MRS-S OUTLOOK

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

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CONTENTS

➢ MRS-S Activities: Past, Present and Future

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

The biennial National Conferences were held in 2004, 2006 and 2008. MRS-S also sponsored/supported several other conferences, workshops, symposia and public lectures. It instituted gold medals for the best outgoing students in Materials Science at the National University of Singapore (NUS) and Nanyang Technological University (NTU). It instituted the `MRS Singapore Student Bursary Fund' at the National University of Singapore. MRS-S also instituted the `MRS-S Book Prize' at the `Republic Polytechnic' of Singapore. This yearly Book Prize will be awarded to the top final-year student from the `Diploma in Materials Science'.

To reach out to the public, MRS-S has organized number of public lectures by Nobel Laureates and also an Astronaut.

ICMAT 2009 &IUMRS-ICA 2009 was held during June 28- July 3, 2009 in Singapore. There were 23 Symposia, 9 Plenary and 3 Theme Lectures in addition to the Keynote, Invited, Oral talks and Poster presentations, covering almost all the aspects of materials science, engineering and technology. There were 2170 registered participants. There was also an Exhibition with 43 Booths, of the products and services by the manufacturers, book and journal publishers. 37 Best Poster Awards were given away on the last day of the Conference. There were three Public Lectures by three Nobel Laureates during the Conference.

Prof. B. V. R. Chowdari, President, MRS-S attended the `2nd World Materials Summit' at Suzhou, China during 12-15, Oct., 2009 and gave an Invited Talk.

The fourth National Conference on `Advanced Materials' will be held at IMRE (Institute of Materials Research & Engineering), Singapore during 17-19, March, 2010.

The ICMAT 2011 will be held in Singapore during June, 26-July1, 2011.

Highlights of Recent Literature

Highlights of Previous ICMAT Conferences

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

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

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

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

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

Highlights of Previous National Conferences

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

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

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

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Highlights of Recent Literature

(*Contributed by the Editor*)

Preferential Growth of Single-Walled Carbon Nanotubes with Metallic Conductivity

Single-walled carbon nanotubes can be classified as either metallic or semiconducting, depending on their conductivity, which is determined by their chirality. Existing synthesis methods cannot controllably grow nanotubes with a specific type of conductivity. By varying the noble gas ambient during thermal annealing of the catalyst, and in combination with oxidative and reductive species, Harutyunyan *et al.* [1] could alter the fraction of tubes with metallic conductivity from one-third of the population to a maximum of 91%. *In situ* transmission electron microscopy studies revealed that this variation leads to differences in both morphology and coarsening behavior of the nanoparticles that were employed to nucleate nanotubes. These catalyst rearrangements demonstrate that there are correlations between catalyst morphology and resulting nanotube electronic structure, and indicate that chiral-selective growth of nanotubes may be possible.

Reference

1. A. R. Harutyunyan, G. Chen, T. M. Paronyan, E. M. Pigos, O. A. Kuznetsov, K. Hewaparakrama, S. M. Kim, D. Zakharov, E. A. Stach and G. U. Sumanasekera, Science, **326** (No. 5949), 116–120 (2009) (2 Oct. Issue).

Enhanced Sulfur and Coking Tolerance of a Mixed Ion Conductor for SOFCs: $BaZr_{0.1}Ce_{0.7}Y_{0.2-x}Yb_xO_{3-\delta}$

The anode materials that have been developed for solid oxide fuel cells (SOFCs) are vulnerable to deactivation by carbon buildup (coking) from hydrocarbon fuels or by sulfur contamination (poisoning). Yang *et al.* [1] report on a mixed ion conductor, $Ba(Zr_{0.1}Ce_{0.7}Y_{0.2-x}Yb_x)O_{3-\delta}$, that allows rapid transport of both protons and oxide ion vacancies. The mixed oxide exhibits high ionic conductivity at relatively low temperatures(500° to 700°C). Its ability to resist deactivation by sulfur and coking appears linked to the mixed conductor's enhanced catalytic activity for sulfur oxidation and hydrocarbon cracking and reforming, as well as enhanced water adsorption capability.

Reference

1. L. Yang, S. Wang, K. Blinn, M. Liu, Z. Liu, Z. Cheng and M. Liu, Science, **326** (No. 5949), 126-129 (2009) (2 Oct., Issue).

High-Temperature Superconductivity in a Single Copper-Oxygen Plane

The question of how thin cuprate layers can be while still retaining high-temperature superconductivity (HTS) has been challenging to address, in part because experimental studies require the synthesis of near-perfect ultrathin HTS layers and ways to profile the superconducting properties such as the critical temperature and the superfluid density across interfaces with atomic resolution. Logvenov [1] used atomic-layer molecular beam epitaxy to synthesize bilayers of a cuprate metal ($La_{1.65}Sr_{0.45}CuO_4$) and a cuprate insulator(La_2CuO_4) in which each layer is just three unit cells thick. They selectively doped the layers with isovalent Zn atoms, which suppress superconductivity and act as markers, to show that this interface HTS occurs within a single CuO_2 plane. The authors state that, "this approach may also be useful in fabricating HTS devices".

Reference

1. G. Logvenov, A. Gozar and I. Bozovic, Science, **326** (No. 5953), 699 -702 (2009) (30 Oct., Issue).

4D Nanoscale Diffraction Observed by Convergent-Beam Ultrafast Electron Microscopy.

Diffraction with focused electron probes is among the most powerful tools for the study of time-averaged

nanoscale structures in condensed matter. Here, Yurtsever and Zewail [1] report four-dimensional (4D) nanoscale diffraction, probing specific site dynamics with 10 orders of magnitude improvement in time resolution, in convergent-beam ultrafast electron microscopy (CB-UEM). As an application, they measured the change of diffraction intensities in laser-heated crystalline silicon as a function of time and fluence. The structural dynamics (change in 7.3 ± 3.5 ps), the temperatures (up to 366 K), and the amplitudes of atomic vibrations(up to 0.084 Å) are determined for atoms strictly localized within the confined probe area (10 to 300 nm in diameter).The authors "anticipate a broad range of applications for CB-UEM and its variants, especially in the studies of single particles and heterogeneous structures".

Reference

1. A. Yurtsever and A. H. Zewail, Science, **326** (No. 5953), 708-712 (2009) (30 Oct., Issue).

Fractional quantum Hall effect and insulating phase of Dirac electrons in graphene.

In this and the following paper, the Fractional Quantum Hall Effect (FQHE) observed in graphene through the use of devices containing suspended graphene sheets, is reported, and thus, the results open a door to the further elucidation of the complex physical properties of graphene.

In graphene, which is an atomic layer of crystalline carbon, two of the distinguishing properties of the material are the charge carriers' two-dimensional and relativistic character. The first experimental evidence of the two-dimensional nature of graphene came from the observation of a sequence of plateaus in measurements of its transport properties in the presence of an applied magnetic field. These are signatures of the so-called integer quantum Hall effect. However, as a consequence of the relativistic character of the charge carriers, the integer quantum Hall effect observed in graphene is qualitatively different from its semiconductor analogue. As a third distinguishing feature of graphene, it has been conjectured that interactions and correlations should be important in this material, but surprisingly, evidence of collective behavior in graphene is lacking. In particular, the quintessential collective quantum behavior in two dimensions, the fractional quantum Hall effect (FQHE), has so far resisted observation in graphene despite intense efforts and theoretical predictions of its existence.

Here Du *et al.* [1] report the observation of the FQHE in graphene. These observations are made possible by using suspended graphene devices probed by two-terminal charge transport measurements. This allowed the authors to isolate the sample from substrate-induced perturbations that usually obscure the effects of interactions in this system and to avoid effects of finite geometry. At low carrier density, they find a field-induced transition to an insulator that competes with the FQHE, allowing its observation only in the highest quality samples. The authors "believe that these results will open the door to the physics of FQHE and other collective behavior in graphene".

Reference

1. X. Du, I. Skachko, F. Duerr, A. Luican and E. Y. Andrei, Nature **462** (No. 7270), 192-195 (2009) (12 Nov., Issue).

Observation of the fractional quantum Hall effect in graphene

When electrons are confined in two dimensions and subject to strong magnetic fields, the Coulomb interactions between them can become very strong, leading to the formation of correlated states of matter, such as the fractional quantum Hall liquid. In this strong quantum regime, electrons and magnetic flux quanta bind to form complex composite quasiparticles with fractional electronic charge; these are manifest in transport measurements of the Hall conductivity as rational fractions of the elementary conductance quantum. The experimental discovery of an anomalous integer quantum Hall effect in graphene has enabled the study of a correlated two-dimensional electronic system, in which the interacting electrons behave like massless chiral fermions. However, owing to the prevailing disorder, graphene has so far exhibited only weak signatures of correlated electron phenomena, despite intense experimental and theoretical efforts.

Here, Bolotin *et al.* [1] report the observation of the fractional quantum Hall effect FQHE) in ultraclean, suspended graphene. In addition, they showed that at

low carrier density graphene becomes an insulator with a magnetic-field-tunable energy gap. According to the authors, "these newly discovered quantum states offer the opportunity to study correlated Dirac fermions in graphene in the presence of large magnetic fields".

Reference

1. K. I. Bolotin, F. Ghahari, M. D. Shulman, H. L. Stormer and P. Kim, Nature **462** (No. 7270), 196-199 (2009) (12 Nov., Issue).

A Strain-Driven Morphotropic Phase Boundary in $BiFeO_3$

Piezoelectric materials, which convert mechanical to electricale nergy and vice versa, are typically characterized by the intimate coexistence of two phases across a morphotropic phase boundary.Electrically switching one to the other yields large electromechanical coupling coefficients. Driven by global environmental concerns,there is currently a strong push to discover practical lead-free piezoelectrics for device engineering.

Using a combination of epitaxial growth techniques in conjunction with theoretical approaches, Zeches *et al.* [1] show the formation of a morphotropic phase boundary through epitaxial constraint in lead-free piezoelectric bismuth ferrite ($BiFeO_3$) films. Electric field–dependent studies show that a tetragonal-like phase can be reversibly converted into a rhombohedral-like phase, accompanied by measurable displacementsof the surface, making this new lead-free system of interest for probe-based data storage and actuator applications.

Reference

1. R. J. Zeches, M. D. Rossell, J. X. Zhang, A. J. Hatt, Q. He, C.-H. Yang, A. Kumar, C. H. Wang, A. Melville, C. Adamo, G. Sheng, Y.-H. Chu, J. F. Ihlefeld, R. Erni, C. Ederer, V. Gopalan, L. Q. Chen, D. G. Schlom, N. A. Spaldin, L. W. Martin, and R. Ramesh, Science, **326** (No.5955) 977-980 (2009) (13 Nov., Issue).

Ultraflat Graphene

Graphene, a single atomic layer of carbon connected by sp^2 hybridized bonds, has attracted intense scientific interest since its recent discovery five years ago. Much of the research on graphene has been directed towards exploration of its novel electronic properties, but the structural aspects of this model two-dimensional (2D-) system are also of great interest and importance. In particular, microscopic corrugations have been observed on all suspended and supported graphene sheets studied so far. This rippling has been invoked to explain the thermodynamic stability of free-standing graphene sheets. Many distinctive electronic and chemical properties of graphene have been attributed to the presence of ripples, which are also predicted to give rise to new physical phenomena that would be absent in a planar 2D- material. Direct experimental study of such novel ripple physics has, however, been hindered by the lack of flat graphene layers.

Here Lui *et al.* [1] demonstrate the fabrication of graphene monolayers that are flat down to the atomic level. These samples are produced by deposition on the atomically flat terraces of cleaved mica surfaces. The apparent height variation in the graphene layers observed by high-resolution atomic force microscopy (AFM) is less than 25 pm, indicating the suppression of any existing intrinsic ripples in graphene. The authors state that, 'availability of such ultraflat samples will permit rigorous testing of the impact of ripples on various physical and chemical properties of graphene'.

Reference

1. C. H. Lui, L. Liu, K. F. Mak, G. W. Flynn and T. F. Heinz, Nature, **462** (No., 7271), 339-341 (2009) (19 Nov., Issue).

Electrical creation of spin polarization in silicon at room temperature

The control and manipulation of the electron spin in semiconductors is central to spintronics, which aims to represent digital information using spin orientation rather than electron charge. Such spin-based technologies may have a profound impact on nanoelectronics, data storage, and logic and computer architectures. Recently it has become possible to induce and detect spin polarization in otherwise non-magnetic semiconductors (gallium arsenide and silicon) using all-electrical structures, but so far only at temperatures below 150 K and in n-type materials, which limits further development.

Here, Dash *et al.* [1] demonstrate room-temperature electrical injection of spin polarization

into n-type and p-type silicon (Si) from a ferromagnetic tunnel contact, spin manipulation using the Hanle effect and the electrical detection of the induced spin accumulation. A spin splitting as large as 2.9 meV is created in n-type Si, corresponding to an electron spin polarization of 4.6%. The extracted spin lifetime is greater than 140 ps for conduction electrons in heavily doped n-type Si at 300 K and greater than 270 ps for holes in heavily doped p-type Si at the same temperature. The spin diffusion length is greater than 230 nm for electrons and 310 nm for holes in the corresponding materials. The authors say that 'these results open the way to the implementation of spin functionality in complementary Si-devices and electronic circuits operating at ambient temperature, and to the exploration of their prospects and the fundamental rules that govern their behavior'.

Reference

1. S. P. Dash, S. Sharma, R. S. Patel, M. P. de Jong and R. Jansen, Nature, **462**, 491-494 (2009) (26 Nov., Issue).

From Hydrogenases to Noble Metal–Free Catalytic Nanomaterials for H_2Production and Uptake

Interconversion of water and hydrogen in unitized regenerative fuel cells is a promising energy storage framework for smoothing out the temporal fluctuations of solar and wind power. However,replacement of presently available platinum catalysts by lower-cost and more abundant materials is a requisite for this technology to become economically viable.

Here, Goff *et al.* [1] show that the covalent attachment of a nickel bisdiphosphine-based mimic of the active site of hydrogenase enzymes onto multiwalled carbon nanotubes results in a high-surface area cathode material with highcatalytic activity under the strongly acidic conditions required in proton exchange membrane technology. Hydrogen evolves from aqueous sulfuric acid solution with very low overvoltages (20mV), and the catalyst exhibits exceptional stability(more than 100,000 turnovers). The same catalyst is also found to be very efficient for hydrogen oxidation in this environment, exhibiting current densities similar to those observed for hydrogenase-based materials.

Reference

1. A. L. Goff, V. Artero, B. Jousselme, P. D. Tran, N. Guillet, R. Métayé, A. Fihri,
2. S. Palacin and M. Fontecave, Science, **326** (No.5958), 1384-1387 (2009) (4 Dec., Issue).

Organic Nonvolatile Memory Transistors for Flexible Sensor Arrays

Using organic transistors with a floating gate embedded in hybrid dielectrics that comprise a 2-nm-thick molecular self-assembled monolayer and a 4-nm-thick plasma-grown metal oxide, Sekitani *et al.* [1] have realized nonvolatile memory arrays on flexible plastic substrates. The small thickness of the dielectrics allows verysmall program and erase voltages ($\leq$ 6 volts) to produce a large, nonvolatile, reversible threshold-voltage shift. The transistors were shown to endure more than 1000 program and erase cycles, which is within two orders of magnitude of silicon-based floating-gate transistors widely employed in flash memory.

By integrating a flexible array of organic floating-gate transistors with a pressure-sensitive rubber sheet, the authors have realized a sensor matrix that detects the spatial distribution of applied mechanical pressure andstores the analog sensor input as a two-dimensional image overlong periods of time.

Reference

1. T. Sekitani, T. Yokota, U. Zschieschang, H. Klauk, S. Bauer, K. Takeuchi, M. Takamiya, T. Sakurai and T. Someya, Science, **326** (No.5959), 1516-1519 (2009) (11 Dec., Issue).

Contrasting Pressure Effects in $Sr_2VFeAsO_3$ and $Sr_2ScFePO_3$

Recently, a new series of Fe- pnictide based superconductors with a thick perovskite oxide layer were discovered: Ogino *et al.* have reported superconductivity with a transition temperature (T_c) of 17 K in $Sr_2ScFePO_3$ (actual formula: $(Fe_2P_2)(Sr_4Sc_2O_6)$), which is the highest T_c among those of FeP-based oxide-pnictide systems. On the other hand, Zhu *et al.* have reported a T_c of 37 K in $Sr_2VFeAsO_3$(actual formula: $(Fe_2As_2)(Sr_4V_2O_6)$).

Kotegawa *et al.* [1] (group of Ogino) now report on the resistivity measurements under pressure of the

above two superconductors. The T_c of $Sr_2VFeAsO_3$ markedly increases with increasing pressure. Its onset value, which was $T_{c(onset)}$= 36.4 K at ambient pressure, increases to $T_{c(onset)}$= 46.0 K at ~ 4 GPa, ensuring the potential of the "21113" system as a high- T_c material. However, the superconductivity of $Sr_2ScFePO_3$ is strongly suppressed under pressure: The $T_{c(onset)}$of ~16 K decreases to ~ 5 K at ~ 4 GPa, and the zero-resistance state is almost lost. The authors discuss the factor that induces this contrasting pressure effect.

Reference

1. H. Kotegawa, T. Kawazoe, H. Tou, K. Murata, H. Ogino, K. Kishio, and J.-I. Shimoyama, J. Phys. Soc. Japan, **78** (12), 123707-1 to 123707- 4 (2009).

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Readers are invited to become members of the Materials Research Society of Singapore (MRS-S).

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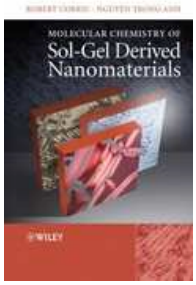
Recent Books and Review Articles in the Area of Materials Science, Engineering and Technology

(*Contributed by the Editor*)

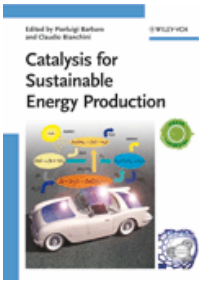
Books

- *Advanced Condensed Matter Physics.* By Leonard M. Sander, Cambridge University Press, Cambridge, 2009. Hardback: 286 pp., $80. ISBN 9780521872904.

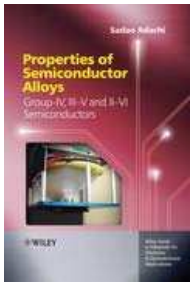
- *Molecular Chemistry of Sol-gel Derived Nanomaterials.* By Corriu, Robert and Anh, Nguyen Trong, Wiley-VCH, Weinheim, 2009. Hardcover. 200 Pages. 99.90 EUR. ISBN 978-0-470-72117-9.



- *Catalysts for sustainable energy production.* Edited by Barbaro, Pierluigi and Bianchini, Claudio. Wiley-VCH, Weinheim, 2009. Hardcover. 452 Pages. 149.- EUR. ISBN 978-3-527-32095-0.

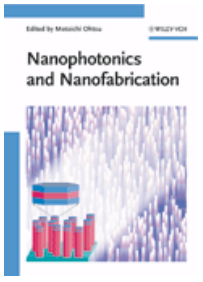


- *Properties of Semiconductor Alloys. Group-IV, III-V and II-VI Semiconductors.* By Adachi, Sadao, Wiley-VCH, Weinheim, 2009. Hardcover.422 Pages. 155.- EUR. ISBN 978-0-470-74369-0.

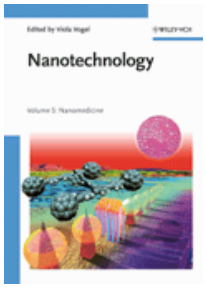


- *Surface Analysis. The Principal Techniques.* Edited by Vickerman, John C. and Gilmore, Ian. Wiley-VCH, Weinheim, 2009. Hardcover. 686 Pages. 155.- EUR. ISBN 978-0-470-01763-0. Softcover. 686 Pages. 54.90.- EUR. ISBN 978-0-470-01764-7.

- *Nanophotonics and nanofabrication.* Edited by Ohtsu, Motoichi. Wiley-VCH, Weinheim, 2009. Hardcover. 259 Pages. 129.- EUR. ISBN 978-3-527-32121-6.

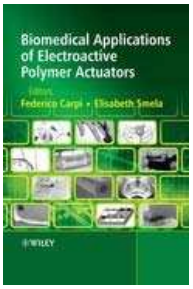


- *Nanotechnology Volume 5: Nanomedicine.* Edited by Vogel, Viola. Wiley-VCH, Weinheim, 2009. Hardcover. 425 Pages. 149.- EUR. ISBN 978-3-527-31736-3.

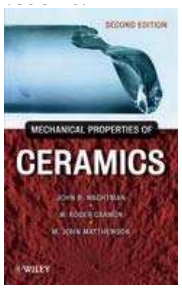


- *Dynamics of Self-Organized and Self-Assembled Structures.* By Rashmi C. Desai and Raymond Kapral, Cambridge University Press, Cambridge, 2009. Hardback: 342 pp. $80. ISBN 9780521883610.

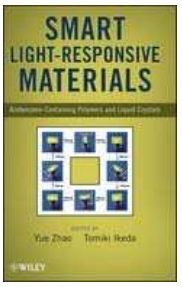
- *Biomedical Applications of Electroactive Polymer Actuators.* Edited by Carpi, Federico and Smela, Elisabeth, Wiley-VCH, Weinheim, 2009. Hardcover. 496 Pages. 119.- EUR. ISBN-10: 0-470-77305-7; ISBN-13: 978-0-470-77305-5 - John Wiley & Sons.



- *Mechanical properties of ceramics.* By Wachtman, John B., Cannon, W. Roger and Matthewson, M. John, Wiley-VCH, Weinheim, 2009. Second edition. Hardcover. 480 Pages. 109.- EUR. ISBN 978-0-471-73581-6.



- *Smart Light-Responsive Materials. Azobenzene-Containing Polymers and Liquid Crystals.* Edited by Zhao, Y and Ikeda, Tomiki. Wiley-VCH, Weinheim, 2009. Hardcover. 514 Pages. 119.- EUR. ISBN-10: 0-470-17578-8; ISBN-13: 978-0-470-17578-1 - John Wiley & Sons.



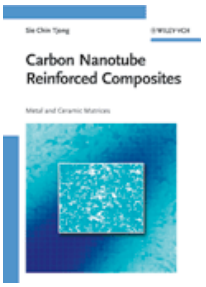
- *Carbon Nanotube Science Synthesis, Properties and Applications.* By Peter J. F. Harris. Cambridge University Press, New York, 2009. Hardback. 313 pp., illus. $90. ISBN 9780521828956.

- *Nanosciences- The Invisible Revolution*. By Christian Joachim and Laurence Plevert. World Scientific, Singapore,2009. Paperback. 200 pp. $25. ISBN 978-981-714-1.

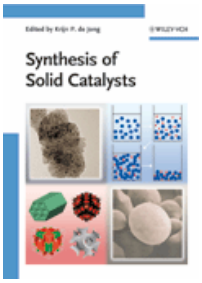
- *Selected Topics in Nanoscience and nanotechnology.* Edited by A.T.S. Wee. World Scientific, Singapore, 2009. Paperback. 250 pp. $78. ISBN 978-981-283-955-8.

- *Viscoelastic Materials.* By Roderic Lakes. Cambridge University Press, New York, 2009. Hardback: 479 pp., illus. $125. ISBN 9780521885683.

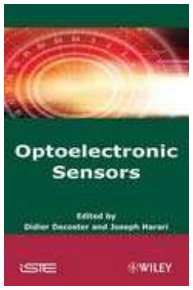
- *Carbon Nanotube Reinforced Composites.* By Tjong, Sie Chin. Wiley-VCH, Weinheim, 2009. Hardcover. 228 Pages. 129.- EUR. ISBN 978-3-527-40892-4.



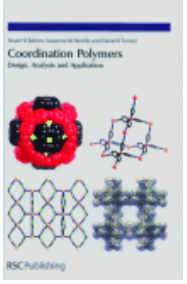
- *Synthesis of Solid Catalysts.* Edited by de Jong, Krijn P. Wiley-VCH, Weinheim, 2009. Hardcover. 402 Pages. 139.- EUR. ISBN 978-3-527-32040-0.



- *Optoelectronic Sensors.* By Decoster, Didier and Harari, Joseph. Wiley-VCH**,** Weinheim, 2009. Hardcover. 256 Pages. 82.9- EUR. ISBN-10: 1-84821-078-7; ISBN-13: 978-1-84821-078-3 - John Wiley & Sons.



- *Coordination Polymers. Design, Analysis and Application.* By Stuart R. Batten, Suzanne M. Neville and David R. Turner. Royal Society of Chemistry, Cambridge 2008. 471 pp. Hardcover. £ 89.95. ISBN 978-0854048373.



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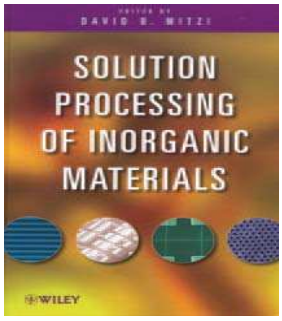

For a Review, see, Angew. Chem. Int. Ed., 48 (30), 5399 (2009).

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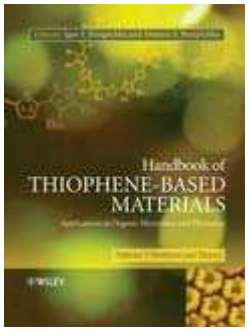

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Review Articles

- Ionic liquids as electrolytes for Li-ion batteries-An overview of electrochemical studies. By A. Lewandowski and A. S. -Mocek, J. Power Sources, **194** (2), 601-609 (2009).

Abstract

The paper reviews properties of room temperature ionic liquids (RTILs) as electrolytes for lithium and lithium-ion batteries (LIBs). It has been shown that the formation of the solid electrolyte interface (SEI) on the anode surface is critical to the correct operation of secondary LIBs, including those working with ionic liquids as electrolytes. The SEI layer may be formed by electrochemical transformation of (i) a molecular additive, (ii) RTIL cations or (iii) RTIL anions. Such properties of RTIL electrolytes as viscosity, conductivity, vapour pressure and lithium-ion transport numbers are also discussed from the point of view of their influence on battery performance. 85 References.

- Graphene: Status and Prospects. By A. K. Geim, Science, **324** (No.5934), 1530-1534 (2009).

Abstract

Graphene is a wonder material with many superlatives to its name. It is the thinnest known material and the strongest ever measured. Its charge carriers exhibit giant intrinsic mobility, have zero effective mass, and can travel for micrometers without scattering at room temperature. Graphene can sustain current densities six orders of magnitude higher than that of copper, shows record thermal conductivity and stiffness,is impermeable to gases, and reconciles such conflicting qualities as brittleness and ductility. Electron transport in graphene is described by a Dirac-like equation, which

allows the investigationof relativistic quantum phenomena in a bench-top experiment.This review analyzes recent trends in graphene research and applications, and attempts to identify future directions in which the field is likely to develop. 43 References.

- Nanostructures and lithium electrochemical reactivity of lithium titanites and titanium oxides: A review. By Z. Yang, D. Choi, S. Kerisit, K. M. Rosso, D. Wang, J. Zhang, G. Graff and J. Liu J. Power Sources, 192 (2), 588-598 (2009).

Abstract

Being inherently safe and chemically compatible with the electrolyte, titanium oxide-based materials, including both Li-titanites and various TiO_2 polymorphs, are considered alternatives to carbonaceous anodes in Li-ion batteries. Given the commercial success of the spinel lithium titanites, TiO_2 polymorphs, in particular in nanostructured forms, have been fabricated and investigated for the applications. Nanostructuring leads to increased reaction areas, shortened Li^+ diffusion and potentially enhanced solubility/capacity. Integration with an electron-conductive second phase into the TiO_2-based nanostructures eases the electron transport, resulting in further improved lithium electrochemical activity and the overall electrochemical performance. This article reviews structural characteristics and Li-electrochemical reactivity, along with synthetic approaches, of nanostructures and nano-composites based on lithium titanites and TiO_2 polymorphs that include rutile, anatase, bronze and brookite. 89 References.

- Organometallic chemistry: an alternative approach towards metal oxide nanoparticles. By M. L. Kahn, A. Glaria, C. Pages, M. Monge, L. S. Macary, A. Maisonnat and B. Chaudret, J. Mater. Chem., **19** (24)**,** 4044 - 4060 (2009).

Abstract

The synthesis of nanoparticles of controlled size, shape, size distribution and surface state is nowadays recognized to be of prime importance both from a fundamental point of view and for applications. Among all nanomaterials, nanoparticles of metal oxides are very attractive as their unique characteristics make them the most diverse class of materials with properties covering almost all aspect of solid-state physics, materials science and catalysis. In this article, the authors present their efforts toward the synthesis of metal oxide nanoparticles of controlled size and shape using organometallic chemistry. They show that this approach is versatile and can be generalized to several metal oxides from semiconducting to magnetic materials as well as from monometallic to mixed-metal-oxide nanomaterials. They point out that control over the size, shape, and surface state of such materials is of prime importance for understanding and controlling their physical properties, and report the use of such semiconducting nanoparticles for two different applications, highlighting the importance of the implementation of the nanoparticles in the fabrication of devices. 165 References.

- Synthesis and applications of nanocrystalline nitride materials. By B. Mazumder and A. L. Hector, J. Mater. Chem., **19** (27)**,** 4673-4686 (2009).

Abstract

Most current applications of nitride materials are based on films deposited from the vapour phase. However, a series of other potential uses of nitrides have been envisaged based on properties such as higher electronic conductivity than oxides, hardness, inertness and catalytic or electrochemical activity. Many current applications use nanocrystalline nitrides, and increasingly the size and shape dependent properties are of interest. This article reviews synthesis methods to make nanocrystalline and nanoparticulate nitride materials, and discusses the current applications and several potential ones. 151 References.

- Solvent-Free Ionic Liquid Electrolytes for Mesoscopic Dye-Sensitized Solar Cells. By S. M. Zakeeruddin and M. Grätzel, Adv. Funct. Mater., **19** (14), 2187 - 2202 (2009).

Abstract

Ionic liquids have been identified as a new class of solvent that offers opportunities to move away from the traditional solvents. The physical-chemical properties of ionic liquids can be tuned and controlled by tailoring their structures. The typical properties of

ionic liquids, such as non-volatility, electrochemical stability and high conductivity, render them attractive as electrolytes for dye-sensitized solar cells. However, the high viscosity of ionic liquids leads to mass transport limitations on the photocurrents in the solar cells at full sunlight intensity, but the contribution of a Grotthous-type exchange mechanism in these viscous electrolytes helps to alleviate these diffusion problems. This article discusses recent developments in the field of high-performance dye-sensitized solar cells with ionic liquid-based electrolytes and their characterization by electrochemical impedance analysis. 62 References.

- Physics and Applications of Bismuth Ferrite. By G. Catalan and J. F. Scott, Adv. Mater., **21** (24), 2463 – 2485 (2009).

Abstract

$BiFeO_3$ is perhaps the only material that is both magnetic (antiferromagnetic) and a strong ferroelectric at room temperature. As a result, it has had an impact on the field of multiferroics that is comparable to that of yttrium barium copper oxide (YBCO) on superconductors, with hundreds of publications devoted to it in the past few years. In this Review, the authors try to summarize both the basic physics and unresolved aspects of $BiFeO_3$ (which are still being discovered with several new phase transitions reported in the past few months) and device applications, which center on spintronics and memory devices that can be addressed both electrically and magnetically. 205 References.

- A review of recent developments in the synthesis procedures of lithium iron phosphate powders. By D. Jugovic and D. Uskokovic, J. Power Sources, **190** (2) 538-544 (2009).

Abstract

Olivine structure $LiFePO_4$ attracted much attention as a promising cathode material for lithium-ion batteries. The overwhelming advantage of iron-based compounds is that, in addition to being inexpensive and naturally abundant, they are less toxic than Co, Ni, and Mn. Its commercial use has already started and there are several companies that base their business on lithium phosphate technology. Still, there is a need for a manufacturing process that produces electrochemically active $LiFePO_4$ at a low cost. Therefore the interest in developing new approaches to the synthesis of $LiFePO_4$ did not fade. Here is presented a review of the synthesis procedures used for the production of $LiFePO_4$ powders along with the highlights of doped and coated derivatives. Apart from already established conventional routes of preparation, numerous alternative procedures are mentioned. 99 References.

- Ionic-liquid materials for the electrochemical challenges of the future. By M. Armand, F. Endres, D. R. MacFarlane, H. Ohno and B. Scrosati, Nature Materials, **8** (8), 621 - 629 (2009).

Abstract

Ionic liquids are room-temperature molten salts, composed mostly of organic ions that may undergo almost unlimited structural variations. This review covers the newest aspects of ionic liquids in applications where their ion conductivity is exploited; as electrochemical solvents for metal/semiconductor electrodeposition, and as batteries and fuel cells where conventional media, organic solvents (in batteries) or water (in polymer-electrolyte-membrane fuel cells), fail. Biology and biomimetic processes in ionic liquids are also discussed. In these decidedly different materials, some enzymes show activity that is not exhibited in more traditional systems, creating huge potential for bioinspired catalysis and biofuel cells. The authors survey the recent key developments and issues within ionic-liquid research in these areas. As well as informing materials scientists, the authors hope to generate interest in the wider community and encourage others to make use of ionic liquids in tackling scientific challenges. 73 References.

- Chemical and Physical Solutions for Hydrogen Storage. By U. Eberle, M. Felderhoff and F. Schüth, Angew. Chem. Int. Ed., **48**(36) 6608-6630 (2009).

Abstract

Hydrogen is a promising energy carrier in future energy systems. However, storage of hydrogen is a substantial challenge, especially for applications in vehicles with fuel cells that use proton-exchange membranes (PEMs). Different methods for hydrogen

storage are discussed, including high-pressure and cryogenic-liquid storage, adsorptive storage on high-surface-area adsorbents, chemical storage in metal hydrides and complex hydrides, and storage in boranes. For the latter chemical solutions, reversible options and hydrolytic release of hydrogen with off-board regeneration are both possible. Reforming of liquid hydrogen-containing compounds is also a possible means of hydrogen generation. The advantages and disadvantages of the different systems are compared. 160 References.

- Spin routes in organic semiconductors. By V. A. Dediu, L. E. Hueso, I. Bergenti and C. Taliani, Nature Materials, **8** (9), 707 - 716 (2009).

Abstract

Organic semiconductors are characterized by a very low spin–orbit interaction, which, together with their chemical flexibility and relatively low production costs, makes them an ideal materials system for spintronics applications. The first experiments on spin injection and transport occurred only a few years ago, and since then considerable progress has been made in improving performance as well as in understanding the mechanisms affecting spin-related phenomena. Nevertheless, several challenges remain in both device performance and fundamental understanding before organic semiconductors can compete with inorganic semiconductors or metals in the development of realistic spintronics applications.

In this article the authors summarize the main experimental results and their connections with devices such as light-emitting diodes and electronic memory devices, and outline the scientific and technological issues that make organic spintronics a young but exciting field. 160 References.

- Graphene-based electrode materials for rechargeable lithium batteries. By M. Liang and L. Zhi, J. Mater.Chem., **19** (33)**,** 5871–5878 (2009).

Abstract

Recent progress in the study of graphene has triggered a gold rush for exploiting its possible applications in various areas. Graphene-containing carbonaceous materials have long been selected as electrodes in rechargeable lithium batteries. However, the understanding of the relationship between material structure and electrode performance is still poor due to the complexity of the carbon structures, which hinders the development of high performance batteries. The authors state that 'now it is time to focus on the structure–property relationship of carbonaceous electrodes again, but from the viewpoint of graphene'. 76 References.

- Synthesis of high-performance ceramics based on polymerizable complex method. By M. Kakihana, J. Ceram. Soc. Japan, **117** (No.1368; Aug. Issue), 857-862 (2009).

Abstract

The polymerizable complex (PC) method was developed to prepare copper-based high-T_c superconducting oxides with improved superconducting properties, phosphor materials with excellent emission intensities and water-splitting photocatalysts with higher activities. The PC method is based on the formation of metal complexes and subsequent polyesterification between a hydroxy-caroboxylic acid such as citric acid and a glycol such as propylene glycol, so that homogeneity of the metal species inside the polyester resin precursor is maintained on the molecular scale. An example of Y_2SiO_5:Ce^{3+}, Tb^{3+} co-activated phosphor synthesis utilizing a new water soluble silicon compound is provided. The PC method is also an efficient methodology for the preparation of promising compounds for testing, without the requirement of tailoring the synthesis for each candidate; a scheme to search for the potential Tm^{3+} -activated phosphors in the series of complex gallates as hosts has been demonstrated as a representative example. 42 References.

- Recent advances in layered $Li(Ni)_xCo_yMn_{1-x-y})O_2$ cathode materials for lithium ion batteries. By L. Wang, J. Li, X. He, W. Pu, C. Wan and C. Jiang, J. Solid State Electrochem., **13** (8), 1157–1164(2009).

Abstract

Lithium cobalt oxide, $LiCoO_2$, has been the most widely used cathode material in commercial lithium ion batteries. Nevertheless, cobalt has economic and

environmental problems that leave the door open to exploit alternative cathode materials, among which $Li(Ni_xCo_yMn_{1-x-y})O_2$ may have improved performances, such as thermal stability, due to the synergistic effect of the three ions. Recently, intensive effort has been directed towards the development of $Li(Ni_xCo_yMn_{1-x-y})O_2$ as a possible replacement for $LiCoO_2$. Recent advances in layered $Li(Ni_xCo_yMn_{1-x-y})O_2$ cathode materials are summarized. The preparation and the performance are reviewed, and the future promising cathode materials are also prospected. 110 References.

- The theory-driven quest for a novel family of superconductors: fluorides. By W. Grochala, J. Mater. Chem., **19** (38), 6949–6968 (2009).

Abstract

Due to the enormous electronegativity of fluorine, the vast majority of binary and higher inorganic fluorides are high-melting, large-band-gap electronic insulators, which are transparent in the visible region of the electromagnetic spectrum. Rare examples of metallic fluorides are known, but valence orbitals of F marginally participate in the electronic transport in these compounds. In this review, the author describes recent theory-driven attempts to turn unusual fluorides of divalent silver – called fluoroargentates(II) – into a novel class of high-temperature superconductors. 151 References.

- Metal-Organic Frameworks: Opportunities for Catalysis. By D. Farrusseng, S. Aguado and C. Pinel, Angew. Chem. Int. Ed., **48**(41), 7502-7513 (2009).

Abstract

The role of metal-organic frameworks (MOFs) in the field of catalysis is discussed, and special focus is placed on their assets and limits in light of current challenges in catalysis and green chemistry. Their structural and dynamic features are presented in terms of catalytic functions along with how MOFs can be designed to bridge the gap between zeolites and enzymes. The contributions of MOFs to the field of catalysis are comprehensively reviewed and a list of catalytic candidates is given. The subject is presented from a multidisciplinary point of view covering solid-state chemistry, materials science, and catalysis. 131 References.

- Chemical, Electrochemical, and Structural Properties of Endohedral Metallofullerenes. By M. N. Chaur, F. Melin, A. L. Ortiz and L. Echegoyen, Angew. Chem. Int. Ed., **48** (41), 7514-7538 (2009).

Abstract

Ever since the first experimental evidence of the existence of endohedral metallofullerenes (EMFs) was obtained, the search for carbon cages with encapsulated metals and small molecules has become a very active field of research. EMFs exhibit unique electronic and structural features, with potential applications in many fields. Furthermore, functionalized EMFs offer additional potential applications because of their higher solubility and their ease of characterization by X-ray crystallography and other techniques. Herein we review the general field of EMFs, particularly of functionalized EMFs. We also address their structures and their (electrochemical) properties, as well as applications of these fascinating compounds. 155 References.

- Electrospinning of Manmade and Biopolymer Nanofibers - Progress in Techniques, Materials, and Applications. By S. Agarwal, A. Greiner and J. H. Wendorff, Adv. Funct. Mater., **19** (18), 2863-2879 (2009).

Abstract

Electrospinning of nanofibers has developed quickly from a laboratory curiosity to a highly versatile method for the preparation of a wide variety of nanofibers, which are of interest from a fundamental as well as a technical point of view. A wide variety of materials has been processed into individual nanofibers or nanofiber mats with very different morphologies. The diverse properties of these nanofibers, based on different physical, chemical, or biological behavior, mean they are of interest for different applications ranging from filtration, antibacterial coatings, drug release formulations, tissue engineering, living membranes, sensors, and so on. A particular advantage of electrospinning is that

numerous non-fiber forming materials can be immobilized by electrospinning in nanofiber nonwovens, even very sensitive biological objects such as virus, bacteria, and cells. The progress made during the last few years in the field of electrospinning is fascinating and is highlighted in this review Article, with particular emphasis on results obtained in the authors' research units. Specific areas of importance for the future of electrospinning, and which may open up novel applications, are also highlighted. 98 References.

- Hollow Micro/Nanomaterials with Multilevel Interior Structures. By Yong Zhao and Lei Jiang, Adv. Mater., **21** (36), 3621-3638 (2009).

Abstract

In this Review, recent achievements in the multilevel interior-structured hollow 0D and 1D micro/nanomaterials are presented and categorized. The 0D multilevel interior-structured micro/nanomaterials are classified into four main interior structural categories that include a macroporous structure, a core-in-hollow-shell structure, a multishell structure, and a multichamber structure. Correspondingly, 1D tubular micro/nanomaterials are of four analogous structures, which are a segmented structure, a wire-in-tube structure, a multiwalled structure, and a multichannel structure. Because of the small sizes and complex interior structures, some special synthetic strategies that are different from routine hollowing methods, are proposed to produce these interior structures. Compared with the same-sized solid or common hollow counterparts, these fantastic multilevel hollow-structured micro/nanomaterials show a good wealth of outstanding properties that enable them broad applications in catalysis, sensors, Li-ion batteries, microreactors, biomedicines, and many others. 162 References.

- Toward the Development of Printable Nanowire Electronics and Sensors. By Z. Fan, J. C. Ho, T. Takahashi, R. Yerushalmi, K. Takei, A. C. Ford, Y.-L. Chueh and A. Javey, Adv. Mater., **21** (37), 3730-3743 (2009).

Abstract

In recent years, there has been tremendous progress in the research and development of printable electronics on mechanically flexible substrates based on inorganic active components, which provide high performances and stable device operations at low cost. In this regard, various approaches have been developed for the direct transfer or printing of micro- and nanoscale, inorganic semiconductors on substrates. In this review article, we focus on the recent advancements in the large-scale integration of single crystalline, inorganic-nanowire (NW) arrays for electronic and sensor applications, specifically involving the contact printing of NWs at defined locations. We discuss the advantages, limitations, and the state-of-the-art of this technology, and present an integration platform for future printable, heterogeneous-sensor circuitry based on NW parallel arrays. 134 References.

- The Tetragonal-Monoclinic Transformation in Zirconia: Lessons Learned and Future Trends. By J. Chevalier, L. Gremillard, A. V. Virkar and D. R. Clarke, J. Amer. Ceram. Soc., **92** (9), 1901-1920 (2009).

Abstract

Zirconia ceramics have found broad applications in a variety of energy and biomedical applications because of their unusual combination of strength, fracture toughness, ionic conductivity, and low thermal conductivity. These attractive characteristics are largely associated with the stabilization of the tetragonal and cubic phases through alloying with aliovalent ions. The large concentration of vacancies introduced to charge compensate of the aliovalent alloying is responsible for both the exceptionally high ionic conductivity and the unusually low, and temperature independent, thermal conductivity. The high fracture toughness exhibited by many of zirconia ceramics is attributed to the constraint of the tetragonal-to-monoclinic phase transformation and its release during crack propagation. In other zirconia ceramics containing the tetragonal phase, the high fracture toughness is associated with ferroelastic domain switching. However, many of these attractive features of zirconia, especially fracture toughness and strength, are compromised after prolonged exposure

to water vapor at intermediate temperatures (~ 30 ° – 300 ° C) in a process referred to as low-temperature degradation (LTD), and initially identified over two decades ago. This is particularly so for zirconia in biomedical applications, such as hip implants and dental restorations. Less well substantiated is the possibility that the same process can also occur in zirconia used in other applications, for instance, zirconia thermal barrier coatings after long exposure at high temperature. Based on experience with the failure of zirconia femoral heads, as well as studies of LTD, it is shown that many of the problems of LTD can be mitigated by the appropriate choice of alloying and/or process control. 81 References.

- Graphene: The New Two-Dimensional Nanomaterial. By C. N. R. Rao, A. K. Sood, K. S. Subrahmanyam, A. Govindaraj, Angew. Chem. Int. Ed., **48** (42), 7752-7777 (2009).

Abstract

Every few years, a new material with unique properties emerges and fascinates the scientific community, typical recent examples being high-temperature superconductors and carbon nanotubes. Graphene is the latest sensation with unusual properties, such as half-integer quantum Hall effect and ballistic electron transport. This two-dimensional material which is the parent of all graphitic carbon forms is strictly expected to comprise a single layer, but there is considerable interest in investigating two-layer and few-layer graphenes as well. Synthesis and characterization of graphenes pose challenges, but there has been considerable progress in the last year or so. In this review, the authors present the status of graphene research which includes aspects related to synthesis, characterization, structure, and properties. 196 References.

- Un sie‘cle de Hautes Pressions : De’veloppements technologiques et scientifiques. *(A century of high pressure: technological and scientific developments).* By G. Demazeau, Compt. Rend. Chimie, **12** (9), 933-942(2009).

Abstract

This review is devoted to the development of high pressures during approximately one century and the main scientific domains concerned by such a development. Roughly three main periods have been considered: (i) the early period at the beginning of 20^{th}century (1900-1970), the second period (1970-2005) taking into account some important technical developments (the high pressure vessels with a large volume, the diamond anvil cell associated with the laser heating), and a prospective concerning, on the basis of recent results, the possible developments during the next 10 years.

The early period was mainly characterized by some industrial problems: the improvement of the mechanical properties of alloys and consequently the requirement for performant cutting and machining tools (leading to the diamond synthesis), the synthesis of ammonia (initiated both by the development of explosives and the requirement of fertilizers), the preservation of foods (correlated to a new organization of the Society), and the elaboration of single crystals characterized by specific physical properties with functional properties for the development of some industrial sectors (telecommunications, computer science). The more recent period (1970-2005) has been characterized by the development of new performant tools able to improve the development of scientific domains (diamond-anvil-cell and Geosciences, Belt-type, multi-anvils and toroid equipments and the Chemistry of Materials, high pressure vessels and Food-Science). During these years, roughly three main tendencies have been observed: (i) the investigation of researches at extreme (P, T) conditions, (ii) the improvement of researches involving mild (P, T) conditions mainly in liquid phase (hydrothermal and solvothermal synthesis), and (iii) the development of high pressures in Biology and Biotechnology.

During the next years the extension of high pressure level and also the development of the next scientific domains would improve research involving different planes. In parallel, the development of chemical reactions in mild P, T conditions in a liquid phase would allow to prepare new hybrid nano-systems at the interface between inorganic and organic chemistry, inorganic and biological chemistry or new supramolecular systems. The applications of high pressures in Biotechnology, due in particular to the low energy conveyed by pressure would lead to new research domains or industrial processes involving either the inactivation of pathogen microorganisms with the development of

new vaccines, or the domain of the proteins. 155 References.

- Calcium phosphate coatings for bio-implant applications: Materials, performance factors, and methodologies. By S. R. Paital and N. B. Dahotre, Mater. Sci. & Engg., **R 66** (1-3), 1-70 (2009).

Abstract

With an ageing population, war, and sports related injuries there is an ever-expanding requirement for hard tissue replacement such as bone. Engineered artificial scaffold biomaterials with appropriate mechanical properties, surface chemistry and surface topography are in a great demand for enhancing cell attachment, cell growth and tissue formation at such defect sites. Most of these engineering techniques are aimed at mimicking the natural organization of the bone tissues and thereby create a conducive environment for bone regeneration. As the interaction between the cells and tissues with biomaterials at the tissue–implant interface is a surface phenomenon, surface properties play a major role in determining both the biological response to implants and the material response to the physiological condition. Hence surface engineering of biomaterials is aimed at modifying the material and biological responses through changes in surface properties while still maintaining the bulk mechanical properties of the implant. Therefore, there has been a great thrust towards development of Ca–P-based surface coatings on various metallic and nonmetallic substrates for load bearing implant applications such as hip joint prosthesis, knee joint prosthesis and dental implants.

Typical coating methodologies like ion beam assisted deposition, plasma spray deposition, pulsed laser physical vapor deposition, magnetron sputtering, sol–gel derived coatings, electrodeposition, micro-arc oxidation and laser deposition are extensively studied at laboratory scale. In the present article, attempts are made to give an overview of the basic principles behind the coating techniques as well as advantageous features such as bioactivity and biocompatibility associated with these coatings. A strong emphasis was given on laser-induced textured and bioactive coatings obtained by the author's research group. Since cells are sensitive to topographical features ranging from mesoscale to nanoscale, formation of these features by both pulsed and continuous wave Nd:YAG laser system are highlighted. This can also be regarded as advancement towards third generation biomaterials which are bioinert, bioactive and which once implanted, will stimulate cell adhesion, proliferation and growth at the interface. Further, an overview of various bio-implants and biodevices and materials used for these kinds of devices is presented. Performance factors such as mechanical and corrosion behavior and surface science associated with these materials are also explained.

As the present review is aimed at describing the multidisciplinary nature of this exciting field, the authors state that, 'it also provides a common platform to understand this subject in a simple way for students, researchers, teachers and engineers in the fields ranging from medicine, dentistry, biology, materials science, biomedicine, biomechanics to physics'. 308 References.

- Negative thermal expansion: a review. By W. Miller, C. W. Smith, D. S. Mackenzie and K. E. Evans, J. Mater. Sci., **44** (20), 5441-5451 (2009).

Abstract

Most materials demonstrate an expansion upon heating. However, a few are known to contract, that is, exhibit a negative coefficient of thermal expansivity (NTE). This naturally occurring phenomenon has been shown to occur in a range of solids including complex metal oxides, polymers and zeolites, and opens the door to composites with a coefficient of thermal expansion (CTE) of zero.

The state of the art in NTE solids is reviewed, and understanding of the driving mechanisms of the effect is considered along with experimental and theoretical evidence. The various categories of solids with NTE are explored, and experimental methods for their experimental characterization and applications for such solids are proposed. An abstraction for an underlying mechanism for NTE at the supramolecular level and its applicability at the molecular level is discussed. 88 References.

- Review: environmental friendly lead-free piezoelectric materials. By P.K. Panda, J. Mater. Sci., **44** (19), 5049–5062 (2009).

Abstract

Lead zirconate titanate (PZT) based piezoelectric materials are well known for their excellent piezoelectric properties. However, considering the toxicity of lead and its compounds, there is a general awareness for the development of environmental friendly lead-free materials as evidenced from the legislation passed by the European Union in this effect. Several classes of materials are now being considered as potentially attractive alternatives to PZTs for specific applications. In this article, attempts have been made to review the recent developments on lead-free piezo materials emphasizing on their preparation, structure–property correlation, etc. In this context, perovskite systems such as bismuth sodium titanate, alkali niobates ($ANbO_3$), etc. and non-perovskites such as bismuth layer-structured ferroelectrics are reviewed in detail. From the above study, it is concluded that some lead-free compositions show stable piezoelectric responses even though they do not match the overall performance of PZT. This has been the stimulant for growing research on this subject. 129 References.

- Reliability of Organic Field-Effect Transistors. By H. Sirringhaus, Adv. Mater., **21** (39), 3859–3873(2009).

Abstract

In this article, the author reviews the current understanding of the reliability of organic field-effect transistors, with a particular focus on degradation of device characteristics under bias stress conditions. The various factors that have been found to influence the operational stability of different material systems, including dependence on stress voltage and duty cycle, gate dielectric, environmental conditions, light exposure, and contact resistance, are discussed. A key question concerns the role of extrinsic factors, such as oxidation or presence of moisture, and that of intrinsic factors, such as the inherent structural and electronic disorder that is present in thin organic semiconductor films. The current understanding of the microscopic defects that could play a role in charge-trapping in organic semiconductors, is also reviewed. 94 References.

- Diffusion pathway of mobile ions and crystal structure of ionic and mixed conductors-A brief review. By M. Yashima, J. Ceram. Soc. Japan, **117** (No. 1370), 1055-1059 (2009).

Abstract

A brief review on the field of Solid State Ionics, including the diffusion pathway of mobile ions, crystal structure and materials, is presented. In the fluorite-structured ionic conductors such as ceria solid solution $(Ce_{0.93}Y_{0.07})O_{1.96}$, bismuth oxide solid solution δ-$(Bi_{1.4}Yb_{0.6})O_3$ and copper iodide CuI, a similar curved diffusion pathway along the $<100>$ directions is observed. In the ionic and mixed conductors with the cubic ABO_3 perovskite-type structure such as lanthanum gallate and lanthanum cobaltite solid solutions, the mobile ions diffuse along a curved line keeping the interatomic distance between the B cation and O^{2-} anion to some degree. The structure and diffusion path of double-perovskite-type $La_{0.64}Ti_{0.92}Nb_{0.08}O_{2.99}$, K_2NiF_4-type $(Pr_{0.9}La_{0.1})_2(Ni_{0.74}Cu_{0.21}Ga_{0.05})O_{4+\delta}$, and apatite-type $La_{9.69}(Si_{5.70}Mg_{0.30})O_{26.24}$, are described. The diffusion paths of Li^+ ions in $(La_{0.62}Li_{0.16})TiO_3$ and $Li_{0.6}FePO_4$ are two- and one-dimensional, respectively. 30 References.

- Complex ceramic structures. I. Weberites. By L. Cai and J.C. Nino, Acta Cryst., **B65** (3), 269-290 (2009).

Abstract

The weberite structure ($A_2B_2X_7$) is an anion-deficient fluorite (CaF_2)-related superstructure. Compared with fluorites, the reduction in the number of anions leads to a decrease in the coordination number of the B cations (VI coordination) with respect to the *A* cations (VIII coordination), thus allowing the accommodation of diverse cations. As a result, weberite compounds have a broad range of chemical and physical properties and great technological potential.

This review article summarizes the structural features of weberite and describes the structure in several different ways. This is the first time that the stacking vector and stacking angle are used to represent the weberite structure. This article also discusses the crystallographic relationship between weberite, fluorite and pyrochlore (another fluorite-related structure). The cation sublattices of weberite and pyrochlore are correlated by an axial transformation. It has been

shown that the different coordination environment of anions is due to the alternating layering of the AB_3 and A_3B close-packed cation layers. A stability field of weberite oxides is proposed in terms of the ratio of ionic radius of cations and relative bond ionicity. In addition, a selection of weberite compounds with interesting properties is discussed. 132 References.

- New and Old Concepts in Thermoelectric Materials. By J. R. Sootsman, D. Y. Chung and M. G. Kanatzidis, Angew. Chem. Int. Ed., **48** (46), 8616-8639 (2009).

Abstract

The authors cover the key concepts in the field of thermoelectric materials research, present the current understanding, and show the latest developments. Current research is aimed at increasing the thermoelectric figure of merit (ZT) by maximizing the power factor and/or minimizing the thermal conductivity. Attempts at maximizing the power factor include the development of new materials, optimization of existing materials by doping, and the exploration of nanoscale materials. The minimization of the thermal conductivity can come through solid-solution alloying, use of materials with intrinsically low thermal conductivity, and nanostructuring. The authors describe the most promising bulk materials with emphasis on results from the last decade. Single-phase bulk materials are discussed in terms of chemistry, crystal structure, physical properties, and optimization of thermoelectric performance. The new opportunities for enhanced performance bulk nanostructured composite materials are examined and a look into the not-so-distant future is attempted. 230 References.

- Boron: Elementary Challenge for Experimenters and Theoreticians. By B. Albert and H. Hillebrecht, Angew. Chem. Int. Ed., **48** (46), 8640-8668 (2009).

Abstract

Many of the fundamental questions regarding the solid-state chemistry of boron are still unsolved, more than 200 years after its discovery. Recently, theoretical work on the existence and stability of known and new modifications of the element combined with high-pressure and high-temperature experiments have revealed new aspects.

A lot has also happened over the last few years in the field of reactions between boron and main group elements. Binary compounds such as B_6O, MgB_2, LiB_{1-x}, Na_3B_{20}, and CaB_6 have caused much excitement, but the electron-precise, colorless boride carbides $Li_2B_{12}C_2$, $LiB_{13}C_2$, and $MgB_{12}C_2$ as well as the graphite analogue BeB_2C_2 also deserve special attention. Physical properties such as hardness, superconductivity, neutron scattering length, and thermoelectricity have also made boron-rich compounds attractive to materials research and for applications. The greatest challenges to boron chemistry, however, are still the synthesis of monophasic products in macroscopic quantities and in the form of single crystals, the unequivocal identification and determination of crystal structures, and a thorough understanding of their electronic situation. Linked polyhedra are the dominating structural elements of the boron-rich compounds of the main group elements. In many cases, their structures can be derived from those that have been assigned to modifications of the element. Again, even these require a critical revision and discussion. 348 References.

Forthcoming Conferences

ICONSAT 2010, Feb., 17-20, 2010, Mumbai, India

The International Conference on Nanoscience and Technology (ICONSTAT 2010) will be held in Mumbai, India during Feb., 17-20, 2010.

Contact address: Contact address: Prof. D. Bahadur, Convener, ICONSAT2010, Dept. of Matallurg. Engg.& Mater. Sci., IIT Bombay, Powai, Mumbai 400076, India.

For additional details, see, http://www.iconsat2010.in

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

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

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

Topics

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

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

Awards

The prestigious Paul J. Flory research award and further prizes for young scientists and poster presenters will be awarded during the Conference.

Conference chairman and chairman of the Organising committee: Werner Mormann

Important Dates
Pre-registration : August 30, 2009
Abstract submission : October 30, 2009
Abstract acceptance : December 15, 2009
Registration fee payment: January 15, 2010
Submission of Abstracts and Online Registration
For instructions on preparation and submission of abstracts, online registration, technical program and further

information please visit the conference website: http://polychar18.uni-siegen.de
Website: http://www.uni-siegen.de/fb8/polychar18
Publication : Manuscripts of contributions will be published in Macromolecular Symposia after peer review.

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

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

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

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

Specific areas to be covered are:

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

Abstracts

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

Papaers

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

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

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

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

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

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

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

Conference Chair: Prof. Kian Ping Loh**,** Dept. of Chemistry, National University of Singapore, Singapore. E-mail: chmlohkp@nus.edu.sg
Conference Website: http://www.engconfintl.org/10ah.html

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

International Union of Materials Research Societies - International Conference on Electronic Materials 2010 will be held at KINTEX (Korea International Exhibition Center), Goyang, Gyeonggi-do, Korea, from August 22(Sun)-27(Fri), 2010. It is being organized by the Materials Research Society of Korea (MRS-K).

Organizing Committee
General Chair: Prof. Hyeong Joon Kim (Seoul National University) e-mail: thinfilm@snu.ac.kr
Secretariat: Prof. Woo-Gwang Jung (Kookmin University) e-mail: wgjung@kookmin.ac.kr
Program Committee Chair: Prof. Hyungsun Kim (Inha University) e-mail: kimhs@inha.ac.kr
Organizing Committee Chair: Prof. Taik Nam Kim (Paichai University) e-mail: tnkim@pcu.ac.kr
Administrator: Ms. Ji Young Kim (MRS-K) e-mail: mrsk@mrs-k.or.kr
Important Dates (tentative): Abstract Submission Due: Mar.,15, 2010; Notification to Authors: Apr., 30, 2010 ; Final Announcement with Program: June, 15, 2010; Advance Registration: June, 30, 2010.

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

Members of the international scientific and engineering communities interested in recent developments in superconductivity, magnetism, magnetic materials and related technologies are cordially invited to attend the Conference and contribute to its technical sessions. The ICSM2010 will provide a platform, where solid state physicists, chemists and material scientists, engineers and other professionals meet together for mutual benefits and collaboration.

There will also be an Educational Courses during 20-25, Apr., 2010 (prior to the Conference).

Major Topics: Superconducting Materials and Basic Properties; Magnetism and Magnetic Materials; Large Scale Applications, Science and Technology; Electronics Applications, Science and Technology.

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

'Theme Articles' appeared in 'MRS-S OUTLOOK', Vol. 4, Nos.1-2

From applied science to commercial application – synchrotron radiation as a broad R&D platform: Part V.

H.O. Moser[1], K. Banas[1], M. Cholewa[1], C.Z. Diao[1], X.Y. Gao[2], L.K. Jian[1], S.M.P. Kalaiselvi[1], Z.J. Li[1], G. Liu[1], T. Liu[2], S.K. Maniam[1], A.T.S. Wee[2], P. Yang[1], Y. Adam Yuan[3,4], MRS-S OUTLOOK, **4** (1), 12-20(2009).

[1]*Singapore Synchrotron Light Source, National University of Singapore, Singapore*
[2]*Department of Physics, National University of Singapore, Singapore*
[3]*Department of Biological Sciences, National University of Singapore, Singapore*
[4]*Temasek Life Sciences Laboratory, National University of Singapore and Nanyang Technological University, Singapore*

Abstract: Synchrotron radiation based soft X-ray spectroscopy, namely X-ray photoemission spectroscopy (XPS) and X-ray absorption spectroscopy (XAS)/X-ray absorption near edge structure (XANES) are powerful tools for studying novel materials from thin films to nanostructures with surface sensitivity. These techniques can offer unique electronic, magnetic, chemical, and even some structural information. The SINS beamline at Singapore Synchrotron Light Source (SSLS) is ideal for the photoemission (XPS/UPS) and XAS to study the surface, interface, and nanostructure science. In this Article, several different sample systems studied at SINS beamline, comprising inorganic and organic compounds/thin films are described and discussed.

From applied science to commercial application – synchrotron radiation as a broad R&D platform: Part VI.

H.O. Moser[1,2], K. Banas[1], M. Cholewa[1], C.Z. Diao[1], X.Y. Gao[2], L.K. Jian[1], S.M.P. Kalaiselvi[1], Z.J. Li[1], G. Liu[1], T. Liu[2], S.K. Maniam[1], A.T.S. Wee[2], P. Yang[1], Y. Adam Yuan[3,4], MRS-S OUTLOOK, **4** (2),43-54(2009).

[1]*Singapore Synchrotron Light Source, National University of Singapore, Singapore*
[2]*Department of Physics, National University of Singapore, Singapore*
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[4]*Temasek Life Sciences Laboratory, National University of Singapore and Nanyang Technological University, Singapore*

Abstract: Over the past few years, results from the phase contrast imaging and tomography (PCIT) beamline at the Singapore Synchrotron Light Source (SSLS) have shown that high resolution (about 2 μm) 2-dimensional (2D) and

3-dimensional (3D) imaging can be achieved. Using white radiation, the photon flux is high enough to perform real time radiology (100 ms per frame) at high lateral resolution as well as high-speed 2D imaging and 3D tomography. Refractive edge enhancement was also observed. PCIT is mostly used for materials and process characterization.

Although several research groups have already documented a resolution down to 20 nm with X-rays and 3D tomography when imaging cryogenic single cells, and down to below 1 nm with Transmission Electron Microscopy (TEM), the useful sample sizes were limited to less than a few μm. However, there is a large pool of applications for which 1 μm resolution tomography is optimal when sample sizes approach 1-2 mm. In this part of the Theme Article, the authors concentrate on selected applications at about 1 μm resolution. Additionally, a new project at SSLS will be discussed for reaching a resolution down to 50 nm.

Please see: www.mrs.org.sg for accessing the MRS-S OUTLOOK Issues containing the Parts I to VI.

Materials Education & Research in Singapore

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

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

Nanyang Technological University: www.ntu.edu.sg

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

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

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

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

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

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

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

INVITATION

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

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

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

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

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

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