

CORPORATE NEWS



- Building at the microscale  
- IMRE is a bizSafe partner

RESEARCH



- Taking a leaf from nature  
- Mass producing low cost nano-sized structures

AWARDS



SSEF award winners

VISITS & EVENTS



Highlight of recent events

UPCOMING EVENTS



Seminars and workshops to look out for!

PATENTS



Patents filed and granted

CORPORATE NEWS

## Building at the microscale, nanoscale and beyond

The ability to build complex three-dimensional shapes and patterns at the scale of one millionth of a meter allows the creation of surfaces and structures with specifically tailored characteristics. Going beyond the conventional methods for making tiny structures, researchers are drilling down to the bare basics – manipulating atoms, one-by-one, to literally build structures from the “bottom-up”.

Forming one of the capability groups in IMRE, the Patterning and Fabrication team develops advanced patterning and fabrication techniques, and turns these into functional surfaces, devices and systems. The R&D work focuses on manipulating the materials properties of nano and molecular structures. Its current research activities include:

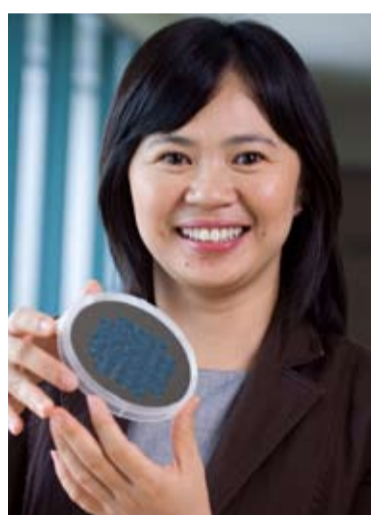
### Top-down Surface Patterning Techniques

#### Nanoimprinting lithography (NIL)

NIL is a low cost, high throughput surface patterning technique for making high-resolution micro- and nanosized structures. IMRE has developed a series of unique NIL technologies which include the ability to create complex 3D micro and nanostructures. This has allowed IMRE to build complex surfaces onto engineered plastics that successfully mimic the unique properties of natural systems. These include the anisotropic wetting of a rice leaf or the superhydrophobic (water-proof) lotus leaf. Learn more about this research in the article, “Taking a leaf from nature”.

#### Nanostenciling

Much like the stencils used to trace shapes onto paper, nanostencils are used in micro and nanotechnology as miniature masks through which



Dr Low Hong Yee leads the Patterning and Fabrication group in IMRE.

materials can be deposited, etched or ions implanted onto a substrate. The patterns on the masks are made by various lithographic techniques (such as electron beam and photolithography). Stenciling allows patterns to be created on 3D topographies and does not require heat or chemical treatment of the substrate, paving the way for the usage of a wide range of substrates and materials.

### Molecular-assembly Techniques

#### Anodic aluminium oxide (AAO)

AAO is a nanoporous template with hexagonally packed pores having diameters ranging from

tens to hundreds of nanometers. This template is simple to prepare - via anodisation of a pre-treated aluminum foil at controlled conditions. ALD is a vapour-based thin-film deposition technique that allows for conformal, very uniform, atomic-level film thickness coating on 3D nanostructures. The ALD technique and AAO template are combined to allow the preparation of well-controlled metal oxide nanostructures that are used for sensing, photocatalytical and photovoltaic applications.

### Grafted molecular assembly (for immobilisation of biomolecules)

By adjusting the architecture of a grafted polymer scaffold, the surface properties of a cell, such as density, can be customised to probe specific biological cell responses. Control over the

surface density at attachment sites has been used to regulate cell spreading and mobility. This technology is now being applied to the propagation of human embryonic stem cells on a defined, artificial substrate.

### Self-assembly of soft materials

Self-assembly techniques exploit the inherent tendency of molecules or nanoscale objects to order themselves spontaneously into structures or patterns in the nanoscale, driven by non-covalent forces of interaction between the building blocks. The technique is a cost effective way of creating a macroscopic collection of nanostructures in parallel. A wide variety of materials can be patterned this way, with feature sizes < 50 nm and densities of the order of 1Tb/in<sup>2</sup>, uniformly spread over a full 4” wafer.

### Nanoscale Device Design and System Integration

#### Photonic devices

The photonics work in IMRE focuses on semiconductor lasers and optical switches, the two key components for optical communication and on-chip photonics integration. Unique semiconductor lasers and optical switches have been made by integrating the device architecture with innovative material growth and device fabrication technologies, e.g. the complex coupled DFB laser and ultra-compact 1xN optical splitters. IMRE is now producing a compact CW terahertz (THz) source as well as using photonic crystals and metamaterials for novel photonic applications.

### Lab-on-a-chip based portable water analyser licensed to AWA Instruments Pte Ltd



Early prototype of IMRE's portable water analyser.

IMRE, through Exploit Technologies, A\*STAR's commercialisation arm, has licensed its lab-on-a-chip technology to AWA Instruments Pte Ltd. The hand-held analyser is a packaged prototype with integrated microfluidics, contactless conductivity detection and electronic components within a system that brings sensitive, accurate and reliable water analysis out of the laboratory and into the field.

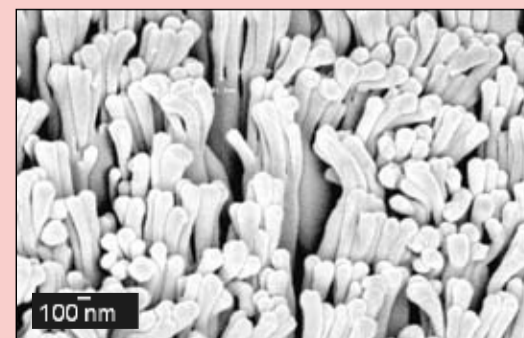
For more information about the research, please contact  
Dr Isabel Rodriguez  
i-rodriguez@imre.a-star.edu.sg

### Taking a leaf from nature (Part 1)

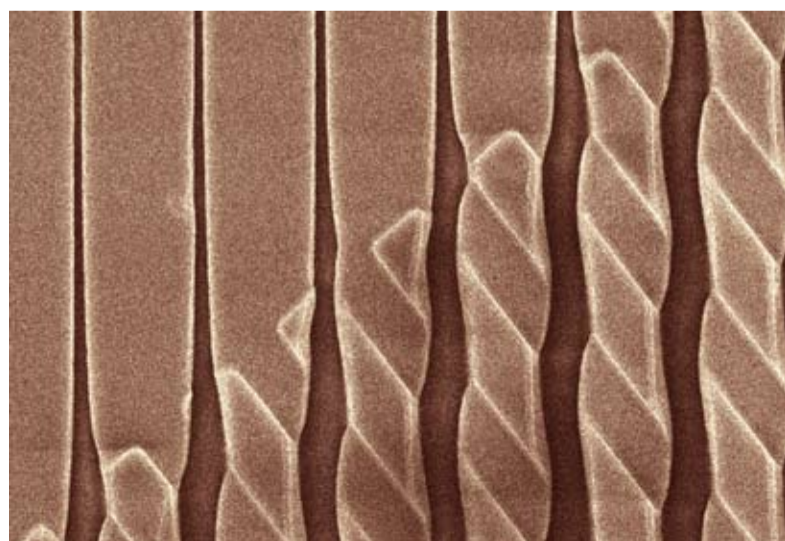
#### Adhesive gecko-like non-sticky tape?

Have you ever been annoyed by the residue marks left behind by adhesive tape? That may become a thing of the past as IMRE scientists, using nanofabrication tools, have mimicked the hairy surface structure of a gecko's feet to create a non-sticky, residue-free adhesive tape alternative.

For more information about the research, please contact  
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Artificially nanofabricated polymeric hierarchically branched fibrils that mimic the gecko foot-hair feature and its adhesive properties.



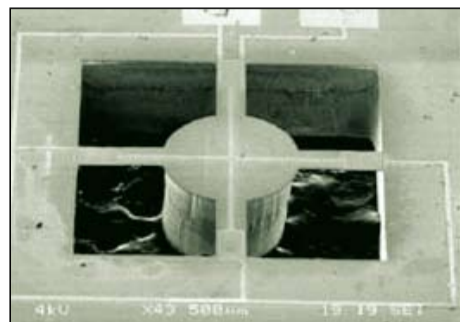
Complex hierarchical structures can be created by IMRE scientists using sequential imprinting, an extension of a thermal NIL process.



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 and granted from Sep'08 - Feb'09

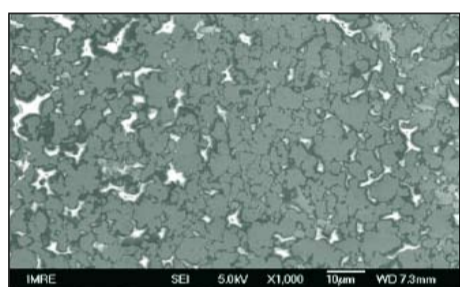
### Miniaturised piezoelectric accelerometers



Top view of the Scanning Electron Microscopic image of a miniaturised piezoelectric accelerometer.

An IMRE team has designed and fabricated a high sensitivity miniaturised piezoelectric accelerometer. The accelerometer has significantly improved structural robustness and flexibility as compared to existing accelerometers. The fabrication process also allows mass production of good quality miniaturised accelerometers.

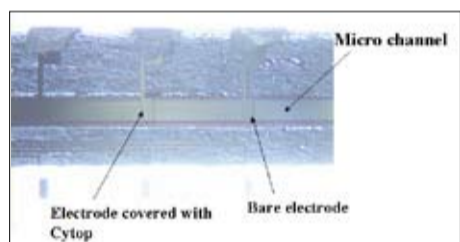
### Conductive paste



Scanning electronic microscopic image of die-attached paste with silver nanoparticles upon curing.

IMRE has developed a method to improve the thermal conductivity of conventional micro-sized metal-flakes filled die-attach pastes. The method makes use of metal nanoparticle fillers with low sintering temperature which can form thermal bridges during thermal processing at elevated temperatures.

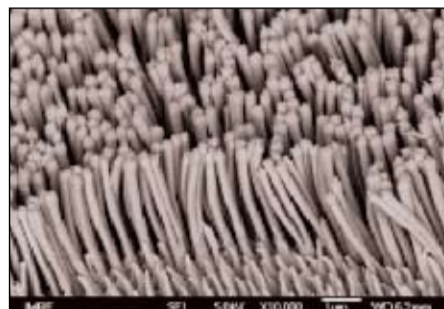
### Systems for pumping continuous liquid columns in a microchannel



A fabricated pump.

A micropumping system was developed to pump ultra-small volume continuous liquid columns in a microchannel. The pump, which makes use of controlled hydrophobicity actuation features, does not have any moving mechanical parts and therefore can be miniaturised to be a truly nano- or micro-pump. Potential applications of this micropump system include microfluidic and drug delivery systems.

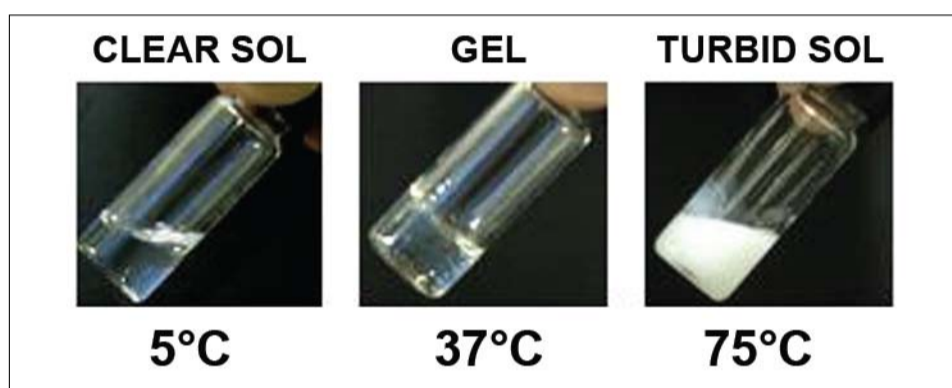
### Adhesive branched structures



Scanning Electron Microscopic images of branched nano-pillars.

A method was established to fabricate high density, high aspect ratio branched polymer nanopillars that mimic a gecko's setae nanostructures, which are the bristly hair-like structure found on its skin. The fabrication process makes use of tiered-branched nano porous anodic aluminium templates and nanoimprint technologies to produce branched structures with tunable dimensions. These branched nanostructures could be used as dry adhesive tapes for medical and semiconductor applications.

### Biodegradable thermogelling polymer



Gel transition of thermogelling polymer with increasing temperature.

An IMRE team has prepared biodegradable thermogelling copolymers with tunable properties and very low critical gelation concentration. The hydrogels formed from the copolymers are very stable and are suitable for long-term sustained release of protein drugs.

Past issues of our newsletters are available on our website at

[www.imre.a-star.edu.sg](http://www.imre.a-star.edu.sg)

For general enquiries please write in to  
[enquiry@imre.a-star.edu.sg](mailto:enquiry@imre.a-star.edu.sg)

## Other IMRE Patents filed from Sept'08 - Feb'09

No.	PATENT TITLE	Description
1	New block polymers and their applications for antifouling	The invention relates to the synthesis of two novel amphiphilic block copolymers based on poly(ethylene glycol) and fluoropolymers (PPFS and PHFBMA) using atom transfer radical polymerization (ATRP) and reversible addition-fragment chain transfer polymerization (RAFT) living radical polymerization.
2	Method for detection of a nucleic acid	The invention relates to the development of a homogeneous phase DNA detection method that is based on the surface plasmon properties of metallic nanoparticles.
3	Polymers functionalised hollow silica and the methods for polymers functionalised surfaces	The invention relates to the grafting of poly(ethylene glycol) (PEG) to hollow silica via urethane linkages. The PEG-graft-hollow silica can be used for encapsulation of active species, and is promising for controlled delivery of anti-cancer drugs.
4	Plants coloured with nanocrystals	The invention relates to methods of engineering attractive luminous flowers by incorporating various emissive nanoparticles-based luminescent materials. The invention can be potentially applied for customizable luminous flowers, ornamental glow-in-the-dark flowers, luminescent costume jewellery and ready-made solution DIY kits for plant dyeing.
5	A method to prepare rare-earth metal-doped luminescent metal oxide nanocrystal	The invention relates to the preparation of nontoxic rare-earth doped metal oxide (i.e. TiO <sub>2</sub> , SiO <sub>2</sub> , Y <sub>2</sub> O <sub>3</sub> , Gd <sub>2</sub> O <sub>3</sub> and ZnO) nanocrystals and their applications in bio-imaging.
6	Particles as bioimaging tags and targeting carriers for diagnostics, delivery and controlled release	The invention relates to the formulation of morphology-visible fluorescent particles which demonstrate size selectivity of cancer cell uptake. These particles can be used as carriers to incorporate drugs for drug delivery and controlled release, potential targeting tool for diagnostic and imaging, and make the quantitative study of particle uptake possible.
7	High power white LEDs	The invention relates to a structure and growth methods for high power white LEDs with band-gap engineered InGaN/GaN quantum dots/quantum wells and p-GaN with multi-stage doping profile. The invention can be applied for various illumination and display purposes.
8	Method to lift off group III-V nitride based epitaxial layers	The invention relates to a method to lift off GaN epitaxial layers from foreign substrates (Si, SiC or sapphire, etc) via a combination of nano-epitaxy and wet chemical etching.
9	Functional amphiphilic polymers-grafted nanoparticles for "click" chemistry-based sensing	The invention relates to a novel coating for quantum dots using functional amphiphilic polymers for applications in sensing, 2D and 3D patterning, or their combination.
10	Method of concurrent imprinting and selective metal patterning on polymeric substrate	The invention relates to a versatile method to pattern gold or other metals selectively onto the protruded or the recessed region on a polymer substrate through nanoimprint lithography (NIL) technique.
11	Biocompatible surface topography for medical devices	The invention relates to the development of a new surface topography with enhanced bio and hemo compatibility.
12	Flexible laminated microfluidic integrated devices	The invention relates to a laminated structure and also the methodology for design and fabrication of low-cost, printed electronics based field effect transistors, circuits, photovoltaics, biosensors and related devices.