Institute of Materials Research and Engineering
A*STAR

PERSPECTIVES

Research, Development and Commercialisation

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Materials - Technology for Tomorrow
IMRE Celebrates!
1997 - 2007

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IMRE is 10!

IMRE reaches another milestone in its history – 10 years of materials knowledge and innovation!

The Institute of Materials Research and Engineering (IMRE) celebrates 10 years of creating materials knowledge, developing human capital and transforming technology through innovative research, in 2007.

Starting life as a small research unit in National University of Singapore (NUS), IMRE is now a state-of-the-art materials research institute of the Agency for Science, Technology and Research (A*STAR). IMRE boasts some of the most advanced analysis and characterisation equipment in the region which is helmed by top expertise from around the world.

Conducting high-tech research on such projects like new age heat-resistant, high-strength polymers, advanced micro- and nano-sized systems, and light emitting devices to replace incandescent bulbs, IMRE's work on materials is indeed *technology for tomorrow*!

Some of the institute's achievements to date include miniature optical lenses made out of liquid and nanometre-sized magnetic tags. These are finding applications in devices like mobile phone cameras with optical zoom, and anti-counterfeit tags to authenticate luxury items.

Presently housed in a 6-storey research facility near the NUS campus, the 200-strong research staff focus on research related to molecular and performance materials, micro- and nano- systems integration, optoelectronics and photonics, and materials characterisation.

From Scratch – IMRE

***Purpose-built**: IMRE during construction (left), at present (above) and it's future home at Fusionopolis (right).*

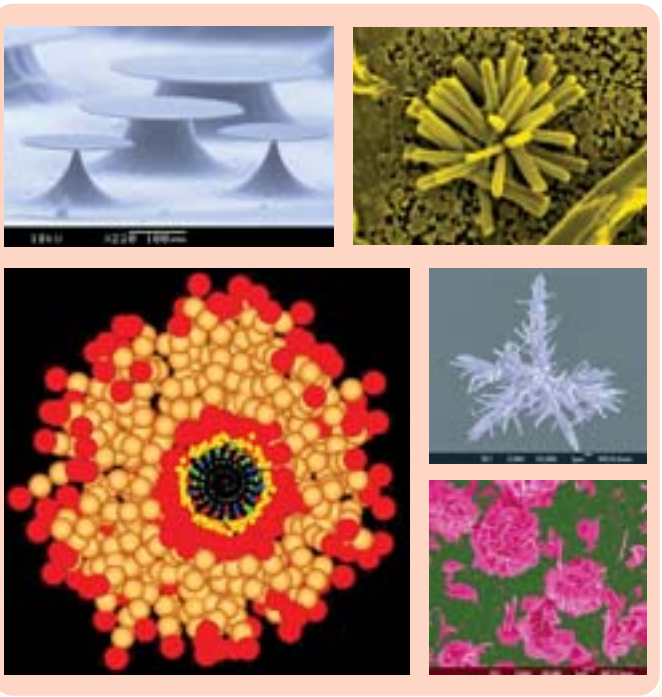
aRt & D – Art in Materials Research

Behind the chemical-filled laboratories and cold, chrome-coloured high-tech tools are spectacular scientific research images that astound and awe, and are truly works of art!

These pictures may look like part of a collection of painted art masterpieces, but have in fact been created by one of the today's greatest artists – *science*.

These images are part and parcel of the materials research work of A*STAR's Institute of Materials Research and Engineering (IMRE). Captured using sophisticated high-powered electron microscopes, the materials are viewed at very high magnification, which is a thousand times that of a regular light microscope. The images are of different types of materials. Materials scientists use these images to look at the link between the structure and the properties these structures confer on a material. From this, existing materials can be enhanced and new materials can be created. Properties like mechanical strength, heat-resistance, controlled porosity and even magnetism can then be exploited for a host of real world applications. These include fire-retardant materials, nano-sized magnetic tags and optical zoom lenses made of liquid.

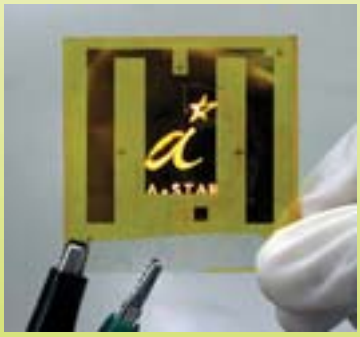
The pictures are part of a collection of outstanding scientific images that are being compiled into a commemorative edition in conjunction with ***IMRE's 10th Anniversary Celebrations in 2007***. Officially launched in 1997, IMRE's mission is to create materials knowledge, develop human capital and transform technology through innovative research.



***Science as an art form**: Some of the scientific images taken by IMRE researchers (clockwise from top left); Gallium nitride (GaN) microdisks pivoted on narrow silicon posts; French fries-shaped zinc oxide (ZnO); ZnO nanowires on GaN; ZnO microstructures; and simulation of the self-assembly of DNA, phospholipids and cations.*

Unidym-IMRE tie-up to develop OLEDs

IMRE and US company Unidym Inc. signs collaboration deal to develop organic light emitting diodes (OLEDs), which incorporate Unidym's transparent electrodes.



***Working together**: IMRE and Unidym will leverage on one another's expertise in developing OLEDs.*

Under the terms of an agreement signed in January this year, Unidym will provide IMRE researchers with access to its proprietary, carbon nanotube-based, transparent electrodes. IMRE will in turn incorporate these into its OLED devices.

"We believe IMRE is a world leader in OLED technology and are pleased that Unidym has entered this collaboration with such a distinguished institution," said Bruce Stewart, President of Arrowhead Research, the parent company of Unidym. "We will continue to look for strategic partners to integrate Unidym's transparent electrodes into optoelectronic systems."

An OLED is a thin-film, light-emitting device generally comprised of organic layers sandwiched between two electrodes on a glass or flexible substrate. OLEDs are primarily used for display and lighting applications. They offer bright, colourful images with a wide viewing angle and low power consumption. According to iSuppli Corp., the market for OLEDs was $408 million in 2004 and is expected to reach $2.9 billion by 2011.

Unidym Inc. is developing low-cost, carbon-based materials, processes, and devices for the electronics industry.

"*An OLED is a thin-film, light-emitting device* generally comprised of organic layers between two electrodes on a glass or flexible substrate. OLEDs are primarily used for display and lighting applications. They offer bright, colorful images with a wide viewing angle and low power consumption."

NTU MSE-IMRE 11th Materials Challenge

The 11th Materials Challenge supported by IMRE draws biggest ever organisation participation – 11 junior colleges and 3 polytechnics.

IMRE and Nanyang Technological University's Material Science and Engineering (NTU MSE) Club organised the 11th Materials Challenge, an annual competition that pits students from invited institutions on materials science related topics.

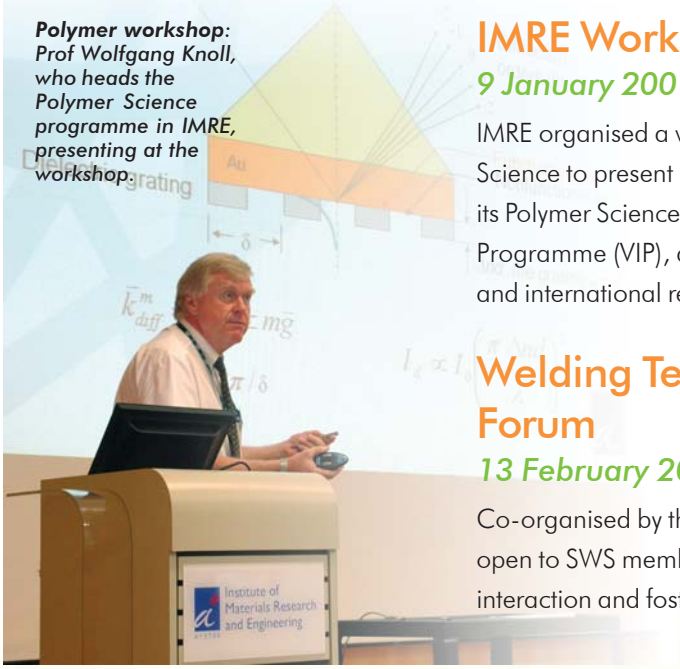
Divided into two categories, 16 teams participated in this year's event – 11 from junior colleges and 5 teams from 3 polytechnics.

The annual competition involves both theoretical and practical components and culminates in an exciting real-time quiz round where participants go head-to-head on questions relating to materials.

Speaking at the opening ceremony of the Challenge, IMRE's Deputy Executive Director, Prof Chua Soo Jin, outlined the importance of materials science in developing technology.

"Materials science contributes to quantum leaps in performance over existing technologies and gives rise to new ones," said Prof Chua, who gave the example of the white LED technology that IMRE was working on. White LEDs for consumer lighting applications have the potential to replace current lighting devices such as incandescent bulbs. LEDs use less energy, are brighter and last longer than current lighting technology.

Visits and Events



***Polymer workshop**: Prof Wolfgang Knoll, who heads the Polymer Science programme in IMRE, presenting at the workshop.*

IMRE Workshop on Polymer Science Programme

9 January 2007

IMRE organised a workshop on Polymer Science to present updates and results from its Polymer Science Visiting Investigator Programme (VIP), as well as to further local and international research collaborations.

***IMRE's forums**: Actively encouraging collaboration with industry.*

Welding Technology Forum

13 February 2007

Co-organised by the Singapore Welding Society (SWS) and IMRE, the forum was open to SWS members as well as A*STAR SERC institutes. The forum encouraged interaction and fostered collaboration between industry and research institutes.

Outreach Webpage

At IMRE, we continually look for ways to spread the message of materials science. We have an Outreach webpage to highlight IMRE's outreach activities and act as a resource for budding scientists. For enquiries or more information, please visit the site at www.imre.a-star.edu.sg/outreach

When prompted for the CODE, enter "Newsletter"

Patents Filed

*Listed below are summaries of some recent patents filed by IMRE. If you want to know more about our patents, please write in to **enquiry@imre.a-star.edu.sg***

Hardcoat Composition

The invention relates to a hardcoat composition comprising a poly(methyl)glycidyl ether compound, a cationic polymerisable group-containing silsesquioxane compound, a silicate compound, a silane compound and/or a partial condensed compound thereof, a cationic photo polymerisation initiator, and an ultraviolet absorber, whose composition has high adhesion to thiourethane resins or resins obtained by thermal ring-opening polymerisation of thioepoxy compounds, high surface hardness and scratch resistance, excellent weather resistance, and contains substantially no solvent for dilution.

Inventors: He Chaobin, Mya Khine Yi, Xiao Yang

Encapsulated Device with Integrated Gas Permeation Sensor

This invention focuses on improving the flexibility and reliability of flexible OLED encapsulation systems. The fabricated OLED devices could be encapsulated with suitable organic interlayer for effective barrier performance. Potential commercial applications include organic light emitting displays and organic-based devices.

Inventors: Adrian P. Burden, Chua Soo Jin, Ke Lin Karen, Senthil Ramadas

Arylamine Compounds and Electronic Devices

This invention relates to electroluminescent materials, which comprise electron donating arylamino groups in the center and electron withdrawing groups at the periphery, methods for their manufacture, and electroluminescent devices incorporating the luminescent materials. Potential applications of invention include emissive layer or charge transporting layer for OLEDs, active layers for thin film transistors and photovoltaic cells and sensing layers for chemical/biosensors.

Inventors: Chen Zhi Kuan, Zhen Chang Gua

Single Pin-holed Hollow Microspheres and Their Controlled Loading/Release Therefrom

This invention describes a novel method of making a tunnel in the shell of a hollow microsphere, through which substances can be loaded into the hollow microspheres and released into different environments. Potential commercial applications for this invention include controlled drug delivery and release, printing, catalysis, medical diagnostics, chemical detection and cosmetics.

Inventors: Han Ming Yong, Wang Yubo, Zheng Wei

Optics Integrated Quartz Crystal Microbalance

The invention describes the development of an optics-integrated quartz crystal microbalance (OQCM) in which both acoustic and optical information can be obtained in one single measurement. The invention has potential applications for monitoring and detection of a variety of surface processes.

Inventors: Su Xiaodi, Wolfgang Knoll, Zong Yun

A Method of Forming a Metal Contact and Passivation of a Semiconductor Feature

The invention presents methods to form self-aligned metal contact layers and passivation layers onto semiconductor devices, especially semiconductor devices in small features, and the devices fabricated using the methods. The technology can be applied to the fabrication of semiconductor devices (both electronic and photonic devices) with mesa or ridge structures that need electrical current injection and passivation, especially for those devices with small features.

Inventors: Chua Soo Jin, Lim Ee Leong, Teng Jinghua

Wide Bandgap Semiconductor Micromechanical Structures and a Method to Fabricate Them Using a Dry Release Technique

The invention relates to a dry releasing technique to realise surface micro-machined wide bandgap nano/ micromechanical structures grown on SOI substrates. Potential commercial applications of this invention include high temperature gas/ chemical sensors, high temperature pressure sensors, biosensors and piezoelectric sensors.

Inventors: S. Tripathy, S. Vicknesh

Device and Method to Realise a Light Processor

This invention provides a method and a device to obtain better performance in terms of image clarity with respect to the Digital Light Processor (DLP) developed by Texas Instruments, which utilises movable micro mirrors. The invention gets rid of the "pixel effect" in the projected image to provide a smoother picture, which is not possible with the DLP. The invention has potential commercial applications in displays, DLP projectors, DLP television.

Inventors: Saman Dharmatilleke

Nano-engineered Barrier Stack

This present invention proposes to seal the defects of barrier oxide layer using Nanostructured organic sealing layer. This Nanostructured sealing layer consists of various metal and metal oxide nanoparticles. Potential applications of the invention include organic RFID, organic solar cells, roll away displays, flexible OLED and organic solid state lighting.

Inventors: Chua Soo Jin, Senthil Ramadas

Patents Granted

A Polymer and Nerve Guide Conduits Formed Thereof

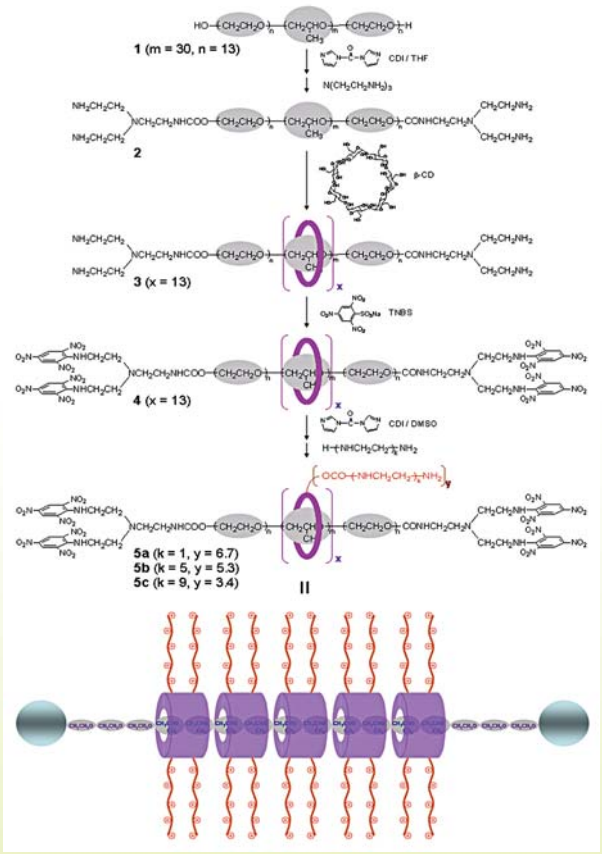
This invention provides an improvement in using biodegradable polymer fabrication of nerve guide conduits that are capable of encouraging the processes of neuronal growth regeneration of nerve function. Potential commercial application of invention includes repairing injury of the peripheral nerves.

Inventors: Wang Shu, Andrew Wan, Hanry Yu, Kam Leong

RESEARCH

Designing and Creating a New Class of Polymeric Gene Delivery Materials

The new design allows better control of the density of amino groups, giving rise to gene carriers with different properties and opening up opportunities for a wide range of applications.



***Schematic**: Designing gene delivery materials.*

WHO

Dr Li Jun, Molecular and Performance Materials
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WHAT

"Cationic supramolecules composed of multiple oligoethylenimine-grafted beta-cyclodextrins threaded on a polymer chain for efficient gene delivery"

WHERE

Published in November 2006 in the high profile journal "Advanced Materials" (Advanced Materials, 2006, 18, 2969-2974). Impact Factor of 9.107. A patent for this technology was jointly filed earlier by A*STAR and NUS.

WHY

Novel cationic supramolecules self-assembled from cyclic molecules and block copolymers were designed and synthesised as a new class of polymeric gene delivery materials. The development of the novel cationic supramolecules will impact the area of polymeric gene delivery. The new system may have many advantages over the existing polymer materials for gene delivery

OPPORTUNITIES

When properly designed, the structures and conformations of the cationic supramolecules can be further controlled in terms of the density of amino groups and flexibility, giving gene carriers with different properties and opening up opportunities for a wide range of applications.

Inexpensive Process for Making Blue Lasers

A structure that can generate an intense pencil beam of blue light has been developed at IMRE for projection display applications.

WHO

Prof Chua Soo Jin, Opto- and Electronics Systems
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WHAT

"Lasing in GaN microdisks pivoted on Si"

WHERE

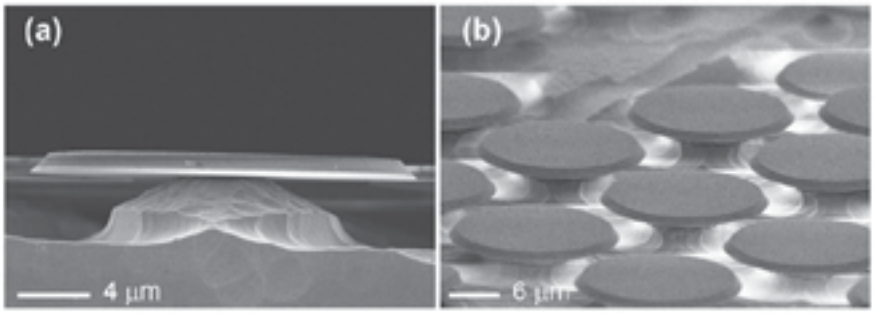
Published in Applied Physics Letters 89, 211101 (2006).

WHY

Arrays of pivoted GaN microdisks have been fabricated on a GaN/Si material by a combination of dry and wet etching. The Si material beneath the GaN microdisks is removed by wet etching, leaving behind a fine pillar to support the disks. Raman spectroscopy reveals substantial strain relaxation in these structures. Resonant modes, corresponding to whispering gallery modes, are observed in the photoluminescence spectra. Stimulated emission is achieved at higher optical pumping intensities.

OPPORTUNITIES

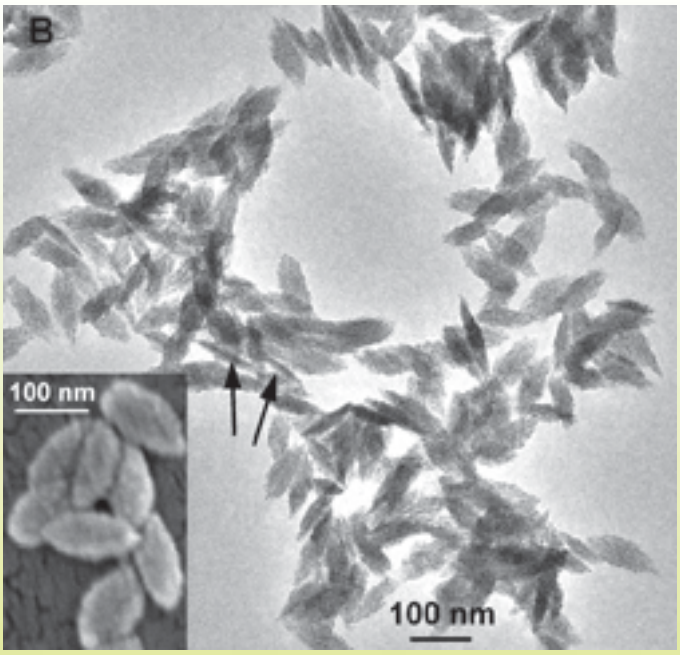
The technology will enable high quality blue lasers and light emitting diodes to be produced more inexpensively on silicon substrates. It also has the potential of being applied to the manufacturing of white LEDs, reducing its cost and thus accelerating the replacement of conventional incandescent bulbs and fluorescent lamps with efficient solid-state lighting.



***Light mushrooms**: GaN microdisks on silicon; (a) side view and (b) top view.*

Construction of 3D Architectures Using Nano-building Blocks

Understanding why and how nanocrystals can be organised into highly ordered 3D monocrystalline structures provides new insight into the aggregation mineralisation mechanism of nanoparticles in biological systems.



***Nano-blocks**: A three-step aggregation-based growth process to form 3D nanoparticle-built architecture of cupric oxide (bottom); and under magnification(top).*

WHO

Dr Han Mingyong, Molecular and Performance Materials
*To view his profile, please visit
http://www.imre.a-star.edu.sg/personal/getListing_action.asp?strID=my-han

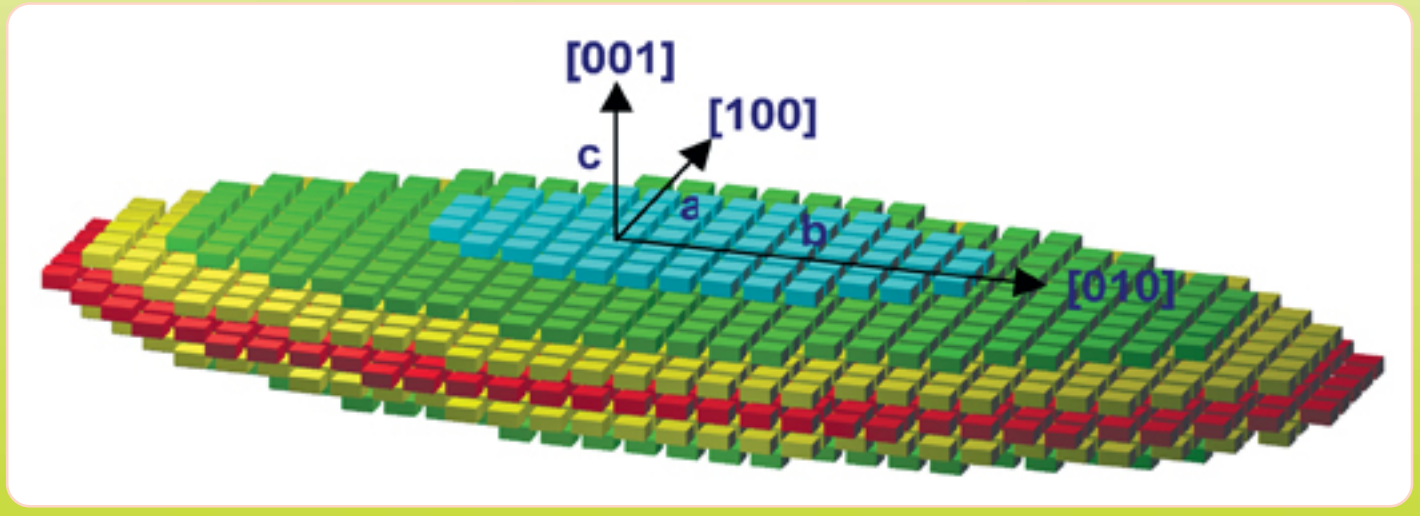
WHAT

"Three-dimensionally oriented aggregation of a few hundred nanoparticles into monocrystalline architectures"

WHERE

Published in January 2005 in the high profile journal "Advanced Materials" (Advanced Materials, 2005, 17, 42-+). Highly cited and selected as "ESI's[1] fast breaking paper in the field of Materials Science for October 2006".

[1] *Essential Science Indicators (ESI) is a resource that enables researchers to conduct ongoing, quantitative analyses of research performance and track trends in science. Covering a multidisciplinary selection of 11,000+journals from around the world, this in-depth analytical tool offers data for ranking scientists, institutions, countries, and journals.*



WHY

This paper describes the first experimental example in controlling the 3D-oriented aggregation of nanoparticles in order to yield ordered-crystal structures by the use of organic molecules. This stepwise 3D-oriented process has been demonstrated, from the formation of primary nanoparticles, to the preferential one-dimensional orientation of nanoparticles, and eventually, transforming a 3D-oriented aggregation into a monocrystalline structure built from nanoparticles. Comprehensive insights into the aggregation-driven growth of nanoparticles will form the basis of a novel strategy for reconstructing nanoparticle assemblies into ordered structures, and also for exploring the formation mechanism of complex biominerals.

OPPORTUNITIES

The understanding of the fundamental properties of nanoparticle assembly is a key step toward the discovery of future applications for nanoparticle materials, which already have applications in catalysts, electronic devices, and biological technologies.

IMRE Scientist selected as Volume Organiser for MRS Bulletin 2008

Dr Alan Sellinger from IMRE's Molecular and Performance Materials group was selected as one of four distinguished materials scientists who will help guide the development of topics for the materials research community's *MRS Bulletin* 2008 volume.

Dr Sellinger is a senior scientist with IMRE and holds adjunct associate professor positions in chemistry and materials science at Nanyang Technological University in Singapore. His research interests are in the area of solution-processable nanocomposite dendrimers and mesostructured thin films for use in organic electronic applications such as organic light-emitting diodes (OLEDs), solar cells, and thin-film transistors.

With a Masters and a PhD in macromolecular science and engineering from the University of Michigan, Dr Sellinger has had extensive research and industrial experience, with past appointments at Sandia National Laboratories and at the industrial R&D laboratories of Canon Research Center America as well as Opsys U.S. Corp. He has co-authored 20 scientific papers that have been cited more than 970 times and is also a co-inventor on 15 patents.

**To view his profile, please visit*
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Events

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