident light, (2) enhancing electron transport due to the compact packing of the nanocrystallites that form the assemblies, and (3) facilitating electrolyte diffusion as a result of the relatively open structure of the photoelectrode films composed of spherical or one-dimensional assemblies. 30 References.

Nanoscale helices from inorganic materials. By M. Yang and N. A. Kotov, *J. Mater Chem.*, **21** (19), 6775–6792 (2011).

#### Abstract

Helical structures with their unique topology have attracted broad attention during the past decade. Rotational symmetry, chirality, and unusual mechanical properties are just a few attributes associated with helical geometry that make it special for materials science. Typically helical geometry was the domain of biological systems which provided in the past amazing examples of their structural diversity. Nowadays, the effective synthesis strategy allows the production of various inorganic helical structures and the recent development of nanotechnology provides additional possibilities to control helical structures at different scales reaching, in fact even greater diversity than those seen in biology.

Understanding what kind of helical inorganic nanoscale materials are available and why different

kinds of inorganic helices exist are the two fundamental topics of this review. Surveying this information sheds light on the possibilities for materials using new helical structures and provides general principles for their preparation. Necessary improvements and further developments of their synthetic protocols, structural features, and properties are also indicated. 148 References.

Catalysis opportunities of atomically precise gold nanoclusters. By Y. Zhu, H. Qian and R. Jin, *J. Mater Chem.*, **21** (19), 6793–6799 (2011).

#### Abstract

Nanogold has been found to be an effective catalyst for many chemical reactions. However, mechanistic studies have thus far only met with limited success, largely due to the unavailability of well-defined catalysts. The authors are motivated to create atomically precise gold (Au) nanoclusters in the hope of unraveling some fundamental aspects of nanogold catalysis.

In this article, the authors summarize recent works on the catalytic promise of a new class of materials: ultra-small (<2 nm), semiconducting Au nanoclusters protected by thiolates, referred to as Au<sub>n</sub>(SR)<sub>m</sub>, where *n* and *m* represent the number of gold atoms and thiolate ligands, respectively. The recent research is focused on the synthesis and structural determination of atomically precise Au<sub>n</sub>(SR)<sub>m</sub> nanoclusters as well as exploring their catalytic properties. The correlation of the X-ray crystal structures of the Au<sub>n</sub>(SR)<sub>m</sub> nanoclusters with their catalytic properties will ultimately permit a deep understanding of the origin of nanogold catalysis and will also benefit the future design of new catalysts with high selectivity and activity. 82 References.

Materials for central nervous system regeneration: bioactive cues. By C. Gumera, B. Rauck and Y. Wang, *J. Mater Chem.*, **21** (20), 7033–7051 (2011).

#### Abstract

Current clinical therapies have limited capacity to restore function in damaged nerves. Regeneration of axons in the injured central nervous system is inhibited by the presence of both physical and mechanical barriers. As such, neural tissue engineering strategies have received considerable attention in recent years. Materials-based approaches offer a way to blend synthetic and biological components in order to generate environments conducive to neural regeneration. While biomaterials themselves can facilitate regeneration simply by providing a substrate for cell growth, incorporation of “bioactive cues”—or molecules which interact with cells to elicit a specific response—has become increasingly necessary in order to promote nerve regeneration.

This review attempts to outline the various biomaterials that are promising for central nerve applications, and discusses the array of bioactive cues that are valuable in promoting nerve repair. 233 References.

Synthesis of high-reactive facets dominated anatase TiO<sub>2</sub>. By C. Z. Wen, H. B. Jiang, S. Z. Qiao, H. G. Yang and G. Q. (Max) Lu, *J. Mater Chem.*, **21** (20), 7052–7061 (2011).

#### Abstract

As an important metal oxide, anatase titanium dioxide (TiO<sub>2</sub>) has been widely investigated because of its many promising properties for catalysis and photocatalysis. The properties of anatase -TiO<sub>2</sub> crystals are largely determined by external surfaces exposed. Many efforts have been made to improve the percentage of high-reactive facets like {001} facets of anatase- TiO<sub>2</sub> to enhance its catalytic properties.

This review reports the recent progress in designing and fabricating high-reactive facets dominated anatase-TiO<sub>2</sub> via various strategies including traditional vapor phase epitaxial processes, hydrothermal/solvothermal methods, non-hydrolytic alcoholysis methods and high

temperature gas phase reactions. Furthermore, focusing on the (001) surface, the article also covers advances in the theoretic simulations of various high-reactive facets of anatase- TiO<sub>2</sub> crystals. Finally, a summary and some perspectives on the challenges and new directions for future research in this emerging frontier are presented. 88 References.

Copper nanoparticles synthesized by hydroxyl ion assisted alcohol reduction for conducting ink. By J. L. C. Huaman, K. Sato, S. Kurita, T. Matsumoto and B. Jeyadevan, *J. Mater Chem.*, **21** (20), 7062–7069 (2011).

#### Abstract

A hydroxyl ion assisted alcohol reduction method has been applied for the preparation of copper nanoparticles with an average diameter of 10.5 nm and narrow size distribution. The addition of specific amounts of hydroxyl ions to the alcoholic solution is the key to enhance the reducing potential of alcohols to obtain metal copper from their salts even with 1-butanol. The synthesis of copper metal was realized through intermediate steps corresponding to the formation of copper oxides (CuO and Cu<sub>2</sub>O). The obtained nanoparticles were coated with necessary surfactants and dispersed in organic solvent such as dodecane to prepare conducting ink. Samples annealed at 250<sup>circ</sup>C in nitrogen and vacuum atmosphere showed electrical resistivity of 26 and 35 μΩ cm, respectively. 41 References.

Organic Charge-transfer Salts and the Component Molecules in Organic Transistors. By T. Mori, *Chem Lett.*, **40** (5), 428–434 (2011).

#### Abstract

Electron donors and acceptors such as tetrathiafulvalene (TTF) and tetracyanoquinodimethane (TCNQ), respectively which have been long known as components of organic metals, act as p- and n-channel organic semiconductors in organic field-effect transistors. High performance, good thin-film properties, and long-term

stability have been achieved on the basis of appropriate molecular design. In addition, their charge-transfer complexes work as the active layers as well as conducting electrode materials showing low contact resistance. 77 References.

Comparing Photosynthetic and Photovoltaic Efficiencies and Recognizing the Potential for Improvement. By R. E. Blankenship, D. M. Tiede, J. Barber, G. W. Brudvig, G. Fleming, M. Ghirardi, M. R. Gunner, W. Junge, D. M. Kramer, A. Melis, T. A. Moore, C. C. Moser, D. G. Nocera, A. J. Nozik, D. R. Ort, W. W. Parson, R. C. Prince and R. T. Sayre, *Science*, **332** (6031), 805–809 (2011).

#### Abstract

Comparing photosynthetic and photovoltaic efficiencies is not a simple issue. Although both processes harvest the energy in sunlight, they operate in distinctly different ways and produce different types of products: biomass or chemical fuels in the case of natural photosynthesis and non-stored electrical current in the case of photovoltaics.

In order to find common ground for evaluating energy-conversion efficiency, the authors compare natural photosynthesis with present technologies for photovoltaic-driven electrolysis of water to produce hydrogen. Photovoltaic-driven electrolysis is the more efficient process when measured on an annual basis, yet short-term yields for photosynthetic conversion under optimal conditions come within a factor of 2 or 3 of the photovoltaic benchmark. The authors consider opportunities in which the frontiers of synthetic biology might be used to enhance natural photosynthesis for improved solar energy conversion efficiency. 67 References.

Ultrasonic Cavitation at Solid Surfaces.

By D. G. Shchukin, E. Skorb, V. Belova and H. Möhwald, *Adv. Mater.*, **23** (17), 1922–1934 (2011).

#### Abstract

In spite of the great potential of applying high-intensity ultrasound, which enables high-temperature and high-pressure chemistry with a reactor near room temperature and ambient pressure, sonochemistry at solid surfaces is at a weak stage of understanding with regards to the development of new materials and composite nanostructures. The science towards a quantitative understanding is only now emerging. On the other hand, in many applications an ultrasonic bath is used without thinking of the mechanism. Often surfaces are exposed to ultrasound for cleaning. Since ultrasonic treatment is not an exotic process and applicable even on large scale in industrial manufacturing, controlling the process may lead to new applications making use of the specially designed surface.

This review is intended to summarize recent progress in this field and to point out most promising directions of ultrasound application for the development of new materials with functional surfaces. 76 References.

Paper Electronics. By D. Tobjörk and R. Österbacka, *Adv. Mater.*, **23** (17), 1935–1961 (2011).

#### Abstract

Paper is ubiquitous in everyday life and a truly low-cost substrate. The use of paper substrates could be extended even further, if electronic applications would be applied next to or below the printed graphics. However, applying electronics on paper is challenging. The paper surface is not only very rough compared to plastics, but is also porous. While this is detrimental for most electronic devices manufactured directly onto paper substrates, there are also approaches that are compatible with the rough and absorptive paper surface.

In this review, recent advances and possibilities of these approaches are evaluated and the limitations of

paper electronics are discussed. 230 References.

Design Rules for Phase-Change Materials in Data Storage Applications. By D. Lencer, M. Salinga and M. Wuttig, *Adv. Mater.*, **23** (18), 2030–2058 (2011).

#### Abstract

Phase-change materials can rapidly and reversibly be switched between an amorphous and a crystalline phase. Since both phases are characterized by very different optical and electrical properties, these materials can be employed for rewritable optical and electrical data storage. Hence, there are considerable efforts to identify suitable materials, and to optimize them with respect to specific applications. Design rules that can explain why the materials identified so far enable phase-change based devices would hence be very beneficial.

This article describes materials that have been successfully employed and discusses common features regarding both typical structures and bonding mechanisms. It is shown that typical structural motifs and electronic properties can be found in the crystalline state that are indicative for resonant bonding, from which the employed contrast originates. The occurrence of resonance is linked to the composition, thus providing a design rule for phase-change materials. This understanding helps to unravel characteristic properties such as electrical and thermal conductivity which are discussed in the subsequent section. Then, turning to the transition kinetics between the phases, the current understanding and modeling of the processes of amorphisation and crystallization are discussed. Finally, present approaches for improved high-capacity optical discs and fast non-volatile electrical memories, that hold the potential to succeed present-day's Flash memory, are presented. 203 References.

An Emerging Pore-Making Strategy: Confined Swelling-Induced Pore Generation in Block Copolymer Materials. By Y. Wang and F. Li, *Adv. Mater.*, **23** (19), 2134–2148 (2011).

#### Abstract

Block copolymers (BCPs) composed of two or more thermodynamically incompatible homopolymers self-assemble into periodic microdomains. Exposing self-assembled BCPs with solvents selective to one block causes a swelling of the domains composed of this block. Strong swelling in the confinement imposed by the matrix of the other glassy block leads to well-defined porous structures via morphology reconstruction. This confined swelling-induced pore-making process has emerged recently as a new strategy to produce porous materials due to synergic advantages that include extreme simplicity, high pore regularity, involvement of no chemical reactions, no weight loss, reversibility of the pore forming process, etc.

The mechanism, kinetics, morphology, and governing parameters of the confined swelling-induced pore-making process in BCP thin films are discussed, and the main applications of nanoporous thin films in the fields of template synthesis, surface patterning, and guidance for the areal arrangements of nanomaterials and biomolecules are summarized. Recent, promising results of extending this mechanism to produce BCP nanofibers or nanotubes and bulk materials with well-defined porosity, which makes this strategy also attractive to researchers outside the nanocommunity, are also presented. 89 References.

Photocontrollable Liquid-Crystalline Actuators. By H. Yu and T. Ikeda, *Adv. Mater.*, **23** (19), 2149–2180 (2011).

#### Abstract

Coupling photochromic molecules with liquid crystalline (LC) materials enables one to reversibly photocontrol unique LC features such as phase transition, photoalignment, and molecular cooperative motion. LC elastomers show photomechanical and photomobile properties, directly converting light energy into

mechanical energy. In well-defined LC block copolymers, regular patternings of nanostructures in macroscopic scales are fabricated by photo-manipulation of LC actuators. 208 References.

Spin-Driven Ferroelectricity and Magneto-Electric Effects in Frustrated Magnetic Systems. By T.–H. Arima, *J. Phys. Soc. Jpn.*, **80** (5), 052001–14 (2011).

#### Abstract

The interplay between magnetism and electricity in matter has become a central issue of condensed-matter physics. This review focuses on the ferroelectricity induced by magnetic order mostly in frustrated magnets, which is nowadays referred to as magneto-electric (ME) multiferroic, or often only as multiferroic. Some distinct types of microscopic origins relevant to the spin-driven ferroelectricity are discussed in detail. Then one sees that the frustration-based spin-driven ferroelectrics can exhibit nonlinear and giant ME responses of phase-transition type and of domain-control type, in contrast to the conventional magneto-electrics hosting linear ME effects. 91 References.

Hybrid Colloidal Heterostructures of Anisotropic Semiconductor Nanocrystals Decorated with Noble Metals: Synthesis and Function. By A. Vaneski, A. S. Susa, J. Rodríguez-Fernández, M. Berr, F. Jackel, J. Feldmann and A. L. Rogach, *Adv. Funct. Mater.*, **21** (9), 1547–1556 (2011).

#### Abstract

This Article offers an overview of hybrid colloidal heterostructures of anisotropic semiconductor nanocrystals decorated with metals; primarily gold and platinum. The nonspherical shapes of the semiconductor components create a great variety of metal-decorated hybrid nanostructures, whose synthesis and morphology are considered here. Due to the current interest in photocatalytic systems able to utilize solar energy for water-splitting, the use of Pt-decorated CdS-based nanorods for hydrogen

generation is specifically addressed. Great flexibility of the colloidal synthesis leading to well-defined hybrid semiconductor–metal nanostructures drastically increases the possibility of their integration into functional nanosystems with novel synergetic properties, making them promising candidates for a variety of photovoltaic, catalytic, and sensing applications. 74 References.

Biomaterials that Regulate Growth Factor Activity via Bioinspired Interactions.

By G. A. Hudalla and W. L. Murphy, *Adv. Funct. Mater.*, **21** (10), 1754–1768 (2011).

#### Abstract

Growth factor activity is localized within the natural extracellular matrix (ECM) by specific noncovalent interactions with core ECM biomolecules, such as proteins and proteoglycans. Recently, these interactions inspired the development of synthetic biomaterials that can noncovalently regulate growth factor activity for tissue-engineering applications. For example, biomaterials covalently or noncovalently modified with heparin glycosaminoglycans (GAGs) can augment growth factor-release strategies. In addition, recent studies demonstrate that biomaterials modified with heparin-binding peptides can sequester cell-secreted heparin proteoglycans and, in turn, sequester growth factors and regulate stem cell behavior. Another set of studies shows that modular versions of growth factor molecules can be designed to interact with specific components of natural and synthetic ECMs, including collagen and hydroxyapatite. In addition, layer-by-layer assemblies of GAGs and other natural polyelectrolytes retain growth factors at a cell/material interface via specific noncovalent interactions.

This Article provides a detailed overview of the various bio-inspired strategies that are used to noncovalently localize growth factor activity within biomaterials, and will highlight in vivo examples of the efficacy of these materials to promote tissue regeneration. 161 References.

Zeolites — From curiosity to cornerstone.  
By A. F. Masters and T. Maschmeyer,  
*Microporous & Mesoporous. Mater.*, **142**  
(2–3), 423–438 (2011).

#### Abstract

The term ‘zeolite’ was first coined about 250 years ago by Cronstedt. However, the field of zeolite chemistry lay almost dormant for some nineteen decades thereafter, until the discovery of synthetic zeolites by Barrer and Milton – one of the pivotal episodes that made zeolites into a technological cornerstone of our age. The story is as fascinating as it is complex. In particular, the historical perspective, regarding some of the key events, might not always be easily accessible to younger researchers or students just starting out in the field.

Therefore, here, the authors try and offer a balanced, but necessarily selective and personal overview of the context and motivation(s) behind many of the defining episodes in that transformation of zeolites from ‘curiosity to cornerstone’ up until the mid-1980s, citing a selection of the major scientific/technical works as appropriate to offer the detail where required. They do not aim to provide a comprehensive scientific review, but instead aim to develop some of the historical aspects of zeolite discovery and the interconnections that exist between these discoveries and their protagonists, so as to showcase the fascination that was and still is inherent to the field. 289 References.

Hierarchical Mesoporous Films: From Self-Assembly to Porosity with Different Length Scales. By P. Innocenzi, L. Malfatti and G. J. A. A. Soler-Illia, *Chem. Mater.*, **23** (10), 2501–2509 (2011).

#### Abstract

Hierarchical porous films are formed by interconnected pores of different dimensions, and are particularly attractive for the development of smart materials with multiple functions and enhanced transport properties. This review focuses on hierarchical porous films whose synthesis, at least at one scale of porosity, is based on self-assembly. Several strategies have been proposed

for the preparation of hierarchical porous films which for bulks and monoliths are more difficult to obtain. These materials represent a step further in the fabrication of complex materials through self-assembly, and achieving order through templating routes at different length scales is the ultimate goal. 67 References.

A review on prognostics and health monitoring of Li-ion battery. By J. Zhang and J. Lee, *J. Power Sources*, **196** (15), 6007–6014 (2011).

#### Abstract

The functionality and reliability of Li-ion batteries (LIBs) as major energy storage devices have received more and more attention from a wide spectrum of stakeholders, including federal/state policymakers, business leaders, technical researchers, environmental groups and the general public. Failures of LIB not only result in serious inconvenience and enormous replacement/repair costs, but also risk catastrophic consequences such as explosion due to overheating and short circuiting. In order to prevent severe failures from occurring, and to optimize LIB- maintenance schedules, breakthroughs in prognostics and health monitoring of LIBs, with an emphasis on fault detection, correction and remaining-useful-life prediction, must be achieved.

This paper reviews various aspects of recent research and developments in LIB prognostics and health monitoring, and summarizes the techniques, algorithms and models used for state-of-charge (SOC) estimation, current/voltage estimation, capacity estimation and remaining-useful-life (RUL) prediction. 43 References.

Responsive Photonic Crystals. By J. Ge and Y. Yin, *Angew. Chem. Int. Ed.*, **50** (7), 1492–1522 (2011).

#### Abstract

This review summarizes recent developments in the field of responsive photonic crystal structures, including principles for design and fabrication and many strategies for applications, for example, as optical

switches or chemical and biological sensors.

A number of fabrication methods are now available to realize responsive photonic structures, the majority of which rely on self-assembly processes to achieve ordering. Compared with microfabrication techniques, self-assembly approaches have lower processing costs and higher production efficiency; however, major efforts are still needed to further develop such approaches. In fact, some emerging techniques such as spin coating, magnetic assembly, and flow-induced self-assembly have already shown great promise in overcoming current challenges. When designing new systems with improved performance, it is always helpful to bear in mind the lessons learnt from natural photonic structures.

#### PEGylated Inorganic Nanoparticles.

By A. S. Karakoti, S. Das, S. Thevuthasan and S. Seal, *Angew. Chem. Int. Ed.*, **50** (9), 1980–1994 (2011).

#### Abstract

Application of inorganic nanoparticles in diagnosis and therapy has become a critical component in the targeted treatment of diseases. The surface modification of inorganic oxides is important for providing diversity in size, shape, solubility, long-term stability, and attachment of selective functional groups.

This review describes the role of polyethylene glycol (PEG) in the surface modification of oxides and focuses on their biomedical applications. Such a PEGylation of surfaces provides “stealth” characteristics to nanomaterials otherwise identified as foreign materials by human body. The role of PEG as structure-directing agent in synthesis of oxides is also presented.

#### TiO<sub>2</sub> Nanotubes: Synthesis and Applications.

By P. Roy, S. Berger and P. Schmuki, *Angew. Chem. Int. Ed.*, **50** (13), 2904–2939 (2011).

#### Abstract

TiO<sub>2</sub> is one of the most studied compounds in materials science. Owing to some outstanding properties it is used for instance in photocatalysis, dye-sensitized

solar cells, and biomedical devices. In 1999, first reports showed the feasibility to grow highly ordered arrays of TiO<sub>2</sub> nanotubes by a simple but optimized electrochemical anodization of a titanium metal sheet. This finding stimulated intense research activities that focused on growth, modification, properties, and applications of these one-dimensional nanostructures.

This review attempts to cover all these aspects, including underlying principles and key functional features of TiO<sub>2</sub>, in a comprehensive way and also indicates potential future directions of the field.

J-Aggregates: From Serendipitous Discovery to Supramolecular Engineering of Functional Dye Materials. By F. Würthner, T. E. Kaiser and C. R. Saha-Möller, *Angew. Chem. Int. Ed.*, **50** (15), 3376–3410 (2011).

#### Abstract

J-aggregates are of significant interest for organic materials conceived by supramolecular approaches. Their discovery in the 1930s represents one of the most important milestones in dye chemistry as well as the germination of supramolecular chemistry. The intriguing optical properties of J-aggregates (in particular, very narrow red-shifted absorption bands with respect to those of the monomer and their ability to delocalize and migrate excitons) as well as their prospect for applications have motivated scientists to become involved in this field, and numerous contributions have been published.

This review provides an overview on the J-aggregates of a broad variety of dyes (including cyanines, porphyrins, phthalocyanines, and perylene bisimides) created by using supramolecular construction principles, and discusses their optical and photophysical properties as well as their potential applications. Thus, this review is intended to be of interest to the supramolecular, photochemistry, and materials science communities.

From the Surface to Volume: Concepts for the Next Generation of Optical–Holographic Data-Storage Materials. By F.–K. Bruder, R. Hagen, T. Rölle, M.–S. Weiser and T. Fäcke, *Angew. Chem. Int. Ed.*, **50** (20), 4552–4573 (2011).

#### Abstract

Optical data storage has had a major impact on daily life since its introduction to the market in 1982. Compact discs (CDs), digital versatile discs (DVDs), and Blu-ray discs (BDs) are universal data-storage formats with the advantage that the reading and writing of the digital data does not require contact and is therefore wear-free. These formats allow convenient and fast data access, high transfer rates, and electricity-free data storage with low overall archiving costs. The driving force for development in this area is the constant need for increased data-storage capacity and transfer rate. The use of holographic principles for optical data storage is an elegant way to increase the storage capacity and the transfer rate, because by this technique the data can be stored in the volume of the storage material and, moreover, it can be optically processed in parallel.

This Review describes the fundamental requirements for holographic data-storage materials and compares the general concepts for the materials used. An overview of the performance of current read–write devices shows how far holographic data storage has already been developed.

Synthesis and self-assembly of complex hollow materials. By H. C. Zeng, *J. Mater. Chem.*, **21** (21), 7511–7526 (2011).

#### Abstract

Hollow materials with interiors or voids and pores are a class of lightweight nanostructured matters that promise many future technological applications, and they have received significant research attention in recent years. On the basis of well-known physicochemical phenomena and principles, for example, several solution-based protocols have been developed for the general preparation of these complex materials under mild reaction conditions.

This article is a short introductory review on the synthetic aspects of this field of development. The synthetic methodologies can be broadly divided into three major categories: (i) template-assisted synthesis, (ii) self-assembly with primary building blocks, and (iii) induced matter relocations. In most cases, both synthesis and self-assembly are involved in the above processes. Further combinations of these methodologies appear to be very important, as they will allow one to prepare functional materials at a higher level of complexity and precision. The synthetic strategies are introduced through some simple case studies with schematic illustrations. Salient features of the methods developed have been summarized, and some urgent issues of this field have also been indicated. 162 References.

Noncovalent assembly of carbon nanotube-inorganic hybrids. By X. Li, Y. Qin, S. T. Picraux and Z.–X. Guo, *J. Mater. Chem.*, **21** (21), 7527–7547 (2011).

#### Abstract

The combination of carbon nanotubes (CNTs) with inorganic nanostructures is believed to be a powerful tool for constructing novel organic-inorganic hybrid architectures with desirable functionalities and applications in many fields ranging from energy storage and conversion, to catalysis, sensing, and medical diagnosis and treatment. Due to the chemically inert graphitic surface of the CNT, different assembly protocols for building functional CNT-inorganic hybrids, including covalent and noncovalent routes, have been designed and demonstrated. A better understanding of the chemistry associated with the hybrid assembly holds a key to rational manipulation of the hybrid properties.

This critical review discusses nondestructive-noncovalent-assembly methodologies for constructing diverse CNT-inorganic hybrid materials and provides the latest advances in this field. Particular focus is given to the noncovalent assembly *via* functional linking molecules which play pivotal roles in the control of morphology, composition, structure, interface, and thus properties of the hybrid materials. 117 References.

The renaissance of unsupported nanostructured catalysts for low-temperature fuel cells: from the size to the shape of metal nanostructures. By E. Antolini and J. Perez, *J. Mater. Sci.*, **46** (13), 4435–4457 (2011).

#### Abstract

A resurgence of interest in unsupported catalysts, commonly nanostructured Pt or Pt-based catalysts, for use in low-temperature fuel cells has occurred in recent years: indeed, the use of unsupported nanostructured catalysts may provide improved long-term stability during fuel cell operation compared to the carbon-supported catalysts because the carbon corrosion issue is eliminated. Catalyst utilization can be increased by developing novel nanostructures with high surface area and/or high catalytic activity. Indeed, in recent years, the strategy to increase the catalyst utilization has gone from decreasing the nanoparticle size to tailoring new nanostructures. This work presents an overview of recent studies on novel metal nanostructures for their possible use in low-temperature fuel cells, highlighting that these materials can better perform than the commonly utilized carbon-supported catalysts at similar catalyst loadings, having at the same time a higher stability. 123 References.

Metamaterials: a new frontier of science and technology. By Y. Liu and X. Zhang, *Chem. Soc. Rev.*, **40** (5), 2494–2507 (2011).

#### Abstract

Metamaterials, artificial composite structures with exotic material properties, have emerged as a new frontier of science involving physics, material science, engineering and chemistry. This review focuses on the fundamentals, recent progresses and future directions in the research of electromagnetic metamaterials.

An introduction to metamaterials followed by a detailed elaboration on how to design unprecedented electromagnetic properties of metamaterials is presented. A number of intriguing phenomena and applications associated with metamaterials are discussed, including negative refraction, sub-diffraction-limited

imaging, strong optical activities in chiral metamaterials, interaction of meta-atoms and transformation optics. Finally, an outlook on future directions of metamaterials research is offered, including but not limited to, three-dimensional optical metamaterials, nonlinear metamaterials and ‘quantum’ perspectives of metamaterials. 142 References.

Electrolytes for solid-state lithium rechargeable batteries: recent advances and perspectives.

By E. Quartarone and P. Mustarelli, *Chem. Soc. Rev.*, **40** (5), 2525–2540 (2011).

#### Abstract

This article presents an overview of the various classes of Li-ion conductors for use as electrolytes in lithium polymer batteries and all-solid state microbatteries.

Initially, the authors recall the main models for ion transport and the structure–transport relationships at the basis of the observed conductivity behaviors. Emphasis is then placed on the physico-chemical and functional parameters relevant for optimal electrolytes preparation, as well as on the techniques of choice for their evaluation. Finally, the state of the art of polymer and ceramic electrolytes is reported, and the most interesting strategies for the future developments are described. 121 References.

Graphene nanosheet: synthesis, molecular engineering, thin film, hybrids, and energy and analytical applications. By S. Guo and S. Dong, *Chem. Soc. Rev.*, **40** (5), 2644–2572 (2011).

#### Abstract

The emergence of graphene nanosheet (GN) has recently opened up an exciting new field in the science and technology of two-dimensional (2D) nanomaterials with continuously growing academic and technological impetus. GN exhibits unique electronic, optical, magnetic, thermal and mechanical properties arising from its strictly 2D structure and thus has many important technical applications. Actually, GN-based materials have enormous potential to rival

or even surpass the performance of carbon nanotube-based counterparts, given that cheap, large-scale production and processing methods for high-quality GN become available. Therefore, the studies on GN in the aspects of chemistry, physical, materials, biology and interdisciplinary science have been in full flow in the past five years.

In this review, from the viewpoint of chemistry and materials, the authors cover recent significant advances in synthesis, molecular engineering, thin film, hybrids, and energy and analytical applications of the ‘star-material’ GN, together with discussion on its major challenges and opportunities for future GN research. 315 References.

Recent advances in molecular imprinting technology: current status, challenges and highlighted applications. By L. Chen, S. Xu and J. Li, *Chem. Soc. Rev.*, **40** (5), 2922–2942 (2011).

#### Abstract

Molecular imprinting technology (MIT) concerns formation of selective sites in a polymer matrix with the memory of a template. Recently, molecularly imprinted polymers (MIPs) have aroused extensive attention and been widely applied in many fields, such as solid-phase extraction, chemical sensors and artificial antibodies owing to their desired selectivity, physical robustness, thermal stability, as well as low cost and easy preparation. With the rapid development of MIT as a research hotspot, it faces a number of challenges, involving biological macromolecule imprinting, heterogeneous binding sites, template leakage, incompatibility with aqueous media, low binding capacity and slow mass transfer, which restricts its applications in various aspects.

This article briefly reviews the current status of MIT, particular emphasis on significant progresses of novel imprinting methods, some challenges and effective strategies for MIT, and highlights applications of MIPs. Finally, some significant attempts in further developing MIT are also proposed. 236 References.

Organic host materials for phosphorescent organic light-emitting diodes. By Y. Tao, C. Yang and J. Qin, *Chem. Soc. Rev.*, **40** (5), 2943–2970 (2011).

#### Abstract

Phosphorescent organic light-emitting diodes (PhOLEDs) unfurl a bright future for the next generation of flat-panel displays and lighting sources due to their merit of high quantum efficiency compared with fluorescent OLEDs.

This review focuses on small-molecular organic host materials as triplet guest emitters in PhOLEDs. At first, some typical hole and electron transport materials used in OLEDs are briefly introduced. Then the hole transport-type, electron transport-type, bipolar transport host materials and the pure-hydrocarbon compounds are comprehensively presented. The molecular design concept, molecular structures and physical properties such as triplet energy, HOMO/LUMO energy levels, thermal and morphological stabilities, and the applications of host materials in PhOLEDs are reviewed. 152 References.

One-dimensional inorganic nanostructures: synthesis, field-emission and photodetection. By T. Zhai, L. Li, Y. Ma, M. Liao, X. Wang, X. Fang, J. Yao, Y. Bando and D. Golberg, *Chem. Soc. Rev.*, **40** (5), 2986–3004 (2011).

#### Abstract

One-dimensional (1D) inorganic nanostructures have drawn prime attention due to their potential for understanding fundamental physical concepts and constructing nanoscale electronic and optoelectronic devices. This review mainly focuses on the authors’ recent research progresses in 1D inorganic nanostructures, including their rational synthesis and potential applications, with an emphasis on field-emitter and photodetector applications.

Firstly, the authors discuss the rational design of synthetic strategies and the synthesis of 1D nanostructures *via* a vapour phase approach. Secondly, they present recent progresses with respect to several kinds of important inorganic nanostructures and

their field-emission and photoconductivity characteristics. Finally, the review concludes with some perspectives/outlook and future research in these fields. 212 References.

Molecular magnetic materials based on 4d and 5d transition metals. By X.–Y. Wang, C. Avendaño and K. R. Dunbar, *Chem. Soc. Rev.*, **40** (6), 3213–3238 (2011).

#### Abstract

The study of paramagnetic compounds based on 4d and 5d transition metals is an emerging research topic in the field of molecular magnetism. An essential driving force for the interest in this area is the fact that heavier metal ions introduce important attributes to the physical properties of paramagnetic compounds. Among the attractive characteristics of heavier elements *vis-à-vis* magnetism are the diffuse nature of their d-orbitals, their strong magnetic anisotropy owing to enhanced spin–orbit coupling, and their diverse structural and redox properties.

This review is intended to introduce readers to the topic and to report recent progress in this area. It is not fully comprehensive in scope although the authors strived to include all relevant topics and a large subset of references in the area. A survey of the history and current status of research that has been conducted on the topic of second and third row transition metal molecular magnetism is provided. The article is organized according to the nature of the precursor building blocks with special topics being highlighted as illustrations of the special role of heavier transition metal ions in the field. This paper is addressed to readers who are interested in molecular magnetism and the application of coordination chemistry principles to materials synthesis. 231 References.

Molecular spintronics. By S. Sanvito, *Chem. Soc. Rev.*, **40** (6), 3336–3355 (2011).

#### Abstract

The electron spin made its debut in the device world only two decades ago but today our ability of detecting the spin state of a moving electron underpins the entire magnetic data storage industry. This technological revolution has been driven by a constant improvement in our understanding on how spins can be injected, manipulated and detected in the solid state, a field which is collectively named, Spintronics. Recently a number of pioneering experiments and theoretical works suggest that organic materials can offer similar and perhaps superior performances in making spin-devices than the more conventional inorganic metals and semiconductors. Furthermore they can pave the way for radically new device concepts. This is Molecular Spintronics, a blossoming research area aimed at exploring how the unique properties of the organic world can marry the requirements of spin-devices. Importantly, after a first phase, where most of the research was focused on exporting the concepts of inorganic spintronics to organic materials, the field has moved to a more mature age, where the exploitation of the unique properties of molecules has begun to emerge. Molecular spintronics now collects a diverse and interdisciplinary community ranging from device physicists to synthetic chemists to surface scientists.

In this review, a survey of this field with a particular eye on new directions and opportunities is presented. The main differences and challenges with respect to standard spintronics are discussed, and so are the potential cross-fertilization with other fields. 177 References.

Experimental Techniques for the Fabrication and Characterization of Organic Thin Films for Field-Effect Transistors. By Y. Wen, Y. Liu, Y. Guo, G. Yu and W. Hu, *Chem. Rev.*, **111** (5), 3358–3406 (2011).

#### Abstract

Organic thin-film transistors (OTFTs) have developed rapidly over the past decade due to their promise as

components in cheap and flexible electronic circuits. Many potential applications have been demonstrated, ranging from flexible displays and sensor systems to radio frequency identification (RF-ID) tags, and some of these systems are now getting excitingly close to the commercial world.

This review begins by describing the use of characterization techniques in OTFTs, including high-resolution microscopy techniques, various spectroscopic techniques, and other characterization methods. Next, fabrication or processing techniques are described—ranging from patterning and printing techniques to deposition techniques—that have been successfully employed in the fabrication of the key components of organic devices. Finally, some discussion is given of the likely future trends and advances in such sophisticated experimental techniques for the fabrication and characterization of OTFTs. 363 References.

Electrochemical Energy Storage for Green Grid. By Z. Yang, J. Zhang, M. C. W. Kintner-Meyer, X. Lu, D. Choi, J. P. Lemmon and J. Liu, *Chem. Rev.*, **111** (5), 3577–3613 (2011).

#### Abstract

This review focuses on electrochemical storage technologies or batteries that constitute a large group of technologies that are potentially suitable to meet varied broad market needs.

Although it was not intended to cover every potential technology, the four categories of electrochemistries are selected and discussed in detail: redox flow batteries, Na-beta alumina membrane batteries, unique Li-ion chemistries, and lead-carbon technologies. These technologies, as any other potential technologies, appear promising to meet the requirements and economic matrices for mostly distributed and end-user applications that range from power reliability, regulation, and energy management to renewable firming. There remain significant challenges, and the fundamental challenges are the cost that is still too high for broad market penetration and the performance that does not yet fully meet the requirement targets.

The costs must be reduced, the performance must be improved, and advances in materials, chemistries, cell/stack design, and system engineering must be achieved. It was also intended to provide general guidelines for investigating other technologies, particularly emerging technologies. 363 References.

Selecting Conversion Phosphors for White Light-Emitting Diodes. By P. F. Smet, A. B. Parmentier and D. Poelman, *J. Electrochem. Soc.*, **158** (6), R37–R54 (2011).

#### Abstract

Light emitting diodes (LEDs) are on the verge of a breakthrough in general lighting, due to their rapidly improving efficiency. Currently, white LEDs with high color rendering are mainly based on wavelength conversion by one or more phosphor materials.

This Review first describes how to quantify the quality of a light source, discussing the color rendering index (CRI) and alternative color quality indices. Then, six main criteria are identified and discussed, which should be fulfilled by a phosphor candidate to be considered for actual application in LEDs. These criteria deal with the shape and position of the emission and the excitation spectra, the thermal quenching behavior, the quantum efficiency, the chemical and thermal stability and finally with the occurrence of saturation effects. Based on these criteria, the most common dopant ions (broad-band emitting  $\text{Eu}^{2+}$ ,  $\text{Ce}^{3+}$  and  $\text{Mn}^{2+}$ , line-emitting rare earth ions, . . .) and host compounds (garnets, sulfides, (oxy)nitrides, . . .) are evaluated. Although many phosphor materials have been proposed in literature in recent years, the number of phosphors effectively fulfilling all six requirements is relatively small. 165 References.

Self-cleaning fibers via nanotechnology: a virtual reality. By W. S. Tung and W. A. Daoud, *J. Mater. Chem.*, **21** (22), 7858–7869 (2011).

#### Abstract

With the fast-growing demand toward innovative functional and intelligent fibrous materials, the

photocatalytic self-cleaning surface functionalization of fibers has universally aroused tremendous interest in recent years. Due to the promising properties of nanosized photosensitive substances in decomposing undesirable contaminants, intensive research has incessantly been conducted to explore their multi-functional properties and potential applications.

This review summarizes recent developments of contemporary technologies, particularly emphasizing on the progress achieved in the past five years in the application of nanostructured titanium dioxide photocatalyst in fibrous materials. The fundamental concepts, limitation, societal impact and future prospects are also discussed. 82 References.

Polymer-stabilized optically isotropic liquid crystals for next-generation display and photonics applications. By J. Yan, L. Rao, M. Jiao, Y. Li, H. C. Cheng and S.-T. Wu, *J. Mater. Chem.*, **21** (22), 7870–7877 (2011).

#### Abstract

Polymer-stabilized optically isotropic liquid crystals, including blue phases, are emerging as a strong contender for next-generation display technology because they exhibit some revolutionary features such as no need for surface alignment, sub-ms response time, isotropic dark state, and cell gap insensitivity. The basic material properties, including electric field-induced birefringence, dispersion relation of Kerr constant, and temperature dependent Kerr constant, are reviewed. Recent progress on blue phase liquid crystal material development and device structures for lowering the operating voltage are introduced. Promising applications and remaining technical challenges are also discussed. 47 References.

The physical chemistry of mechanoresponsive polymers. By T. J. Kucharski and R. Boulatov, *J. Mater. Chem.*, **21** (23), 8237–8255 (2011).

#### Abstract

Stretching a polymer can accelerate chemical reactions of its monomers by many orders of magnitude.

Exploiting such effects may enable materials scientists to engineer a material's response to mesoscopic loads at the single-monomer level. Such mechanochemical coupling underlies diverse phenomena including the operation of actuating polymers, the catastrophic failure of strained materials, the behavior of polymer flows and chemical mechanosensing. Yet, our conceptual understanding of this coupling, which cannot be described either by continuum mechanics or chemical kinetics alone, is very limited. A general, physically sound and quantitative model to relate structural distortion at any length scale to reaction rates is needed to facilitate the design of new mechanoresponsive polymers.

This article reviews the state-of-the-art recent efforts to understand the physical chemistry of such polymers, particularly the effect of mechanical loads on the reactivity of its building blocks. 105 References.

Mechanochromic systems for the detection of stress, strain and deformation in polymeric materials. By D. R. T. Roberts and S. J. Holder, *J. Mater. Chem.*, **21** (23), 8256–8268 (2011).

#### Abstract

The detection of stress in polymeric materials such as plastics, elastomers, composites and coatings is critical in the monitoring of material failure including stress fractures, fatigue and hysteresis. Mechanochromic systems that utilise a change in fluorescent output as a result of the mechanical deformation of a polymer have only been actively investigated relatively recently and whilst the field is still relatively small, a considerable number of examples of such systems now exist.

This article discusses the principles behind such systems and reviews examples in the literature and surveys the most common fluorophores used in such systems including phenylene vinylene oligomeric derivatives, polycyclic aromatic compounds, carbazole derivatives and conjugated polymers. 54 References.

Mechanochromic polymer blends. By A. Pucci and G. Ruggeri, *J. Mater. Chem.*, **21** (23), 8282–8291 (2011).

#### Abstract

Mechanochromic polymer blends, that is, polymer blends characterized by optical responsiveness to mechanical stimuli, have evoked major interest and experienced significant progress in recent years. Various examples are reported of chromogenic materials composed of a functional dye covalently linked to the polymer chains or physically dispersed in the continuous macromolecular matrix, the latter appears to be a more sustainable route for the industrial scale-up of these materials.

This article examines the properties and performances of various mechanochromic materials prepared by using different thermoplastic polymers with non-covalently incorporated aggregachromic dyes. More specifically, the general mechanism underlying the optical phenomenon is introduced and the different approaches used to obtain chromogenic materials are presented and discussed considering both dye features and polymer characteristics. The combination of the properties of the blend components can often result in drastic differences in the material chromogenic responsiveness. The article concludes commenting and discussing the application of these kind of polymer devices as a new type of advanced materials and the perspective thereof. 100 References.

Nanocelluloses: A New Family of Nature-Based Materials. By D. Klemm, F. Kramer, S. Moritz, T. Lindström, M. Ankerfors, D. Gray and A. Dorris, *Angew. Chem. Int. Ed.*, **50** (24), 5438–5466 (2011).

#### Abstract

Cellulose fibrils with widths in the nanometer range are nature-based materials with unique and potentially useful features. Most importantly, these novel nanocelluloses open up the strongly expanding fields of sustainable materials and nanocomposites, as well as medical and life-science devices, to the natural polymer cellulose. The nano-dimensions of the structural

elements result in a high surface area and hence the powerful interaction of these celluloses with surrounding species, such as water, organic and polymeric compounds, nanoparticles, and living cells.

This review assembles the current knowledge on the isolation of microfibrillated cellulose from wood and its application in nanocomposites; the preparation of nanocrystalline cellulose and its use as a reinforcing agent; and the biofabrication of bacterial nanocellulose, as well as its evaluation as a biomaterial for medical implants.

Multifunctional Hybrid Polymer-Based Porous Materials. By A. Lee, S. Dubinsky, E. Tumarkin, M. Moulin, A. A. Beharry and E. Kumacheva, *Adv. Funct. Mater.*, **21** (11), 1959–1969 (2011).

#### Abstract

Polymer-based porous hybrid materials (PHMs) carrying inorganic nanoparticles on the surface of pores have important applications in chemical and biological sensing, in chromatography, and in heterogeneous catalysis. This Article provides an overview of the recent developments in the synthesis and fabrication of multifunctional PHMs using polymerization-induced phase separation. Exemplary applications of a PHM coated with gold nanorods were demonstrated for the simultaneous detection of different analytes using surface enhanced Raman scattering (SERS) spectroscopy and fluorescence microscopy. 65 References.

Upconverting Nanoparticles. By M. Hasse and H. Schäfer, *Angew. Chem. Int. Ed.*, **50** (26), 5808–5829 (2011).

#### Abstract

Upconversion (UC) refers to nonlinear optical processes in which the sequential absorption of two or more photons leads to the emission of light at shorter wavelength than the excitation wavelength (anti-Stokes type emission). In contrast to other emission processes based on multiphoton absorption, upconversion can be efficiently excited even at low excitation densities. The

most efficient UC mechanisms are present in solid-state materials doped with rare-earth ions.

The development of nanocrystal research has evoked increasing interest in the development of synthesis routes which allow the synthesis of highly efficient, small UC particles with narrow size distribution able to form transparent solutions in a wide range of solvents. Meanwhile, high-quality UC nanocrystals can be routinely synthesized and their solubility, particle size, crystallographic phase, optical properties and shape can be controlled. In recent years, these particles have been discussed as promising alternatives to organic fluorophosphors and quantum dots in the field of medical imaging.

#### Hybrid Colloidal Plasmonic-Photonic Crystals.

By S. G. Romanov, A. V. Korovin, A. Regensburger and U. Peschel, *Adv. Mater.*, **23** (22–23), 2515–2533 (2011).

#### Abstract

The recently emerged class of hybrid metal-dielectric colloidal photonic crystals are reviewed. The hybrid approach is understood as the combination of a dielectric photonic crystal with a continuous metal film. It allows to achieve a strong modification of the optical properties of photonic crystals by involving the light scattering at electronic excitations in the metal component into moulding of the light flow in series to the diffraction resonances occurring in the body of the photonic crystal.

The authors considered different realizations of hybrid plasmonic-photonic crystals based on two- and three-dimensional colloidal photonic crystals in association with flat and corrugated metal films. In agreement with model calculations, different resonance phenomena determine the optical response of hybrid crystals leading to a broadly tuneable functionality of these crystals. 105 References.

The Potential of Perylene Bisimide Derivatives for the Solubilization of Carbon Nanotubes and Graphene. By C. Backes, F. Hauke and A. Hirsch, *Adv. Mater.*, **23** (22–23), 2588–2601 (2011).

#### Abstract

Carbon nanotubes and graphene are outstanding materials of the 21<sup>st</sup> century with a broad spectrum of applications. However, major challenges are faced such as the intrinsically low solubility of both sp<sup>2</sup> carbon allotropes. To overcome this hurdle the potential of noncovalent functionalization is summarized with a special focus on the establishment of the perylene bisimide unit as aromatic anchor to the graphitic surface. Rational surfactant design is unmasked as the key to solubilization of the carbon allotropes, while at the same time tailoring their surface properties, or even electronic properties in a fully reversible fashion. 145 References.

Zeolitic Materials with Hierarchical Porous Structures. By S. Lopez-Orozco, A. Inayat, A. Schwab, T. Selvam and W. Schwieger, *Adv. Mater.*, **23** (22–23), 2588–2601 (2011).

#### Abstract

During the past several years, different kinds of hierarchical structured zeolitic materials have been synthesized due to their highly attractive properties, such as superior mass/heat transfer characteristics, lower restriction of the diffusion of reactants in the mesopores, and low pressure drop.

This article provides general information regarding types and preparation methods of hierarchical zeolitic materials and their relative advantages and disadvantages. Thereafter, recent advances in the preparation and characterization of hierarchical zeolitic structures within the crystallites by post-synthetic treatment methods, such as de-alumination or de-silication; and structured devices by in situ and ex situ zeolite coatings on open-cellular ceramic foams as (non-reactive as well as reactive) supports are highlighted. Specific advantages of using hierarchical zeolitic catalysts/structures in selected catalytic reactions, such as

benzene to phenol and methanol to olefins are presented. 144 References.

Nanostructured Tungsten Oxide – Properties, Synthesis, and Applications. By H. Zheng, J. Z. Ou, M. S. Strano, R. B. Kaner, A. Mitchell and K. Kalantar-zadeh, *Adv. Funct. Mater.*, **21** (12), 2175–2196 (2011).

#### Abstract

Metal oxides are the key ingredients for the development of many advanced functional materials and smart devices. Nanostructuring has emerged as one of the best tools to unlock their full potential. Tungsten oxides ( $WO_x$ ) are unique materials that have been rigorously studied for their chromism, photocatalysis, and sensing capabilities. However, they exhibit further important properties and functionalities that have received relatively little attention in the past.

This article presents a general review of nanostructured  $WO_x$ , their properties, methods of synthesis, and a description of how they can be used in unique ways for different applications. 216 References.

The Future of Seawater Desalination: Energy, Technology, and the Environment. By M. Elimelech and W. A. Phillip, *Science*, **333** (6043), 712–717 (2011).

#### Abstract

In recent years, numerous large-scale seawater desalination plants have been built in water-stressed countries to augment available water resources, and construction of new desalination plants is expected to increase in the near future. Despite major advancements in desalination technologies, seawater desalination is still more energy intensive compared to conventional technologies for the treatment of fresh water. There are also concerns about the potential environmental impacts of large-scale seawater desalination plants.

Here, the authors review the possible reductions in energy demand by state-of-the-art seawater desalination technologies, the potential role of

advanced materials and innovative technologies in improving performance, and the sustainability of desalination as a technological solution to global water shortages. 52 References.

Graphene as Transparent Electrode Material for Organic Electronics. By S. Pang, Y. Hernandez, X. Feng and K. Müllen, *Adv. Mater.*, **23** (25), 2779–2795 (2011).

#### Abstract

Organic electronics have led to a rapidly growing market for flexible transparent electrodes. Novel two-dimensional graphene is considered a realistic candidate to replace ITO electrode due to its unique properties, such as favorable work function, low resistance, high optical transmittance, good chemical and thermal stability, high mechanical strength and flexibility. 139 References.

Advances in Tailoring Resorcinol-Formaldehyde Organic and Carbon Gels. By A. M. EIKhatat and S. A. Al-Muhtaseb, *Adv. Mater.*, **23** (26), 2887–2903 (2011).

#### Abstract

An overview on the preparation and properties of resorcinol-formaldehyde (RF) organic and carbon gels reveals the fascinating and remarkably flexible properties of RF carbon and organic gels and how these properties are related to the synthesis and processing conditions. The structural properties can be easily tailored by rigidly controlling such conditions. However, slight variations in some conditions may cause drastic variations in the structural characteristics, and hence properties. Therefore, the effects of different conditions must be well-understood before attempting to tailor organic or carbon gels to specific applications. The most important factors that affect the properties of an organic gel are the precursor concentrations, the catalyst type and concentration, the time and temperature of curing, and the drying method. In addition to these factors, characteristics of activated carbon gels

also depend on the pyrolysis temperature and the activation method. These conditions impact the structural and performance characteristics significantly. 123 References.

#### Fundamental Theory of Piezotronics.

By Y. Zhang, Y. Liu and Z. L. Wang, *Adv. Mater.*, **23** (27), 3004–3013 (2011).

#### Abstract

Due to polarization of ions in crystals with non-central symmetry, such as ZnO, GaN, and InN, a piezoelectric potential (piezopotential) is created in the crystal when stress is applied. Electronics fabricated using the inner-crystal piezopotential as a gate voltage to tune or control the charge transport behavior across a metal/semiconductor interface or a p–n junction are called piezotronics. This is different from the basic design of complementary metal oxide semiconductor (CMOS) field-effect transistors and has applications in force and pressure triggered or controlled electronic devices, sensors, microelectromechanical systems (MEMS), human-computer interfacing, nanorobotics, and touch-pad technologies. Here, the theory of charge transport in piezotronic devices is investigated. In addition to presenting the formal theoretical frame work, analytical solutions are presented for cases including metal–semiconductor contact and p–n junctions under simplified conditions. Numerical calculations are given for predicting the current–voltage characteristics of a general piezotronic transistor: metal–ZnO nanowire–metal device. This study provides important insight into the working principles and characteristics of piezotronic devices, as well as providing guidance for device design. References.

Dual-Gate Thin-Film Transistors, Integrated Circuits and Sensors. By M.–J. Spijkman, K. Myny, E. C. P. Smits, P. Heremans, P. W. M. Blom and D. M. de Leeuw, *Adv. Mater.*, **23** (29), 3231–3242 (2011).

#### Abstract

The first dual-gate thin-film transistor (DGTFT) was

reported in 1981 with CdSe as the semiconductor. Other TFT technologies such as *a*-Si:H and organic semiconductors have led to additional ways of making DGTFTs. DGTFTs contain a second gate dielectric with a second gate positioned opposite of the first gate. The main advantage is that the threshold voltage can be set as a function of the applied second gate bias. The shift depends on the ratio of the capacitances of the two gate dielectrics.

Here, the authors review the fast growing field of DGTFTs. They summarize the reported operational mechanisms, and the application in logic gates and integrated circuits. The second emerging application of DGTFTs is sensitivity enhancement of existing ion-sensitive field-effect transistors (ISFET). The reported sensing mechanism is discussed and an outlook is presented. 77 References.

Structure and Properties of Functional Oxide Thin Films: Insights From Electronic-Structure Calculations. By J. M. Rondinelli and N. A. Spaldin, *Adv. Mater.*, **23** (30), 3363–3381 (2011).

#### Abstract

The confluence of state-of-the-art electronic-structure computations and modern synthetic materials growth techniques is proving indispensable in the search for and discovery of new functionalities in oxide thin films and heterostructures. Here, the authors review the recent contributions of electronic-structure calculations to predicting, understanding, and discovering new materials physics in thin-film perovskite oxides. They show that such calculations can accurately predict both structure and properties in advance of film synthesis, thereby guiding the search for materials combinations with specific targeted functionalities. In addition, because they can isolate and decouple the effects of various parameters which unavoidably occur simultaneously in an experiment—such as epitaxial strain, interfacial chemistry and defect profiles—they are able to provide new fundamental knowledge about the underlying physics. The article concludes by outlining the limitations of current computational techniques, as well as some important open questions that

will motivate further methodological developments in the field.

#### Microchemomechanical Systems.

By J. S. Randhawa, K. E. Laffin, N. Seelam and D. H. Gracias, *Adv. Funct. Mater.*, **21** (13), 2395–2410 (2011).

#### Abstract

The development of microchemomechanical systems (MCMS) as an analogy to microelectromechanical systems (MEMS) is reviewed, with the distinction that the mechanical actuation of microscale structures is effected by chemical cues as opposed to electricity. The intellectual motivation to pursue MCMS, or the creation of integrated chemical-stimuli-responsive devices, is that such structures are widely observed in nature. From a practical standpoint, since chemicals can readily diffuse and produce changes over large distances, this approach is especially attractive in enabling wireless and autonomous devices at small size scales. 124 References.

#### Supported Metal Oxide Nanosystems for Hydrogen Photogeneration: Quo Vadis?

By D. Barreca, G. Carraro, V. Gombac, A. Gasparotto, C. Maccato, P. Fornasiero and E. Tondello, *Adv. Funct. Mater.*, **21** (14), 2611–2623 (2011).

#### Abstract

Hydrogen has attracted a great share of attention both as an energy carrier and as an irreplaceable reagent for many industrial processes. Photoactivated routes, ranging from photocatalytic and photo-electrochemical water splitting to photo-reforming of suitable oxygenates, appear to be attractive long-term solutions among possible strategies for hydrogen production. However, the success of such processes depends on the efficient use of solar energy and on the identification of active and stable catalysts, which, in addition, should be eco-friendly and available in large amounts at accessible costs. Researchers are exploring the use of supported oxide nanomaterials, which enable an

easy catalyst recovery and exhibit unique advantages due to their peculiar nano-organization.

In this Article, the potential of such systems towards photoinduced hydrogen evolution is discussed based on selected case studies that highlight the relations between structure, morphology, composition, and functional performances of oxide nanomaterials. In addition, potential limitations of oxide-based nanomaterials as well as unexplored key aspects that require special attention in future investigations are discussed. 121 References.

Organic Resistive Memory Devices: Performance Enhancement, Integration, and Advanced Architectures. By B. Cho, S. Song, Y. Ji, T.-W. Kim and T. Lee, *Adv. Funct. Mater.*, **21** (15), 2806–2829 (2011).

#### Abstract

In recent years, organic resistive memory devices in which active organic materials possess at least two stable resistance states have been extensively investigated for their promising memory potential. From the perspective of device fabrication, their advantages include simple device structures, low fabrication costs, and printability. Furthermore, their exceptional electrical performances such as a nondestructive reading process, nonvolatility, a high ON/OFF ratio, and a fast switching speed meet the requirements for viable memory technologies. Full understanding of the underlying physics behind the interesting phenomena is still challenging. However, many studies have provided useful insights into scientific and technical issues surrounding organic resistive memory.

This Article begins with a summary on general characteristics of the materials, device structures, and switching mechanisms used in organic resistive devices. Strategies for performance enhancement, integration, and advanced architectures in these devices are also presented, which may open a way toward practically applicable organic memory devices. 139 References.

Thermal properties of graphene and nanostructured carbon materials.

By A. A. Balandin, *Nature Mater.*, **10** (8), 569–581 (2011).

#### Abstract

Heat removal has become a crucial issue for continuing progress in the electronic industry, and thermal conduction in low-dimensional structures has revealed truly intriguing features. The room-temperature thermal conductivity of carbon materials span an extraordinary large range — of over five orders of magnitude

— from the lowest in amorphous carbons to the highest in graphene and carbon nanotubes.

Here, the author reviews the thermal properties of carbon materials focusing on recent results for graphene, carbon nanotubes and nanostructured carbon materials with different degrees of disorder. Special attention is given to the unusual size dependence of heat conduction in two-dimensional crystals and, specifically, in graphene. Also described are the prospects of applications of graphene and carbon materials for thermal management of electronics. 148 References.

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## Report on the ICMAT 2011 Conference held in Singapore

*(Contributed by the Editor)*

The sixth 'International Conference on Materials for Advanced Technologies' (ICMAT-2011) was organized by the Materials Research Society of Singapore (MRS-S), in association with the National University of Singapore (NUS), Nanyang Technological University (NTU), and the Institute of Materials Research and Engineering, with the support of A\*STAR, in Singapore. It was held during June 26-July 1, 2011 at the Sun Tech City Convention Center. There were 40 Symposia, 9 Plenary and 3 Theme Lectures in addition to the Keynote, Invited, Oral talks and Poster presentations in various Symposia, covering varied aspects of materials science, engineering and technology. These included modern topics like, graphene: science and technology, topological insulators, nano-structures of various materials, biomaterials for healthcare, metamaterials, photovoltaics, dye sensitized solar cells and lithium (Li) ion battery materials for electric vehicles (EVs).

The Conference was inaugurated by Mr. Lim Hng Kiang, Minister for Trade and Industry, Government of Singapore. Prof. Tan Chorh Chuan, President of NUS, and Prof. B. V. R. Chowdari, Organizing Chairman of the ICMAT Conference, also from the NUS, welcomed the gathering on the first-day of the Conference. The Ambassadors of France and China and the Indian High Commissioner graced the inaugural function.

Prof. Chowdari welcomed the more than 3,200 attendees from 64 countries, and the 68 companies that are exhibiting here, before thanking the long list of sponsors who made the Conference possible, which included Singapore Tourism Board, US Army Research Office-Far East, Embassy of France, Institute of Physics, Singapore and Vel Tech Dr RR & Dr SR Tech. Univ., Chennai, India. He mentioned that some of the new initiatives of the Conference are: Incorporation of 4<sup>th</sup> Asian Nanoimprint Lithiography Symposium (ASNIL), Nanoformulation -2011, Crystal Growth and Crystal Technology-5 (CGCT-5) and organization of 'Young Scientists Workshop', Industry Workshops on 'Applied Surface Engineering' and '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.'

Prof. Tan, in his welcome address, mentioned that he was privileged and honored to be part of the Conference, because advances in materials science research lie at the heart of development in many fields and NUS is keen on supporting researches in this area. Finally, the Guest of Honor, Mr. Lim spoke about how the research and development (R&D) is the cornerstone of Singapore's transformation to a knowledge and technology-based economy. He broke the news of a S\$16.1 billion Research, Innovation, and Enterprise 2015 (RIE 2015) fund, which will provide funds over the next five years to achieve R&D goals. The initiative's intention is to support multidisciplinary and breakthrough science, while taking ideas from research to commercialization. Materials science is a key research area under RIE 2015 and Conferences such as ICMAT play a significant role, by focusing minds on developing solutions for global problems through multidisciplinary research efforts, he added.

The Plenary talks were delivered by four Nobel Laureates, namely, Prof. Albert Fert (Unité Mixte de Physique CNRS/Thales and the Univ. Paris-Sud, France), Prof. Ada Yonath (Weizmann Inst., Israel), Prof. Andre Geim (Univ. of Manchester, UK) and Prof. Klaus von Klitzing (Max Planck Inst. für Festkörperforsch., Germany) and also, by Prof. Joachim Luther (Solar Energy Renewable Initiative of Singapore and NUS), Prof. Susumu Kitagawa (Kyoto Univ., Japan), Prof. Charles Lieber (Harvard Univ., USA) and Prof. Jean M. J. Frechet (King Abdullah Univ. of Sci. & Technol., Saudi Arabia). Prof. Fert and Prof. Yonath also delivered Public Lectures at the NUS Cultural Center, which were open to the delegates as well as general public, high school and junior college students. The three Theme lectures were given by Mr. Jonathan Adams (Thomson-Reuters, UK), Prof. Qi-Kun Xue (Tsinghua Univ., China) and Prof. D. D. Sarma (Indian Inst. of Sci., Bangalore, India).

A total of 3139 papers were presented by 3212 attendees of which 842 students formed part of the total delegates. Many of the student-delegates enjoyed partial financial support. 48 Best Poster Awards, consisting of cash

prize of S\$200 and a certificate, were given away by Prof. Bertil Andersson, President of NTU on the last day of the Conference. The list of Best Poster Awards is given below.

Meeting Matters Pte Ltd, Singapore provided the Secretarial service. 'Meeting Scenes', the highlights of each day of the Conference were compiled and edited by Tim Palucka, Science News Editor, with contributions from Alison Hatt and Matthew Martin of MRS-USA, and were circulated to all the delegates by e-mail.

A CD containing all the Abstracts presented at the Conference is available up on request.



Informal gathering during the ICMAT 2011 Conference. (From left to right): Prof. B.V.R. Chowdari (Organizing Chairman); Plenary Speakers: Prof. Albert Fert, Prof. Ada Yonath, Prof. Klaus von Klitzing and Prof. Andre Geim.

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### Poster Award Winners (ICMAT-2011)

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<b>Poster</b>	A-PO4-47
<b>Title of the Paper</b>	Constructive Photovoltaic Effects for Ultraviolet (UV) Detector
<b>Authors</b>	<i>Bee Keen GAN, Kui YAO, Szu Cheng LAI, Phoi Chin GOH and Yi Fan CHEN</i>
<b>Affiliation, Country</b>	<i>Institute of Materials Research and Engineering (IMRE), Singapore.</i>
<b>Poster</b>	A-PO4-64
<b>Title of the Paper</b>	Micro-pyramidal III-Nitride MQWs Array with ZnO Nanopillar Reflectors
<b>Authors</b>	<i>Chew Beng SOH, Chuan Beng TAY, Jayce CHENG, Norman, Soo Seng ANG, Rayson TAN, Wei LIU, Xuan Sang NGUYEN and Soo Jin CHUA</i>
<b>Affiliation, Country</b>	<i>IMRE, Singapore.</i>
<b>Poster</b>	A-PO4-76
<b>Title of the Paper</b>	Strain Effect Study on Quasi Two Dimensional Electron Gas at LaAlO <sub>3</sub> /SrTiO <sub>3</sub> Interfaces
<b>Authors</b>	<i>A. ANNADI, X. WANG, Weiming LU, Kalon GOPINADHAN, Zhiqi LIU, Arkajit ROY BARMAN, Sankar DHAR, T. VENKATESAN and Ariando ARIANDO</i>
<b>Affiliation, Country</b>	<i>National University of Singapore (NUS), Singapore.</i>

- Poster** BB-PO3-13  
**Title of the Paper** Proton Beam Writing in Semiconductors  
**Authors** *Martina SCHULTE-BORCHERS, Ulrich VETTER and Hans HOFSAESS*  
**Affiliation, Country** *Goettingen University, Germany.*
- Poster** B-PO1-41  
**Title of the Paper** Fabrication of H-bonded Multilayers Containing Polymer-stabilized Basic Copper(II) Sulphate Fine Crystals and a Natural Organic Matter  
**Authors** *Huseyin Enis KARAHAN, Recep KAS, Ozgur BIRER and Adem Levent DEMIREL*  
**Affiliation, Country** *Koc University, Turkey.*
- Poster** B-PO1-50  
**Title of the Paper** Novel Method to Enhance Intragrain Critical Current Density in Bi-based Superconductor  
**Authors** *Hiromi TANAKA, Hideki YOSHIKAWA, Chusei TSURUTA, Yoshio MATSUI and Satoru KISHIDA*  
**Affiliation, Country** *Yonago National College of Technology, Japan.*
- Poster** C-PO4-28  
**Title of the Paper** Large Area Nanoimprinting with UV Nanoimprint Under Atmospheric Pressure for Silicon and Polymer Substrate  
**Authors** *Kentaro ISHIBASHI, Hiroshi GOTO, Shuichi SHOJI and Jun MIZUNO*  
**Affiliation, Country** *Waseda University, Japan.*
- Poster** DD-PO2-26  
**Title of the Paper** Nucleation of Si and Ge by Rapid Cooling Using Molecular-dynamics Simulation  
**Authors** *Yanping XIAO, Ryo TERANISHI and Munetoh SHINJI*  
**Affiliation, Country** *Kyushu University, Japan.*
- Poster** DD-PO2-45  
**Title of the Paper** Separate Process of Nucleation, Coalescence and Growth in Vapor Phase  
**Authors** *Yuki KIMURA, Kyoko TANAKA, Hitoshi MIURA and Katsuo TSUKAMOTO*  
**Affiliation, Country** *Tohoku University, Japan.*
- Poster** EE-PO4-15  
**Title of the Paper** Lattice-guided Low Temperature Deposition of High Response Piezoelectric Thin Films  
**Authors** *Sharath SRIRAM and Madhu BHASKARAN*  
**Affiliation, Country** *Royal Melbourne Institute of Technology University, Australia.*
- Poster** EE-PO4-28  
**Title of the Paper** Float Zone Growth and Spectroscopic Properties of Nd:LaVO<sub>4</sub> Single Crystals  
**Authors** *Shohei YOMOGIDA, Mikio HIGUCHI, Takayo OGAWA, Satoshi WADA and Junichi TAKAHASHI*  
**Affiliation, Country** *Hokkaido University, Japan.*

- Poster** EE-PO4-69  
**Title of the Paper** Properties of InSbN Alloys on GaSb Substrates by MOCVD  
**Authors** Yunjiang JIN, Xiaohong TANG, Xizi CHEN, Jinghua TENG and Dao Hua ZHANG  
**Affiliation, Country** Nanyang Technological University (NTU), Singapore.
- Poster** FF-PO1-5  
**Title of the Paper** Growth and Characterization of Organic Material, 4-(benzyloxy)benzaldehyde Single Crystal by Modified Vertical Bridgman Technique with Nano Translation  
**Authors** Supraja R., Kameshwari R., Suthan T. and Rajesh N. P.  
**Affiliation, Country** Sri Sivasubramaniya Nadar College of Engineering, India.
- Poster** GG-PO1-3  
**Title of the Paper** Co-crystallization of Adefovir Dipivoxil with Dicarboxylic Acids  
**Authors** Sung Yup JUNG and Il Won KIM  
**Affiliation, Country** Soongsil University, South korea.
- Poster** G-PO3-39  
**Title of the Paper** Soft Contact-lens Biosensor based on MEMS Techniques for in-situ Monitoring of Tear Glucose  
**Authors** Hiroyuki KUDO, MingXing CHU, Yoshitaka HIRANUMA, Daishi TAKAHASHI, Kumiko MIYAJIMA, Takahiro ARAKAWA and Kohji MITSUBAYASHI  
**Affiliation, Country** Tokyo Medical and Dental University, Japan.
- Poster** G-PO3-54  
**Title of the Paper** Stopping Micro-Particle on the Ring/Waveguide by Using Double Coupled Ring Resonator  
**Authors** Ye Feng YU, Hong CAI, Jifang TAO, Min REN, Tarik BOUROUINA and Ai-Qun LIU  
**Affiliation, Country** NTU, Singapore.
- Poster** G-PO3-64  
**Title of the Paper** Microfluidic Droplet-based Liquid-liquid Extraction for Fluorescence-indicated Mass Transfer  
**Authors** Jiaqing YU, Lip Ket CHIN and Ai-Qun LIU  
**Affiliation, Country** NTU, Singapore.
- Poster** HH-PO4-4  
**Title of the Paper** Practical Applications of X-ray Pseudolocal Tomography for Enhancing the Visualization of Discontinuity Structures Inside Material  
**Authors** Trong Nghia VO, Herbert MOSER and M. BREESE  
**Affiliation, Country** NUS, Singapore.
- Poster** H-PO2-24  
**Title of the Paper** High Mobility Field Effect Transistor Based on Donor–acceptor Noncovalent Amphiphilic Molecular Fibre  
**Authors** Abhay SAGADE, K VENKATARAO, Subi GEORGE and Giridhar KULKARNI  
**Affiliation, Country** Jawaharlal Nehru Centre for Advanced Scientific Research, India.

- Poster** H-PO2-39  
**Title of the Paper** Investigation of Copper Oxide Nanotube Formation from Copper Nanowires Arrays Fabricated by Electrodeposition Through AAO Template  
**Authors** *Shu Rong CHUN, Chee Lip GAN, Anyan DU, Qing LIU and Chee Mang NG*  
**Affiliation, Country** *NTU, Singapore.*
- Poster** I-PO2-49  
**Title of the Paper** Mechanism and Orientation Evolution of Tin Oxide Nanowire Arrays Growth  
**Authors** *Jun PAN, Hao SHEN, Qing ZHANG, Qihua XIONG and Sanjay MATHUR*  
**Affiliation, Country** *University of Cologne, Germany.*
- Poster** I-PO2-56  
**Title of the Paper** Fabrication of Efficient Light Scattering Functionalized Photoanode Using Well-aligned ZnO Hemisphere Crystals for Dye-sensitized Solar Cells  
**Authors** *Ki Seok KIM, Jinju KIM, Yusin PAK, Hui SONG and Gun Young JUNG*  
**Affiliation, Country** *Gwangju Institute of Science and Technology, South korea.*
- Poster** JJ-PO3-1  
**Title of the Paper** Synthesis of Superparamagnetic Iron Nanoparticles  
**Authors** *David HERMAN, Soshan CHEONG, Sujay PRABAKAR, Conrad LENDRUM, Ben RUCK, Guy JAMESON and Richard D. TILLEY*  
**Affiliation, Country** *Victoria University of Wellington, New zealand.*
- Poster** JJ-PO3-18  
**Title of the Paper** Microwave Assisted Hydrothermal Growth of Epitaxial ZnO Films  
**Authors** *Laura Lynn LIEW, Hong Quang LE and Gregory K. L. GOH*  
**Affiliation, Country** *IMRE, Singapore.*
- Poster** J-PO2-25  
**Title of the Paper** High Catalytic Activity Metal Oxide-noble Metal with Durability  
**Authors** *Haoshuai WU, Huan-Ping ZHOU, Lingdong SUN and Chunhua YAN*  
**Affiliation, Country** *Peking University, China.*
- Poster** J-PO2-45  
**Title of the Paper** Colorimetric Detection of HIV-1 Ribonuclease H Activity by Gold Nanoparticles  
**Authors** *Xiaoji XIE, Wei XU, Tianhu LI and Xiaogang LIU*  
**Affiliation, Country** *NUS, Singapore.*
- Poster** K-PO2-35  
**Title of the Paper** Controlled Synthesis of Dendritic Gold Nanostructures from Solutions  
**Authors** *Ming PAN and Hongyu CHEN*  
**Affiliation, Country** *NTU, Singapore.*

- Poster** K-PO2-53  
**Title of the Paper** Engineering Functional Nanocomposites By Controlled Self-assembly of Colloidal Nanoparticles  
**Authors** Gang CHEN, Cuicui LIU, Yong WANG and Hongyu CHEN  
**Affiliation, Country** NTU, Singapore.
- Poster** L-PO3-32  
**Title of the Paper** Angled Media Deposition Effects on the Magnetic and Structural Properties of Pre-patterned Substrates for Bit Patterned Media Applications  
**Authors** Naganivetha THIYAGARAJAH, Joel K.W. YANG, Huigao DUAN, Yunjie CHEN, Tianli HUANG, Siang Huei LEONG and Vivian NG  
**Affiliation, Country** NUS, Singapore.
- Poster** L-PO3-45  
**Title of the Paper** Advanced Magnetic Force Microscopy Tips for High Resolution Magnetic Imaging  
**Authors** Mojtaba RANJBAR, S.N. PIRAMANAYAGAM, Rachid SBIAA and Tow Chong CHONG  
**Affiliation, Country** Data Storage Institute, Singapore.
- Poster** M-PO1-30  
**Title of the Paper** Understanding the Effect of Surface Ligands on CdSe Nanorods for Hybrid Photovoltaics Devices  
**Authors** Jun Yan LEK, Lifei XI, Beata KARDYNAL, Lydia WONG and Yeng Ming LAM  
**Affiliation, Country** NTU, Singapore.
- Poster** M-PO1-73  
**Title of the Paper** Electrospun Tenary Transition Metal Oxide for Supercapacitor Application  
**Authors** Wai Fatt MAK, Yogesh SHARMA, Madhavi SRINIVASAN and Subodh MHAISALKAR  
**Affiliation, Country** NTU, Singapore.
- Poster** M-PO1-78  
**Title of the Paper** Platinum Nanoparticle Films with Good Adhesion to Substrates Fabricated by Solution Processing and Polyol Reduction of a Platinum Precursor  
**Authors** Swee Jen CHO and Jianyong OUYANG  
**Affiliation, Country** NUS, Singapore.
- Poster** N-PO1-41  
**Title of the Paper** Kinetics of Nucleation and Growth in Two-phase Electrode Reaction of  $\text{Li}_x\text{FePO}_4$   
**Authors** Gosuke OYAMA, Yuki YAMADA, Ryuichi NATSUI, Shin-ichi NISHIMURA and Atsuo YAMADA  
**Affiliation, Country** University of Tokyo, Japan.
- Poster** N-PO1-49  
**Title of the Paper** Unique Structural Stability of Three Dimensionally Ordered Macroporous  $\text{TiO}_2$  Electrode Materials  
**Authors** Hyejung KIM, Min Gyu KIM and Jaephil CHO  
**Affiliation, Country** Ulsan National Institute of Science and Technology, South Korea.

- Poster** N-PO1-60  
**Title of the Paper** Interface Effects in Lithium Storage and Ion Conductivity: Recent Results  
**Authors** Lijun FU, Jiyong SHIN, Chilin LI, Dominik SAMUELIS and Joachim MAIER  
**Affiliation, Country** Max Planck Institute for Solid State Research, Germany.
- Poster** O-PO3-21  
**Title of the Paper** Toward High Efficiency Ultrathin Si Film-based Solar Cells: Surface Texturing Via Low Aspect-ratio Si Nano-hemisphere Arrays  
**Authors** Yali LI, Hong Yu YU, Junshuai LI, She-Mein WONG, Jian WANG, Xinpeng WANG, Navab SINGH, Patrick G. Q. LO and Dim-Lee KWONG  
**Affiliation, Country** NTU, Singapore.
- Poster** O-PO3-31  
**Title of the Paper** Optimized Antireflection Coatings Using Silicon Nitride on Textured Silicon Surfaces Based on Measurements and Multidimensional Modeling  
**Authors** Shubham DUTTA GUPTA, Fajun MA, Bram HOEX, Thomas MUELLER and Armin ABERLE  
**Affiliation, Country** NUS, Singapore.
- Poster** P-PO4-4  
**Title of the Paper** Advanced Ozone-membrane Reactor for Treatment of Endocrine Disrupting Compounds in Water  
**Authors** Wai Kit CHAN, Wei HAN and King Lun YEUNG  
**Affiliation, Country** Hong Kong University of Science and Technology, HONG KONG, China.
- Poster** Q-PO1-7  
**Title of the Paper** Orientation Dependent Charge Transfer at the DIP/F16CuPc Interface  
**Authors** JianQiang ZHONG, Dongchen QI, Liang CAO, Yuzhan WANG, Xiaojiang YU, Andrew WEE and Wei CHEN  
**Affiliation, Country** NUS, Singapore.
- Poster** R-PO2-17  
**Title of the Paper** Improved Performance of Organic Photovoltaic Cells Through the Reduction of Phase Separation Via Solvent Mixture  
**Authors** Seung hee KIM, Soo Won HEO and Doo Kyung MOON  
**Affiliation, Country** Konkuk University, South korea.
- Poster** S-PO2-10  
**Title of the Paper** Electric and Magnetic Coupling of Three Dimensional U-shaped Metamaterial in Optical Region  
**Authors** Chen Jung CHEN, Wei Ting CHEN, Pin Chien WU, Kuang Yu YANG, Chih Ting HSIAO, Yuan Fong CHAU, Chieh Hsiung KUAN and Din Ping TSAI  
**Affiliation, Country** National Taiwan University, Taiwan.

- Poster** T-PO2-22  
**Title of the Paper** ZnO Surface Acoustic Wave Sensor for the Orthogonal Detection of DMMP  
**Authors** V. Bhasker RAJ, Monika TOMAR, A. Theodore NIMAL, Yashoda PARMAR, M. U. SHARMA and Vinay GUPTA  
**Affiliation, Country** University of Delhi, India.
- Poster** T-PO2-7  
**Title of the Paper** Synthesis and Electrochromic Properties of Novel Star-like C60-polyaniline  
**Authors** Shanxin XIONG, Fan YANG, Jan MA and Xuehong LU  
**Affiliation, Country** NTU, Singapore.
- Poster** U-PO4-29  
**Title of the Paper** Locating Carbon Nanotubes (CNTS) at the Surface of Polymer Microspheres Using Poly(Vinyl Alcohol)-Grafted CNTS as Dispersion Co-Stabilizers  
**Authors** Michael ALEXANDRE, Jean-Michel THOMASSIN, Daniela VULUGA, Isabel MOLENBERG, Isabelle HUYNEN, Antoine DEBUIGNE, Christine JEROME and Christophe DETREMBLEUR  
**Affiliation, Country** University of Liege, Belgium.
- Poster** U-PO4-33  
**Title of the Paper** Fabrication of Coaxial Fibrils of Multiwall Carbon Nanotube/Polypyrrole  
**Authors** Ravi BHATIA, Prasad VISHNUBHOTLA and Reghu MENON  
**Affiliation, Country** Indian Institute of Science, Bangalore, India.
- Poster** X-PO3-7  
**Title of the Paper** si-RNA Hydrogel Microparticles for Gene Silencing  
**Authors** Cheol Am HONG, Soo Hyeon LEE, Jee Seon KIM, Ji Won PARK, Ki Hyun BAE and Tae Gwan PARK  
**Affiliation, Country** Korea Advanced Institute of Science and Technology, South korea.
- Poster** Y-PO3-6  
**Title of the Paper** To Investigate the Mechanical and Micro-architecture Properties of a New Biocomposite  
**Authors** Boon Horng KAM and Weifen ONG  
**Affiliation, Country** Republic Polytechnic, Singapore.

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Note: Affiliation and Country of the first author only is given.

## Forthcoming Conferences

### 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

**2<sup>nd</sup> Molecular Materials Meeting (M3) @ Singapore**  
**Jan., 9–11, 2012, Singapore**

Organised by Singapore A\*STAR's Institute of Materials Research and Engineering (IMRE), in partnership with other A\*STAR institutes, research organisations and industries, the event, themed around molecular materials, welcomes leading researchers in chemistry, materials science, physics, biology, medicine, engineering etc. with the intention of developing cross-disciplinary and collaborative research ideas on the following themes:

- (1) Materials Synthesis, Assembly & Device Fabrication;
- (2) Energy & Sustainable Materials;
- (3) Optical & Electronic Materials;
- (4) Materials for Imaging & Sensing

*Invited Speakers:* Prof. Ada Yonath (Plenary); Prof. Tobin J. Marks (Plenary); Dr. Katsuhiko Ariga (Key Note)

*Conference Chairman:* Andy Hor (IMRE);

*Abstract Submission:* 15 Oct., 2011

*General Enquiries:* m3conference imre.a-star.edu.sg

*Website:* <http://www.imre.a-star.edu.sg/m3conference>

**Multiscale Materials Modeling (MMM 2012)**  
**Oct., 15–19, 2012, Singapore**

The Multiscale Materials Modeling (MMM) conference series is the world's largest theoretical and computational materials science forum which aims to disseminate the latest development in the field of multiscale materials modeling.

MMM 2012 is organized jointly by the Materials Research Society of Singapore (MRS-S) and A\*Star Institute of High Performance Computing (IHPC), Singapore.

Our overriding motivation to host the 2012 edition of the MMM conference is to provide an international forum for the exchange and sharing of the recent advances in multiscale modeling and simulation of materials. Emphasis will be placed on new ideas in the form of novel theories, refined mathematical models, innovative simulation approaches and application of computation methodology to both traditional and emerging materials applications. Emphasis will be on the hierarchy of simulation techniques, coupling techniques from first principles to continuum models and methods that are multiscale in both/either space and time.

The scientific environment in Singapore is vibrant, advanced and a priority for the highest level policy makers within Singapore. Furthermore, Singapore possesses excellent intellectual property rights and regulatory infrastructure, further adding to its exceptional environment for research and development. Hence, the 2012 edition of the MMM conference has been chosen to be held in Singapore.

We are looking forward to welcoming you and your partners in Singapore. A series of interesting and fruitful plenary and invited talks have been lined up for all of you

*Co-Chairs:* David J. Srolovitz (IHPC) and B. V. R. Chowdari (MRS-S and NUS)

*Abstract Submission:* 15 January, 2012

*Notification of Abstract Acceptance:* 15 March, 2012

*Conference Registration & Payment (Early Bird):* 15 July, 2012

*Conference Registration & Payment (Normal Rate):* 1 Sept., 2012

*Contact:* Ms. Eileen So, Project Executive, Materials Research Society of Singapore.

*Telephone:* (+65) 6874 1176.

*Email:* mmm2012@mrs.org.sg/sotye@imre.a-star.edu.sg

*Conference Website:* www.mrs.org.sg/mmm2012

### 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](http://www.nus.edu.sg)

Nanyang Technological University: [www.ntu.edu.sg](http://www.ntu.edu.sg)

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

Institute of Microelectronics (IME): [www.ime.a-star.edu.sg](http://www.ime.a-star.edu.sg)

Data Storage Institute: [www.dsi.a-star.edu.sg](http://www.dsi.a-star.edu.sg)

Institute of Chemical & Engineering Sciences: [www.ices.a-star.edu.sg](http://www.ices.a-star.edu.sg)

Institute of High Performance Computing: [www.ihpc.a-star.edu.sg](http://www.ihpc.a-star.edu.sg)

Singapore Institute of Manufacturing Technology: [www.SIMTech.a-star.edu.sg](http://www.SIMTech.a-star.edu.sg)

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

## 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](mailto: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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