Research, Development and Commercialisation
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JANUARY 2013

# PERSPECTIVES

Institute of Materials Research and Engineering
A*STAR
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Highlight on Awards

CORPORATE NEWS

## L'Oréal Award for women scientists - Three years in a row for IMRE

For her materials science work in biomimetic materials technology Dr Jaslyn Law won the 2012 L'Oréal For Women in Science (FWIS) National Fellowship. Jaslyn is the third female scientist from IMRE to be honoured with the award. As further recognition of IMRE's high calibre talent pool, Dr Tan Yen Nee and Dr Teo Ee Jin were also shortlisted as finalists for the award.

*Dr Jaslyn Law - 2012 L'Oréal For Women in Science National Fellowship recipient.*

Jaslyn's award was for her work in developing engineered nano-sized structures that give materials like plastics unique properties that mimic those of naturally-occuring surfaces. Her studies on micro and nano-topographies can be used to produce plastic films that have anti-reflectivity, self-cleaning properties or allow viewing of 3D movies without special glasses. The research is inspired by studying natural surfaces such as the anti-reflection property of a moth's eye or the water-repelling effects of water lily leaves.

"I am very glad to receive the award," said Jaslyn, who is a Deputy Head of IMRE's Patterning and Fabrication capability group. "Fellowships like this help bring prominence to R&D as a viable career option for women."

"The award is a testament and recognition not just for the cutting edge research that Singapore has produced but for the important role that women scientists play in R&D," added Prof Andy Hor, IMRE's Executive Director.

### Other L'Oreal FWIS 2012 Finalists from IMRE

**Dr Tan Yen Nee**
Shortlisted for her work on multifunctional biogenic metal nanoparticles for biomedicine.

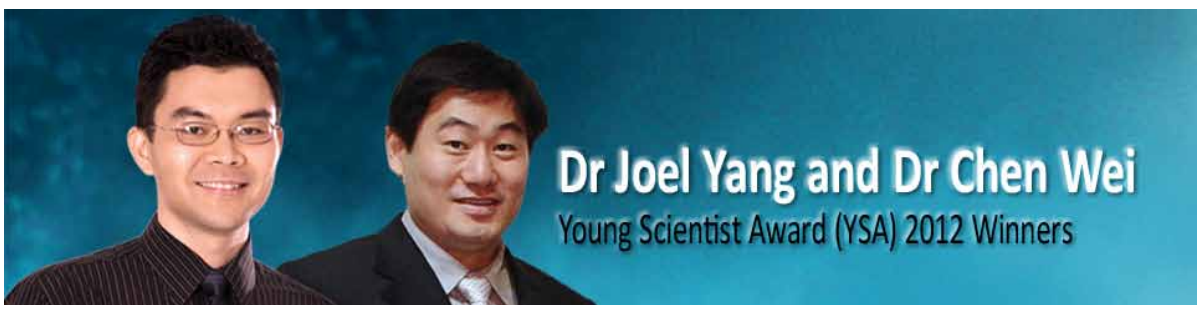
**Dr Teo Ee Jin**
Shortlisted for her work on next generation optical communications and a new class of super bright and high-speed LEDs.

### Past L'Oréal FWIS winners from IMRE

**Dr Liu Bin (2011)**
Dr Liu was recognised for her efforts to make solar energy accessible to the masses.

**Dr Low Hong Yee (2010)**
Dr Low was recognised for her work in nanoimprint technology.

*More awards on page 4*




Dr Joel Yang Kwang Wei and Dr Chen Wei, an IMRE adjunct from NUS, were conferred the prestigious awards at the annual President's Science and Technology Awards ceremony which honours Singapore's best and brightest scientific talents.


*Dr Chen Wei (2nd from right) and Dr Joel Yang (right) with their awards posing for a picture with the other winners as well as Mr S Iswaran, Second Minister for Trade and Industry (3rd from left) and Mr Lim Chuan Poh, A*STAR Chairman (3rd from right) during the President's Science and Technology Awards ceremony.*

Joel was honoured for his research on nanolithography and nanoplasmonics where he leads a research group in IMRE that focuses on the development of high-resolution (sub-10-nm) lithographic processes and their application to create metal nanostructures that act as antennas for light. Chen Wei was awarded for his research on interface engineering for molecular, organic and graphene electronics which focuses on surface and interface science.

## Sofshell wins Silver Prize at Asian Innovation Awards 2012

IMRE spin-off company, Sofshell Pte Ltd, which commercialises soft, flexible and lightweight body-armour padding technology that was developed in IMRE, was given the Silver Prize in the competition organised by the Wall Street Journal.

*Elgin Yap (left) and Davy Cheong (right) from Sofshell Pte Ltd with the AIA 2012 Silver Prize.*

Inspired by a popular science experiment where a liquid cornstarch solution would harden when impacted by a sudden force, Dr Davy Cheong, a former IMRE scientist, used the principles of shear thickening fluids to invent a new flexible, lightweight, impact-resistant composite material. The armour padding material is now being commercialised by Sofshell, which Davy had set up together with Mr Elgin Yap who was from Exploit Technologies, A*STAR's commercialisation arm.

The company, which had also won the 'Coolest Innovation' award at TECHVENTURE Asian Innovation Awards 2011, is planning to start manufacturing operations in the early half of 2013. For a start, Sofshell will focus on products for the elderly and for sportswear.

For more information about Sofshell, please visit www.sofshell.com.sg

*Elgin and Davy (left and 2nd from left) from Sofshell Pte Ltd with the other AIA 2012 winners.*

### What is shear thickening?

*Prototype products that Sofshell hopes to market include protective padding for the elderly and sports equipment.*

The composite material is based on the concept of shear thickening, whereby the material is soft and fluid at rest but becomes rigid upon impact. When moved gently, the molecular chains that hold the material together can 'slide' past one another, hence giving the material a soft consistency. In other words, the material will bend and flex smoothly under lightly applied force. But hit it or make sudden movements and the molecular chains do not have time to react properly and become entangled, turning the material rock-solid.

Highlight on Industry News — CORPORATE NEWS

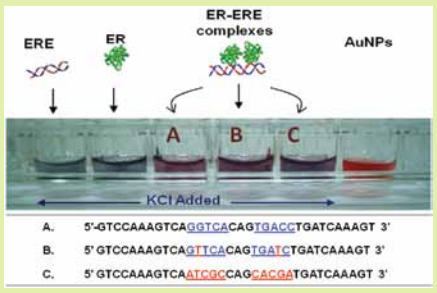
# New easy-to-use and quick protein-DNA analysis kits developed

ColoQuik™, a line of label-free kits for the rapid colorimetric detection of protein-DNA interactions was developed by The Biofactory, a Singapore start-up for biomedical and life sciences related technologies, with technology licensed from IMRE. The three kits in the pipeline, which are used for assessing well-known cancer transcription factors - ERα, ERβ, and p53 - are suitable for high-throughput drug discovery applications and batch functional analysis of transcription factor production.

Conventional analysis of protein-DNA interactions are laborious, expensive and time-consuming with some methods lasting as long as two days. Others use potentially harmful radioactive isotope-tagged DNA while newer label-free assays require high hardware and software costs. The ColoQuik™ assays need only about 30 minutes to complete with the results easily visible via the visual detection of reagent colour changes, which is based on the quality and affinity of binding between a protein and a specified DNA sequence. No time and cost intensive radioactive or fluorescent labeling of DNA is needed as ColoQuik™ uses standard equipment such as microplate absorbance readers for semi-quantitative readouts.

"These kits offer the easiest and fastest ways to date for scientists to analyse a particular DNA binding protein for its impact on the gene transcription mechanism of specific diseases," said Dr Su Xiaodi, the IMRE Senior Scientist who led the nanoparticle work.

## What makes ColoQuik™ tick?




*Protein-DNA complexes can protect gold nanoparticles from salt induced aggregation, leading to a retained red colour.*

The key technology in the kits is the custom-made, nanometer-sized metal particles created at IMRE. The particles act as probes which give off different colours depending on the specific protein-DNA combinations that are formed in the nanoparticle solution.

"The licensing of our materials technology for use in protein-DNA analysis is testament to the value of our research to industry. This development is also a prime example of cross-disciplinary research in action," said Prof Andy Hor, IMRE's Executive Director. "We look forward to seeing this revolutionary new technique being developed further to aid in advancing global healthcare."

"The Biofactory is honoured to be part of the commercialisation process. With our expertise in product and business development, we will continue to guide other Singapore-based biomedical innovations towards market success," said Theodore Tan, Managing Director of The Biofactory.

For more information, please contact

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# Cheaper and more flexible next generation transparent conductors

IMRE and US multinational, Cima NanoTech, are jointly working on new and improved transparent conductors that will potentially enable faster response touch screens for large flexible displays and reduce production cost.

*Cima's revolutionary SANTE Technology.*

## What are transparent conductors?

Transparent conductors basically allow light to pass through but are also electrically conductive, hence their application in displays and organic solar cells. Current transparent conductors use materials like indium tin oxide (ITO) which is very expensive. Conventional ITO and other oxides in today's solar cells, OLEDs, flat panel TVs, and touchscreen displays also have limitations in conductivity and flexibility.

Cima's SANTE™ Technology and IMRE's know-how in printed electronics are being combined to develop efficient conductive interfaces with high transparency, which can be developed into low cost and high performance products for displays, organic solar cells, and flexible electronics.

Current conventional transparent conductors with Indium Tin Oxide (ITO) and Transparent Conductive Oxides (TCO) that are used in today's solar cells, OLEDs, flat panel TVs, and touchscreen displays have limitations in conductivity, flexibility and are costly.

"Cima is particularly interested in IMRE's extensive electronics materials systems and device fabrication capabilities," said Mr Jon Brodd, Cima NanoTech's Chief Executive Officer (Singapore).

"We are collaborating with Cima to develop new transparent conductor applications that will lead to cheaper, flexible, more eco-friendly and sustainable products," said Dr Zhang Jie, the key scientist leading IMRE's printed electronics initiative.

"IMRE's research portfolio covers the entire printed electronics value chain that includes materials, processes, optimisation and reliability testing for integrated printed electronics prototypes. I am glad that we can present a diverse suite of capabilities in partnering Cima in the area of transparent conductors and printed electronics," said Prof Andy Hor, IMRE's Executive Director.

For more information, please contact

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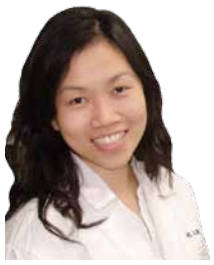
PEOPLE



*Dr Leong Wei Lin*
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# Harnessing sustainable solar energy: Profile - Dr Leong Wei Lin

Having worked with some of best in the world including Nobel Laureate, Prof Alan Heeger, Dr Leong hopes to make her mark in organic solar cell technology to produce efficient and cheap solar energy.

The Assistant Manager of IMRE's Molecular Materials Laboratory talks about her research career and the insights she's gained.

**What was your inspiration for taking up a career in science?**

I had always been interested in the science and technology featured in engineering magazines. The constant innovation in these fields inspired me to look at how big ideas could produce revolutionary breakthroughs and improve quality of life. I wanted to work on experiments that would help create such new technologies. After my PhD, I spent 2 years of postdoctoral research at University of California, Santa Barbara (UCSB), in the laboratory of Prof Alan Heeger, a world leader in organic solar cells who has been a tremendous model of inspiration for me. I am amazed by his drive for science and his eye for detail. I still fondly remember how he would draw energy band diagrams just to explain the fundamental physics to me.

**What is your research area of expertise and what are you currently working on in IMRE?**

My area of expertise is in organic electronics, especially organic materials that are solution processable and display unique properties that allow low-cost manufacturing. These printed electronics devices offer interesting alternatives to silicon technologies in a number of niche applications such as large area, low-cost, flexible electronics, or novel functionality such as light emission, photovoltaics and chemical or biological sensitivity. In IMRE, I focus on solar cells with high solar to electricity efficiencies, fabricated through facile means.

**What sort of impact do you think your work will have?**

The introduction and exploration of various renewable or sustainable energy sources such as direct conversion of solar energy (via solar cells) can contribute to the society by providing green energy solutions for today's energy problems.

**What was the most important lesson learned from having had a chance to work with the best?**

Like at IMRE, I was fortunate to be surrounded by many bright people at UCSB. By interacting with them, I have learnt to be more inquisitive and persistent. I have also learnt that one needs to move fast as the scientific world is very competitive. Once you have good ideas, you need to make sure the work is executed quickly!

**What do you see is the greatest challenge for you as an early career researcher?**

Early career researchers need to prove themselves and to clearly demonstrate their strengths and expertise to their peers. I am glad there are many such opportunities in IMRE for this.

**What do you think are the most important qualities a scientist must have?**

Good scientists must be creative and have the passion for their work. It is also important to have the communication skills necessary to express the ideas and results effectively, and clearly.

**Do you have any words of advice for aspiring scientists?**

Find the area of research you are passionate about and be really good at it. It is also important to establish critical contacts within your field.

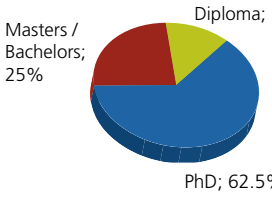
# New Staff at IMRE

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

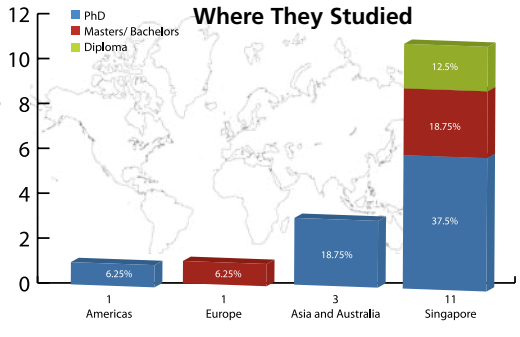
*(Sitting, left to right) Liu Lei; Lance Tan; Goutam Kumar Kole; Wang Zhijuan; Lau Chit Siong*

*(Standing, left to right) Ge Xiaoming; Dong Zhaogang; Chien Sheau Wei; Su Xingfang; Chieng Yu Yuan; Wu Siji; Dewi Pitrasari Go; Janet Teo; Laura Sutarlie; Wu Shixin; Hannah Lim*

**Our Learned Colleagues**



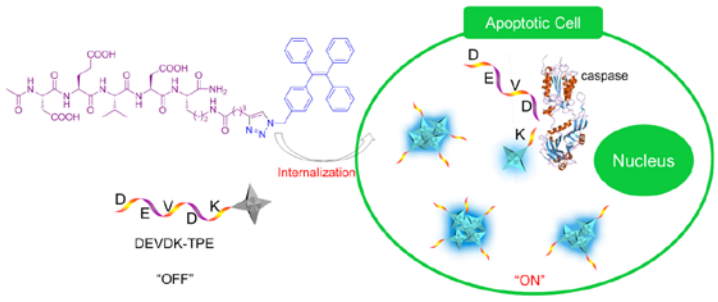

**Where They Studied**



# Publication Highlights

## New live-cell-permeable, fluorescent probe for real-time cell apoptosis imaging and monitoring

***Haibin Shi, Ryan T. K. Kwok, Jianzhao Liu, Bengang Xing, Ben Zhong Tang, and Bin Liu, "Real-time Monitoring of Cell Apoptosis and Drug Screening Using Fluorescent Light-up Probe with Aggregation-Induced Emission Characteristics," J. Am. Chem. Soc. 134 (43), pp 17972–17981, 2012.***




*Fluorescent probe with aggregation induced emission characteristics lights up in apoptotic cells.*

**What:** A research team has developed a probe for real-time monitoring of cell apoptosis. Cell apoptosis can be an early indicator of diseases such as cancers, neurodegenerative disorders, autoimmune diseases and myocardial infarction. The brightness and the light-up speed of the new probe indicates the response of a cell to drugs, which can induce cell apoptosis. Within a specific time period, the brighter the probe fluorescence correlates to the higher efficiency of the drug to induce cell death.

**How:** The probe is comprised of a hydrophilic caspase-specific Asp-Glu-Val-Asp (DEVD) peptide and a hydrophobic tetraphenylethene (TPE) unit, a typical fluorogen with aggregation-induced emission characteristics. In aqueous solution, the probe is almost nonfluorescent but displays significant fluorescence enhancement in response to caspase-3/-7, which are activated in the apoptotic process and able to cleave the DEVD moieties. This fluorescence "turn-on" response is ascribed to aggregation of cleaved hydrophobic TPE residues, which restricts the intramolecular rotations of TPE phenyl rings and populates the radiative decay channels. Compared to other types of cell apoptosis monitoring such as targeting the negatively charged phosphatidylserine with annexin V or using dual-labeled probes, this new method is much simpler, non-invasive and has high signal to noise ratio.

> **"...Cell apoptosis can be an early indicator of... cancers,neurodegenerative disorders, autoimmune diseases and myocardial infarction."**

**Why:** Real-time imaging of the progress of apoptosis in living organisms can help in early diagnosis of diseases, evaluation of disease progression and therapy efficiency of drugs. The probe also provides a new opportunity to screen enzyme inhibitors for potential use as new drugs and evaluate the apoptosis-associated drug efficacy.

For more information about the publication, please contact

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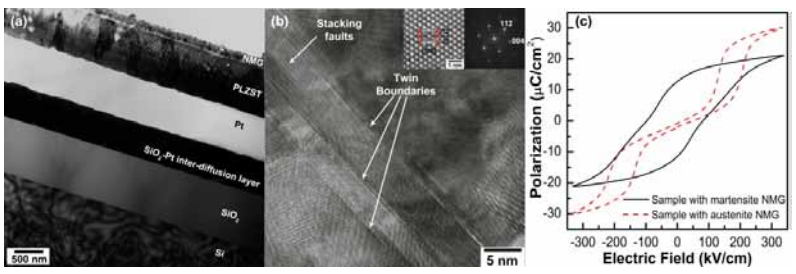
## Discovery fuels new devices that incorporate ferroic thin film designs and functionalities

***Meysam Sharifzadeh Mirshekarloo, Kui Yao, and Thirumany Sritharan, "Ferroelastic strain induced antiferroelectric-ferroelectric phase transformation in multilayer thin film structures," Advanced Functional Materials 22, pp. 4159–4164, 2012.***




*(a) Cross sectional bright field TEM micrograph of the NMG/PLZST/Pt/$SiO_2$ /Si multilayer thin film sample. (b) Structural analysis of the martensite NMG thin film. HRTEM micrograph of annealed martensite NMG thin film along [110] zone axis. The insets present corresponding FFT micrograph (right) and enlarged view of HRTEM micrograph showing arrangement of Ni, Mn and Ga atoms on (110) plane (left). (c) Out-of plane polarization-electric field (P-E) hysteresis loops of the PLZST films with austenite and martensite NMG film on the top.*

**What:** Ferroelectric thin films are being used as capacitors in microelectronics, various sensors and actuators, and in non-volatile memories. IMRE researchers have discovered new methods for controlling the crystal structure and functional properties of ferroic multilayer thin film structures by using unique characteristics of phase change materials. For thin films deposited on a substrate, their mechanical stress and microstructure are usually determined by the composition and processing of the films and the lattice and thermal mismatch with the substrate.

> **"...new methods for controlling the crystal structure and functional properties of ferroic multilayer thin film."**

**How:** IMRE researchers have discovered that the stress and structure of an antiferroelectric PLZST thin film were changed completely by a ferroelastic strain in a magnetic shape memory (MSM) alloy Ni-Mn-Ga (NMG) thin film on the top of the PLZST, despite the existence of the substrate constraint. The ferroelastic strain in the NMG film resulted in antiferroelectric (AFE) to ferroelectric (FE) phase transformation in the PLZST layer underneath.

**Why:** This finding indicates a new strategy to modulate the structure and function for multilayer thin films, which has potential for creating unprecedented devices with ferroic thin films. The discovery allows the design of devices with unique coupling among mechanical, electrical, and magnetic parameters.

For more information about the publication, please contact

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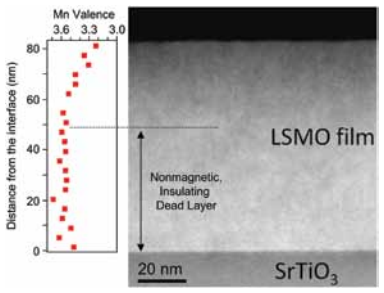
## Oxygen breathes life into interfacial dead layers

***Zhipeng Li , Michel Bosman, Zhen Yang, Peng Ren, Lan Wang, Liang Cao, Xiaojiang Yu, Chang Ke, Mark B. H. Breese, Andrivo Rusydi, Weiguang Zhu, Zhili Dong, and Yong Lim Foo; "Interface and Surface Cation Stoichiometry Modified by Oxygen Vacancies in Epitaxial Manganite Films"; Advanced Functional Materials, Vol. 22, p. 4312-4321.***




*Scanning TEM (STEM) cross-sectional image of the manganite (LSMO) film, after standard oxygen-annealing. Electron energy-loss spectroscopy (EELS) was used to plot the manganese valence, visualizing the location of the dead layer in the first ~50 nm adjacent to the interface. This dead layer was absent when the layer growth was done under high oxygen pressure.*

> **"...oxygen pressure during manganite film growth will critically impact the fabrication of high-performance spintronic devices."**

**What:** Perovskite manganites ($La_{1-x}Sr_xMnO_3$) are one of the very few materials that can have room-temperature ferroelectric and ferromagnetic ordering, which are critical for 'spintronic' devices, such as high-density memory elements or, read heads for hard drives. However, the performance of manganite-based devices has been sub-optimal due to the presence of 'dead layers' near interfaces where the ferromagnetic ordering is lost. Researchers from IMRE have studied these 'dead layers' and demonstrated how the layers can be avoided.

**How:** The growth of thin manganite films using Pulsed Laser Deposition at low oxygen pressure usually results in atomically sharp interfaces, which leads to high oxygen vacancies in the structure and gives unwanted dielectric properties. To resolve this, these films are often annealed in an oxygen-rich atmosphere after completion of the film growth. The scientists discovered that during growth, the presence of oxygen vacancies in the ionic lattice can reorganise the charge and chemistry of the atoms. This change in ionic organisation is permanent, explaining why later oxygen-annealing does not help. When the films are grown under normal (low oxygen pressure) growth conditions, the $Mn^{3+}/Mn^{4+}$ ratio near interfaces becomes less than one. This prevents most electrons from hopping, and forms the electrical 'dead layer'. Therefore, the oxygen pressure during manganite film growth will critically impact the fabrication of high-performance spintronic devices.

**Why:** This finding suggests that the oxygen pressure serves as a tuning parameter for the interfacial dead layers and, hence, for control over device properties.

For more information about the publication, please contact

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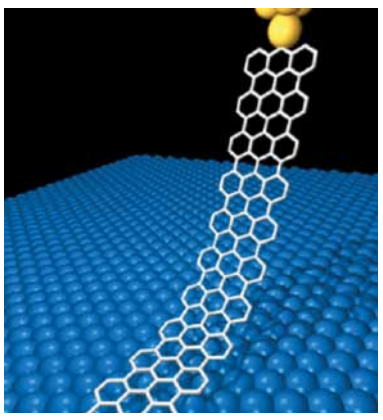
## Wiring up nano-sized computers



*An artist view of a graphene nanoribbon (white) 1 nm in width being pulled up from the metal surface (blue) by the end atom (yellow) of the metallic tip apex of a scanning tunneling microscope.*

Long range electronic tunneling phenomenon through a single molecular wire just 1 nm wide, the smallest to date, could pave the way for future nanocomputer circuitry. Understanding the phenomena is essential for the future of graphene nano-electronics and molecular electronics which may form the basis of new molecule-sized electronics and computers. The research by a multinational team from Europe and Singapore moves scientists a step closer to understanding the "super-tunnel" effect and may one day allow scientists to incorporate a nano-calculating unit, which is essentially a computing processor, in a single molecule.

One nm-wide, nanoribbon graphene molecules were synthesised in-situ on the surface of a metal substrate in ultra-high vacuum. Quantum-state images of each of the nanoribbons found on the surface were obtained by low temperature scanning tunneling microscopy. From these images, perfect nanoribbons were selected one by one. The tip of the microscope is then used to contact one end of a chosen nanoribbon to lift it from the surface by its extremity. The other end is in contact with the metal surface. Progressive retraction of the tip electronically disconnects one end of the wire. The other end remains in electronic interaction with the metal surface while sliding on it.

The breakthrough, which was reported in *Nature Nanotechnology*, shows that it is already possible to produce perfect ultra-small width graphene nanoribbons and to measure their electrical conductance. This discovery makes it possible to optimise the chemical composition of molecular nanoribbons and allows the long range electronic exchange phenomenon to be carried as far as possible in space. The data also opens the door for understanding long distance electron transfer in the elementary biochemical processes of life (e.g. vision, photosynthesis) and to master the rapid transmission of long distance quantum information in a quantum computer.

For more information about the research, please contact

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Reference: Matthias Koch, Francisco Ample, Christian Joachim, Leonhard Grill; "Voltage-dependent conductance of a single graphene nanoribbon"; Nat Nanotechnol. 2012 Oct 14: DOI: 10.1038/NNANO.2012.169).

## AWARDS


A proposed project by IMRE's Dr Chin Jia Min and IBN's Dr Michael Reithofer on "Ultrashort Peptide Hydrogels as Scaffolds for In Situ Silver Nanoparticle Synthesis and its Potential Application for Wound Healing" was awarded the grant during the A*STAR Scientific Conference, held from 18-19 October 12.

The project is one of only three that were successfully awarded to projects submitted from across A*STAR's research institutes. The project's research will look at new peptide-based hydrogel wound dressings with silver nanoparticles. Such wound dressings can easily be changed without further damage to the wound and possess anti-bacterial properties to aid in quicker healing. The project was also given the 'People's Choice Award' for the best poster as voted by the participants of the conference. The YRCG grant is for novel project ideas independent of theme or discipline that are collaborated across different RIs.

For more information about the research, please contact

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Dr Emma Luong Van was one of only four scientists accepted as a Fellow to the 2013 Singapore-Stanford Biodesign (SSB) programme. The programme trains the next generation of medical technology innovators in Asia. The team examines the clinical needs in Singapore and Asia, and identifies opportunities for medical technology innovations. Dr Luong Van will begin her 1-year Fellowship in January 2013 which will involve a 6-month stint at Stanford University, USA.

## OUTREACH

# Visits and Events

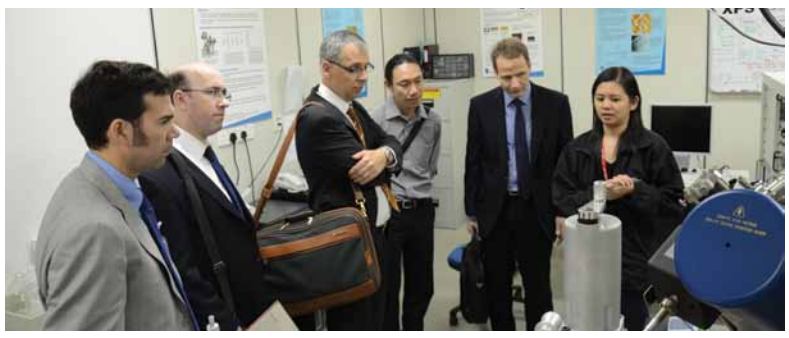
## The 2nd IMRE-LAM Bilateral Workshop on Advanced Materials

*The IMRE and LAM representatives who co-organised the workshop.*

**28 Sep 12**

Jointly organised by IMRE and Laboratory of Advanced Materials (LAM) at Fudan University (Shanghai, China), the objective of this workshop was to bring together leading scientists from Singapore and China to facilitate interactions and collaborations between these two premier materials institutes in the areas of materials science and engineering.

## First ever Dalton Transactions International Symposium held in Singapore



*Participants of the symposium on a tour of IMRE's facilities.*

**05 Nov 12**

The 4th Dalton Transactions International Symposium was organised jointly by the Royal Society of Chemistry (UK), the Singapore National Institute of Chemistry (SNIC) and IMRE. The first such event in Singapore, the symposium featured a selection of lectures covering organometallic chemistry and catalysis given by some of the world's leading international scientists. Dalton Transactions is the Royal Society of Chemistry's journal that covers inorganic, bioinorganic and organometallic chemistry.

## Lab-on-a-chip Workshop: Novel 3D Microfluidics, Bioassays, and Signal Enhancement

**02 Nov 12**

Several novel lab-on-a-chip technologies were presented at the workshop, including 3D dynamic microfluidic chips to detect the cells in an in-vivo biomimetic environment, novel plasmonic-based bioassays that can be used for lab-on-a-chip, and optimal plasmonic nanostructure designs for signal enhancement in a lab-on-a-chip.

## SERC RI ED Talk


*The panelists were kept busy by the constant flow of questions from the undergraduates who attended the talk.*

**12 Oct 12**

Prof Andy Hor, ED IMRE and Prof Alfred Huan ED IHPC gave a talk at the NUS Science Faculty as part of the inaugural "RI ED Talk Series". The talks provided students with direct access to A*STAR's Executive Directors and helped promote the activities at A*STAR's Science and Engineering Research Council as well as its research career opportunities.

## Nanyang Girls High (NYGH) School attachment

**09-16 Nov 12**

17 students from NYGH School were attached to IMRE for a research immersion programme. For their project they learned how to fabricate a microfluidic device using chemically treated human hair.

*The students from NYGH posing for a group photo.*

## Introduction to nanoimprinting for Republic Polytechnic students

*Republic Polytechnic students listening to a briefing by Dr Jaslyn Law on nanoimprinting.*

**26-29 Nov 12**

Four groups of students from the Republic Polytechnic visited IMRE to learn about nanostructures fabrication methods. The visit was hosted by Dr Jaslyn Law and Dr Yap Fung Ling.

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OR Visit our website at
**www.imre.a-star.edu.sg**
For general enquiries please write in to
**enquiry@imre.a-star.edu.sg**

## UPCOMING EVENTS

### Diary of upcoming events @ IMRE

**07-08 January 13**
SNIC-RSC International Symposium on Inorganic Chemistry
www.rsc.org/conferencesandevents/rscevents/international/singapore/index

**14-16 January 13**
3rd Molecular Materials Meeting (M3) @ Singapore 2013 Conference

**17 January 13**
Metamaterials Industry Forum

**01 March 13**
IMRE Industry Day – "Materials Technology for SMEs"

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