

# ECONNECT

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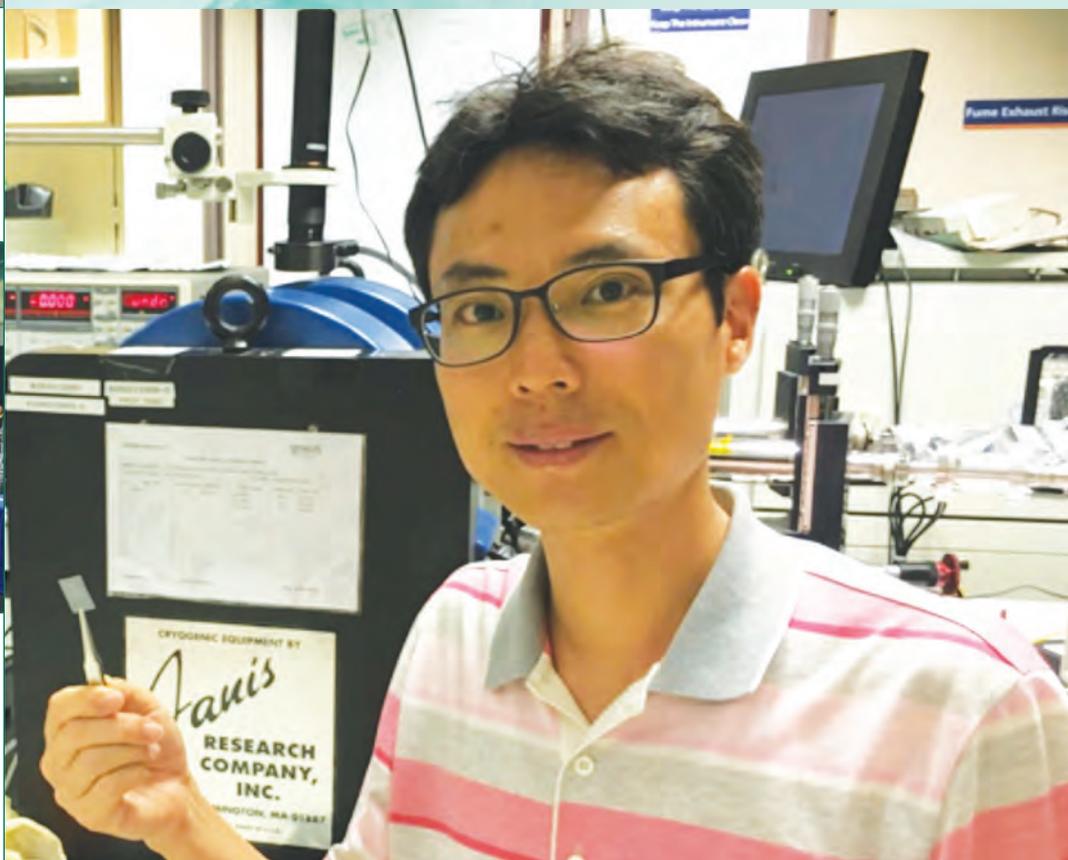
Department celebrates first batch of ECE Scholarship graduates **PAGE 03**



**NUS ECE RANKED 6TH IN THE QS WORLD UNIVERSITY RANKINGS BY SUBJECT 2016 FOR ELECTRICAL & ELECTRONIC ENGINEERING**

**MAKING POWERFUL MAGNETIC MEMORY DEVICES POSSIBLE ON FLEXIBLE PLATFORMS**

Tan Kah Kee Young Inventors' and Great Women of Our Time Awards 2016 **PAGE 05**



ECE Department is honoured to have two winners for the Springer Thesis Award in April 2016 **PAGE 15**



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## HoD SPEAKS...



Prof John **Thong**  
Head, Department of Electrical & Computer Engineering, NUS

“ Faculty talent is a key ingredient of a successful academic department...”

Universities are organizations that revolve around talent. One of the main missions of any university is to educate its students. Specifically, for ECE, we are in the business of developing graduates who meet the increasing demands for talent in a high-value-add industry sector of considerable importance to Singapore's economy. This starts with the recruitment of the best and brightest students from schools and polytechnics. Particularly for high-school students, who have limited exposure to engineering beyond the pure sciences and mathematics, it is important to provide them an appreciation of what ECE is about before they make up their minds about degree programs to pursue. It was with these considerations in mind that the Department launched the ECE Scholarships in 2012, with generous support from staff and corporate partners, to augment ECE's outreach and recruitment efforts. The first ECE scholarship recipients were featured in the September 2012 issues of E.ConnEct, and we are proud to see them graduate at the July 2016 commencement ceremony.

Faculty talent is a key ingredient of a successful academic department, and one which has brought NUS ECE to the echelons of top EE departments in the world. In the continual process of renewal, we strive to bring in fresh talent across the professorial ranks. We are happy to have Professor Aaron Thean, Professor Li Haizhou, and Dr Jimmy Peng join us over the summer. They will build on the foundations established by our past and present colleagues. Among them are three stalwarts of the ECE Department who retired in June - Prof Daniel Chan was a former Head of Department and was an exemplary mentor to many younger colleagues, Prof Kam Pooi Yuen played an important role in the development of the communications & networks group, while Prof Chua Soo Jin led the microelectronics group for a number of years. Our future generation of leaders in ECE have been making their mark both locally and internationally by winning awards alongside their students. We feel a sense of pride to see our students and graduates being recognized for their achievements, as a testament to the mentoring and nurturing of talent by our faculty members.

Some of our graduates have gone on to take their research work to the market, and in this issue we profile our alumnus Dr Wang Fei, who did his Bachelor's degree and PhD with us. He founded AeroLion Technologies to commercialize Unmanned Aerial Vehicles (UAVs, or drones) using technology developed by the ECE Unmanned Systems Group. We hope that this story will inspire others to follow in his footsteps.

## FACULTY APPOINTMENTS AND PROMOTION

### APPOINTMENTS

The Department extends a warm welcome to the following faculty members:

- Dr Aaron **Thean** Voon-Yew joined the Department as Professor on 3 May 2016. Professor Thean was previously the Vice-President of Logic Technologies at IMEC in Leuven, Belgium, the world's largest university-led microelectronics research laboratory with strong industry participation. At NUS, he is playing a key role in strategising and bridging university electronic-device-related research and industry, in collaboration with industry and R&D partners in Singapore. In addition to beyond-CMOS and beyond-Si logic and memory devices, material-device-circuit co-innovation for emerging computational and sensor systems, Prof Thean's research interests include translating research innovation to technology implementation.
- Dr **Li** Haizhou joined the Department as Professor on 1 August 2016. Professor Li headed the Department of Human Language Technology, and was also research director for I2R. His main research interest is in natural language processing. He is a leading researcher in multilingual speech processing, and speaker and language recognition, having made key contributions to the field. In recognition of his accomplishments, he was elevated to Fellow of IEEE in 2014. Prof Li holds a secondary appointment with the Mechanical Engineering Department, and a joint-appointment with I2R.
- Dr Jimmy **Peng** Chih-Hsieh joined the Department as Assistant Professor on 1 July 2016. Dr Peng was previously from the Masdar Institute of Technology where he was an Assistant Professor. His expertise is in the field of smart grids with particular focus on power system stability. His interests extend to adjoining areas of research such as those related to microgrids and integration of electric vehicles into smart grids.



### PROMOTION

The Department congratulates Dr Mandar Anil **Chitre** on his promotion to Associate Professor, with effect from 1 July 2016. Assoc Prof Chitre's research covers signal processing, ambient noise imaging, underwater acoustic communications, autonomous underwater vehicles (AUVS), complex dynamic systems and emergent behaviour.



# AWARD OF ECE SCHOLARSHIP

The Department offers attractive scholarships to freshmen admitted to its undergraduate programmes. The bond-free, merit-based award, known as the ECE Scholarship, is awarded to outstanding local freshmen who have performed well academically.

From this year onwards, the coverage of the ECE Scholarship has been enhanced. Scholars are now able to enjoy greater benefits such as:

- Tuition fees (after MOE Tuition Grant subsidy) plus S\$6,000 annual living allowance
- One-time computer allowance of S\$2,000
- Guaranteed offer of on-campus accommodation at Ridge View Residential College for the first two years of undergraduate studies
- One-semester Student Exchange Programme (SEP) with one of NUS' overseas partner universities
- Membership in the ECE Undergraduate Student Council (USC serves as the voice for the ECE undergraduate student body to enhance the experience of the ECE community via student-led activities)

The ECE scholarship is made possible by generous donations by staff, alumni and corporate partners. The awardees of this prestigious award this year are **Khoo Jun Hao** Desmond (EE) and Jelena **Neo Hui Ling** (CEG).

Let's hear from our new scholars.

## KHOO JUN HAO DESMOND (ELECTRICAL ENGINEERING)

Hello! I am Desmond. I am currently pursuing an Honours Degree in Electrical Engineering at NUS. Since young, I have been mesmerised by science, technology and engineering, more specifically robotics, as I strongly believe that it has the potential to connect societies cohesively. I aspire to be a world-leading electromechanical engineer specialising in intelligent, versatile robotics systems for national defence, such as transformable, autonomous drones. I hope to inspire others by introducing technology and engineering concepts to children from their early childhood.

Currently, I am eager to join the varsity team in intelligent, versatile robotics systems, pioneering corresponding projects and to represent the university at international competitions. In addition, as the treasurer of the ECE Undergraduate Student Council (USC), I am looking forward to organising meaningful events for the ECE community.

I began my robotics journey from secondary one. Pioneering the Robotics Club as President and Chief Programmer with passion and dedication, I was fortunate to win many robotics competitions at the national level. Additionally, I was very blessed to be sponsored by corporate organisations with their products and was offered opportunities in their product testing, and research and development.

Thereafter, I pursued a diploma in Electronics, Computer and Communications Engineering at Nanyang Polytechnic, where I was given the opportunity to learn directly from the world renowned international robotics champion and worked on digital signal processing and motion control

projects. These experiences motivated me to start a technological and educational company focusing on robotics training for Singapore educational institutions.

After my national service, I was approached by companies to spearhead their technology and research and development team. I am grateful to be offered several scholarships by companies and organisations to further my studies. Ultimately, I decided to take the NUS ECE Scholarship for a challenging and enriching undergraduate experience.

For leisure, I enjoy a wide range of activities such as reading, gaming, bowling, pool billiards, basketball, cycling, swimming, kayaking and sightseeing.



From left to right: Assoc Prof Vivian **Ng**, **Khoo Jun Hao** Desmond, Jelena **Neo Hui Ling**

## JELENA NEO HUI LING (COMPUTER ENGINEERING)

Hello! I am Jelena. I was from Pioneer Junior College and am currently pursuing a degree in Computer Engineering in NUS.

I chose Computer Engineering because it will give me the skills and knowledge required to take part in the national effort of building a smart nation. As this initiative is currently in its infancy, there is still a lot of room for development and innovation. Hence, there will be many opportunities available in the future as the initiative gains momentum to tap on the potential of infocomm and media.

I wish to contribute to the vibrancy of the ECE student body by organising different activities which will give students the chance to contribute to the community and mingle with their peers. Being in the ECE USC also

allows me to address students' concerns and to make our university life together more exciting.

During my time in secondary school, I was part of the National Cadet Corps. It gave me a peek into Singapore's military as well as the opportunity to build up essential skills such as discipline and teamwork. I also enjoyed taking up water sports such as kayaking and dragon boating. In junior college, I had the chance to learn more about Singapore's biodiversity through the Eco Club. Throughout my time in the club, I picked up leadership skills and learnt more about planning and organising events.

In my free time, I enjoy kayaking and exploring the different parks and nature trails in Singapore.

# DEPARTMENT CELEBRATES FIRST BATCH OF ECE SCHOLARSHIP GRADUATES

We celebrated the joyous graduation of our first batch of two scholars on 12 July 2016.

Launched in 2012, the ECE Scholarship is offered to freshmen admitted to the Electrical Engineering or Computer Engineering Programmes. The ECE Scholarship is bond-free, merit-based and awarded to outstanding local freshmen who have performed well academically.

ECE Scholar graduate Mr **Chan Wai Cheung**, the ex-Vice President of the 2nd Undergraduate Student Council (USC), said, "Being a pioneer batch ECE scholar, I wanted to contribute to the department and the ECE community as much as I could. I have been participating and organising events held by the department since my first undergraduate year. I did not expect that the more active I became in my volunteerism, the more I learnt about myself and the world. Being part of the USC, I was privileged to attend workshops that further refined my leadership and project management skills. This spirit of gratitude, giving back, is something that I hope will be passed on to my fellow scholars."



(Standing, from left) ECE Scholar graduate Mr **Chan Wai Cheung**, Assoc Prof Vivian **Ng**, Prof John **Thong**, Assoc Prof **Loh Ai Poh**, ECE Scholar graduate Mr Jason **Ang**

Wai Cheung was glad that ECE gave him the opportunity to broaden his horizons and establish his direction in life early. He added, "Being on the ECE scholarship is unlike being on most other scholarships. An advantage of being a scholar is the opportunity to interact with higher management which helped me understand the rationale behind decisions made."

For ECE Scholar graduate, Mr Jason **Ang**, the ECE experience was an eye-opener. He said, "I had experiences far beyond academics and have cultivated valuable life lessons. Actively volunteering and organising events for the ECE community gave me a glimpse into the working world, and an appreciation of the discipline and mental sharpness needed to thrive in a dynamic environment. The exposure enhanced my leadership and time management skills. This eventually made my final year study more enjoyable. I hope that the junior scholars can continue to play an influential role by contributing their talents and efforts in shaping a more active and integrated ECE student community. It will be exceptionally satisfying to see your motivation and actions impact the students in one way or another."

Both Wai Cheung and Jason hope to apply what they have acquired here in NUS ECE into practice so that they may better ace the test of life. Eagerly seeking out opportunities to learn and grow, they hope that they would be able to give back to the NUS ECE community in future.

# RETIREMENT CUM FAREWELL LUNCH FOR PROFESSORS

On 12 May 2016, the Department hosted a retirement-cum-farewell lunch for our three long-serving professors. They were Professors Daniel **Chan**, **Chua** Soo Jin and **Kam** Pooi Yuen. They retired on 30 June 2016, and were re-appointed as adjunct professors.

They have served the department and university well through their many years of valuable contributions in their respective expertise. We thank and honour them for their years of service and wish them all the best.



Prof John **Thong** (HoD, 2<sup>nd</sup> from right) with the 3 retiring profs



Prof **Chua** Soo Jin with HoD



Prof Daniel **Chan** with HoD



Prof **Kam** Pooi Yuen with HoD



The farewell gifts



The sumptuous lunch



Retiring profs with colleagues

# TAN KAH KEE YOUNG INVENTORS' AND GREAT WOMEN OF OUR TIME AWARDS 2016

The ECE research team comprising Associate Professor **Ho** Ghim Wei, Research Fellow **Zhu** Liangliang and Research Engineer **Tan** Chuan Fu, has clinched the Tan Kah Kee Young Inventors' Merit Award (Open category) for their invention that provides clean energy and air/water resources. The team proudly received the award from Mr **Ng** Chee Meng, Acting Minister for Education and Senior Minister of State, Ministry of Transport, on 28 May 2016 at the Science Centre Singapore.

Given to outstanding inventors, the award aims to inspire creativity among youths and promote an innovative and inventive culture. A prestigious and well-established invention award in Singapore, the Tan Kah Kee Young Inventors' Award attracted 810 entries this year.

The use of sustainable solar energy and material for environmental and energy remediation has always commanded great interest. The team's creation of a highly absorbent and solar-mediated carbon aerogel photocatalytic foam uses an intricate functional material design that achieves both elevated absorbent and photocatalytic performances with unprecedented practicality.

For air/water purification, its ultra-lightweight and compressible properties allow straightforward and portable deployment. Besides its ability to absorb air/water pollutants readily into the photocatalytic-active cells, the invention is easy to use and adaptable to multiple scenarios.

Such a feature makes it especially useful in a water-scarce environment with limited stagnant water bodies.

Moreover, the porous and compressible nature of the foam invention allows tailorable permeability levels to act as a versatile filtration system. With its photocatalytic capabilities, the invention offers much higher reusability by degrading absorbed organic impurities compared to conventional filtration systems.

Congratulations to the team!



The research team at the awardee exhibition at the Science Centre Singapore. The team showing Mr **Ng** Chee Meng (2<sup>nd</sup> picture, left), Acting Minister for Education and Senior Minister of State, Ministry of Transport, at its invention at the exhibition booth



Assoc Prof **Ho** (middle) at the award ceremony with Ms Indraneel **Rajah** (left, Senior Minister of State, Ministries of Finance and Law) and Ms Barbara **Koh** (right, The Singapore Women's Weekly's Editor-in-Chief) (Photo: The Singapore Women's Weekly)

We especially extend our congratulations to Assoc Prof Ho who also clinched this year's Great Women of Our Time Award (Science and Technology category). Incepted 10 years ago, this award aims to honour outstanding, talented and high-achieving Singaporean women who are inspiring pioneers and game-changers, and who have impacted various sectors of our economy.

Believing that women can excel in the Science, Technology, Engineering and Mathematics (STEM) industry, Assoc Prof Ho encourages women with these words, "Let your passion drive you, and do not be put down by failures or stereotyping".

# FACULTY MEMBERS BRING TRIPLE HONOURS TO THE DEPARTMENT

Our heartiest congratulations to Professor **Hong** Minghui, Associate Professor **Tan** Kok Kiong and Dr **Luo** Sha for clinching the Institution of Engineers Singapore (IES) Prestigious Engineering Achievement Awards 2016.



The research team comprising Ms **Wu** Mengxue (left) and Prof **Hong** Minghui (2<sup>nd</sup> from left) at the award ceremony

With the support of a grant from the National Research Foundation's Competitive Research Programme, Prof Hong's team successfully developed the **Optical Microsphere Nanoscope**. The nanoscope allows observation of our nano-world in ambient air with a controllable working distance, to acquire super-resolution images over a large area.

This affordable optical nanoscope can be used on a daily basis anywhere, such as in homes, schools or laboratories, and for industrial product inspections or early diagnoses at hospitals.

Also honoured for their invention were Assoc Prof Tan Kok Kiong and his team comprising Dr **Liang** Wenyu and M.Eng student **Qin** Geng. Supported by Sincere IVF Centre, the team developed the **Digital In-Vitro Fertilisation (IVF) Device**.



The awards of both teams



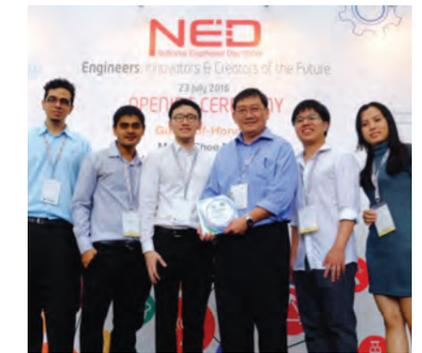
The team's invention is an innovative medical device to assist doctors in oocyte retrieval processes for IVF applications. It combines all the required functions of aspiration and flushing units, and a test tube warmer in a single unit for oocyte retrieval. Not only can the device improve the efficiency and success rate of oocyte retrieval/IVF, it can reduce the cost of IVF procedures which may be helpful for couples considering IVF for pregnancy or the freezing of embryos for future use.

In addition, Dr Luo Sha's project titled "**Galassia - NUS First Nanosatellite**" also clinched the IES award.

Galassia is the first nano-satellite designed and built by a team of 35 undergraduates and 6 research staff from years 2012 to 2015. The 2U nano-satellite was successfully launched on 16 December 2015 and is orbiting in a near equatorial orbit of 550 km altitude with 15 degrees inclination. It flies three scientific payloads and demonstrates NUS's capability in building reliable space systems.



The award won by Dr **Luo** Sha's Galassia team for the first nanosatellite built by NUS



Dr Luo Sha's Galassia team

## CIS TNNLS OUTSTANDING PAPER AWARD

Associate Professor **Tan** Kay Chen and his team (comprising graduated ECE Ph.D. student **Yu** Qiang, Dr **Tang** Huajin [I2R] and Prof **Li** Haizhou) were awarded the Computational Intelligence Society (CIS) IEEE Transactions on Neural Networks and Learning Systems (TNNLS) Outstanding Paper Award.



Assoc Prof **Tan** Kay Chen (middle) at the award ceremony

The winning paper, entitled "Rapid Feedforward Computation by Temporal Encoding and Learning with Spiking Neurons", was published in the IEEE Transactions on Neural Networks and Learning Systems, Vol. 24, No. 10, October 2013.

The award was presented during the banquet of IEEE World Congress on Computational Intelligence on 27 July 2016 in Vancouver, Canada. The prize consists of US\$1,000 and a certificate.

This annual award recognises outstanding papers published in TNNLS.

## APPOINTMENT TO IEEE FELLOW COMMITTEE 2016



Prof **Kam** Pooi Yuen

Professor **Kam** Pooi Yuen has been appointed to serve on the IEEE Fellow Committee for Year 2016.

The IEEE Fellow Committee is responsible for making recommendations to the IEEE Board of Directors for nominees to be elevated to the grade of Fellow.

# BREAKTHROUGH BY NUS-MICHIGAN TEAM IN ULTRA-LOW ENERGY MICROPROCESSORS FOR THE INTERNET OF THINGS – BREAKING THE BARRIER BETWEEN PURE RESEARCH CONCEPTS AND REAL SMART OBJECTS

A major advance in the area of microprocessors and memories for the Internet of Things (IoT) has been enabled by a research team from the ECE Department led by Associate Professor Massimo **Alioto**, and the EECS Department of the University of Michigan – Ann Arbor, led by Professors David **Blaauw** and Dennis **Sylvester**.

Introducing intelligence into ordinary objects is a major driver of the IoT worldwide and part of the Smart Nation vision in Singapore. Enabling intelligence ubiquitously is very difficult due to the very tight energy constraints imposed by the extreme miniaturisation of the energy source (e.g. battery).



Ultra-low energy consumption of microprocessor and memory circuits is typically achieved through operation at very low voltage, e.g. down to 0.4 V as opposed to more typical operation at 0.7-1.2 V. However, operation at such low voltages determines a drastic degradation of the circuit robustness, and, hence, severely degrades the percentage of functional chips (also called “yield”) coming out of the semiconductor manufacturing chain. As such percentage degradation determines a substantial cost increase for semiconductor manufacturers, the market for IoT chips is still very limited in spite of the wide interest in IoT applications. The main problem with prior techniques to reduce such cost is the large additional silicon area cost that is typically so high it negates the potential cost reduction.

At the prestigious ISSCC 2016 conference, the NUS-UMich team demonstrated the new iRazor circuit methods to eliminate the above cost increase by introducing ultra-lightweight methods to achieve adequate robustness in microprocessors operating at 0.4 V. Indeed, iRazor entails only three additional transistors for each sequential element (e.g., flip-flop – see Fig. 1). The overall area increase due

to iRazor in an ARM Cortex-R4 core in 40-nm CMOS technology was demonstrated to be only 4% (see iRazor chip micrograph in Fig. 2).

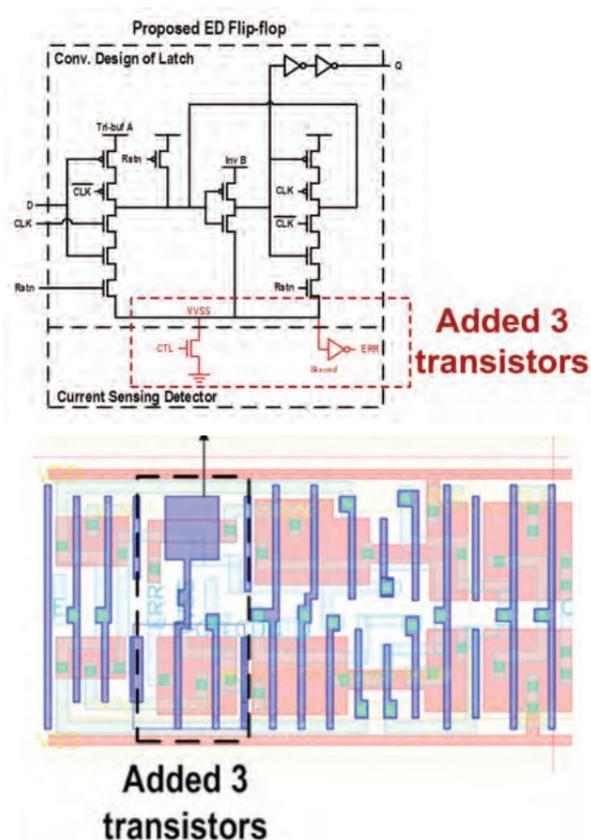


Fig. 1. The iRazor concept: Only three additional transistors per sequential element are needed (circuit on the top, physical layout at the bottom)

Previous techniques from other teams required 15 to 30 additional transistors per flip-flop, and an overall silicon area cost of 30-50%. For the first time, iRazor enables semiconductor companies to design and manufacture microprocessors for IoT with excellent robustness and at very low cost, thus making processors for IoT viable both from a technological and financial perspective. In short, iRazor promises to be the ultimate error detection/correction technique for IoT processors, and to be widely adopted by the semiconductor industry.

**The NUS-UMich team has also demonstrated that the above general design concept can be applied to drastically improve the robustness of on-chip memories at ultra-low cost. The novel circuit techniques enabling this concept in memories have been demonstrated in the innovative RazorSRAM chip that is the first demonstration of a memory able to correct itself in the presence of reported timing errors.**

The RazorSRAM techniques were presented in another session at the same ISSCC 2016 conference. The RazorSRAM prototype in 28-nm CMOS technology in Fig. 3 demonstrates that on-chip memories operating at ultra-low voltages can be made very robust at the cost of 8% area increase only. As further benefits, RazorSRAM eliminates the traditional design pessimism to reduce the energy by 70% and improve the performance by five times.

In short, the NUS-UMich team has demonstrated that both microprocessors and memories for IoT can be designed to achieve adequate robustness and very low cost in spite of the challenges posed by their ultra-low voltage operation. Thanks to the significant advances over the previous best-in-class techniques, the novel iRazor and RazorSRAM techniques can now fill the technological gap between prior IoT research concepts and future chips for IoT applications, thus enabling mass-production.

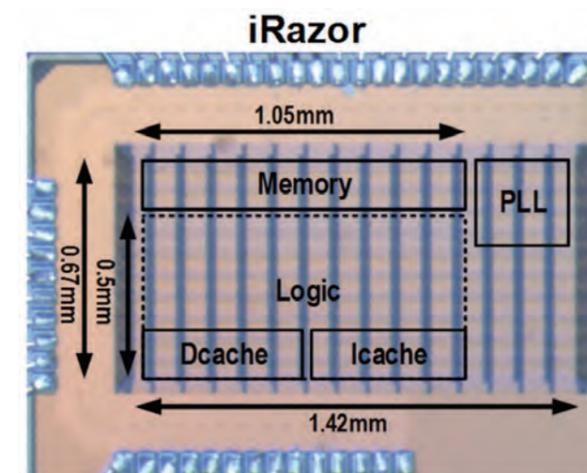


Fig. 2. iRazor chip micrograph (ARM Cortex-R4 microprocessor), as published at ISSCC

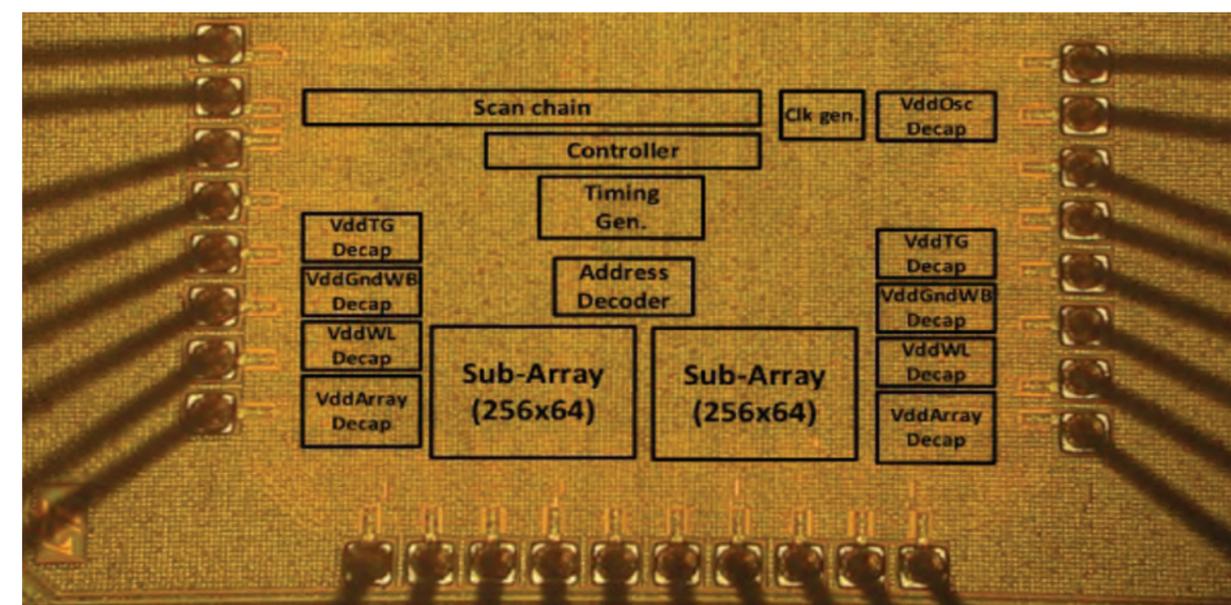


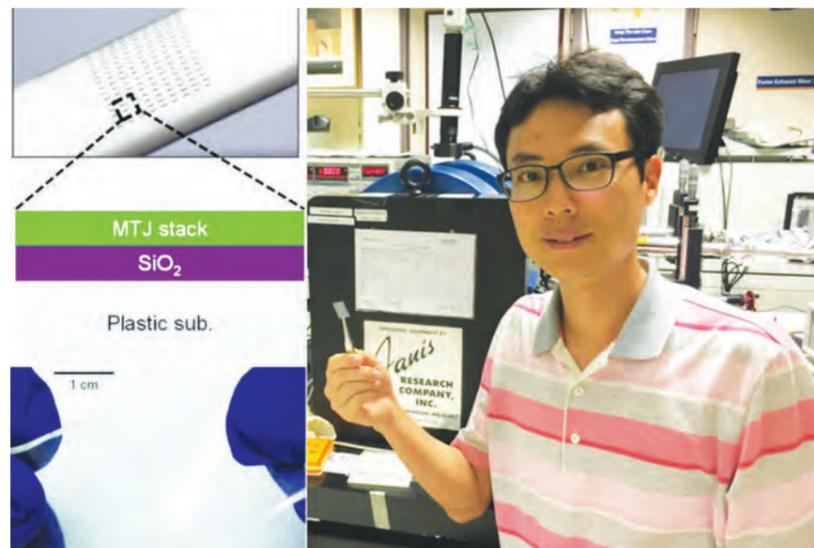
Fig. 3. RazorSRAM chip micrograph, as published at ISSCC

# MAKING POWERFUL MAGNETIC MEMORY DEVICES POSSIBLE ON FLEXIBLE PLATFORMS

MAGNETORESISTIVE Random Access Memory (MRAM) is emerging as the next big thing in data storage. It is a relatively new technology but it has so many advantages that it may become a leader in memory storage.

What is MRAM? It is a type of non-volatile RAM which uses magnetic states to store data. This means that data can be retrieved even when the electronic equipment or device is not powered up, a key advantage of MRAM. To do this, a magnesium oxide (MgO)-based magnetic tunnel junction (MTJ), which is a key building block of MRAM, will store each bit of the data information.

Today, MgO-based MTJ devices have recently been fabricated mostly on rigid and flat platforms. Flexible magnetic memory devices have recently received a lot of attention because it is an important component of various emerging applications such as wearable smart devices and biomedical sensors, which require important functions like wireless communication, data storage, and code processing. However, the ability to produce flexible magnetic memory devices on soft platforms without sacrificing its performance is a challenge.



**Top left inset:** Optical images of the magnetic memory devices after the transfer onto a flexible plastic platform with a schematic diagram of an individual memory unit.

**Bottom left inset:** The versatility of the platform transfer process: Optical images of magnetic memory devices can be transferred onto a flexible platform.

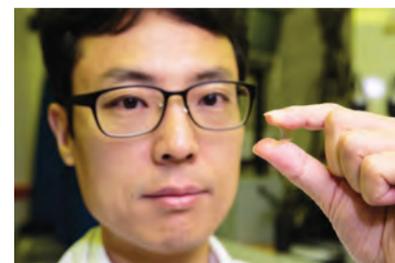
**Main photo (above) and photo (left column):** Assoc Prof Yang holding a piece of the magnetic memory device on a flexible material.

of strain that might be placed on these surfaces. This research discovery has enabled the NUS team to realise the potential to develop high performance flexible magnetic data storage devices.

Assoc Prof Yang and his team developed a flexible magnetic memory structure that is important to the development of the next generation of MRAM chip. This revolutionary innovation, two years in the making, is the world's first magnetic memory device that is flexible enough to bend. It takes the technology a step closer to fully flexible electronic devices that can be utilised on a myriad of applications, ranging from automobile, transportation, industrial management (motor control and robotics, power and energy) to diverse usage in military and avionics systems, and healthcare electronics. The innovation can potentially be applied to enhance users' experience even in consumer electronics such as laptops and mobile devices.

This breakthrough has been featured not only in The Straits Times (on 20 July 2016), but in other media such as The Business Times, BioTech In Asia, Channel 8 News Online, 938 LIVE, Capital 95.8FM, New Electronics, Phys Org, Science Newline, Nanowerk, E Science News and Electronic Specifier.

The NUS research team has received US and Korea patents for their technology. Not resting on their laurels, the team has started planning the next phase of their research. They hope to apply the invented structure to memory cells and are looking for industry partners to develop a flexible MRAM.



The ECE team, led by Associate Professor Yang Hyunsoo, was able to overcome this challenge. In collaboration with Yonsei University in Korea, Ghent University in Belgium, and the Institute of Materials Research and Engineering (IMRE), the team adopted the transfer printing approach, which allows the fabrication of MTJs on various flexible surfaces such as plastic, glass, metal foil, and rubber, whilst controlling the amount

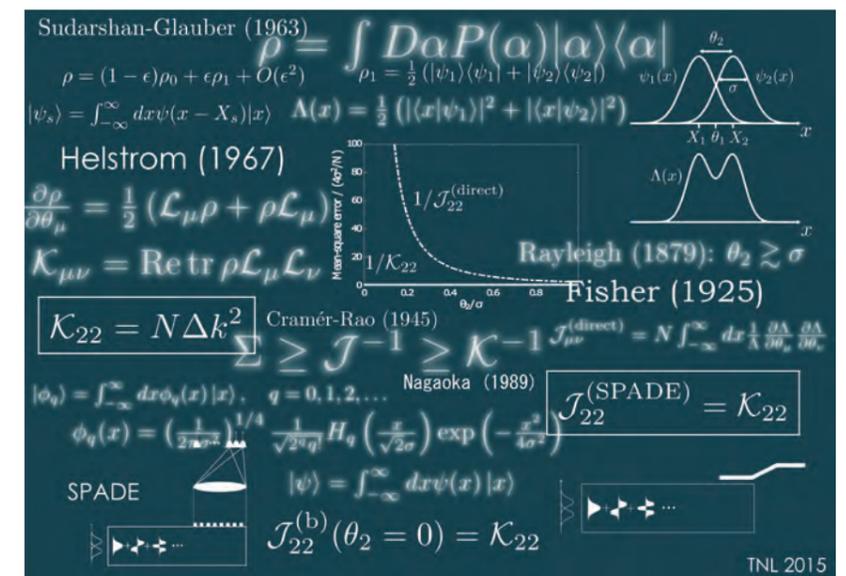
# QUANTUM TECHNOLOGY TO ENHANCE RESOLUTION OF MICROSCOPES AND TELESCOPES

ECE engineers have discovered new optical techniques that can measure the separation between two light sources more precisely than ever before, potentially improving the resolution of microscopes and telescopes by orders of magnitude.

With conventional imaging methods, the wave nature of light blurs the image while the particle nature of light brings noise. These nuisances make it difficult to determine the separation between two light sources, hindering especially the study of fluorescent particles in microscopy and binary stars in astronomy.

Scientists have long considered this difficulty to be insurmountable but Assistant Professor Tsang Man Kei, and his research fellows, Drs Ranjith Nair, and Xiao-Ming Lu, have now shown that it can be overcome.

**Using a powerful theory called quantum metrology, their calculations reveal that the light emitted by two typical light sources actually contains much more information about their separation than previously realised, and cleverer quantum optical methods can extract the full information, thus allowing the separation to be measured more accurately than ever before.**



The mathematics that led to the breakthrough by Assistant Professor Tsang Man Kei's team at NUS Engineering.

Since Asst Prof Tsang and his team members announced their discovery in an online preprint in November 2015, no less than four independent groups from Singapore, Canada, and Europe have performed experimental demonstrations of their theory. One of the groups is headed by Dr Alexander Ling, a principal investigator at the Centre for Quantum Technologies in Singapore. In addition, the seminal work by Asst Prof Tsang and his team has recently been published in Physical Review X, a highly selective journal by the American Physical Society.

These rapid developments suggest that applications of their ideas in both microscopy and astronomy should not be far away; their next step is to explore how their techniques can be applied to the imaging of biological samples and to solve difficult problems in biology.

Other Links:

- <http://physicsworld.com/cws/article/news/2016/sep/02/tapping-into-lights-hidden-information-topush-fundamental-diffraction-limit>
- <http://dx.doi.org/10.1103/Physics.9.100>
- <http://physicsbuzz.physicscentral.com/2016/08/resolving-starlight-with-quantum.html>
- <http://phys.org/news/2016?09-quantum-mechanics-technique-rayleigh-curse.htm>
- <http://news.nus.edu.sg/highlights/10796-quantum-technology-enhances-resolution>

# LAUNCH OF THE CORPORATE LABORATORY AT NUS ENGINEERING

SEMBCORP Industries (Sembcorp) and the National University of Singapore (NUS) established the Sembcorp-NUS Corporate Laboratory on Wednesday, 20 April 2016. Mr **Teo** Chee Hean, Deputy Prime Minister and Coordinating Minister for National Security, and Chairman of the National Research Foundation (NRF) Singapore, was the Guest-of-Honour at the launch event.

Set up with an investment of S\$60 million, the new joint Corporate Laboratory, which is based at the Faculty of Engineering, is supported by NRF under its Corporate Laboratory@University Scheme. Tapping on the combined expertise of 45 researchers from NUS and 35 engineers from Sembcorp, the Corporate Laboratory aims to generate new scientific and engineering knowledge, as well as develop competitive and sustainable solutions for three core areas: power generation, industrial wastewater treatment and water reuse, and the transformation of waste into useful and high-value products such as ultra-light composites for modular construction.

The Sembcorp-NUS Corporate Laboratory will deepen the industry-university partnership and pioneer green technologies in the three areas to promote sustainable development in Singapore. The Corporate Laboratory will also work with NUS' research centres, such as the Centre for Water Research and Centre for Advanced Materials Structures,



DPM **Teo** Chee Hean (second from right) with Assoc Prof **Panda** (left of DPM Teo); Mr **Wong** Ngit Liong, Chairman of NUS Board of Trustees (right of DPM Teo); NUS President Prof **Tan** Chorh Chuan (right of Mr Wong) and Prof **Ng** How Yong (right of Prof Tan) at the exhibition featuring capabilities of the Sembcorp-NUS Corporate Laboratory's three research areas: energy, water and waste-to-resource.

located in the Faculty, to develop new, competitive and sustainable solutions. The laboratory will provide a key platform not only for NUS students and researchers to gain experience in industrial R&D, but at the same time, promote interaction and exchange of ideas with engineers from Sembcorp.

**Said Professor Tan Chorh Chuan, NUS President, "NUS is pleased to partner Sembcorp and NRF in setting up the Sembcorp-NUS Corporate Laboratory that will strengthen the synergy between industry and academia. We are very excited to have this opportunity to contribute NUS' experience in basic and applied engineering research to create knowledge and novel technologies that will enhance the long-term competitiveness of Singapore and our industries, and, at the same time, improve environmental sustainability. We look forward to working**

**closely with researchers from Sembcorp to develop innovative and sustainable solutions in the areas of energy, water and waste-to-resource."**

The NRF's Corporate Laboratory@University Scheme seeks to strengthen Singapore's innovation system by encouraging public-private research and development collaboration between universities and companies. It ensures that universities achieve impact by developing cutting-edge solutions for problems faced by the industries. The collaboration also creates employment opportunities and trains a pool of industry-ready research manpower.

Associate Professor Sanjib Kumar **Panda** from the ECE Department is one of the project investigators in this corporate laboratory.

More details: <http://news.nus.edu.sg/press-releases/10290-semcorp-and-nus-establish-corporate-laboratory>

# DR WANG FEI AND HIS AEROLION TECHNOLOGIES

With support from the NUS ECE UAV Research Group, the founding CEO of AeroLion Technologies (ALT – [www.aerolion.com](http://www.aerolion.com)), Dr **Wang** Fei, has started on the journey of company incorporation and commercialisation since November 2014.

ALT is a spin-off company from the National University of Singapore. ALT's technologies and founders were from the Unmanned Systems Research Group of the ECE department known as NUSUAV (<http://uav.ece.nus.edu.sg/>). Led by Professor Ben M. **Chen**, researchers from NUSUAV have done in-depth studies over the past 10 years on sophisticated UAV technologies ranging from modelling and control of unmanned helicopters, UAV vision-based landing and vertical replenishment between moving platforms, GPS-less indoor and forest navigation, UAV miniaturisation, to multi-UAV formation control.



Dr **Wang** Fei with BlackLion



BlackLion device

Dr Wang came to Singapore 16 years ago as an MOE scholarship holder to study at Chinese High School. Since then, he has been living in Singapore while doing his higher level education. He received his B.Eng. degree with First Class Honours at ECE in 2009, and obtained his Ph.D. degree at the NUS Graduate School for Integrative Science and Engineering in 2014.

Since he joined NUSUAV for his undergraduate final-year project, Dr Wang has been active in the research fields of modelling and control of UAVs and UAV indoor navigation systems. Not only has he led teams from NUSUAV to participate in various local and international UAV competitions, including the Singapore Amazing Flying Machine Competitions (SAFMC), the International UAV Innovation Grand Prix (AVIC Cup), and the International Micro Air Vehicles Competition (IMAV), he and his teams have obtained several championships.

Since its incorporation, ALT has focused on the conversion of UAV technologies into commercially viable products and services.

AeroLion's business model covers three areas:

- Produce state-of-the-art small-scale UAVs that can solve modern industrial problems.
- Provide professional flight and data collection services.
- Provide professional services for handling, processing and interpreting of information and data collected by UAVs.



BlackLion in action

The company's first product, the BlackLion-168, has top-notch industrial specifications such as hour-long flight endurance, 4-kg payload capacity, adaptation to different types of environmental factors (temperature, pressure, wind speed etc.) and fully autonomous waypoint flight and image analytics capabilities such as 3D mapping and object detection.

With these cutting-edge specifications and smart features, BlackLion-168 has been deployed for applications spanning power line inspection in different provinces of China, plantation mapping and tree counting in Indonesia, and aerial mapping and inspection works demanded by Singapore local customers.

Its second product, the BlackLion-068, is a relatively smaller but even smarter UAV platform-designed for autonomous missions in GPS-denied environments. It is suitable for surveillance and inspection works in special environments such as indoor, underground sewerage and under bridges where GPS signals are inaccessible or where there are cluttered obstacles. Based on these unique and high-tech capabilities, the AeroLion's BlackLion series UAV products are Singapore iDA accredited, further highlighting the company's innovation and competitiveness in both technical and business aspects.

# ECE UNDERGRADUATE STUDENT COUNCIL (USC) INDUCTION CEREMONY 2016

The induction of the ECE 3rd Undergraduate Student Council (USC) for the new academic year 2016/2017 was formalised on 9 September 2016 at the Engineering Auditorium. The induction ceremony was a very special event as we celebrated and recognised the achievements of the 2nd USC, while acknowledging the potential leaders of the future in NUS ECE. This also marked a significant beginning of this new academic season for the 28 student councillors.

More importantly, the incoming council members took the stage to officially pick up the batons from their seniors, and to show that they are ready to fulfil their responsibilities as student leaders. This meaningful event was witnessed by Deputy Head of Undergraduate Programmes, Assoc Prof Vivian **Ng**, Assoc Prof Abdullah **Al Mamun**, Dr **Qiu** Cheng Wei, Dr **Chua** Dingjuan and Ms Nicole **Phua**.

One of the highlights of the ceremony was the final address by the Vice President of the 2nd USC, **Chan** Wai Cheung. Wai Cheung proudly announced that, for the first time, a USC bazaar raised approximately \$2,000 for the USC fund. In addition, the USC's community service initiative took its first steps in the current academic year. Besides giving an overview of the achievements of the 2nd USC, Wai Cheung offered the 3rd USC sound advice and his good wishes. In recognition of the 2nd USC councillors' contributions, Assoc Prof Ng presented them with certificates of service.

Next, the President of the 3rd USC, **Lim** Yi Hong, shared his vision for the 3rd USC. He outlined the goals for the council with three alphabets: "ECE" (Encourage feedback, Care for students, Empower clubs and council members). He noted that "a good leader is one who doesn't just talk a good game but also gets others to follow him to play a great game."



**Lim** Yi Hong, President of the 3rd USC leading the council in the recitation of the USC oath



The ECE 3rd USC, together with its advisors and academic staff

The ceremony ended on a high note with the President leading his fellow council members in the recitation of the USC Oath, pledging to serve the student community with excellence and passion. As students snapped pictures to commemorate this milestone in their lives, these fond memories will stay with the council members as they embark on their new term of service to bring positive changes to the student life in the department.

# UNDERGRADUATE STUDENT RESEARCH AWARDS

## RECIPIENTS OF THE NUS OUTSTANDING UNDERGRADUATE RESEARCHER PRIZE 2015/2016



From left: **Li** Shengmu, **Wang** Yuyao and **Xue** Yushu

Kudos to our undergraduates, **Li** Shengmu, **Wang** Yuyao and **Xue** Yushu, who took home the NUS Outstanding Undergraduate Researcher Prize 2015/2016. Their project entitled "Snowstorm – Design and Construction of an Electric Recreational Flying Machine" won in the group category of the competition.

We extend our congratulations to other ECE winners of this 30th Innovation and Research Awards in the Faculty of Engineering.

### Recipients of the Faculty 30th Innovation & Research Award (IRA) and the NUS Outstanding Undergraduate Researcher (OUR) Prize 2015/2016

Names	Category	Award/ Prize
<b>Liu Shengmu, Wang Yuyao and Xue Yushu</b>	Group	IRA and OUR Prize (High Achievement)
<b>Lee Jian Yun</b>	Individual	IRA (High Achievement)
<b>Lim Han Yang</b>	Group	IRA (High Achievement)
<b>Abonti Bte Mohd Tawheed Alan</b>	Group	IRA (Merit)
<b>Zhao Chenxu</b>	Group	IRA (Merit)
<b>Mahit Shridhar</b>	Group	IRA (Merit)
<b>Wu Shiming</b>	Group	IRA (Merit)

## SPRINGER THESIS AWARD

ECE Department is honoured to have two winners for the Springer Thesis Award in April 2016.

Dr **Yeo** Jueyuan was a Ph.D. student supervised by Prof Bhatia Charanjit **Singh**.

Dr Yeo's thesis, entitled "Ultrathin Carbon-Based Overcoats for Extremely High Density Magnetic Recording", won him an award.



Dr **Zhao** Jiajun was a Ph.D. student supervised by Dr **Qiu** Cheng Wei.

Dr Zhao's award-winning thesis is entitled "Manipulation of Sound Properties by Acoustic Metasurface and Metastructure".

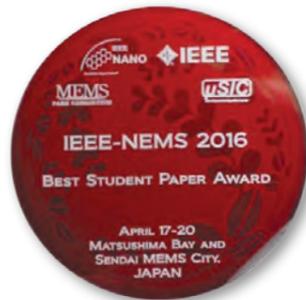


Both Dr Zhao and Dr Yeo graduated in February 2016. Each received prize money of €500. They will also see their Ph.D. work published in Springer's collection of outstanding theses.

## IEEE-NEMS BEST STUDENT PAPER AWARD

Dihan **Hasan** (Ph.D. student supervised by Assoc Prof Vincent **Lee** Chengkuo) is the winner of the Best Student Paper Award (Special Session) at the 11th Annual IEEE International Conference on Nano/Micro Engineered and Molecular Systems (IEEE-NEMS 2016). The conference was held at Matsushima Bay and Sendai MEMS City in Japan, from 17 to 20 April 2016.

The winning entry, entitled "Thermally Robust Coupled Mode at Mid IR Mediated by Highly Dense Plasmonic Nanostructure" (authors: Dihan Hasan, Prakash **Pitchappa**, Ho Chong Pei, Vincent **Lee** Chengkuo, National University of Singapore), won Dihan a prize comprising a recognition certificate and a crest.

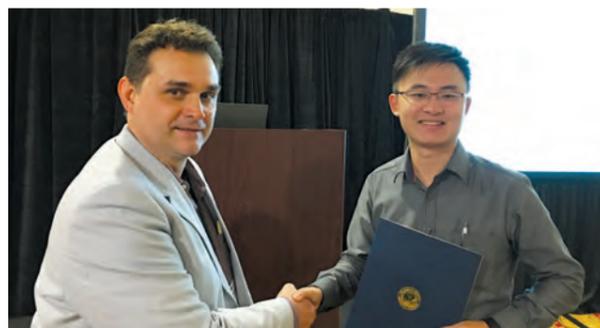


## ASME ISPS GRADUATE STUDENT FELLOWSHIP

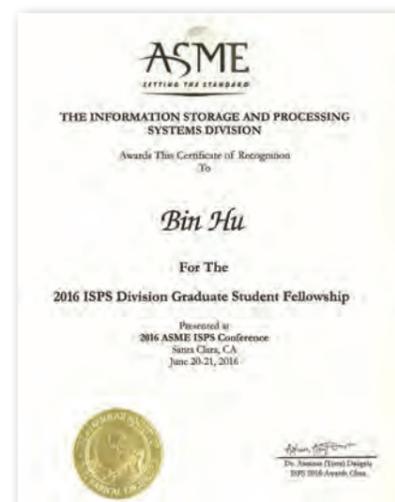
Ph.D. student **Hu** Bin was awarded the Graduate Student Fellowship at the American Society of Mechanical Engineers (ASME) Information Storage and Processing Systems (ISPS) Conference. The award ceremony was held on 20 and 21 June 2016, in Santa Clara, California, USA.

The prize consisted of a cash sum of US\$2,500 while the conference registration fee of US\$300 was waived.

Hu Bin is supervised by Dr Justin **Pang** and Dr **Wan** Jie (from Western Digital Corporation).



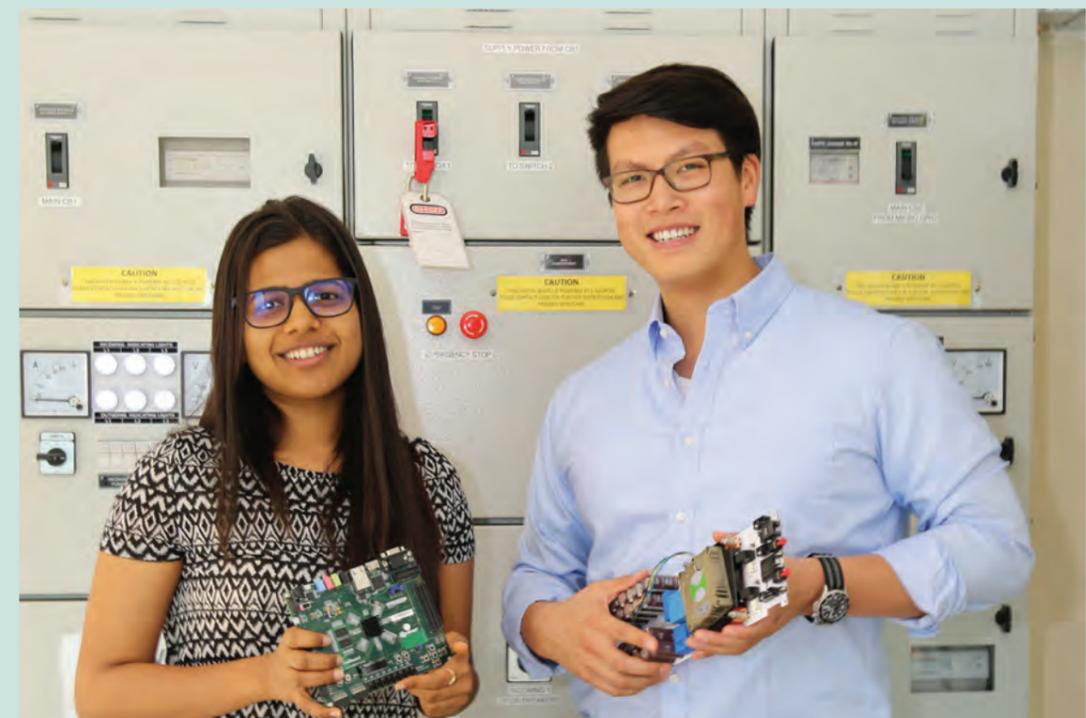
Hu Bin (right) with ISPS Award Chair Dr Tony **Daugela**



## COMPEL BEST PAPER AWARD

NUS Ph.D. graduate student Palak **Jain** and University of California (UC) Berkeley Ph.D. graduate student Jason **Poon** were awarded the Best Paper Award at the 2016 IEEE Workshop on Control and Modelling for Power Electronics (COMPEL). Their work is entitled "Fault Diagnosis via PV Panel-Integrated Power Electronics".

In their work, the students explored an innovative method for improving the reliability and fault tolerance of photovoltaic systems by using smart power electronics. The co-authors of this paper include Associate Professor Sanjib Kumar **Panda** and Professor **Xu** Jianxin of NUS, and Professors Seth R. **Sanders** and Costas **Spanos** of UC Berkeley.



Students Palak **Jain** (left) with Jason **Poon** (right)

# OHBM MERIT ABSTRACT AWARD

**Kong Ru** (Ph.D. student supervised by Dr Thomas **Yeo**) received the Organisation of Human Brain Mapping (OHBM) Merit Abstract Award in Geneva, at the OHBM annual meeting held from 26 to 30 June 2016.

Her work, "Individual Cerebral Cortex Parcellation with Group-level Spatial and Connectivity Priors", won her a cash award of US\$2,000.



**Kong Ru** at OHBM meeting



# APEC BEST PRESENTER AWARD

**Ali Kawsar** (Ph.D. student supervised by Dr Pritam **Das** and Assoc Prof Sanjib Kumar **Panda**) won the Best Presenter Award at the Applied Power Electronics Conference (APEC) 2016, held from 20 to 24 Mar 2016, in California, USA. His prize comprised a recognition certificate and a US\$100 gift card.

His winning entry, entitled "A New Control Scheme to Improve Load Transient Response of Single Phase PWM Rectifier with Auxiliary Current Injection Circuit" (authors: Naga Brahmendra Yadav **Gorla**, Sandeep **Kolluri**, Pritam Das and Sanjib Kumar Panda), was presented at the conference session of Control of AC-DC Converters.



**Ali Kawsar** (left) with Assoc Prof Sanjib Kumar **Panda**



**Ali Kawsar** (left) with Dr Pritam **Das**