Research, Development and Commercialisation
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PERSPECTIVES

Institute of Materials Research and Engineering
A*STAR
www.imre.a-star.edu.sg

Better materials and newer ways of making them

Studying and harnessing the true potential of a material is the job of the Synthesis and Integration group at IMRE.

Discovering new materials, exploring the capabilities of existing materials and enhancing the properties of materials are at the core of the work to create new materials designs and technology innovation. The group's R&D focus is on Advanced Materials, Nanocrystals and Electronic Materials.

Advanced Materials

Work in this area is to develop advanced materials and processes in support of industrial needs.

Nanocomposites - High performance automotive parts and anti-scratch coatings

Examples of R&D work includes the development of high-performance polymer composites for automobile body and component casing as part of the A*STAR automotive programme. Robust anti-scratch and anti-crazing coatings for lenses and windows have also been invented in collaboration with industry partners.

Functional materials - Better consumer care products and lubricants for HDDs

Some of the ongoing work in studying and creating better functional materials includes novel rheological modifiers, or the deformations and stresses that affect molecules and materials, to enhance the design of consumer care products. IMRE has also successfully developed high-performance monolayered lubricants for use in next-generation hard disk drives (HDDs).

Nanocrystals

Unique nanocrystal designs are used to solve the inherent problems of conventional quantum dot (QD) technologies, which can be used as biomarkers and for lighting. The team also develops novel electrocatalysts for high-performance fuel cells.

Highly luminescent composition-based quantum dots (QDs)

The research team had successfully developed colour-tunable QDs with a range from violet to near infrared. The QDs were also thermally stable above 300°C for more than 10 hours and less toxic metal elements were also used to make the QDs.

See-through organic photovoltaics or solar cells

Efficient large-scale synthesis of quantum dots (QDs)

IMRE has also perfected large-scale synthesis of QDs, having achieved 20gm per batch in a 500ml reaction flask at a quantitative yield of ≥ 95%. Theoretically, there is no limit in the production capacity, which is restricted only by the size of the reaction container, and effective stirring and heating. The process is coupled with relatively low materials cost.

Better fuel cell electrocatalysts

Carbon / carbon nanotube-supported Pt, PtRu and PtSn catalysts developed at IMRE have exhibited higher and longer electrocatalytic activities, enabling higher power density in fuel cells.

Electronic Materials

The focus in this area is to enable the development of next-generation electronic devices through innovative materials design.

Organic photovoltaics (OPVs)

OPV research at IMRE focuses on the improvement of device efficiency and device lifetime through the development of new functional OPV materials, new device architectures and fabrication processes. A sizable patent portfolio comprising low band gap polymer semiconductors, n-type organic semiconductors, and transparent cathode technologies has been generated.

Novel semiconductors

IMRE conducts R&D on the processability of semiconductor materials in non-toxic solvents as well as creating new materials with excellent ambient stability and self-assembly capability. These materials have applications in the manufacturing of printed transistors for large-area devices and ultra-low-cost electronics.

Intrinsically coloured luminescent silk fibroin

Light emitting transistors

IMRE has developed integrated active-matrix switching and light emission in one simple device. This can be beneficial in the manufacture of low-cost display devices.

OLED materials and devices

IMRE has built up a solid portfolio of patents in the development of organic light emitting diode (OLED) technology, including ITO conductors and blue emitters and other component technologies.

Tera-Barrier Films launched to develop breakthrough plastic barrier film

TERA-BARRIER

IMRE's newest spin-off to bring high performance barrier films to the printed electronics market

Tera Barrier's breakthrough barrier film

Set up by Dr Mark Auch and Mr Senthil Ramadas, researchers from IMRE, Tera-Barrier Films Pte Ltd will further develop a breakthrough plastic barrier film for solar, display and printed electronics applications.

The barrier film protects the easily degraded moisture-sensitive flexible and lightweight electronic devices like disposable or wraparound displays, identification tags, flexible and light weight solar cells and chemical and pressure sensitive sensors.

Tera-Barrier Films has established strong partnerships with subcontractors for significant volume production of barrier films, as well as with solar cell, displays and printed electronics manufacturers. Tera-Barrier Films has received several product validation reports and is now focusing on obtaining product qualification.

For more information about Tera Barrier Films, please contact

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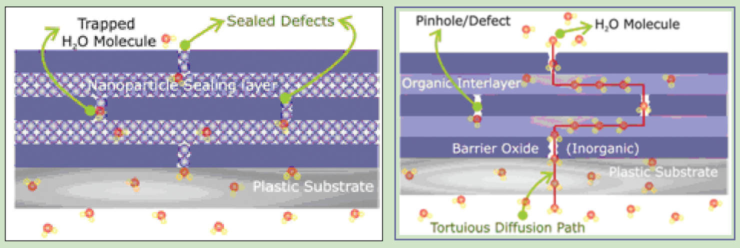
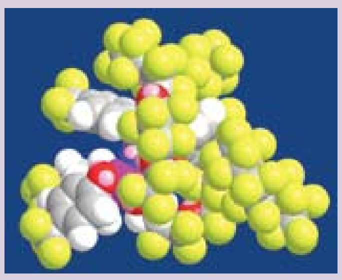


Comparison of a conventional barrier film (left) and Tera-Barrier Films' product (right) that literally 'plugs the gaps' in technology

World's best flexible, plastic barrier film

One of IMRE's OLED component technologies, Tera-Barrier Films' plastic film, is 1,000 times more effective at keeping out air and moisture than conventional films available in the market. Using nanotechnology, the film effectively reduces the tiny pores inherently found in plastic material layers. The inventors of the film have set-up a spin-off company to further develop and market the technology.

Only 2nm thick but single lubricant layer protects next generation HDDs

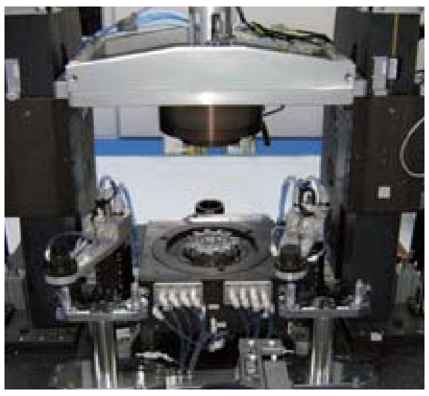


Simulation depicting the molecular structure of a lubricant

IMRE's Synthesis and Integration group developed phosphazene-based lubricants which can self assemble on hard disks to form a 2nm protective and lubricant monolayer with higher thermal stability (~220°C higher) for next-generation high-density hard disks. Current hard disks rely on separate lubricant and protective layers which together are tens of nanometers thick. Our thinner layer allows the read heads of hard disks to read faster and clearer, paving the for even higher density and smaller storage devices.

CORPORATE NEWS

First made-in-Singapore mass production nanoimprinter



The nanoimprinter's top and bottom assembly allows a disk to be imprinted on both sides at one go

Local precision equipment manufacturer Solves Innovative Technology Pte Ltd, together with A*STAR's Institute of Material Research and Engineering (IMRE) and Data Storage Institute (DSI), builds a machine capable of producing nanometer-size components and in wafer-scale volumes, for a host of applications in consumer electronics such as hard disk media and optical storage media.

IMRE's nanoimprint lithography and DSI's hard disk media technologies were licensed to Solves Innovative Technology to design a production-grade nanoimprint system for the manufacturing of patterned media for hard disk drives. The prototype significantly improves conventional nanoimprinting processes with its new features such as double-sided imprinting to reduce processing time; a customised dosing system; and imprinting in vacuum to prevent air bubbles, for more accurate patterning.

Said Mr Koh Teng Hwee, Managing Director of Solves Innovative Technology, "The collaboration with IMRE and DSI accelerated the development of this tool without having to start from scratch. The nanoimprint and recording media research expertise of IMRE and DSI had significantly facilitated the design of the prototype. We were also able to tap on IMRE's advanced measurement and characterisation equipment that we might otherwise have to buy.".

For more information about this research, please contact

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RESEARCH

World's only controllable molecule-gear

IMRE scientists, led by Professor Christian Joachim, have scored a breakthrough in nanotechnology by becoming the first in the world to build a 1.2nm molecular gear - rotation can be deliberately controlled. This marks a radical shift in the scientific progress of molecular machines and was published on 15 June 09 in Nature Materials, one of the most prestigious journals in materials science.

To learn more about the molecule-gear, please contact

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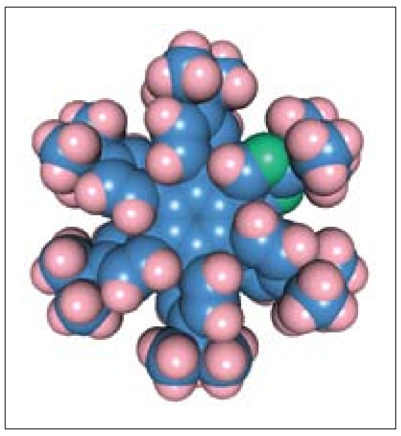
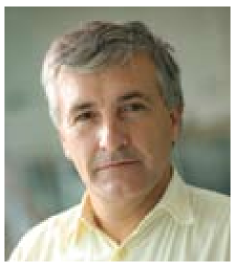


Computer simulation of the molecule-gear

Towards molecule machines



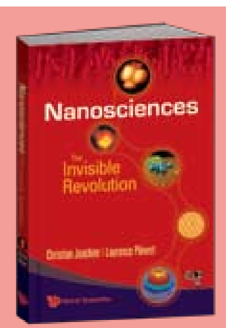
Prof Christian Joachim

"Making a gear the size of a few atoms is one thing, but being able to deliberately control its motions and actions is something else altogether. What we've done at IMRE is to create a truly complete working gear that will be the fundamental piece in creating more complex molecular machines that are no bigger than a grain of sand."

– Prof Joachim, IMRE Visiting Research Scientist, A*STAR Visiting Investigator Programme.

About Prof Christian Joachim

- Director of Research and Head of Molecular Nanoscience and Picotechnology Group (CEMES-CNRS, France)
- Visiting Research Scientist, IMRE, A*STAR, Singapore under the Visiting Investigator Programme
- Accolades include:
  - French Chemical Physics Prize (1988)
  - IBM France Prize (1991)
  - CNRS Silver Medal (2002)
  - Feynman Prize (1997 & 2005)
- Research Interests:
  - Single Molecule Manipulation and Molecule Machine
  - Quantum Resources
  - Molecular Logic Gate Based Computing



NANOSCIENCES
The Invisible Revolution

Nanosciences - the invisible revolution
by Prof Christian Joachim

Prof Christian Joachim's groundbreaking book "Nanosciences: The Invisible Revolution" provides a scientific and historical perspective of nanosciences and molecule machines. Prof Joachim is currently working with IMRE scientists on atom-scale technology.

What's in a word?

Nanotechnology – Of 'Bottom-up' and 'Top-down'

Scanning tunneling microscope image showing the word 'IMRE' formed by individual gold atoms

Nanotechnology involves the use of the "bottom-up" approach of building nanometer-sized structures atom by atom. The reverse of this process is miniaturisation where the "top-down" approach is taken, in which devices and structures are made smaller by whittling extra materials. Miniaturisation will one day hit a limit and will no longer be possible due to technological constraints at the nanometer scale. Nanotechnology optimises the use of materials and energy required to build structures, and allows miniaturisation beyond traditional "top-down" approaches.

On the cover of a magazine...

"Supramolecular Triblock Copolymer" in Macromolecules Journal, Vol 42, Issue 12. "Polymersomes" in the Small Journal (inside cover).

The work of an IMRE researcher, Dr Madhavan Nallani's "Sorting Catalytically Active Polymersome Nanoreactors by Flow Cytometry" in collaboration with a team of researchers from the Netherlands, was highlighted on the inside cover of Small Journal (volume 5, issue 10). The work describes how the activity of enzymes encapsulated in polymersome nanoreactors (300-500 nm) can be probed using flow cytometry.

Another research paper by a team of researchers from IMRE (Dr Li Jun) and the National University of Singapore was highlighted on the journal cover of Macromolecules (volume 42, issue 12). Entitled "Novel Supramolecular Block Copolymer: A Polyrotaxane Consisting of Many Threaded α- and γ-Cyclodextrins with an ABA Triblock Architecture", the paper demonstrated a strategic synthesis of a novel polyrotaxane consisting of many threaded a-cyclodextrin (a-CD) and g-cyclodextrin (g-CD) rings with an ABA triblock architecture.

AWARDS

Continuous training of talent - Scientific Staff Development Award (SSDA)

The SSDA is a training initiative by A*STAR that continuously builds the talent pool by offering sponsorship to existing research and technical support staff to do a local part-time or joint PhD studies offered by the local universities, NUS and NTU. To date, a total of 14 research technical support staff (RO) in IMRE have been awarded SSDAs.

IMRE up to the mark again!

Singapore Quality Class (SQC) re-certification is successful.

SQC is based on performance in 7 categories, namely, Leadership, Planning, Information, People, Processes, Customers and Results.

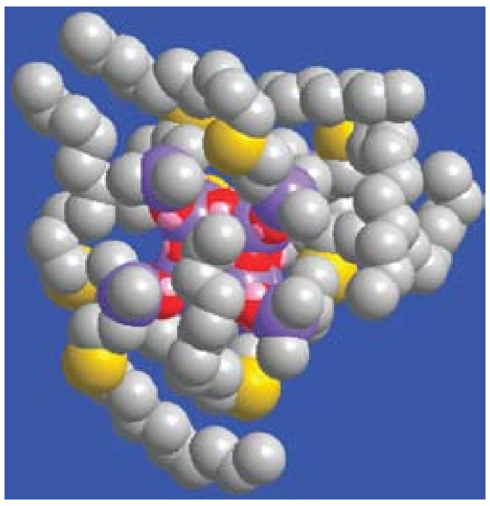
SINGAPORE QUALITY CLASS

IMRE has successfully been re-certified with the SQC award for another 3 years until July 2012. The SQC is a national certification that recognises overall business excellence standard. Benchmarked against international business excellence frameworks, the SQC provides organisations with a holistic model for organisational excellence.

PATENTS FILED & GRANTED

Lubricants that withstand higher heat environments

Polyhedral Oligomeric Silsesquioxane (POSS) Lubricating Oil



Computer simulated image of POSS molecule

POSS Lubricating Oil

The invention describes a new POSS derivative with thioether corner substituents and its preparation methods. These oily POSS derivatives can be used as part of lubricants. The advantages of these materials are the enhanced high temperature thermal properties, making it very useful in extreme temperature environments. The lubricant composition can comprise POSS oil alone or in combination with other materials.

Ester-type high temperature lubricants suffer from a relatively high evaporation loss and experience gradual decomposition at high temperatures. Using POSS structures as the internal core to develop synthetic lubricants, IMRE scientists have incorporated an inorganic moiety into an organic molecule that has led to significant improvement in thermal stability and anti-oxidation ability, among others. For example, one POSS lubricant loses only 5.6% of its mass at 220°C for 48 hours without addition of any antioxidant. The sample also did not freeze when it was cooled to -80°C.

High temperature lubricants can be used as bearing lubricants, hydraulic fluid, and nuclear industry lubricants as well as in high temperature equipment and jet engines.

For more information about this patent, please email

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VISIT & EVENTS

Meet-The-Scientist Talk

9 April 09

Dr Wulf Hofbauer from IMRE and Dr Eileen Tan from DSI co-hosted a Meet-The-Scientist Talk on "The Physics of Sound" at Science Center, Singapore.

Visit by Nanyang Polytechnic (NYP) teaching staff

22 Apr 09

The NYP delegation was briefed on IMRE's characterisation facilities and techniques as part of NYP's internal training programme for its teaching staff.

Teaching staff from NYP being briefed on IMRE's capabilities

MSE-IMRE Materials Challenge

MSE-IMRE Challenge 2009

2 May 09

The NTU Materials Science and Engineering (MSE) Department and IMRE co-organised the Materials Challenge 2009 – an event that promotes and creates awareness of materials science by involving students from junior colleges and post-secondary institutions in a quiz and lab-based competition.

Workshop on challenges in laser-material application

19 May 09

IMRE organised a laser-material interactions workshop to promote the science in this field and to look at developing industrial applications.

Participants of the Laser-Material Interaction Workshop

A*GA Research Exposure Programme (REP)

Students attending the REP presenting their results

5 June 09

The Outreach Team hosted 21 ASEAN scholars as part of the A*STAR Graduate Academy's REP. The students were briefed on IMRE's research facilities and conducted a mini case study that demonstrated the use of materials science characterisation techniques.

NUS Chemistry Camp visit

9 June 09

IMRE hosted a visit for 24 junior college students attending the NUS Chemistry Camp as an introduction to a research-oriented environment.

NUS Chemistry Camp visitors

International Conference on Materials for Advanced Technologies (ICMAT 2009)

28 June - 3 July 09

Organised by the Materials Research Society (Singapore) in association with IMRE, ICMAT is one of the premiere materials science conferences in the world, which regularly has Nobel Laureates attending as speakers. IMRE organised the *3rd Industrial Symposium on Nanoimprint Lithography* in conjunction with the conference. Dr Lim Khiang Wee, Executive Director of IMRE was also the Moderator for the main Panel Discussion that centred on "Entrepreneurship in Materials Science and Engineering".

Participants at the 3rd Industrial Symposium on Nanoimprint Lithography

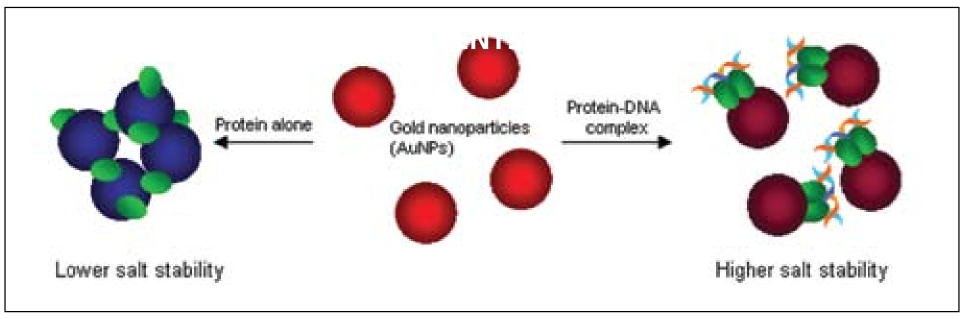
PATENTS FILED & GRANTED

Listed below are highlights of some recent IMRE patents filed and granted. To find out more about our patents, please write in to enquiry@imre.a-star.edu.sg.

Highlights of IMRE patents filed from Apr 09 – Jun 09

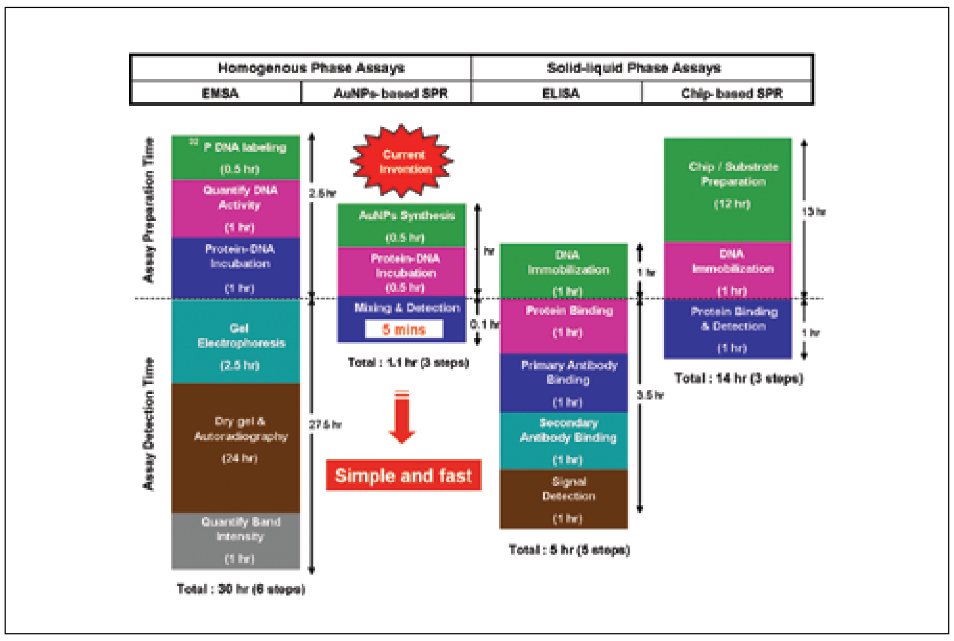
Faster, safer and fuss-free measurement of protein-DNA interaction

Scientists from IMRE have developed an assay method that is safer, faster, simpler and cheaper for studying protein-DNA interactions.



(Top) Illustration of the colorimetric sensing principle where the protein-DNA complexes have a greater ability to protect gold nanoparticles (AuNPs) against salt-induced aggregation than protein without forming a complex.

(Bottom) AuNPs' salt stability, which correlates to the colours produced, is the result of the binding of different biomolecules thus providing the measure of the protein-DNA complex formation.



Comparison between our method to the EMSA, ELISA and chip-based SPR spectroscopy in term of assay preparation procedures and detection time

IMRE has developed a new assay method that does away with sophisticated detection equipment, omits any labelling steps for either DNA or proteins, involves no complicated surface chemistry for probe immobilisation or substrate preparation, and allows rapid detection in less than 5 minutes.

Electrophoretic mobility shift assay (EMSA) is the most commonly used method to study protein-DNA interactions. This technique employs hazardous 32P-labeled DNA to detect the formation of protein-DNA in polyacrylamide gels. The assay is also tedious, labour-intensive, and requires a costly and stringent detection facility (e.g., radio protection lab). IMRE scientists have developed a label-free 'in solution' detection method to study protein-DNA interactions. Colloidal gold nanoparticles (AuNPs) were used as the sensing platform that relies on its unique surface plasmon resonance properties (associated with changes in the colour of the solution), which is determined by the interparticle distance.

This colorimetric assay can measure parameters that are essential in modern molecular biology research quickly and fuss-free:

1. Sequence specific protein-DNA complex formation
2. Screen nucleotide composition impact on binding affinity
3. Determine binding stoichiometry, and
4. Measure sequence-independent transient binding

For more information about this patent, please email

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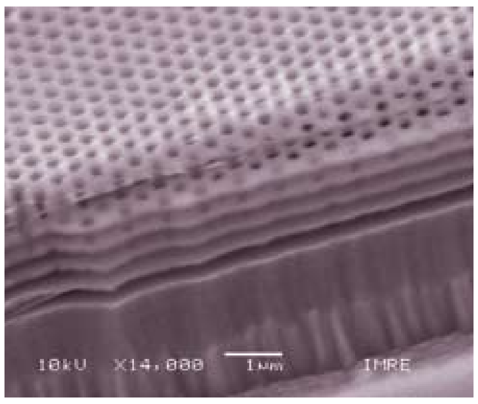
Easy-to-make semiconductor three-dimensional (3D) photonic crystals

IMRE researches have developed a new process for easily producing 3D photonic crystals (PhCs) in semiconductor material



SEM picture of the 3D-PhC structure formed in InGaAsP material

The invention relates to a technique for fabricating 3D photonic crystals (3D-PhCs) or photonic bandgap structures in semiconductor materials, such as InGaAsP/InP, GaAs/AlGaAs or SiGe/Si. 3D photonic crystals are important components in portable, small size and high-performance photonic devices, such as lasers, high Q cavity and compact waveguides that are used in optical communications, photonic integrated circuits and optical quantum computers.

Making 3D PhCs in semiconductors is problematic as the semiconductor process is naturally a 2D thin film technology where organising a 3D lattice in deep submicron scale is inherently difficult.

At IMRE we have developed a process to easily produce 3D PhC structures using semiconductor materials. The use of epitaxy and 2D-planar lithography in the respective vertical and planar directions does away with the laborious and time-consuming arrangement of the crystal lattice in 3D. The process also makes uniform patterns in all semiconductor layers and at all depths, which is impossible in direct etching and other inventions, especially for 3D PhC in the visible-to-near IR wavelength range.

For more information about this patent, please email

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UPCOMING EVENTS

Diary of upcoming events @ IMRE

October 2009
2nd Marine Fouling Prevention Workshop

22 October 2009
IMRE Industry Day

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

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www.imre.a-star.edu.sg

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