Institute of Materials Research and Engineering
A*STAR

PERSPECTIVES

Research, Development and Commercialisation

MICA (P) 098/03/20 • ISSN 0219-1830 • Vol. 8/ Issue 1 • November 2006

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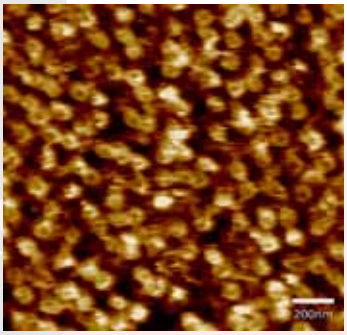
Home-grown Talent Solves 25-year-old Mystery Using Materials Research

Dr Roderick Lim, a postdoctoral scholar from IMRE who is currently a scientist at the University of Basel, Switzerland, answers a quarter-century-old mystery about living cells with help from nanotechnology developed here.

The question of how biological cargo moves in and out of the nucleus of a living cell has been hotly-debated by the biological community for more than 25 years. However, this may be a thing of the past, given the recent breakthrough by Singaporean scientist Dr Roderick Lim, who is currently based at the University of Basel's National Center for Competence in Research in Nanoscale Science (NCCR-Nano).



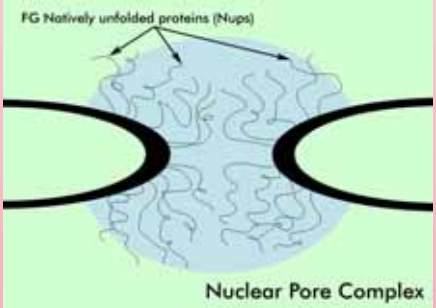
An Atomic Force Microscopy (AFM) image of nuclear pore complexes (NPCs) taken on the surface of a cell nucleus. The NPCs are the round, 100-nm-wide, "donut-like" structures.

Working with world-renowned Swiss structural biologist, Prof. Ueli Aebi, Roderick has unravelled the enigma that is the nuclear pore complex (NPC) - the biological structure responsible for controlling cargo transport between the nucleus and the cytoplasm or cell matter.

His landmark paper entitled *"Flexible Phenylalanine-Glycine Nucleoporins as Entropic Barriers to Nucleocytoplasmic Transport"*, was published in the June issue of the *Proceedings of the National Academy of Sciences USA*. It has since been highlighted in top scientific journals such as the Journal of Cell Biology and the "Faculty of 1000 – Biology", an online research tool that highlights the most notable papers in biology, based on the recommendations of over 1000 leading scientists.

Roderick obtained his PhD studying the nanoscale properties of liquids in IMRE in 2002. His expertise is in Atomic Force Microscopy (AFM), which is a technique that measures and converts the forces acting between molecules on a surface into visual images, literally down to its atoms.

Of Nuclear Pores and Sea Anemones

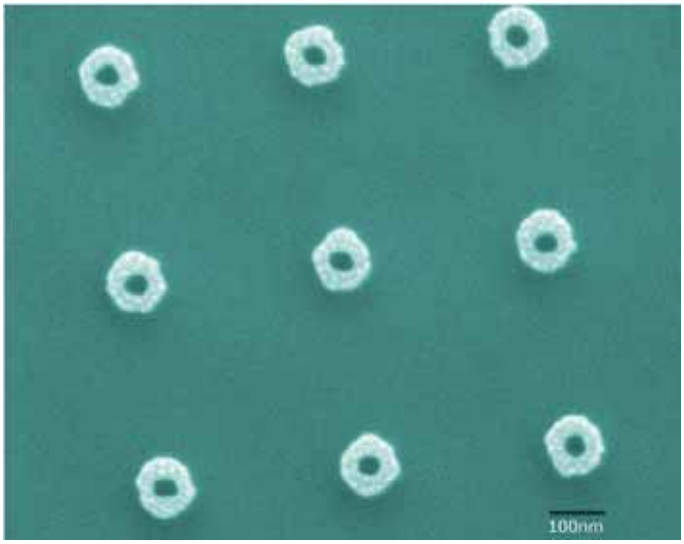


Flexible proteins, or FG Nups, act like the "tentacles of a sea anemone" to pull in selected protein molecules.

Roderick used his training as a physicist to approach the problem.

"Several biological models have been suggested over the last two decades with regards to NPC function, though all remain experimentally unsubstantiated," explained Roderick.

Roderick's novel idea was to study the key components of the



A Scanning Electron Microscopy (SEM) pictures of the new gold nanorings made by Dr Deng Jie, IMRE.

NPC by using nano-sized structures which artificially mimicked the physical dimensions of the "donut-like" NPC. That was when he returned to his roots at IMRE, which had the necessary nanotechnology-related expertise to aid in his research. Dr Deng Jie, a Research Associate with IMRE's nanofabrication and characterisation team, suggested and supplied 100nm gold nanodots, which were ideal for the experiment.

With his NPC model, Roderick then used the AFM to successfully uncover how the NPC worked. He put it simply by equating the NPC to a sea anemone. The central pore or "mouth" of the NPC is surrounded by the unstructured, flexible proteins or "tentacles". The tentacles form a corona-like barrier around the NPC "mouth". For transport to proceed, only selectively targeted cargo binds with the "tentacles", causing them to collapse into the NPC, much like a sea anemone grabbing its prey.

"The NPC is really an energy-efficient cellular *nanomachine* that separates and segregates proteins between the cell's cytoplasm and the nucleus," clarified Roderick.

With this success Roderick is now working on combining the nuclear pore proteins with gold nanorings that have been recently fabricated by IMRE. He hopes also to develop an artificial "minimalist" NPC when he returns to Singapore. Besides bringing many interesting fundamental questions to the fore, he believes that his work may ultimately lead to potential technological applications in any system involving liquids. "Such a technology would obviously be applicable in water, which is the essence of the biomedical and life sciences," he reminds us.

Profile – Making some *Noize* using his AFM!

A self-confessed science junkie, Roderick also happens to be passionate about experimental music, which he cautions is not for the faint-hearted. He has performed at venues such as the Substation in Singapore.

He is presently working on a sound-art installation project in Basel called "*Nanonoize*". The sounds for his improvisations come from the "friction" between atoms that are detected by the AFM. Essentially, *atomic friction* produces characteristic waveforms that are similar to the sounds produced by a violin or a creaking door.

"By simultaneously sending the signal from the AFM to a large projection screen and to speakers, people don't only get to see the image of atoms on a crystal surface in real-time, but will also be able to "hear" the process from which the image is derived - atomic scale friction." "*Nanonoize*" will premier at the University of Basel at the end of the year.

Roderick is slated to return to do research in IMRE in one and a half year's time after his postdoctoral stint in Switzerland.

New Ways of Growing Nanocrystals Clinches Outstanding Thesis Award for IMRE Researcher

Dr Lim Wen Pei's research in the area of nanocrystal growth may contribute greatly to future studies in the building of nanomaterials.

Dr Lim Wen Pei is currently a Research Engineer in IMRE.

The formation of crystals is part science and part nature, with the size and shape being determined by factors beyond control. However, being able to control how crystals are formed can help researchers create novel nanomaterials that possess specific traits or properties.

It was for this research that earned Dr Lim Wen Pei not only her PhD from National University of Singapore (NUS), but also a Gold Medal from the Singapore National Institute of Chemistry (SNIC). That was for the "Most Outstanding PhD Thesis in Chemistry".

Her research centred on new methods for making nanocrystals.

Her thesis was entitled "*Architectural Control of Metal Sulfide Nanocrystals and Polymer Composites*" and supervised by Dr Chin Wee Shong from NUS' Chemistry Department, and co-supervised by IMRE's Dr Low Hong Yee.

''Wen Pei is a creative and observant researcher. Her project was carried out with great care and quality. Her thesis covered synthesising nanocrystals, explaining the synthetic mechanisms, and investigating the optical properties of some

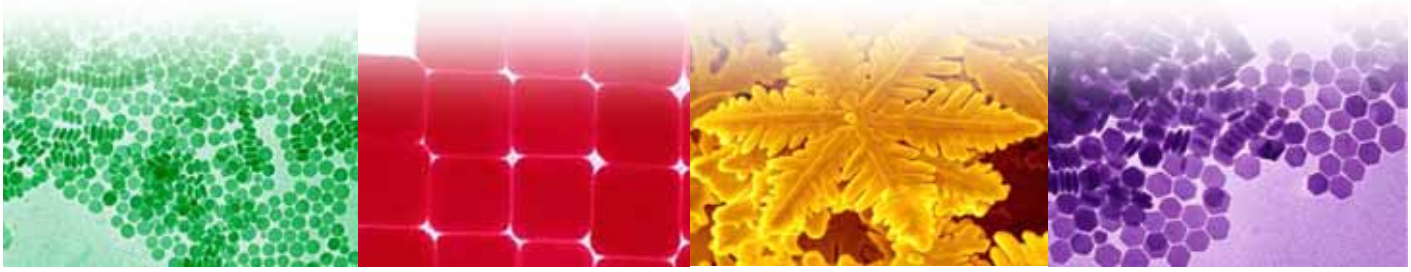
of these nanocrystal," said Dr Low Hong Yee, who is an expert in nanoimprinting technology.

"By studying how these crystals grow we can control its size and shape," said Wen Pei. Though there has been a lot of work published on the fabrication of monodispersed nanostructures, such as nanocrystals, comparatively few reports explain the mechanism for size- or shape-control. The ability to synthesise and process such nanomaterials is the cornerstone for building novel properties and phenomena in materials.

"Before we can systematically study or use nanomaterials, we must first be able to create them in good yield and in regular size and shape. One of the main foci of my thesis was on understanding how nanocrystals grew, in order to produce nanocrystals of a targeted size or shape".

Wen Pei's work will help fellow scientist further their research work on understanding and optimising preparation protocols as well as exploiting the properties of nanoscale materials. These materials may have potential use in a range of nanomaterial-based devices.

Wen Pei is currently working with IMRE's Dr Yao Kui on the assembly of carbon nanotubes, which can be used as interconnects in advanced ultra-large scale integrated circuits, and in the preparation of ferroelectric thin films.



The different shapes and sizes of crystals created by Dr Lim Wen Pei in the course of her work.

Polymer Specialist Lends His Expertise to IMRE

Prof Tom Davis from University of New South Wales, Australia joins IMRE as a visiting investigator to lend his experience and expertise in polymer research.

Prof Thomas Paul Davis is a professor from the University of New South Wales (UNSW), Australia. He is currently a UNSW *Scientia* Professor, an Australian Research Council (ARC) Federation Fellow, and the Director of the Centre for Advanced Macromolecular Design (CAMD).

Prof Davis comes to IMRE with a wealth of experience and know-how. He has been an academic for 14 years and has published over 250 refereed papers, patents and book chapters. Many of his papers were published in *Macromolecules*, the journal with the highest impact factor in polymer science, published by the American Chemical Society.

His many accolades include the distinction of being one of the earliest researchers in pulsed-laser polymerisation, which has resulted in some of his early papers achieving more than 100 citations. He was at the forefront of research into copolymerisation mechanism for ten years.

He is renowned for his work in discovering a new chain transfer isomerism mechanism as well as being the first to apply cobalt chain transfer in supercritical carbon dioxide. His 1995 review in this area was cited 130 times. He has invented a new highly oxygen permeable hydrogel contact lens (PCT), and has a patent on cobalt chain transfer that has gone to the national phase (supported by ICI).

Developing "Smart" Polymers

1. What is the project that you will be working on here in IMRE?

The collaboration with IMRE involves the design of functional macromolecules using living radical polymerisation. These macromolecules will have applications in biotechnology and nanotechnology (e.g. drug delivery, optoelectronics)

2. What is the eventual goal that you hope to achieve with this project?

There are a number of aims – for example if we are successful then we will be able to conjugate synthetic polymers with natural biomolecules to direct anti-cancer drugs to tumour sites. In addition novel anti-fouling coatings may well be developed.

3. What sort of impact does this research have for the layperson?

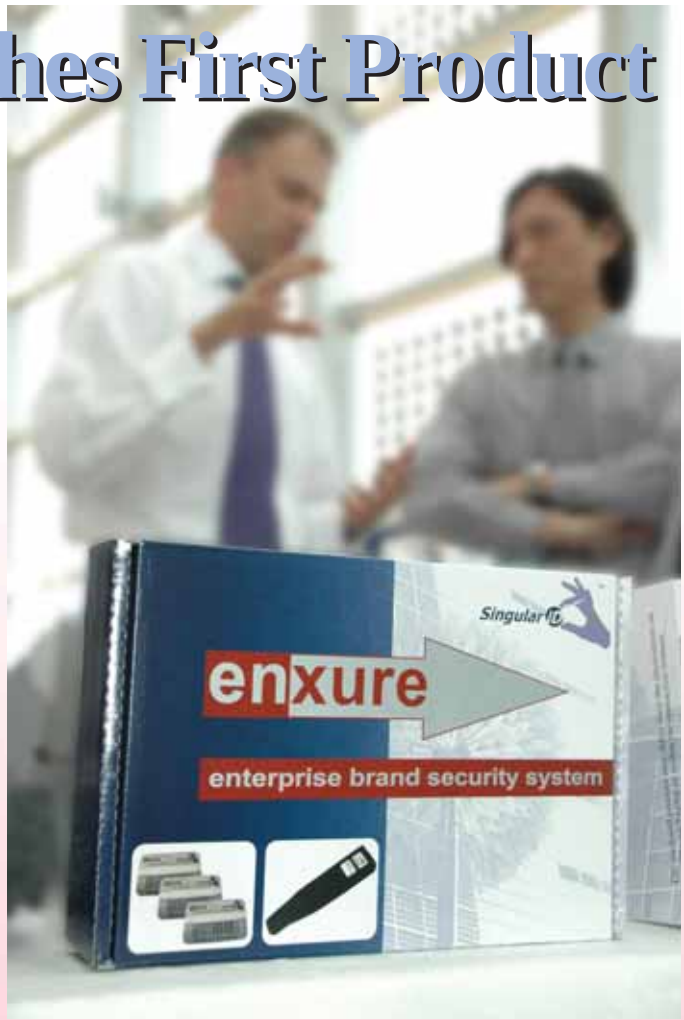
Examples of impact on the layperson include improved therapies and a reduction in side effects from many current chemotherapy treatments.

Singular ID Launches First Product

*Singular ID Pte Ltd, IMRE's first spin-off company, launches **enxure**, its new enterprise brand security system to help fight counterfeits.*

The new anti-counterfeit system from Singular ID Pte Ltd comprises tags that contain unique random arrangements of micrometre to nanometre-size magnetic features, which provide a fingerprint or signature that is prohibitively difficult to reproduce. The tags may either be part of a label or embedded within product packaging or the product itself. In the label format, they essentially form an unforgeable barcode that can be supplied pre-registered to a contract manufacturer of a brand owner. This protects against lost or stolen labels being used to authenticate fake products. The tags are authenticated by hand-held scanners that can connect to a personal computer or a mobile phone. The tag's unique signature is transmitted in an encrypted form to a central database where it is verified. Tailored messages can be returned to the scanner providing product information or a warning that the item was not verified as genuine.

For customers who wish to test **enxure** before integrating it across a product range, an evaluation kit is also available. The evaluation kit comprises a quantity of pre-registered labels, a scanner, a mobile phone, and software and cables to connect the scanner to a phone or a personal computer. The kit also comes with six months access to a central database to make authentication transactions and evaluate the features of the enterprise brand security system. The kit retails in Singapore at S$ 4,995 excluding taxes and freight.



Singular ID's enxure, an evaluation kit for customers who wish to test Singular ID tags before full production integration.

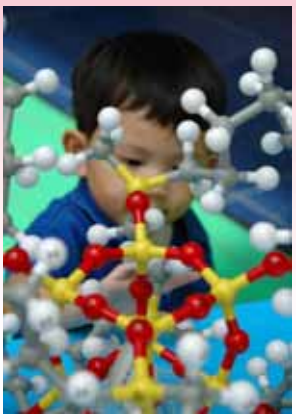
At the launch of the product, the Minister of State for Trade and Industry, Mr S. Iswaran presented tokens of appreciation to Singular ID's manufacturing partners and first major customer in the automotive sector.

*The inventors of the Singular ID tag, Dr Peter Moran (left) and Dr Adrian Burden (right) briefing Minister of State for Trade and Industry, Mr S Iswaran (2nd from left) and Mr Boon Swan Foo (2nd from right), Executive Chairman, Exploit Technologies, A*STAR commercialisation arm, on the product.*

Singular ID is a nanotechnology spin-off company that was founded by two researchers from IMRE in December 2004 to commercialise magnetic tagging technology for use against counterfeit products, contract manufacturing overruns, and grey market diversion. Singular ID was recently confirmed as one of the winners of the 2006 Red Herring 100 Asia award. For more information, please visit www.singular-id.com.

Materials Science and You

To promote science awareness, IMRE continues to reach out to the public, especially students.



Getting the young interested in science.

X-periment Exhibition 2006

1-3 September 2006

Organised by A*STAR and the Singapore Science Centre, X-periment is part of *Science.06*, a high profile national event, which reaches out to the public to promote science, technology and biomedicine. IMRE had showcased its R&D outcome such as liquid lens, OLEDs, LEDs and cubic silsesquioxanes (CSSQ). An activity centre where the public could make "silly putty" was set-up to demonstrate the principle of materials science.

Meet-the-Scientist Session

16 August 2006

Dr Wulf Hofbauer and Mr Kedar Hippalgaonkar from IMRE gave a talk to junior college students and the public at the Singapore Science Centre. Their talk titled, "Scratching the Surface: Interfaces at the Nanoscale", was about R&D on materials at the nanometre scale and the advanced tools used in that research.

National Science Challenge

16 August 2006

Preparing for the challenge ahead – The National Science Challenge participants being briefed about IMRE's research.

IMRE hosted competing junior colleges as part of the filming for the National Science Challenge Semi-Finals round. The teams for this episode include Bukit Panjang Govt High School, Raffles Institution and Victoria Junior College (IP). The episode featured materials and the quest for newer and better materials, an example of which was to strengthen existing materials using fillers to enhance the properties of polymers. The episode was shown on 12 October 2006 on Channel 5.

Outreach Webpage

To enhance our efforts to spread the message of science, an Outreach webpage was also launched to highlight IMRE's outreach activities and act as a resource for budding scientists. For more information, please visit the site at www.imre.a-star.edu.sg/outreach

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***

Tunable wavelength light emitting diode

The invention relates to a GaN-based LED package chip which can give different colour emission by varying the applied voltage. Potential applications of invention include illumination and display devices, LCD backlighting, keypad light guides, digital camera flash light, PC monitors backlighting, solid state lighting, automobile headlights and traffic lights.

Inventors: Soh Chew Beng, Chua Soo Jin, Haryono Hartono

Microneedles and methods for fabricating microneedles

This invention relates to the design and fabrication of side ported plastic microneedles that could be used for all delivery modes (transdermal, intradermal and subcutaneous). Potential commercial application of the invention includes plastic needles that are used for drug delivery into the body.

Inventors: Lim Chee Yen

A method for fabricating micro and nano structures

The invention provides a method for constructing surface textures on semiconductor devices, especially, on light emitting diodes (LEDs). Potential applications for this invention include light emitting diodes, light detectors, solar cells and mico and nano lens arrays.

Inventors: Wang Benzhong, Chua Soo Jin

Power supply device and system

This invention is related to a power supplier that is able to provide temporal electric current to an external electrical load. The power supplier mainly comprises a material with electric polarization, preferably a polarized ferroelectric material, and the electric current originates from the redistribution of the charges on the surfaces of the electrically polarized material. Potential applications of this invention include RFIDs, particularly for tamper indicating electric seals, wireless sensors and sensor networks for monitoring, as well as any other electronic devices that need temporal and low level power.

Inventors: Yao Kui, Tan Yee Yuan

Method for bandwidth broadening of ultra-wide band light emitting device

The invention describes a method to broaden a spectral or bandwidth of a semiconductor light emitter by using a laser-irradiation technique. Potential commercial applications of the invention include pre or post fabrication bandwidth broadening in SLDs, post fabrication wavelength corrections in DFB lasers and photonic device integration.

Inventors: Chia Ching Kean, Dong Jian Rong

Method for arbitrary manipulation and guiding of a capsule and a mechanism for anchoring and dislodging it

The invention relates to a capsule that provides an innovative means of propulsion without needing external moving/turning parts such as propellers or wheels. The invention has potential commercial applications in medical imaging for the gastrointestinal system.

Inventors: Saman Dharmatilleke, Lim Chee Yen

Phosphazene compound, lubricant and magnetic recording medium having such compound, method of preparation, and method of lubrication

The invention relates to a novel lubricant for hard disk drives that exhibits good stability when exposed to heat or under laser radiation. The lubricant also possesses an improved lubrication property, particularly in reducing dynamic friction coefficients of a thin film recording media. Potential commercial application of invention include lubrication for longitudinal recording media, lubrication for perpendicular recording media and lubrication for magnetic hard disk media in high temperature environments.

Inventors: Xu Jian Wei, Joseph Ng Kok Peng, Zhang Jun, Wang Shaofeng, Ji Rong, Hu Shengbin, Xu Baoxi

RESEARCH

Improved Fabrication of 3-D Micro and Nano Structures

Simpler and easier process for the fabrication of 3D-structures may lower processing cost and add functions to devices such as optical components, fluidic channels, and photonic bandgap structures.

WHO

Dr Low Hong Yee, Molecular and Performance Materials

**To view her profile, please visit* http://www.imre.a-star.edu.sg/personal/getListing_action.asp?strID=hy-low

WHAT

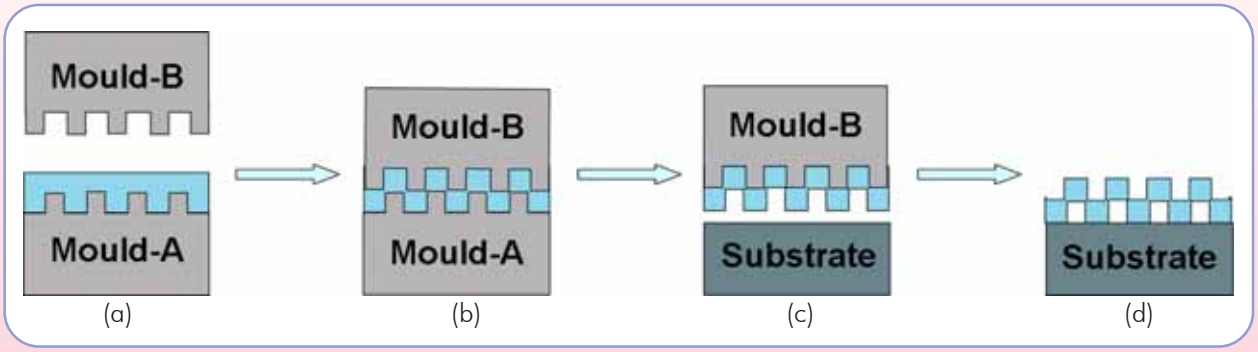
"Combinatorial-mould imprint lithography: A versatile technique for fabrication of three-dimensional polymer structures"

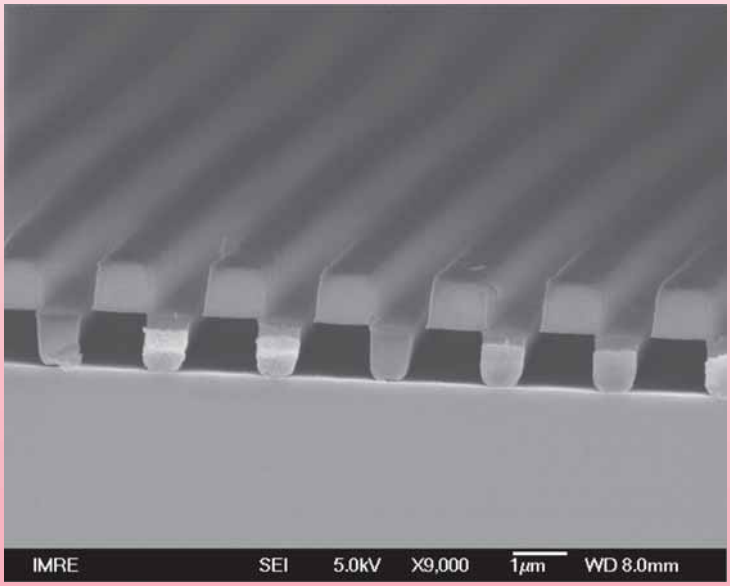
WHERE

Published in Applied Physics Letters 89, 023109 (2006) and July 24, 2006 issue of Virtual Journal of Nanoscale Science & Technology

WHY

A two-step fabrication technique based on nanoimprint lithography is described for the fabrication of 3-dimensional micro- and nano-structures. By combining simple 2-dimensional geometries from two moulds, complex and useful 3-dimensional structures are obtained. The careful selection of mould geometries constitutes a simplified and efficient approach toward building-up desirable 3-dimensional structures without resorting to the use of a sacrificial process or components. 3-dimensional structures fabricated for a variety of specific applications are presented using both thermoplastic and crosslinked polymer materials.





(e)

Combinatorial mould-NIL for a double grating structure is obtained from the combination of two identical moulds:

a. *A polymer film or a liquid resin is spin-coated onto one of the silane treated grating moulds (in this case Mould-A). Mould-B is then pressed into the polymer at elevated temperature and pressure.*

b. *Mould-to-mould imprint step where the double grating structure is formed.*

c. *Upon demoulding, the polymer preferentially adheres to Mould-B.*

d. *The double grating structure is transferred to a substrate.*

e. *SEM cross-section view of an out-of-phase double grating structure on Si.*

Flexible Substrates for Plastic Electronics

Flexible substrates are set to renew the current advanced display, security and semiconductor industries, by offering the possibility of a new suite of applications and products.

WHO

Mr Ramadas Senthil Kumar, Opto- and Electronics Systems
**To view his profile, please visit* http://www.imre.a-star.edu.sg/personal/getListing_action.asp?strID=rs-kumar

WHAT

Flexible Substrates for Plastic Electronics

WHERE

Factsheet – IMRE website (http://www.imre.a-star.edu.sg/rnd/imre_Factsheets.asp)

WHY

A key research focus at IMRE is to develop flexible substrates and a gas permeation measurement test system that are suitable for the emerging display technologies such as OLED, PLED, EP and Flexible LCD. Using our barrier technology, we are able to provide flexible substrates with the highest standards of permeation requirements, and at a reasonable cost. Our immediate goal is to extend the use of our flexible plastic substrates to lighting, solar, organic electronics & medical applications. IMRE has successfully resolved the pore effect issue in multi-layer barrier stacks and developed ultra high barrier plastic substrates for OLED applications [Patent Pending]. Our barrier substrates have shown high water vapour barrier properties and are suitable for OLEDs. Our calcium test results show that there is no calcium oxidation up to 600hrs at 80°C and at 90% relative humidity (RH).

OPPORTUNITIES

We are currently seeking collaborative opportunities and partnerships to validate our flexible substrates in all relevant industries. If you are interested in this technology, please contact:

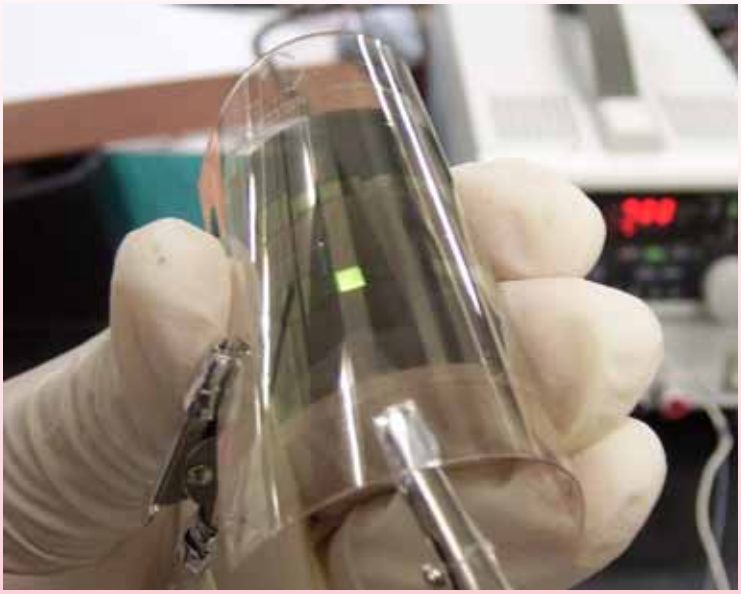
For *business* enquiries,

Colin Leong
Email: colin-leong@imre.a-star.edu.sg

Mark Auch
Email: m-auch@imre.a-star.edu.sg

For *technical* enquiries

Senthil Ramadas
Email: rs-kumar@imre.a-star.edu.sg



Flexible OLED fabricated using IMRE's high barrier substrate and encapsulation technique.

Events

To find out more about IMRE's events, please visit www.imre.a-star.edu.sg/events.
Alternative you can write in to us at events@imre.a-star.edu.sg (Quote "Ref:NEWS" in your email)

Contributors to this issue
Dr Low Hong Yee, Dr Ramadas Senthil Kumar, Ms Kwan Cai Nan, Mr Eugene Low

Institute of Materials Research and Engineering
3 Research Link, Republic of Singapore 117602
Tel: (65) 6874 8111 Fax: (65) 6872 0785
Email: enquiry@imre.a-star.edu.sg *(Quote "Ref:NEWS" in your email)*
Website: www.imre.a-star.edu.sg

November 2006
Printed by First Printers Pte Ltd