Research, Development and Commercialisation
MICA (P) 041/03/2012 • ISSN 0219-1830

APRIL 2013

PERSPECTIVES

Institute of Materials Research and Engineering
A*STAR
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Boosting SMEs technology capability and raising productivity

New industrial UV detectors that last longer and require less maintenance. Automated wireless vibration and stress monitoring sensors that save on labour, time and money. These are just some examples of how the R&D at IMRE is helping to make locally developed technology more competitive, create new businesses and contribute to increased productivity in Singapore.

IMRE staff and participants talking about some of the technologies that have been used to help give SMEs a technological edge.

The high-tech research, advanced know-how and the experience of seasoned scientific talent is making its way to the companies that would otherwise not have access to such high-capital assets – Singapore small and medium enterprises (SMEs). IMRE works with local companies like TechnoDigm and Hoestar to develop home-grown cutting-edge technologies that helps the companies better compete on a local and global scale. IMRE collaborated with TechnoDigm to produce a new, more durable UV detector specially suited for monitoring UV ray exposure in industrial processes thus reducing maintenance.

Singapore SME, Hoestar, licensed IMRE's piezoelectric sensor technology to automate the monitoring of the vibration and physical stresses that impact the efficiency and lifetime of machinery.

IMRE also helped AWAK Technologies develop enhanced medical devices and diversify their product line. Ms Jasmin Wong, Business Director for AWAK Technologies Pte Ltd, said, "IMRE was able to match their scientific expertise to our research needs in chemicals. With their help, we were able to create a more stable sorbent chemical powder and move into the production phase. We were also able to increase our product line from peritoneal dialysis to haemodialysis, thereby increasing our commercial value and attracting interest from MNCs like Baxter. We appreciate IMRE's support and look forward to further collaborations in future."

These projects were just some of those highlighted at IMRE's first industry-themed workshop on 01 March 2013, which was dedicated to SMEs. With the theme *'Materials Technology for SMEs'*, the event also highlighted the opportunities for collaborations, scientific talent secondment and funding that SMEs could tap on from A*STAR.

"The partnerships that IMRE has with local companies are clear examples of how SMEs can leverage the wealth of talent and research know-how at A*STAR research institutes to enhance their technology and products as well as their ability to be globally competitive," said Prof Andy Hor, IMRE's Executive Director. "These science and engineering capabilities built over time in terms of manpower and technology can enable Singapore companies to compete better globally."

"Our charter is to translate good material science into technologies and know-how that propel the capabilities of our industries to higher levels," said Dr Mark Lim, IMRE's Director (Industry & Enterprise). "We do this via innovative collaboration models leveraging on transferring, licensing and commercialising our R&D as well as seconding our scientists to local companies."

For more information on collaboration opportunities or to find out how we can help you, please contact

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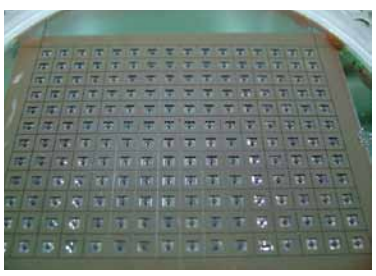
> **"With their help... we were also able to increase our product line from peritoneal dialysis to haemodialysis, thereby increasing our commercial value..."**
>
> - Ms Jasmin Wong, Business Director, AWAK Technologies Pte Ltd, on IMRE's contributions.



These sensors are part of the project between IMRE and Hoestar to develop a system for the automated, remote-monitoring of the 'health' of machinery like motors and pumps.

Green nanotechnology

Nanotechnology is playing an increasingly important part in creating new materials and devices that are eco-friendly or help promote sustainability.

Prof Andy Hor (centre, right), IMRE's Executive Director and Prof Sirirurg Songsivilai (centre, left), NANOTEC's Executive Director, with members of the organising team that made the collaboration and event possible.

IMRE and Thailand's National Nanotechnology Center (NANOTEC) formalised a Memorandum of Understanding (MoU) to pool the strengths of both organisations in developing nanotechnologies with sustainability and the environment in mind. The parties have strong programmes and infrastructure in the area of material technologies for the environment, water as well as energy conversion and storage, to name a few.

NANOTEC's specific experience in the application of nanomaterials in green technologies like nanocatalysts for biorefinery, clean energy and environmental mitigation are of particular interest as IMRE looks toward enhancing its green research activities.

"IMRE is always aspiring to partner organisations with strengths in the areas of sustainability and sustainable materials," said Prof Andy Hor, IMRE's Executive Director at the opening of the IMRE-NANOTEC Joint Workshop on Green Nanotechnology, held in IMRE on 27 Feb 13.

IMRE's existing green technology initiatives include expertise on phase change materials for heat conservation, photovoltaic materials for energy conservation and development of green polymeric materials complements. These projects and IMRE's nanofabrication and charactersation expertise complements the expertise and resources available at NANOTEC. NANOTEC has nanotechnology R&D that focuses on nano-encapsulation, nano-coating, and functional nanostructures. Developments such as nano-based solar cells and batteries, and nano-plastic packaging to enhance food quality, are some of the research being developed.

A meeting of female minds *- (left to right) Dr Liu Bin (L'Oréal Singapore winner 2011), Prof Vivian Yam (L'Oréal-UNESCO winner 2011), Dr Jaslyn Law (L'Oréal Singapore winner 2012), Dr Tan Yen Nee (L'Oréal Singapore finalist 2012) and Dr Low Hong Yee (L'Oréal Singapore winner 2010).*

Prof Vivian Yam and IMRE's L'Oréal For Women in Science Singapore award winners and finalists met on the sidelines of the SNIC-RSC Joint Symposium on Inorganic Chemistry held from 07-08 January 13. Prof Yam was honoured as Laureate of the 13th L'Oréal-UNESCO Women in Science Awards 2011 for her contributions in light-emitting materials and innovative ways of capturing solar energy. She is also the Philip Wong Wilson Wong Professor in Chemistry and Energy, and Chair Professor of Chemistry for The University of Hong Kong.

CORPORATE NEWS

Proposed new joint lab to develop and test materials for green buildings

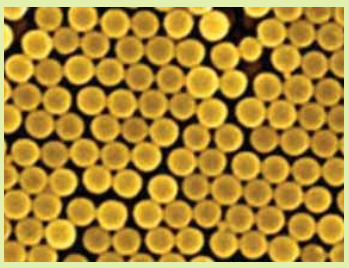
IMRE, the Austrian Institute of Technology (AIT) and the Energy Research Institute @ NTU (ERI@N) sign MoU to look at setting up joint lab that focuses on developing applicable materials for green buildings and on engaging industry to adopt such materials.

Green is the colour of partnership *- (Left to right) Prof Wolfgang Knoll from AIT, Prof Andy Hor from IMRE and Prof Subodh Mhaisalkar from ERI@N after formalising the MoU for a proposed joint laboratory to look into green building materials.*

The Memorandom of Understanding (MoU) of the proposed joint lab was signed between the three organisations at the *"Green Building Envelopes - Workshop on Green Building Envelopes and Materials for the Tropics: Challenges & Opportunities"* event on 18 February 13. The laboratory will seek to leverage the respective expertise of the partners in developing new green building materials as well as fine tune the design and prototyping of the materials via computer simulations, all the while focusing on materials that can be used in buildings located in the tropics. The laboratory will also be used as a test-bed for green building technologies, work in concert with the building and construction industry to identify builders' specific needs as well as to pilot new material prototypes in buildings. The laboratory will also look at research to reduce the energy consumption and greenhouse gas emissions of buildings.

Phase Change Material (PCM) technology that helps cool buildings

IMRE is developing enhanced phase change materials that are specially suited for tropical green buildings.



Development of enhanced phase change materials using nanomaterials for "energy-free" passive-cooling applications in green buildings.

Phase change materials (PCM) are materials that have the ability to alternate between different physical states depending on the environment. This is similar to when ice melts and absorbs latent heat but all the while keeping your drink cold. PCMs can be applied to buildings and are capable of absorbing large amounts of solar heat during the hotter daytime by changing from a solid to a liquid phase. This helps to keep indoor temperatures cooler and reduces artificial cooling via air-conditioning. During the cooler night time, the PCMs return to their solid phase to help keep the temperatures in the building cool. Commonly used PCMs have an inherent low thermal-conductivity problem, which slows the thermal energy transfer and thus significantly reduces the removal of heat. IMRE is developing nano-doped PCMs with enhanced thermal transfer performance with an emphasis on using high yield and low-cost techniques for synthesising nanomaterials. PCMs are used in building facades where the PCMs are doped with thermally-conductive nanomaterials to extend the passive-cooling capability in tropical green buildings. The PCM project is part of a joint A*STAR, Ministry of National Development (MND) and Building and Construction Authority (BCA) programme that awards funding for green building projects under a grant call that encourages research and greater adoption of green building technologies.

For more information about PCM technology please contact

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Green Buildings for the Garden City

Singapore's Sustainable Blueprint has set a target to improve energy efficiency by 35 per cent from 2005 levels by 2030. To meet this target, the Building and Construction Authority (BCA) aims for at least 80 per cent of the buildings in Singapore to be more resource-efficient, and achieve at least a Green Mark Certified rating by 2030.

PEOPLE

Distinguished visitor profile - Prof Vivian Yam

Prof Vivian Yam

Prof Yam is the Philip Wong Wilson Wong Professor and the Chair Professor of Chemistry at the University of Hong Kong. She was also the youngest member to join the Chinese Academy of Sciences and recently named a winner of the L'Oréal-UNESCO Women in Science Awards 2011. Prof Yam was in IMRE recently to speak at the SNIC-RSC Symposium on Inorganic Chemistry during which we took the opportunity to get her insights about being a scientist:

What is your research area of interest?

My research areas of interests include synthetic inorganic/organometallic chemistry, supramolecular chemistry, photochemistry, solar energy conversion, and functional metal-based molecular materials, especially those involving the molecular design and synthesis of new classes of luminescent and chromophoric metal complexes and functional molecules and the investigation of their luminescence and excited state properties. Of particular interests are luminescent carbon-rich metal alkynyls, polynuclear metal complexes and metal chalcogen clusters, and the supramolecular chemistry and assembly of metal complexes using non-covalent metal-metal and π-π stacking interactions. Apart from utilising these non-covalent interactions for directed supramolecular assembly and stabilisation of supramolecular nanostructures and organogels, exploitation of the unique spectroscopic and luminescence properties associated with non-covalent metal-metal interactions of gold(I) and platinum(II) as spectroscopic reporters and probes of assembly and disassembly processes and as chemosensors and biosensors of molecular recognition and aggregation phenomenon has also been one of the major research directions in my group.

What impact does the research have?

The discovery of novel chromophoric and luminescent metal-based materials with tunable absorption and emission colours, excited-state and redox properties and their fundamental spectroscopic study are believed to lay the foundation for development of new classes of solar-energy storage materials for organic photovoltaics and solar fuels as well as phosphorescent materials for organic light emitting diode (OLED) displays and white organic light-emitting diode (WOLED) solid-state lighting that are relevant to energy research.

What are your views on the contributions of women researchers to science?

I do not think there is a difference between men and women, both in terms of their intellectual ability and capabilities for research in science. I am a firm believer that regardless of one's gender and race, as long as one has the passion, the dedication and determination to pursue research wholeheartedly, one can excel and produce work of high quality. Both men and women researchers can make important contributions to science.

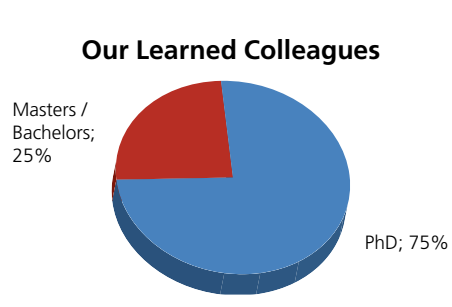
What qualities should a good researcher possess?

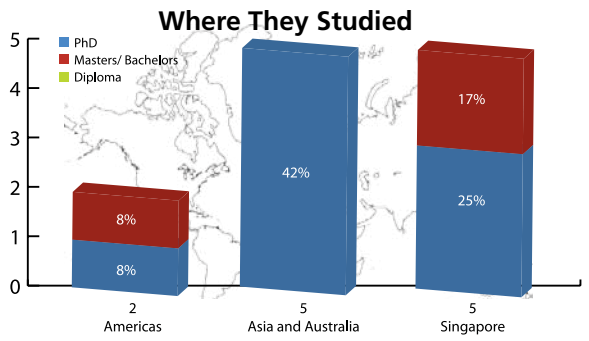
I think, to be a good researcher, you need to have a strong but open and analytical mind, strong determination and dedication to strive for excellence. You need to be creative and innovative, and to engage oneself in a life-long learning process. You also need to possess a high emotional quotient (EQ) so that you will not easily give up. If your experiments fail, you have to try to find ways on how to get around it and to overcome it, rather than to just give up. You also need to be skeptical, be true to your findings and be open to criticism.

New Staff at IMRE

IMRE says 'Welcome!' to its newest batch of scientists, engineers, technicians and corporate staff.

(Front row, left to right) Jin Yunjiang; Goh Fu Wei Thomas; Guo Shifeng; Geng Dongsheng; Goh Xiao Ming; Song Yanling, Joyce
(Back row, left to right) Wang Zuo Qiang Dwayne; Chua Chin Sheng; Shawn Tan; Ding Ning; Gao Meng
Absent: Yang Weifeng



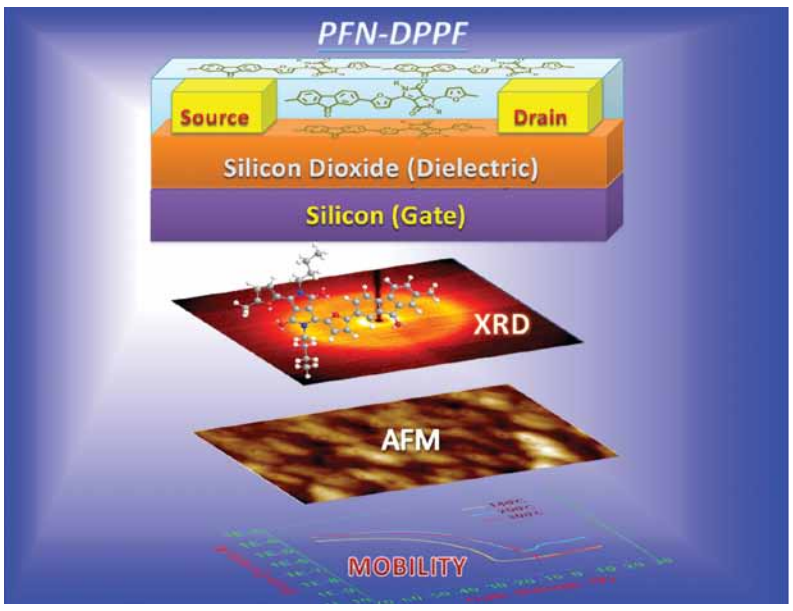


Publication Highlights

Have a look at some highlighted IMRE publications.

New fluorenone-based materials for better organic electronics

Prashant Sonar, Tae-Jun Ha and Ananth Dodabalapur, "A fluorenone based low band gap solution processable copolymer for air stable and high mobility organic field effect transistors", Chem. Commun., 2013, 49, 1588.



Fluorenone- A potential conjugated building block for designing new organic semiconducting polymers for stable and high mobility OFETs.

What: IMRE scientists have designed and synthesised the first-ever fluorenone-based, low band gap, solution processable polymer semiconductor PFN-DPPF for use in OFETs. Fluorene-based polymers are popular light emitting materials and used successfully as an active layer in organic light emitting diode (OLED), organic light emitting transistor (OLET) and basic organic field-effect transistor (OFET) applications. Fluorenone (a ketone group substituted at the C9 position of fluorene), a derivative of fluorene, is a conjugated building block that has not been used to date in making polymers for OFET application. The fluorenone moiety is chemically more stable, commercially available with lower cost, has carbonyl groups that can assist in better solid state interaction/packing, and can provide better air stability for polymer semiconductors. Fluorenone has potential to be used as an alternative conjugated moiety for making novel polymer semiconductors for OFETs.

How: IMRE's new fluorenone-based polymer incorporates two condensed aromatic moieties containing carbonyl rings to create energy levels that are suitable for making stable OFET devices. The possible use of carbonyl substituted two planar fused aromatic blocks (fluorenone and furan flanked DPP) within the conjugated backbone enhances the degree of co-planarity and intramolecular interactions via a large overlapping area and strong O–H interactions among adjacent molecules. The highly occupied molecular orbital (HOMO) arising from the electron withdrawing carbonyl group on fluorenone can also create a higher air stability of this polymer. It has also been previously found that the co-polymerisation of fluorenone (electron deficient unit) with thiophene (electron rich unit) lowers the band gap and improves the stability of the resulting co-polymers.

> **"Fluorene-based polymers are popular light emitting materials and used successfully as an active layer in OLED, OLET and OFET applications."**

Why: IMRE's new PFN-DPPF based OFET devices displayed a high hole mobility of 0.15 $cm^2 V^{-1}s^{-1}$ in air for annealed samples. These results clearly demonstrate that fluorenone is a potential building block for designing novel high performance and stable organic electronic devices. OFETs based on this polymer can be used in RFID tags, chemical sensors, memory devices and light emitting transistor. The polymer is also a good candidate material for use in organic photovoltaics.

For more information about the publication, please contact

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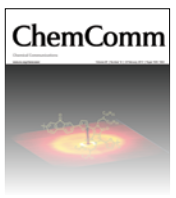
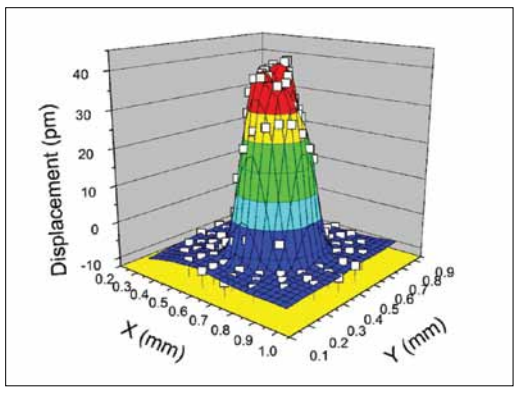


The publication was featured on the cover of Chemical Communications, Vol. 49, No. 16, 25 Feb 2013.

Simple to make and scalable lead-free piezoelectric thin films

Albertus D. Handoko and Gregory K. L. Goh, "Hydrothermal growth of piezoelectrically active lead free (Na,K)NbO3–LiTaO3 thin films," CrystEngComm, 2013, 15, 672.



Piezoelectric response of the hydrothermally grown film.

What: Lead-based ceramics and other materials are still used extensively in sensors, actuators and other piezoelectric devices because an equally high-performance and suitable replacement material has not yet been found. IMRE researchers were the first to successfully demonstrate that an active piezoelectric film could be hydrothermally grown into a single phase, lead-free thin film based on the $(Na,K)NbO_3$–$LiTaO_3$ solid solution near the morphotropic phase boundary and at 130˚C. The new method is simple and self-contained, uses a one-step growth process, and can also be easily scaled up and recycled.

How: IMRE scientists discovered that the growth of a single phase NKN-LT film is hampered by the rapid formation of a Na-rich phase but which could be overcome by the addition of EDTA. The addition of EDTA retards the formation of the Na-rich phase and slows down the overall growth rate such that single phase NKN-LT films can eventually be grown. The initial growth temperature of 200˚C was lowered to 130˚C so as to reduce crystal growth and the eventual formation of much smoother films. A post-growth treatment consisting of O_2 plasma followed by heat treatment at 600˚C was applied to the films to render them ferroelectrically and piezoelectrically active. A 480nm thick film grown at 130˚C had a piezoelectric constant (d_{33}) of 25 pm V^{-1}, as determined by laser scanning vibrometry.

> **"The new method is simple and self-contained, uses a one-step growth process, and can also be easily scaled up and recycled."**

Why: Lead-free, less toxic ferroelectric and piezoeletric materials and thin films will be a boon for the variety of consumer devices where the materials are used, such as sensors and actuators for miniature motors, inkjet printers, hard disk drives, mechanical to electrical energy conversion devices and UV sensors.

For more information about the publication, please contact

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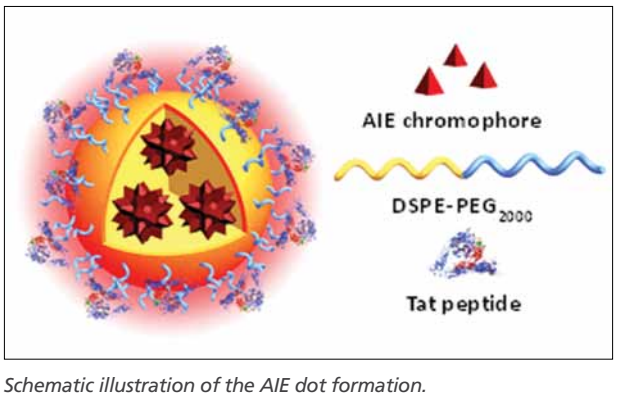
The publication was featured on the cover of Crystal Engineering Communications, Vol. 15, No. 4, 28 Jan 2013.

More stable and brighter organic nanoparticles for long-term cell tracking

Kai Li, Wei Qin, Dan Ding, Nikodem Tomczak, Junlong Geng, Rongrong Liu, Jianzhao Liu, Xinhai Zhang, Hongwei Liu, Bin Liu & Ben Zhong Tang, "Photostable fluorescent organic dots with aggregation-induced emission (AIE dots) for noninvasive long-term cell tracing", Sci. Rep. 2013, 3, 1150.



Schematic illustration of the AIE dot formation.

What: Researchers at IMRE have demonstrated that their newly synthesised 'non-blinking' organic dots have better fluorescent stability and higher quantum yield in biological medium than current commercially used quantum dots. The team successfully developed organic far-red/near-infrared (FR/NIR)-emissive dots with aggregation-induced emission (AIE dots) and demonstrated their potential to be used as long-term cell tracking probes that greatly outperform commercial quantum dot probes. Such organic dots have excellent potential to be used in novel bioimaging applications.

How: IMRE researchers had synthesised AIE-active TPETPAFN dots for *in vitro* and *in vivo* long-term cell tracing applications. A mixture of lipid-poly(ethylene glycol) (PEG) and lipid-PEG-NH_2 was chosen as the encapsulation matrix to endow the AIE dots with biocompatibility and surface functionality. Bio-conjugation of the AIE dots with cell penetrating peptide derived from HIV-1 transactivator of transcription (Tat) protein, yielded Tat-AIE dots with high cellular internalisation efficiency. The performances of the Tat-AIE dots in the *in vitro* and in *vivo* studies were compared with those of commercially available QDs of Qtracker® 655 under similar experimental conditions. It was found that the Tat-AIE dots could trace MCF-7 cells for 10–12 generations *in vitro* and C6 cells for 21 days *in vivo*. One- and two-photon excited *ex vivo* tumor images were taken to highlight the deep tissue imaging ability of the Tat-AIE dots.

> **"…newly synthesised 'non-blinking' organic dots have better fluorescent stability and higher quantum yield in biological medium than current commercially used quantum dots."**

Why: This is the first successful demonstration of the AIE dots for *in vitro* and *in vivo* long-term cell tracing, which offers new opportunities and bright prospects in the areas of cancer research, real-time monitoring of stem cell transplantation and other cell-based therapies. The high emission efficiency, high absorption, excellent biocompatibility, and strong photobleaching resistance of the AIE dots functionalised by cell penetrating peptides ensured outstanding long-term non-invasive *in vitro* and *in vivo* cell tracing. Apart from bioimaging, AIE fluorogens also have great potential in optoelectronic applications, including light-emitting diodes and optical data storage media.

For more information about the publication, please contact

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AWARDS

The prizes were generously sponsored by Gaia Science Pte Ltd represented by Ms Nicole Kwan (left), who gave away the awards together with Prof Andy Hor (right), IMRE's Executive Director.

Best Poster Awards at M3@Singapore

IMRE's Dr Shawn Tan (top, centre) and Dr Zhang Shuang-Yuan (bottom, centre) won two of the five Poster Competition prizes given out for the Molecular Materials Meeting (M3) Singapore 2013, held from 14-16 Jan 2013 in Singapore. Their posters were entitled, respectively, *"Tunable 2D nanoparticle crystallization via non-base-pairing DNA in the high ionic strength regimes"* and *"Temperature and chemical bonding-directed self-assembly of cobalt phosphide nanowires in reaction solutions into vertical and horizontal alignments"*. The prizes were generously sponsored by Gaia Science Pte Ltd.

Johnson Matthey Poster Awards Winners at the SNIC-RSC Joint Symposium on Inorganic Chemistry

Dalton Transactions Johnson Matthey Poster Prize - Dr Zhang Wenhua from IMRE won the prize for his poster presentation on *"Detection of Electron Deficient Chemical Species by Natural Product Supported Ir(III) Complexes"* at the SNIC-RCS Joint Symposium on Inorganic Chemistry, which was co-organised and held at IMRE. The prize was awarded by the Singapore National Institute of Chemistry and Royal Society of Chemistry.

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UPCOMING EVENTS

Diary of upcoming events @ IMRE

19-23 August 2013
15th Asian Chemical Congress (15 ACC)
www.15acc.org

19-23 August 2013
1st Asian Chemistry Research Fair (ACRF-1) in conjunction with the 15 ACC
www.15acc.org

To find out more about IMRE's seminars and events, please visit
www.imre.a-star.edu.sg/eventsall.php

OUTREACH

Visits and Events

Building closer ties with the UK chemistry community

Prof Andy Hor (front row, second from right), Executive Director for IMRE and Prof Lesley Yellowlees (front row, third from right), President of RSC with the other organisers of the event.

07-08 Jan 13

IMRE co-organised and hosted the prestigious *"SNIC-RSC Joint Symposium on Inorganic Chemistry"* with the Royal Society of Chemistry (RSC), UK and the Singapore National Institute of Chemistry (SNIC).

"We had chosen the theme 'Inorganic Chemistry' for this meeting not only because of its central role in chemistry and traditional research strength in Singapore, but also of its value to modern science and technology in areas such as catalysis for pharmaceutical manufacturing and biomass conversion, solid state fuel-cell and photovoltaic materials, metal composites and functional engineering materials, metal oxides and semi-conducting materials, photo-emissive complexes, and covalent porous solids," said Prof Andy Hor, Executive Director of IMRE and President of SNIC in his message to all the participants.

The symposium was also an ideal platform for Singapore scientists to foster closer links with researchers from UK as well as provided young scientists and students the opportunity to experience and discuss the latest advancements in inorganic chemistry. The RSC renewed an International Cooperation Agreement with SNIC at the event that served to continue the cooperation, communication and exchange for the benefit of the chemical science communities of both countries. The agreement was signed by Prof Andy Hor for SNIC and Prof Lesley Yellowlees, the first woman President of RSC.

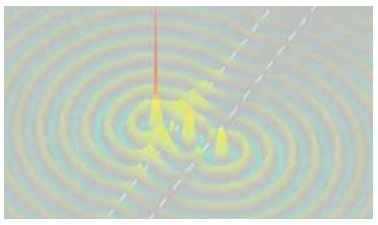
Fostering cross-disciplinary R&D

14-16 Jan 13

IMRE successfully organised the 3rd Molecular Materials Meeting (M3) @ Singapore conference in partnership with other A*STAR institutes, research organisations and industries. The event, themed around molecular materials, gathered leading researchers from across many scientific disciplines such as chemistry, materials science, physics, biology, medicine and engineering to foster cross-disciplinary and collaborative research ideas. Supported by a number of science-related companies, M3 covered topics like new catalysts and catalytic processes, soft materials for cosmetic and health care, electrochemical energy conversion, materials and technology for energy storage, materials for advanced sensors and transducers, lanthanide-doped luminescent nanomaterials, as well as interface engineering for devices. Some of the prominent speakers included Dr Terunori Fujita from Mitsui Chemicals R&D Centre, Singapore, Prof David Cahen from the Weizmann Institute of Science, Israel, and Prof Vivian Yam from the University of Hong Kong.

Participants attending the first plenary session of the M3 @ Singapore 2013.

Metamaterials forum



Super resolution imaging made possible using metamaterials R&D.

17 Jan 13

The unique properties of plasmonics and metamaterials have the potential to significantly impact applications in imaging, green energy, micro and mm wave, optical communication, optoelectronics, sensing, bio-medical and general optics. A*STAR's Metamaterials Programme began in January 2010 by integrating the capabilities and efforts from various A*STAR research institutes and the two Singapore universities. The forum titled, "New Optics & RF Technologies - Opportunities Brought by Metamaterials and Plasmonics", introduced the technologies developed to date, identified potential industry partners, and discussed possible collaboration models and topics.

Welcoming participants and urging them to look closely at the benefits that SPM has to offer.

4th Singapore SPM Symposium

06 Mar 13

The event was to bring the local scanning probe microscopy (SPM) community closer together and to interest industry in the benefits of using the SPM system. SPM is the only tool currently that allows true atomic scale resolution characterisation, which is very important in the miniaturisation of semiconductor integrated circuits below 10nm.