

LIST OF PRESIDENT'S SCIENCE AND TECHNOLOGY AWARD WINNERS FROM NUS

I. President's Science Award (PSA)

Associate Professor Liu Xiaogang

Department of Chemistry, Faculty of Science, National University of Singapore

Is Research and Engineering, Agency for Science, Technology and Research

II. President's Technology Award (PTA)

Individual:

Professor Liu Bin

Department of Chemical and Biomolecular Engineering, Faculty of Engineering, National University of Singapore

Senior Scientist, Institute of Materials Research and Engineering, Agency for Science, Technology and Research

Team comprising 4 parties:

- ST Electronics (Satellite Systems) Pte Ltd
- DSO National Laboratories
- Centre for Remote Imaging, Sensing and Processing, National University of Singapore
- Satellite Research Centre, Nanyang Technological University

PRESIDENT'S SCIENCE AWARD 2016

Associate Professor Liu Xiaogang

Department of Chemistry, Faculty of Science, National University of Singapore
Senior Scientist, Institute of Materials Research and Engineering, Agency for Science,
Technology and Research

“For his outstanding research in developing rare-earth-doped nanocrystals that could be used as luminous tags for tracking cancer cells and deciphering various biologically relevant phenomena”

Over the past 10 years, Associate Professor Liu Xiaogang has devoted himself to developing innovative methods for the synthesis of rare-earth-doped nanocrystals that can emit a palette of visible colors at a wavelength shorter than the excitation wavelength. This phenomenon is known as photon upconversion that makes the emitted light more energetic than the light absorbed.

Due to their good biocompatibility and small physical dimensions (several thousands of these nanomaterials could fit across the width of a human hair), upconversion nanocrystals can be coupled to proteins or other biological macromolecular systems. They are particularly useful for bioimaging and biodetection because their high energy emissions can be clearly distinguished from background noise.

In addition, these nanocrystals can be excited under near-infrared light – a spectral range which is less harmful to biological samples and has greater sample penetration depths than conventional ultraviolet excitation – and this property enhances their prospects as a biological tool to control and monitor the activities of individual cells in living tissue. Therefore, the discovery of these nanocrystals allows for tremendous improvements in our ability to make visible without much photodamage, and study complex biological systems such as proteins or cells over a long period of time. This is a feat virtually unachievable by conventional fluorescent imaging techniques.

Despite the enticing prospects, the applications of upconversion nanocrystals in biological and biomedical fields remained unclear in the early days of investigation. One major challenge was to devise methods for making materials with tunable sizes and shapes as well as a spectrum of emitting colors that are highly sought after for measuring multiple analytes in a single run. Another notable challenge was boosting the brightness of the nanocrystal emission at high dopant concentrations. High dopant concentration can lead to better light-harvesting capabilities, but cross-interactions will lead to the quenching of the generated light. This problem has provided a strong

motivation for the materials science community to improve the nanocrystal's light-harvesting capacities.

Indeed, much of the recent resurgence of upconversion came from the widespread research on controlled nanocrystals synthesis, together with the pressing demand for next-generation luminescent biomarkers that have very high photostability and long luminescence lifetime. Combined with advanced optical microscopies, these biomarkers could be utilised as a versatile platform for high resolution cell imaging and tumor targeting.

Associate Professor Liu brings together a collaborative and multi-disciplinary team which has achieved a broad range of impactful inventions over the past 10 years. He has pioneered technologies for finely controlling upconversion emission colour, improving energy conversion efficiency, and interfacing living cells with upconversion nanocrystals. These fundamental breakthroughs have enabled new applications in anti-counterfeiting, volumetric 3D display, stem cell differentiation, optogenetics, drug delivery, and cancer therapy. More recently, he has demonstrated the use of upconversion nanothermometry as a useful tool to verify Einstein's prediction made in 1907 that the instantaneous Brownian velocity is independent of particle size and shape under infinite dilution conditions. Better understanding of the Brownian motion of suspended nanoparticles in non-equilibrium systems would allow improved understanding of thermal conductivity, convective heat and mass transfer in various types of nano-fluids.

Associate Professor Liu's work on upconversion nanomaterials has inspired many researchers from a broad spectrum of disciplines, including chemistry, physics, materials and life sciences, and biomedical engineering, to join his efforts in expanding the upconversion field worldwide. The research on photon upconversion has flourished as one of the most exciting fields, as there are now over 120 groups in universities and research institutions around the world that are making valuable contributions to it.

Associate Professor Liu's list of accolades include the NUS Young Investigator Award (2006), BASF-SNIC (Singapore National Institute of Chemistry) Award in Materials Chemistry (2011), NUS Young Researcher Award (2011), and Royal Society of Chemistry Chemical Society Reviews Emerging Investigator Lectureship Award (2012). Based on The World's Most Influential Scientific Minds 2014 report published by Thomson Reuters, he is among the top one percent of those cited in their fields for articles published from 2003 to 2013. He has served on a number of editorial advisory boards, including the *Journal of the Chinese Chemical Society*, *Chemistry–An Asian Journal*, *ChemNanoMat*, *Nanoscale Horizons*, and *Advanced Optical Materials*. He is

currently the associate editor of *Nanoscale* (Royal Society of Chemistry) and *Journal of Luminescence* (Elsevier).

For his outstanding research in developing rare-earth-doped nanocrystals that could be used as luminous tags for tracking cancer cells and deciphering various biologically relevant phenomena, Associate Professor Liu Xiaogang is awarded the 2016 President's Science Award.

PRESIDENT'S TECHNOLOGY AWARD 2016

Professor Liu Bin

Department of Chemical and Biomolecular Engineering, Faculty of Engineering,
National University of Singapore
Senior Scientist, Institute of Materials Research and Engineering, Agency for Science,
Technology and Research

“For her outstanding research on organic nanomaterials for environmental and biomedical applications”

Professor Liu Bin has made major contributions to the field of organic nanomaterials. She specialises in bringing organic soluble materials into aqueous media, with a focus on the exploration of their unique applications in biomedical research, environmental monitoring and electronic devices. Professor Liu's research in organic luminescent materials provides important solutions to vital problems presented in the areas of healthcare and environmental monitoring for example in our everyday life.

Since 2011, Professor Liu's research has been focused on a unique luminescent material with aggregation-induced emission (AIE). AIE refers to a unique photophysical phenomenon: fluorogens that are non-emissive in dilute solutions could be induced to emit intensively in aggregates. The behaviour of AIE is opposite to the conventional dyes and inorganic nanomaterials, which provides a unique opportunity to revolutionise the field of fluorescent probes. The simple design and fluorescence turn-on feature of the molecular AIE bioprobes offer direct visualisation of specific analytes (e.g. cancer cell markers) and biological processes (e.g. cellular apoptosis) with higher sensitivity and better accuracy than commercial fluorescent probes.

The AIE nanoparticle probes with different formulations and surface functionalities show advanced features over commercial quantum dots (QD) and small molecule dyes. These nanoparticles enable longer term cell tracing and tumour imaging in a non-invasive and high contrast manner. This is timely as the technology addresses the urgent demand for reagents that could be used in real-time non-invasive cell imaging and tracing, amid the rapid development of cancer research and cell-based therapies. Furthermore, the technology can contribute towards the evaluation of cosmetics, healthcare, drugs and other therapeutics, which are emerging or growing industry sectors in Singapore and around the world.

In 2014, Professor Liu co-founded an NUS start-up company "Luminicell" to commercialise the AIE probe technology. Luminicell is in partnership with potential

international and local bio-tech companies to further develop and advance its technology. Luminicell has regular customers from Singapore, USA and China.

Professor Liu's research has also gained worldwide recognition. Her work has been cited by researchers in more than 30 countries. She has been invited to serve as a member of the Editorial Board of 15 international refereed journals by five publishers. Professor Liu has also received many prestigious awards, including the NUS Young Investigator Award in 2006, Singapore National Academy of Science Young Scientist Award in 2008, L'Oréal Women in Science National Fellowship in 2011, NUS Young Researcher Award in 2013, Asia Rising Star in 2013, Invited Lecturer of Asia Excellence, Japanese Polymer Society in 2013, Dean's Chair Professorship in Faculty of Engineering, NUS in 2014, Singapore National Institute of Chemistry-BASF Materials Award in 2014, Singapore National Research Foundation Investigatorship in 2014, and Materials in Society Lectureship (Elsevier) in 2015. She was recently named as The World's Most Influential Minds and the Top One Per Cent Highly Cited Researchers in Materials Science by Thomson Reuters. Professor Liu was elected as the Fellow of the Royal Society of Chemistry in 2016. She has 26 patents, of which 14 are licensed to companies across the US, UK and Asia.

As a faculty member of the National University of Singapore's Faculty of Engineering, Professor Liu is also passionate about nurturing the next generation research leaders and encouraging more women to pursue careers in engineering and science. In the past 10 years, Professor Liu has provided training to 23 doctoral students as well as 35 post-doctoral fellows, and nurtured more than 20 professors. Professor Liu also has a joint appointment with the Institute of Materials Research and Engineering, A*STAR, where she leads a research team working on conjugated polymer nanoparticles for fluorescence and photoacoustic imaging.

Professor Liu represents a rare example of a passionate scientist whose dedication and perseverance have given rise to scientific discoveries that have a profound impact on our lives. Besides being a prolific researcher, Professor Liu also has a creative and entrepreneurial mindset, which highlights her exceptional talent in the scientific community.

For her outstanding research and innovative work on organic luminescent materials, particularly fluorogens with aggregation-induced emission which have a broad range of applications in the fields of healthcare and environmental monitoring, Professor Liu Bin is awarded the 2016 President's Technology Award.

PRESIDENT'S TECHNOLOGY AWARD 2016

ST Electronics (Satellite Systems) Pte Ltd

Represented by Mr Ong Kien Soo, vice-president/ general manager

DSO National Laboratories

Represented by Dr Desmond Lim Chin Siong, deputy director

Centre for Remote Imaging, Sensing and Processing, National University of Singapore

Represented by Mr Kwoh Leong Keong, director

Satellite Research Centre, Nanyang Technological University

Represented by Mr Lim Wee Seng, executive director

“For the organisations’ outstanding contributions to the advancement of Singapore’s satellite engineering and systems capabilities, with the successful development, launch and operation of TeLEOS-1, Singapore’s first commercial earth observation satellite”

The successful development, launch and operation of TeLEOS-1, a 1-meter resolution satellite is a major step forward in Singapore’s efforts to build capabilities in satellite systems.

The TeLEOS-1 system is one of the most complex engineering systems ever developed in Singapore. It is led by ST Electronics (Satellite System), with DSO National Laboratories, NTU’s Satellite Research Centre (SaRC), NUS’ Centre for Remote Imaging, Sensing and Processing (CRISP) as its main partners. Building on the success of previous satellite programmes such as the XSAT microsatellite by SaRC, DSO and CRISP; ST Electronics integrated its capabilities and expertise with those of its partners to design and develop a highly responsive and reliable satellite within tight budgetary, time, and physical constraints. Since its successful launch and in-orbit testing, TeLEOS-1 has provided high resolution images of the equatorial belt – more frequently and under more varied sun lit conditions that are possible with other satellites of its class so far.

The success of such satellites is dependent on the seamless integration of a myriad of components, technologies, and systems in the hardware, software, and information domains; as well as their ability to survive the launches, and function reliably in harsh operating environments throughout their lifespan. TeLEOS-1 has a design lifespan of about five years.

For a system as complex as TeLEOS-1, countless things could go wrong during launch, deployment and operations. Yet once launched and up in space, there is no chance of physical repair during its entire lifespan. The onus is on its project team to do whatever it could during the design and development stage to ensure the satellite's functionality and reliability. The TeLEOS-1 project team therefore adopted meticulous and stringent system engineering practices, ensured compliance with international quality standards, and paid great attention to details during the analysis, design, development and testing of the satellite system. To achieve a high degree of mission assuredness, the team developed high-fidelity modelling and simulation of the system, incorporated a high degree of fault tolerance in its design and implementation, and subjected the components, subsystems, software and entire system to rigorous functional and environmental testing.

TeLEOS-1 is a commercial project developed and supported by our local industry. Besides DSO, SaRC and CRISP, ST Electronics also worked with local companies to build the electronics, radio frequency based designs, and high precision mechanical fabrications of space-qualified components and sub-systems.

The 400-kg class, TeLEOS-1, with its uniquely high spatial and temporal resolution for earth's observation over the equatorial region is a significant milestone in Singapore's foray into space since the early 2000s. Its success, together with that of the other five Singaporean satellites launched in Dec 2015 was a fitting finale to our SG50 celebrations and has helped to bolster Singapore's position in the league of satellite-building nations. The team behind TeLEOS-1 is an inspiration to Singapore-based scientists and engineers.

For their outstanding contributions to the advancement of Singapore's satellite engineering and systems capabilities; with the successful development, launch and operation of TeLEOS-1, Singapore's first commercial earth observation satellite; the four organisations – ST Electronics (Satellite Systems) Pte Ltd, DSO National Laboratories, Centre for Remote Imaging, Sensing and Processing (NUS), and Satellite Research Centre (NTU), are awarded the 2016 President's Technology Award.

LIST OF YOUNG SCIENTIST AWARD WINNERS

Physical, Information & Engineering Sciences

Dr Benjamin C K Tee

Scientist

Institute of Materials Research and Engineering

Agency for Science, Technology and Research

Adjunct Assistant Professor, Department of Materials Science & Engineering, Faculty of Engineering, National University of Singapore

Adjunct Assistant Professor, Department of Electrical & Computer Engineering, Faculty of Engineering, National University of Singapore

Adjunct Assistant Professor, School of Materials Science & Engineering, Nanyang Technological University

Biological & Biomedical Sciences

Dr Lim Xinhong

Principal Investigator

Institute of Medical Biology

Agency for Science, Technology and Research

Adjunct Assistant Professor, Programme in Cancer and Stem Cell Biology

Duke-NUS Medical School

Adjunct Assistant Professor, Lee Kong Chian School of Medicine

Nanyang Technological University

Dr Guo Huili

Junior Investigator

Institute of Molecular and Cell Biology

Agency for Science, Technology and Research

Adjunct Assistant Professor, Department of Biological Sciences, Faculty of Science

National University of Singapore

YOUNG SCIENTIST AWARD 2016

Physical, Information & Engineering Sciences

Dr Benjamin C K Tee

Scientist

Institute of Materials Research and Engineering

Agency for Science, Technology and Research

Adjunct Assistant Professor, Department of Materials Science & Engineering, Faculty of Engineering, National University of Singapore

Adjunct Assistant Professor, Department of Electrical & Computer Engineering, Faculty of Engineering, National University of Singapore

Adjunct Assistant Professor, School of Materials Science & Engineering, Nanyang Technological University

“For his research in artificial skin – next-generation sensor technologies for human-machine interfaces, robots and healthcare.”

Inspired by the capabilities of human skin, Dr Benjamin Tee’s research goal is to re-create its qualities. He has developed novel sensitive, self-healing, flexible and stretchable materials for next generation human-machine interfaces that are applicable in robotics, healthcare and prosthetic devices.

To achieve high mechanical sensitivity, he invented a novel micro-structuring approach for mechanically sensitive capacitors, thus enabling a suite of devices; from flexible pressure-sensitive transistors to wireless pressure sensors. Using this technology, he created the world’s smallest passive (non-powered) pressure sensor that can be used for intra-cranial pressure and sub-cutaneous heart rate monitoring devices. He also developed a technique to create highly stretchable and transparent electrodes using carbon nanotubes on a stretchable substrate, making them useful for next-generation flexible and stretchable displays.

Dr Tee, too, created the world’s first repeatable self-healing electronic sensor skin by developing a unique composite material with hydrogen bonds as the repeatable healing mechanism. Through the use of nano-structured metallic particles, he further utilised

quantum tunnelling mechanisms to enable conductivity and pressure-sensitivity of this material.

He also demonstrated for the first time, a new biomimetic pressure sensor that generates similar frequency encoded digital signal outputs as human skin sensors. This sensor technology can be used to communicate with brain cells, paving the way for new sensor skins in neural prosthetic devices.

His cross-disciplinary research work in artificial electronic skins can enable a wide range of applications from biomedical neuro-prosthetics, wearable health-monitoring devices, to robotics and immersive virtual reality environments. Dr. Tee has published several highly cited papers in journals such as *Science*, *Nature Nanotechnology* and *Nature Materials*. His innovative work has been recognized with multiple international awards, including the prestigious MIT TR35 Innovators Under 35 Award (Global), MRS Graduate Student Gold Award and TSMC Outstanding Student Research Gold and Academy award. Dr. Tee has also been invited to speak at international conferences for his work. He is a Singapore-Stanford Biodesign Innovation Fellow, and co-founded Privi Medical, a seed-funded medical technology company. He is also a recipient of the Agency for Science, Technology and Research (A*STAR) National Science Scholarship.

YOUNG SCIENTIST AWARD 2016

Biological & Biomedical Sciences

Dr Lim Xinhong

Principal Investigator

Institute of Medical Biology

Agency for Science, Technology and Research

Adjunct Assistant Professor, Programme in Cancer and Stem Cell Biology

Duke-NUS Medical School

Adjunct Assistant Professor, Lee Kong Chian School of Medicine

Nanyang Technological University

“For his work on the molecular mechanisms that govern skin stem cells in development, maintenance and repair.”

Assistant Professor Lim Xinhong seeks to understand and alleviate prevalent skin diseases like hair loss and acne. Skin diseases may result from imbalances in the behaviour of the stem cells in the epidermis and its associated organs like hair and sebaceous gland, and he wants to detect and correct such aberrant cell behaviour with safe and effective treatments.

Assistant Professor Lim studies the molecular signals that govern epidermal stem cells in development, maintenance and repair using a combination of the latest molecular and imaging tools in animal models and human clinical material. This has led to important contributions to the understanding of stem cell regulation. Leading multi-disciplinary and international teams, he discovered novel molecular markers that may enable the study and isolation of epidermal and hair stem cells at higher purity for transplantation and disease modelling. He was the first to show a mechanism of skin stem cell self-regulation that has never been previously reported in mammals. In the sebaceous gland, he is collaborating with industry partners and clinicians to build new tissue platforms for the development of novel actives for sebum control, and the treatment and prevention of acne and allied conditions. He is also involved in several collaborations with bio-engineers at NUS and NTU to develop and test new artificial skin models, drug delivery methods and genetic sensors for the skin and other tissues.

Assistant Professor Lim's interdisciplinary research has led to highly-cited publications in the most prestigious scientific journals, including *Nature*, *Science* and *PNAS*, and mainstream media outlets like *CNN* and *Discover Magazine*. He has also been invited to speak at many international conferences. His work on skin health and regeneration

has been awarded more than S\$6 million worth of research grants for both fundamental and industrially-oriented research. He is the recipient of numerous awards, including the internationally competitive A*STAR-IMB Investigatorship in Skin Biology, the A*STAR National Science Scholarship (B.S.-Ph.D.), and the Theodore Herfurth Award for Initiative and Efficiency, given to only two students in the entire University of Wisconsin (UW) system and considered to be the oldest and most prestigious award a graduating UW senior may earn.

YOUNG SCIENTIST AWARD 2016

Biological & Biomedical Sciences

Dr Guo Huili

Junior Investigator, Institute of Molecular and Cell Biology
Agency for Science, Technology and Research
Adjunct Assistant Professor, Department of Biological Sciences, Faculty of Science,
National University of Singapore

“For her research in understanding how RNA translation, which produces protein to regulate the body’s functions, impacts human health.”

Dr Guo Huili’s long-term research goal is to understand how the control of translation impacts human health and disease. She is particularly interested in studying areas that have been neglected, in order to uncover new regulatory mechanisms and novel therapeutic avenues.

During her graduate studies at the Whitehead Institute for Biomedical Research, Massachusetts Institute of Technology, Dr Guo helped develop the ribosome profiling technique to study the molecular consequences of microRNA-mediated repression in mammalian cells. Much as RNA-Seq is used to profile the transcriptome, ribosome profiling enables the study of translation on a genome-wide scale. Using ribosome profiling, in parallel with RNA-Seq, she showed that microRNAs (miRNAs) predominantly exert their repressive impact by reducing target mRNA levels, rather than by mainly blocking translation. These results went against the prevailing paradigm in the miRNA field when it was published in 2010. Because miRNAs are important regulators in many biological processes, from normal development to cancer progression, the findings of this piece of work exerted a great impact that is still keenly felt today. Dr Guo also used ribosome profiling to probe the dynamics of microRNA-mediated repression and to show that circular RNAs serve non-coding functions in the cell.

Currently, in her own lab, the team is pursuing the following projects that probe how translational control affects different aspects of human health:

- (i) Dr Guo hypothesises that certain ribosomal proteins (RPs) can switch in and out of ribosomes, and impart different properties to ribosomes, such as conferring them the ability to translate different subsets of mRNAs. Through analysing such specialised ribosomes, she hopes to address ribosomopathies such as Diamond Blackfan Anaemia (DBA).

- (ii) Dr Guo's work also focuses on ribosome heterogeneity during enterovirus-71 infection, which causes hand, foot and mouth disease (HFMD). The idea is to characterise the ribosomes translating host and viral RNAs during an infection, in order to evaluate whether certain RPs could be suitable targets for antiviral development. There is currently no effective vaccine or antiviral treatment for HFMD, which is endemic in Singapore. Hence, the search for novel antiviral targets is of paramount importance.
- (iii) She is also profiling mitochondrial ribosomes in sperm cells, which have been documented to have at least a few nuclear-encoded mRNAs that are translated by mitochondrial, instead of cytoplasmic, ribosomes. She plans to use findings from this project to develop a diagnostic toolkit that can be used to assess sperm fitness in the fertility clinic, to aid physicians in triaging patients for fertility treatment. Currently, sperm fitness is only assessed by gross morphology and motility. There is thus a lack of molecular insight that can provide more accurate diagnoses, and she hopes to fill this gap.
- (iv) Dr Guo is also keen on miniaturising ribosome profiling, so that RNA translation profiling can be performed on small samples, such as rare clinical samples like cancer stem cells in microfluidic test kits.

Dr Guo's research has been published in top international journals such as *Nature* and *Molecular Cell*. Her publications have been cited >2,800 times. Her signature piece of work has been highlighted in high-profile journals such as *Nature Reviews Genetics*, and was also recommended by the Faculty of 1000. She is a recipient of the L'Oréal Singapore For Women In Science National Fellowship (2014), the A*STAR Biomedical Research Council Young Investigator Grant (2013), and the IMCB Independent Fellowship (2012). She was also a recipient of A*STAR National Science Scholarships (2002, 2006)

Dr Guo is also an Ambassador for the STEM (Science, Technology, Engineering and Mathematics) programme run by the Singapore Committee for UN Women.