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# Materials Research at Nanyang Technological University, Singapore

*Pooi See Lee,* Jan Ma,* and Freddy Boey**

In Singapore, where the development of innovative solutions to national challenges is a priority, generous government grants have been awarded for research in critical fields such as advanced materials. This has greatly enhanced Singapore's research output as well as attracted renowned global collaborators to work with Singapore's institutions on innovations with societal impact. The strong government support has further boosted NTU's research and educational achievements. From 2005 to 2010, the university's external competitive research funding awards rose six times to about US$357M per annum.

NTU is a leading research-intensive university that is today one of the world's fastest-rising universities It became a full-fledged university in 1991, and supports about 33 200 full-time undergraduate and postgraduate students in the four colleges of Engineering, Science, Business, and Humanities, Arts and Social Sciences. Its lush 200-hectare Yunnan Garden campus (**Figure 1**) is also home to the National Institute of Education, Singapore's only teacher-training institute, and has established a joint medical school with Imperial College London in Singapore. NTU has joint PhD programs with Imperial College London, Karolinska Institutet, Columbia University, Carnegie Mellon University, ParisTech, Hebrew University of Jerusalem, Technical University of Munich, and Technion-Israel Institute of Technology. Advanced materials research forms a large part of these programs, especially in the areas of environment, water and energy sustainability, healthcare, and in defence science and technology.

**Figure 1.** A building model of NTU, Singapore's largest campus at 200 hectares. Photograph courtesy of the Office of Facilities Planning & Management.

As part of its 2015 strategic plan, the university is focusing its research in five key areas to usher in a new era of discoveries. These interdisciplinary pursuits in sustainability, future healthcare, new media, east and west research, and innovation build on the university's diverse strengths. The university is already a world leader in sustainability research, with more than US$678M in research funding in sustainability.

With the support of government agencies such as the National Research Foundation, Ministry of Education, Economic Development Board, Environment and Water Industry Development Council and Media Development Authority, several new multi-million dollar research institutes have been launched in NTU. They include research centers with a strong sustainability focus such as the Earth Observatory of Singapore, Singapore Centre on Environmental Life Sciences Engineering, Institute for Media Innovation, Nanyang Environment and Water Research Institute (NEWRI), and Energy Research Institute at NTU (ERI@N). The establishment of NEWRI and ERI@N, in particular, has brought together materials researchers to work on water remediation, environmental sustainability, clean energy generation, storage and management.

The School of Materials Science and Engineering (MSE) is the stronghold of

Prof. P. S. Lee,[+] Prof. J. Ma, Prof. F. Boey[+]
School of Materials Science and Engineering
Nanyang Technological University (NTU)
50 Nanyang Avenue, Singapore 639798, Singapore
E-mail: pslee@ntu.edu.sg; asjma@ntu.edu.sg; mycboey@ntu.edu.sg
[+] Guest editors for this special issue on Materials Research at Nanyang Technological University, Singapore

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materials research within NTU. A premier research-intensive school with 1,000 undergraduates and 250 PhD students, it is one of the world's largest materials science and engineering schools. To nurture globally connected materials scientists and engineers with cross-disciplinary expertise, MSE conducts its work through a nexus of integrated, science-driven cutting-edge research and application-oriented engineering education in advanced materials. It has also developed a tiptop approach in successfully commercialising research outcomes, which helps nurture students with a passion for research and innovation.

MSE is the first institution in Singapore to win three national Competitive Research Programme grants. Projects with major funding include those in the fields of biomaterials, defense materials, clean energy materials, electronic materials, nanomaterials, ecomaterials, and computational materials science.

Functional biomaterials have been used to develop controlled drug-releasing implants to treat cardiovascular defects. This research has resulted in several start-up companies, one of which is based in Silicon Valley. It works on a fully biodegradable cardiovascular stent, and is funded with US$10M. The group's work on regenerative cardiovascular medicine is also supported by a US$16M grant from the National Research Foundation and a research partnership with Technion-Israel Institute of Technology. The work has been extended to using drug-eluting biomaterials to treat glaucoma and other ocular diseases. It won a large research grant that has resulted in the establishment of the new Ophthalmic Therapeutic Engineering Center with clinician scientists from the Singapore Eye Research Institute.

**Pooi See Lee** is an Associate Professor in the School of Materials Science and Engineering, Nanyang Technological University (NTU), Singapore. She obtained her Ph.D. at the National University of Singapore. Her research work focuses on the theme of electrochemical- and electrical-tunable devices based on nanostructures and nanocomposites, for applications in energy storages, electrochromics, electrical memory devices and nanowire transistors or sensors. She is appointed as the Associate Chair in Research of the School of Materials Science and Engineering (NTU) in June 2012.

**Professor Jan Ma** is the Chair of the School of Materials Science and Engineering in 2011 till now. He also served as the Director of Temasek Laboratories@NTU from 2009 to 2012. He received his Ph. D. from the University of Cambridge, United Kingdom. His expertise lies on synthesis and processing of smart functional materials for advanced application, in particular in translational biomedical and defence fields. Prof. Jan Ma is a registered Chartered Engineering of the Engineering Council in the UK. He received the National Day Public Administration Award (Bronze) in 2008. He was the Helen Levitt Visiting Professor in Mayo Medical College, US in 2006

**Professor Freddy Boey** is the Provost and Deputy President at Nanyang Technological University (NTU). Prior to his current appointment, he was the Chair of NTU's School of Materials Science and Engineering from 2005 to 2010. Professor Boey's research areas are in functional biomaterials for medical devices, nanomaterials and nanostructures for cell regeneration, sensing and energy storage. A keen inventor, Professor Boey has founded several companies to patent and license his many creations. He is a director on the boards of DSO National Laboratories and NTU's Temasek Defence Lab. He is also a member of the SPRING Singapore Technology Policy Advisory Committee and has been on the President's Science and President's Technology Award committee since 2007. He is on the panel of several national funding and award panels and has chaired the National A*STAR Grants Review Committee for the past few years.

Defence materials is another key research area in NTU, and is funded substantially by the Defence Research and Technology Office and supported by the Defence Science Organization National Laboratories. The work includes novel graded functional materials, electrochromism, electro-optics and smart textiles. State-of-the-art facilities at NTU, such as the latest infrastructure for materials analysis and characterization, have helped to elevate research on electronic device and materials failure analysis, reliability and the design of novel nanomaterials. Active collaborations with industry and local research institutions on electronic materials include rugged electronics, nanostructures for semiconductor nanodevices and reliability analysis in interconnect systems. Recent rapid expansion into

electronics and biology interfaces has also led to progress in bioelectronics and nano-biointerfaces. For instance, the Center for Biomimetic Sensor Science, established in 2009 between NTU and Linköping University, is a promising effort to develop nanodevices for bioelectronic sensors.

More recently, NTU won significant research grants from the National Research Foundation to fund joint collaborations with academic partners in the field of sustainable energy and water. It received US$65M for a project in electromobility energy solutions with Technical University of Munich, as well as US$70M for a research initiative with University of California, Berkeley, to enhance the efficiency of buildings in the tropics. NTU has also garnered US$24M funding for a tie-up with Hebrew University of Jerusalem and Ben-Gurion University of the Negev to use nanomaterials for energy and water management respectively. In addition, NTU recently set up a solar fuels laboratory to develop the "artificial leaf" technology which creates efficient and sustainable sources of hydrogen fuel from water.

In partnership with industry, NTU has also advanced the pursuit of innovative materials research, with a growing number of eminent global players setting up laboratories at its campus. Vestas, a world-leading provider of wind energy solutions, has set up a joint laboratory with NTU to focus on materials research for wind turbine applications, while Gamesa has chosen to house its first advanced materials research centre in Southeast Asia at NTU. British engineering giant Rolls-Royce is working with NTU in applied engineering and technology applications. Bosch has also teamed up with ERI@N to develop solutions in organic photovoltaics, a cost-effective alternative to silicon-based solar cells. Australian renewable energy firm, Dyesol Limited has recently forged partnership with ERI@AN on the research and development work involving low-cost dye sensitized solar cells technology.

Through its dedicated community of researchers working at the forefront of advanced materials research, NTU is poised to develop new solutions in the field to address challenging global problems. In a fast-changing global milieu, materials research is vital in uncovering important methods for sustainable growth. The development of new materials, in fact, is vital for a sustainable energy supply and will continue to be an important area of research at NTU.

We are very grateful to the staff members of *Advanced Materials* for their kind support and efforts in the preparation of this issue. We hope this edition will catalyze shared interests and stimulate exciting collaborations between NTU and institutions worldwide. We would also like to encourage readers to continue their discovery of NTU's projects and research breakthroughs beyond this publication.

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