January 2018

PERSPECTIVES

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

TR35 Awards

MIT Technology Review

IMRE scientist, Dr. Wesley Zheng, was honoured as one of the top 10 innovators of the regional MIT Technology Review Innovators Under 35 (TR35) competition for Southeast Asia, Australia, New Zealand and Taiwan. He was commended for his pioneering work in developing high energy density lithium batteries for automotive, aerial and renewable storage applications. This award recognises the development of new technology or the creative application of existing technologies to solve global problems in industries such as energy, materials, biomedicine, computing, communications, web, and transportation.

PROFILE

Dr. Maureen Tan

In this feature of Perspectives, Dr. Tan, Head of the Polymeric Composites Department, shared with us her journey and experiences of her current role.

As the Head of the Polymeric Composites Department, what are the challenges so far and how did you overcome them?

As a Head of Department, I am responsible for developing the potential of the researchers in my department. Transiting from a scientific role to a management role was a big change but it gave me the opportunity to sharpen my management and leadership skills.

One of my key roles is to plan and organise various resources and operations of the department. To do this meaningfully, I must understand the expertise and interest of every researcher in the Department and align these with RIE domains and industry technology maps. The support from fellow colleagues and my family have been a source of encouragement for me as I navigate the tasks and responsibilities of this role. I learn to take challenges that come in the course of my work, head on. My wish is to learn and grow and lead this department to achieve the mission and vision of A*STAR the best I can.

How do you find the transition to a more management-focused role (with less emphasis on research)?

Stepping out of my comfort zone is exciting, yet at the same time unnerving. In contrast to pursuing individual research grants and staying relevant as a researcher, I had to focus on developing capabilities and appropriate scientific talent that will support IMRE's mission-oriented research. With the support of IMRE leadership and my colleagues in IMRE and in my department, the transition was relatively smooth.

The skillsets I have picked up in research project management and in my previous stint as Department Head of Polymeric Materials, together with my familiarity with A*STAR and IMRE's processes are transferrable to a management-focused setting.

What are your thoughts on the immediate areas that you would like to tackle?

My immediate aim is to implement and engage the researchers in my department in a two-way dialogue to understand their perspectives and career goals. Plans are also in place to encourage researchers to take up training courses to equip themselves with pertinent skills.

What advice would you give aspiring female researchers in the research field?

All researchers face different challenges, but female researchers often have additional and unique obstacles to overcome. Especially for those who are mothers, like myself, we have to adjust to the demands of our career and manage the care of our family. Everyone's situation is different, but weighing the concerns and potential upsides can help decide if this is the right career for you. It is also important to learn new ways to harmonise between work and family life.

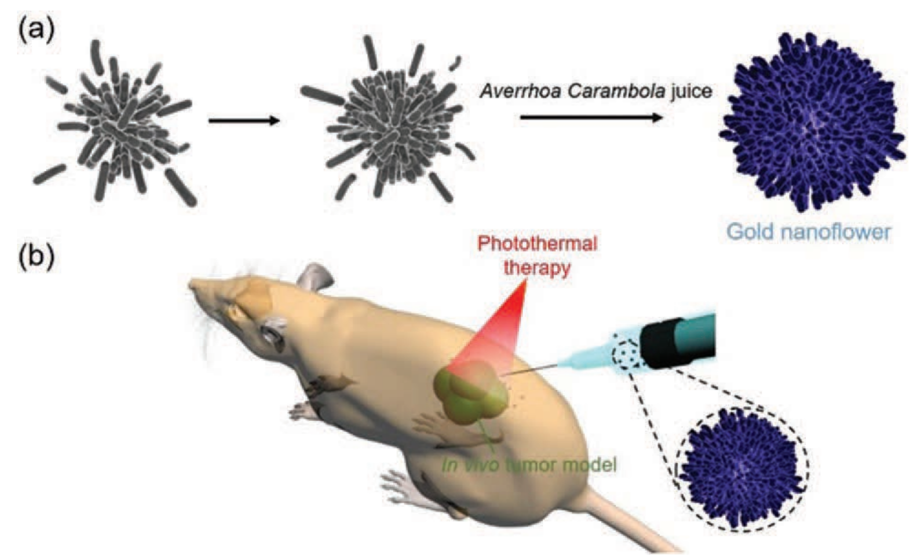
Transitions are tough, but not impossible. You just need to take a strategic approach to it. Seeking advice from other female researchers who had to overcome similar obstacles in this field will be helpful. The road may be long and likely bumpy, but with perseverance and a positive attitude, you will be able to excel in this field.

RESEARCH

Treating medical conditions with fruity gold nanoflowers

Biocompatible functional nanocrystals are commonly used for biomedical applications such as photothermal therapy– a biomedical application used for treatment of various medical conditions, including cancer. During cancer treatment, nanocrystals are exposed to near infrared (NIR) lasers, enabling the capturing of incident light and conversion to heat, thus, destroying cancer cell membranes. Although gold nanocrystals are considered good candidates as photothermal agents, it is a challenge to make such metal nanocrystals with strong NIR absorption suitable for biomedical applications.

IMRE scientists collaborated with a group of multidisciplinary researchers to develop a 'green' synthesis method to produce plasmonic gold nanoflowers with strong NIR absorption. Without using any additional surfactants and reducing agents, they used star fruit juice, which is rich in vitamin C and can be used as a mild reducing agent, with gold chloride ($AuCl_3$). As a result, they were able to obtain gold nanoflowers (GNFs). When tested, the GNFs displayed good NIR absorption and was highly effective for both *in vitro* and *in vivo* photothermal therapy. This discovery demonstrated a successful synthesis between metal ions and bio-ingredients, and could open up possibilities of developing biocomble controllable nanoparticles.



Schematic illustration of (a) the formation of branched gold nanoflowers via the reaction of $AuCl_3$ with Averrhoa Carambola juice (star fruit juice) and (b) their application in in vivo tumor photothermal therapy.

The results of this research were published in *Nanoscale*, entitled "Unexpected formation of gold nanoflowers by a 'green' synthesis method as agents for a safe and effective photothermal therapy".

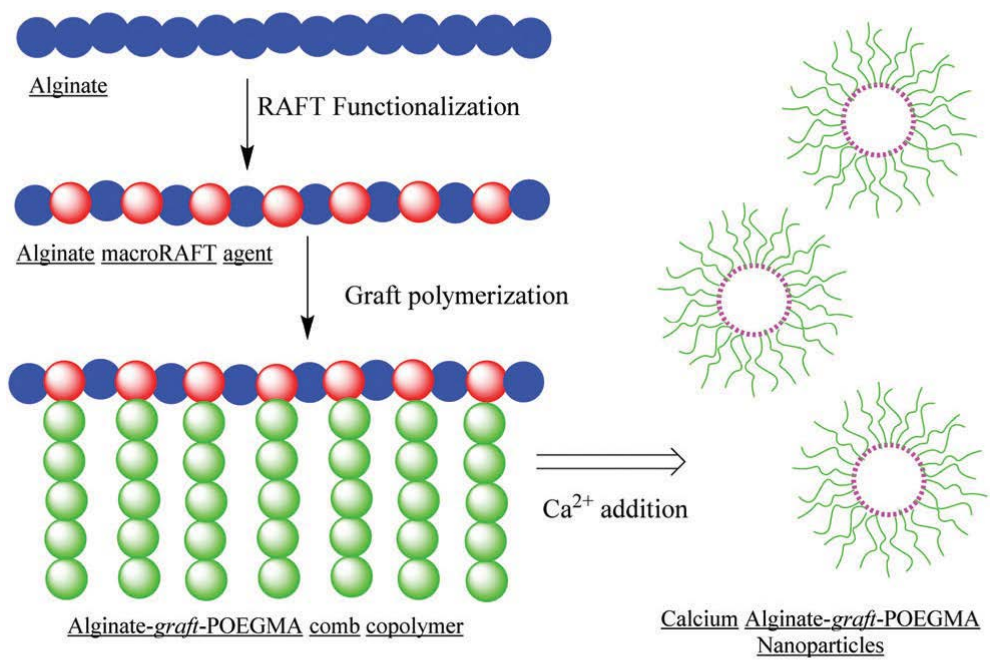
For more information, please contact Dr. Ye Enyi (yeey@imre.a-star.edu.sg)

Smart biomaterial made from seaweed

Alginate, a material derived from seaweed, is known for its innate ability to form capsules, making it a strong candidate for applications such as drug delivery. While it is a renewable and biodegradable material, it is very difficult to process for use in nanotechnology.

IMRE scientist, Dr. Jatin Kumar, came up with a technique to modify alginate with a common polymer (polyethylene glycol– a material found in personal care and food products) via reversible addition–fragmentation chain transfer (RAFT) polymerization. The alginate based comb copolymers self-assembled into ordered nanoparticles upon the addition of calcium chloride in both aqueous and alcoholic solutions. Therefore, demonstrating high encapsulation efficiencies of a hydrophobic cosmetic compound with a smart delivery and release system (that was observed over 6 hours).

This newly developed technique of modifying alginate materials could pave the way for a new class of biomaterials for a range of high-tech applications such as in personal care applications (skincare, mouthwash and shampoo) and pharmaceuticals, where the encapsulation of hydrophobic compounds could improve drug bioavailability for both parenteral and oral drugs.



A schematic showing the grafting of polymers onto an alginate backbone, and its calcium mediated self-assembly into a nanoparticle.

The results of this research were published in *Journal of Materials Chemistry B,* entitled "Calcium triggered self-assembly of alginate-graft-POEGMA via RAFT for the encapsulation of lipophillic actives".

For more information, please contact Dr. Jatin Kumar (kumarjn@imre.a-star.edu.sg)

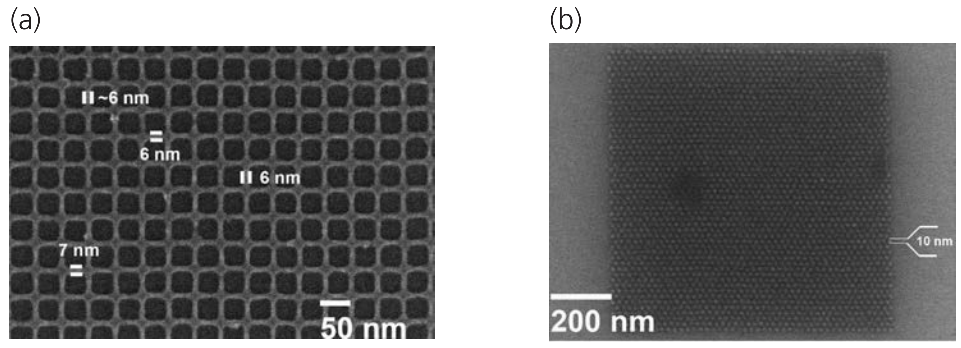
Controlled fabrication of arbitrary nanostructures

Chemical and self-assembly techniques are commonly used to create nanostructures of metal sulfides. However, complications start to arise when various shapes and sizes of nanostructures have to be placed at selected locations.

Dr. Saifullah was part of a research team that demonstrated the controlled fabrication of an ensemble of nanostructures over large areas at different spacing. A spin-coatable and electron beam sensitive zinc butylxanthate resist without the lift-off or etching step was used on a zinc sulfide (ZnS) test sample. Arbitrary shapes of ZnS nanostructures were fabricated as small as 6nm, patterning of 10nm dots with pitches as close as 22nm and placed in selected areas. With further testing, the team plans to apply this research on sensors and hybrid emitters.

The results of this research were published in *ACS Nano*, entitled "Direct Patterning of Zinc Sulfide on a Sub-10 Nanometer Scale via Electron Beam Lithography".

For more information, please contact Dr. Mohammad S. M. Saifullah (saifullahm@imre.a-star.edu.sg).



Scanning electron microscopy images of (a) 6nm ZnS lines in approximately 50nm square grids and (b) 10nm ZnS dots with pitches of 22nm.

Colour printing beyond sRGB with silicon nanostructures

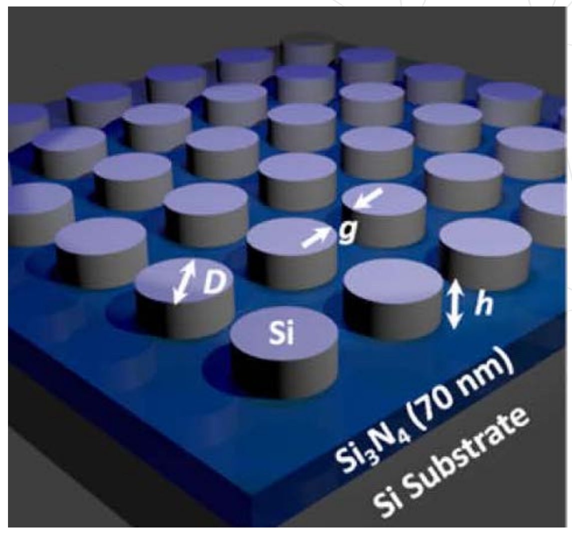
A team of material experts, including IMRE scientist, Dr. Dong Zhaogang, introduced a new nanostructure design to achieve vibrant colours in high-resolution colour printing beyond the optical diffraction limit. Metallic nanostructures are mostly used but they are limited in colour gamut.

During experimental implementation, silicon was used as an alternative material. Silicon nanostructures that showed localised magnetic and electric dipole resonances were fabricated on a silicon substrate coated with a silicon nitride (Si_3N_4) layer index matching layer. As a result, this new design was able to mimic silicon nanostructures in free-space and achieve a much broader colour gamut than the standard Red-Green-Blue (sRGB, a standardised colour space for printers, computer monitors and the internet) in the chromaticity diagram. It is also compatible with complementary metal-oxide semiconductor (CMOS) processes.

This research could be applied when printing colours at the nanoscale. Additionally, it might also extend its application to colour filters and high resolution colour displays.

The results of this research were published in *Nano Letters*, entitled "Printing Beyond sRGB Colour Gamut by Mimicking Silicon Nanostructures in Free-Space".

For more information, please contact Dr. Dong Zhaogang (dongz@imre.a-star.edu.sg).



Schematic of the colour pixel design of silicon nanodisks- 70nm thick Si_3N_4 silicon substrate.

Reconfiguring 3D fabrication

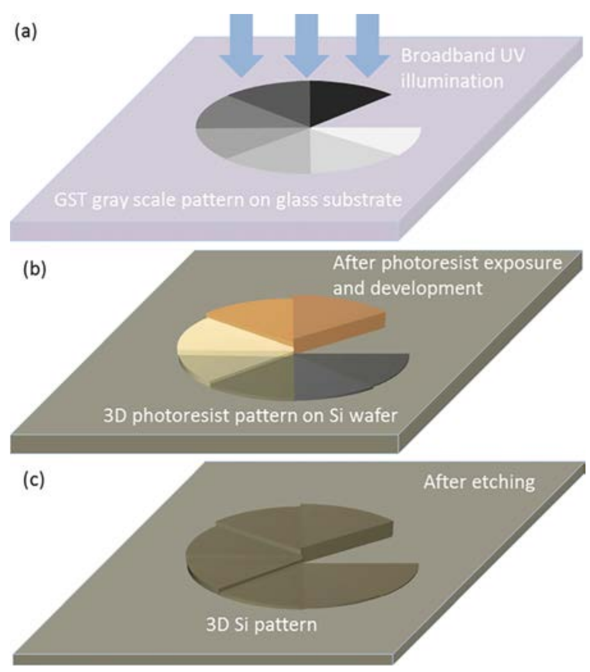
Grayscale photolithography masks are known to ease and speed up the process of three-dimensional (3D) fabrication. However, most of the present photomasks have fixed patterns. A completely new mask would be required if any modifications were made to the design of the original structure.

IMRE scientist, Dr. Wang Qian, and his team developed a reconfigurable grayscale photolithography technique. They used a thin phase-change film as a photomask and induced a refractive-index-changing phase-transition with femtosecond laser pulses. This resulted in enabling the transmission of the phase-change material photomask to be set to a range of gray levels with submicron lateral resolution, and optically reconfigure the mask pattern on demand. Advantages of this reversible technique include the flexibility of modifications and the option to reuse one mask for batch productions.

This advancement in grayscale photolithography could be adopted on a range of applications such as diffractive optical elements, integrated photonics circuits and MEMS systems.

The results of this research were published in *Applied Physics Letters*, entitled "Reconfigurable phase-change photomask for grayscale photolithography".

For more information, please contact Dr. Wang Qian (wangqian@imre.a-star.edu.sg).



Sketch of the 3D spiral phase plate fabrication process. (a) Grayscale photomask is prepared by direct optical writing in a GST ($Ge_2Sb_2Te_5$)thin film. (b) The photoresist is exposed and developed leaving a 3D photoresist structure on the substrate. (c) 3D silicon structure is obtained by uniform etching of the substrate.

OUTREACH & EVENTS

IMRE Get-together

07 November 2017

The IMRE family came together for the annual IMRE Year-End-Party.

Prof. Alfred Huan, Executive Director, IMRE and IHPC (centre), with (from left to right) Dr. Wong Chia Woan, Director, Strategic Planning Office; Ms Tan Su Yuen, Director, Corporate Services; Ms Ho Yuan Lu, Director, Industry Development Office; Dr. Gregory Goh, Director, Strategic Research Office and Dr. Ramam Akkipeddi, Head of Laboratories.

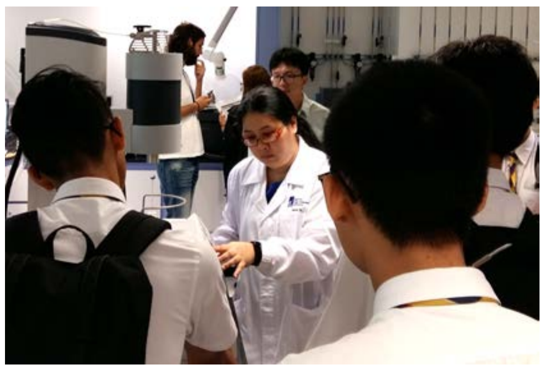
*Established in 1997, IMRE has been an institute with many talent. The live band which performed during the party included both IMRE and IHPC staff. A*STAR's "got talent"!*

While participating in a variety of games that were organised by IMRE's Social Committee, we discovered more hidden 'talents'.

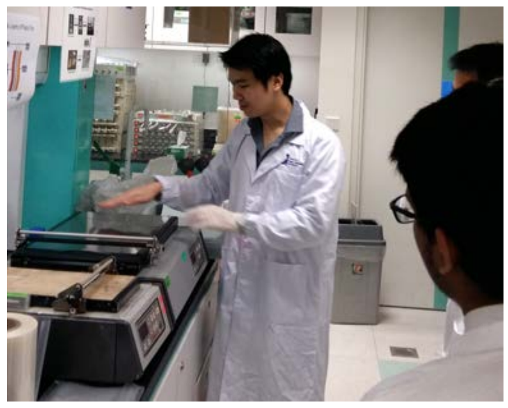
Innovation of materials science

13 November 2017

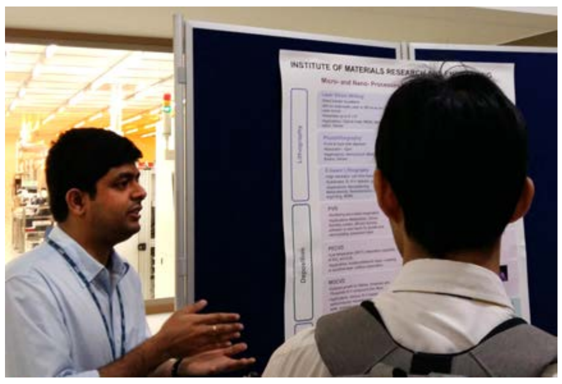
A group of Dean's List students from ACS (Independent) Science (Chemistry) programme were given a glimpse of the research facilities at IMRE. The students visited the polymer characterisation and nanofabrication labs at Kinesis. This outreach initiative is part of IMRE's continuing efforts to introduce the innovation of materials science to enthuse the next generation of scientists.



The students checked out a range of scientific equipment that could conduct composition analysis, sample stability testing and chemical properties analysis.



A demonstration of how polymers can be translated to real-life applications such as coating for food packaging.



While getting a sneak peek into the cleanroom, the students were briefed on an overview of the Nanoimprint Foundry as well as how advanced nanomanufacturing techniques are utilised for applications such as solar energy harvesting, consumer care products and packaging.

NEW STAFF (as at 05 December 2017)

Welcome to IMRE!

Electronics Materials Department

Ady Suwardi

Fengxia Wei

Vipin Kumar

Nanofabrication Department

Neo Kiam Peng

Wang Zeng

Nanomaterials Department

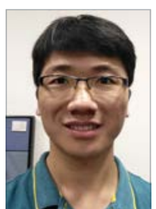
Guan Gujian

Soft Materials Department

Teo Peili

Xue Kun

Polymer Composites Department



Zheng Yun

Executive Director's Office

Angeline Goh

Eileen Teo