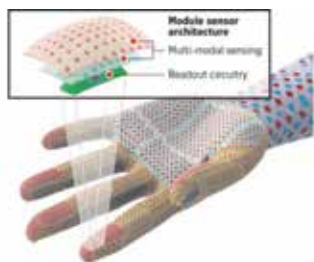


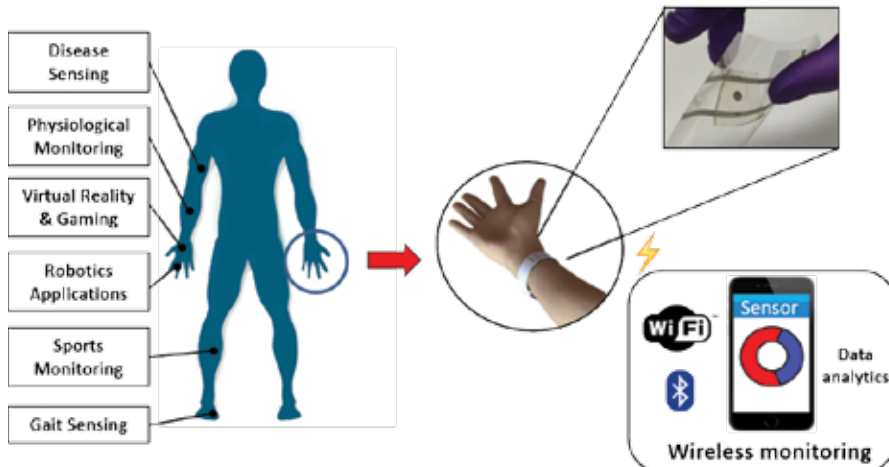
Making undetectable sensing possible – the world's first camouflage shell **PAGE 09**

## HYBRID FLEXIBLE ELECTRONICS – OVERCOMING THE LIMITATIONS OF RIGID AND PRINTED ELECTRONICS

ECE Alumnus Mr Masagos conferred the Distinguished Engineering Alumni Award **PAGE 13**



ECE, NUS Research Institute (Suzhou) and Partner Chinese Universities offer a new education framework **PAGE 14**



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## HoD SPEAKS...



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

“ Our future engineers must rise to the challenge to innovate. ”

Around this time every year, I get to write a congratulatory message for the graduating class at the forthcoming commencement ceremony held in July. This gives me pause to reflect on the value-add professors in a research-intensive university bring to undergraduate education. Is there a disconnection between the pursuit of cutting-edge research, and the professor's role in imparting knowledge, skills, and abilities to the next generation of engineers? As Singapore begins its second 50-years of nationhood, its manufacturing economy has to successfully manage the transition to high-value-added activities. Our future engineers must rise to the challenge to innovate, to discover out-of-the-box solutions, and dare to challenge conventional thinking – and textbook solutions for that matter – with a “why not?” attitude. The desire to discover and create, innate in the human psyche, must be cultivated, and who best to inculcate this in our students other than faculty who have devoted their careers to the creation of knowledge? Hence, we celebrate the successes of our teacher-scholars, but at the same time we need to remind ourselves that as professors, we must continue to strive to exemplify these qualities both within and outside the classroom.

In this issue, we are proud to highlight the achievements of our faculty members, including three who have been listed as Highly Cited Researchers by Thomson Reuters, and three newly elevated Fellows of the IEEE. There are two teams helmed by ECE faculty members who have won the 2016 ASEAN Outstanding Engineering Awards, in recognition of their achievements of significant engineering impact.

In addition, we are honored that our ECE alumnus, Mr **Masagos** Zulkifli, the Minister for the Environment and Water Resources, was conferred the 2016 Distinguished Engineering Alumnus Award (DEAA) for his significant contributions to our nation.

On the research front, we have selected a variety of highlights to show the breadth of research activities undertaken, spanning a spectrum from basic physical phenomena to complex systems. Of particular note is a new program on the Hybrid Integrated Flexible Electronics Systems (HiFES) led by ECE. This initiative represents a significant investment by NUS to spearhead the development of new technology on non-rigid and conformal platforms. This undertaking adopts a systems approach by integrating materials, devices and design, a methodology that has been successfully adopted in the semiconductor industry. As the program gets underway, we hope to report the successful outcomes in a future issue of EConnEct.

## THE WORLD'S MOST HIGHLY CITED RESEARCHERS

Congratulations to Prof Sam **Ge** Shuzhi, Assoc Profs **Yan** Shuicheng and **Zhang** Rui for being listed as Thomson Reuters' Highly Cited Researchers of 2016. They are among the elite researchers representing the world's leading scientific minds of 2016.

The professors are among the 11 NUS scientists and engineers who have been named the most prominent researchers globally by Clarivate Analytics, the former Intellectual Property & Science business of Thomson Reuters.

The Highly Cited Researchers 2016 report evaluated close to 130,000 highly cited papers indexed over 11 years from 2004 to 2014 in 21 fields of science and social sciences. The report also tracked authors who published articles ranked among the top one per cent of the most cited in their respective fields by year of publication.



[http://news.nus.edu.sg/highlights/worlds-most-highly-cited-researchers?utm\\_campaign=World's+prominent+researchers&utm\\_medium=showcase&utm\\_source=corpsite](http://news.nus.edu.sg/highlights/worlds-most-highly-cited-researchers?utm_campaign=World's+prominent+researchers&utm_medium=showcase&utm_source=corpsite)

Highly cited researchers in NUS from ECE Department	Scientific area
	Prof Ge Shuzhi Sam Engineering
	Assoc Prof Yan Shuicheng Engineering
	Assoc Prof Zhang Rui Computer Science

## FACULTY APPOINTMENTS

The Department extends a warm welcome to our new faculty members



Prof **Low** Kay Soon joined the Department on 16 November 2016.

Under Prof Low's charge, a new satellite centre, Satellite Technology And Research centre (STAR), will be established to lead NUS' satellite programme in its next phase of development.

Prof Low was previously the director of the Satellite Research Centre (SaRC) of NTU. He has worked in academia and industry, having served as a

consultant to many companies. A pioneer in Singapore's satellite programmes, he has successfully developed and launched six satellites, starting with the first Singapore-built satellite, X-SAT. These satellites cover different classes of satellites ranging from picosatellites to microsatellite, with weights ranging from 193g to 123kg.

Prof Low received the Singapore Public Administration Medal (Bronze) in 2014 and the Defence Technology Prize (Research & Development category) in 2011. Under his leadership, SaRC received the 2016 President's Technology Award jointly with ST Electronics (Satellite Systems) Pte Ltd, DSO National laboratories and CRISP.





Dr Kelvin **Fong** Xuanyao joined the Department as an assistant professor on 6 December 2016.

Dr Kelvin Fong pursued his B.Sc, Ph.D. and post-doctoral studies at Purdue University, USA. He worked on x86 processor designs during an 8-month internship at Advanced Micro Devices, Inc, in 2008. Dr Fong

returned in 2015 to Singapore as a Research Scientist in A\*STAR. His main research interest is in device/circuit/systems co-design using simulation models. Dr Fong will focus on compact modelling of novel electronic devices and study the use of these devices for various applications. Outside the laboratory, you may find Kelvin enjoying coffee at Starbucks, playing football in a futsal court, or exploring various craft beers.



Dr Jerald **Yoo** joined the Department as an associate professor on 9 January 2017.

Assoc Prof Jerald Yoo received his Ph.D. degree from the Department of Electrical Engineering at the Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea, in 2010. From 2010 to 2016, he was with the Department

of Electrical Engineering and Computer Science, Masdar Institute, Abu Dhabi, UAE, where he was an associate professor. He has developed low-energy body-area-network (BAN) transceivers and wearable body sensor network using planar-fashionable circuit boards.

His current research interests include low-energy circuit technology for wearable bio-signal sensors, flexible circuit board platform, BAN transceivers, ASIC for piezoelectric Micromachined Ultrasonic Transducers (pMUT) and System-on-Chip (SoC) design to system realisation for wearable healthcare applications.

Currently, he serves as a Technical Program Committee Member of the IEEE Asian Solid-State Circuits Conference (A-SSCC), IEEE Custom Integrated Circuits Conference (CICC), and the IEEE International Solid-State Circuits Conference (ISSCC) Student Research Preview (SRP). He is also an Analog Signal Processing Technical Committee Member of IEEE Circuits and Systems Society.

## WELCOME BACK

We welcome Associate Professor Koenraad **Mouthaan** back to our Department.

Assoc Prof Koenraad Mouthaan received his M.Sc. and Ph.D. degrees in electrical engineering from Delft University of Technology. He had previously worked at TNO Defence,



Safety and Security, and SkyGate, both in the Netherlands. Between 2003 and 2015, he was assistant professor and associate professor in the Department of Electrical & Computer Engineering at NUS.

His research and education interests include integrated circuits, microwave and communication engineering,

satellites, radar, digital beamforming, design, and innovation. He returns to the Faculty on a joint appointment between Engineering ECE and Design and Innovation Centre. Assoc Prof Mouthaan looks forward to working with students, colleagues and the industry on innovative and challenging projects.

## TRANSFERS

We also extend our welcome to the following colleagues from the Engineering Science Programme (ESP), who were transferred to our Department on 1 January 2017.

- Dr Nelliyan **Karuppiah**, Instructor
- Mr **Tan** Huei Ming, Teaching Assistant
- Dr **Ng** Gee Wah, Adjunct Associate Professor

## PROMOTIONS

### Academic staff

- Dr Dipti **Srinivasan** - to Professor
- Dr **Qiu** Chengwei - to Associate Professor
- Dr **Luo** Sha - to Senior Lecturer
- Dr **Zhang** Jianwen - to Senior Lecturer
- Dr **Chua** Dingjuan - to Lecturer
- Dr Sangit **Sasidhar** - to Lecturer

### Non-academic staff

- Ms Susan A **Silva** - to Management Assistant 2
- Ms Aruchunan **Sarasupathi** - to Laboratory Technologist 2
- Mr Eric **Poon** Wai Choong - to Laboratory Technologist 2
- Mr **Zhang** Hengwei - to Laboratory Technologist 2
- Ms **Xiao** Yun - to Laboratory Technologist 3

## RETIREMENT

The Department bade farewell to Ms **Sim** Mong Choon and Mr **Teo** Thiam Teck who retired in March 2017. We thank them for their many years of service and wish them all the best.

## ECE'S TRIPLE HONOURS

Three faculty members did ECE proud when they were elevated to IEEE Fellows with effect from 1 January 2017.



### PROF LIM TENG JOON

Engineering Vice Dean (Graduate Programme) Prof **Lim** Teng Joon has great interest in research. His strong research track record can be summarised as the embodiment of "smart" combinations of disparate statistical inference, detection and estimation tools to solve wireless transmission problems of practical significance.

**Prof Lim has made significant contributions to the design and optimisation of code-division multiple access (CDMA), orthogonal frequency division multiplex (OFDM), and cooperative relaying/sensing technologies. The lasting impact of his work is evident from the more than 5,000 citations of his publications and their influence on wireless technology development.**

### ASSOC PROF YAN SHUICHENG

Assoc Prof **Yan** Shuicheng's research areas include machine learning, computer vision and multimedia. Assoc Prof Yan has authored/co-authored hundreds of technical papers over a wide range of research topics, with a Google Scholar citation of over 20,000 times and an H-index of 66. He was also the ISI Highly-cited Researcher of 2014, 2015 and 2016. Besides having received seven prizes or honorable-mention at PASCAL VOC and ILSVRC competitions, Assoc Prof Yan and his team have won for more than 10 times the best (student) paper prizes. Assoc Prof Yan is also an IAPR Fellow.



### ASSOC PROF ZHANG RUI

Assoc Prof **Zhang** Rui is the Assoc Head (Research) in the Department. The IEEE Fellowship is a recognition of his contributions to cognitive radio and energy harvesting communications, two revolutionary and transforming technologies that have the potential of resolving spectrum and energy shortage in wireless communications. Assoc Prof Zhang has made distinctive contributions in both areas and his research work has had a long-lasting impact.

On top of being elevated to IEEE Fellowship, Assoc Prof Zhang Rui received the 5th IEEE Asia-Pacific (AP) Outstanding Paper Award from the IEEE Communications Society (ComSoc) for his paper, "Wireless information and power transfer: Architecture design and rate-energy tradeoff", in IEEE Transactions on Communications 61, no. 11 (November 2013): 4754-4767 X. Zhou, R. Zhang, and C. K. Ho.

In addition, Assoc Prof Zhang also won the 2016 IEEE Signal Processing Society Best Paper Award for his submission, "Optimal energy allocation for wireless communications with energy harvesting constraints," C. K. Ho and R. Zhang, IEEE Transactions on Signal Processing, vol. 60, no. 9, pp. 4808-4818, September, 2012.

Assoc Prof Zhang is honoured to be appointed the Engineering Dean's Chair Professor, from 1 January 2017 to 31 December 2019.





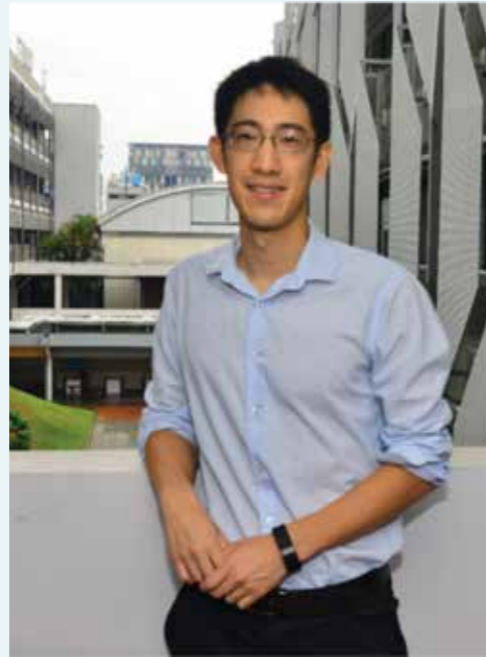
## YOUNG FACULTY WINNING TRIPLE ACCOLADES

Congratulations to Dr John S **Ho** who has been conferred two accolades.

### 2016 NUS YOUNG INVESTIGATOR AWARD

Dr Ho received the 2016 NUS Young Investigator Award. This award seeks to support the early career development activities of young faculty members who are likely to make significant contributions to the development of research at NUS.

**Dr Ho's project broadly aims to develop wireless technologies for bioelectronics and apply them to realise new therapies based on tiny wireless devices. Applications of these systems include miniaturised wireless stimulators for neuromodulation and light delivery for cancer phototherapy.**



### REGIONAL MIT TECHNOLOGY REVIEW 'INNOVATORS UNDER 35'

Dr Ho is also one of 10 honourees of the regional MIT Technology Review 'Innovators under 35' competition for Southeast Asia, Australia, New Zealand and Taiwan. With this honour, he qualifies for consideration to be on the 2017 Global MIT Technology Review 'Innovators under 35' List which recognises the achievements of the world's top young innovators. The event will take place at the MIT Media Lab, US, in the fall of 2017.

Dr Ho is being recognised and awarded for his pioneering research in the development of wireless technologies for bioelectronic (the convergence of biology and electronics) systems that can be used to help treat intractable diseases like cancer and diabetes. By enabling smaller and deeper bioelectronic devices, these technologies could one day enable doctors to prescribe a tiny, wireless device instead of a pill. He has successfully demonstrated this technology via rice grain-sized wireless devices for wireless cardiac pacing and optogenetics in freely moving animals such as mice.

Since the year 1999, MIT Technology Review has been honouring young deserving innovators globally, for their exciting research and innovations spanning a wide spectrum of fields ranging from electronics, computing, nanotechnology, medicine, communications, etc.

Dr Ho is honoured to be placed in the 2017 Forbes 30 under 30 Asia List (Healthcare and Science category). He is amongst the 30 honourees under the age of 30 from 24 countries across Asia Pacific, to be recognised for their achievements and contributions.

Dr. Ho obtained his Master's and Ph.D. from Stanford University, where he was a National Defense Science and Engineering Graduate Fellow.

Well done, Dr Ho!



Wireless powering of a tiny bioelectronic device in a transparent model of the human heart

## ASEAN OUTSTANDING ENGINEERING ACHIEVEMENT AWARDS 2016

Congratulations to Prof **Hong** Minghui, and Dr **Luo** Sha of ECE Department, who received the ASEAN Outstanding Engineering Achievement Awards 2016 in recognition of their remarkable engineering accomplishments.



Prof Hong at CAFEQO, Philippines



(From left) Mr Ajie Nayaka **Nikicio** and Mr Harsh **Kumar** receiving Dr **Luo** Sha's award on her behalf and Prof Hong Minghui (extreme right) together with other NUS recipients of the ASEAN Outstanding Engineering Achievements Awards 2016

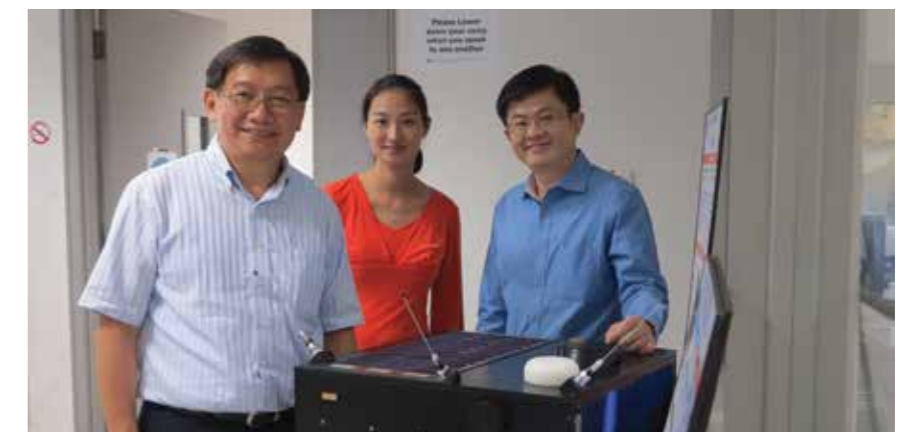


Launch of NUS' First Two Satellites



The awards were presented at the 34th Conference of ASEAN Federation of Engineering Organisations (CAFEQO 34), held from 20 to 24 November 2016 in Manila, Philippines.

Both ECE faculty were conferred the awards for the engineering excellence shown in their scientific research on Optical Microsphere Nanoscopy (Prof Hong Minghui) and NUS' First Nanosatellite (Dr Luo Sha).



NUS Engineering Team comprising (from left) Prof **Goh** Cher Hiang, Dr Luo Sha and Assoc Prof **Soh** Wee Seng



# TOP PROJECT AWARD AT SMI RESEARCH SHOWCASE

ECE's Assoc Prof Sanjib K **Panda** and his team of researchers were conferred one of the Top Project awards of the SMI (Singapore Maritime Institute) Research Showcase in October 2016. The project, "Condition Monitoring and Predictive Maintenance of Marine Transformers", was led by Assoc Prof Panda as Principal Investigator.



NUS Researcher Mr Saurabh **Bhandari**, a member of the project team, with the team's research exhibit at the SMI Research showcase in NTU

The project focuses on minimising unscheduled breakdowns and downtime for critical marine assets such as transformers, thus paving the way for futuristic unmanned ships in the long term.

The Top Project award, announced on 5 December 2016, comes with a cash prize of S\$3,000. The awards were selected on 22 November 2016 after a closed-door presentation session and evaluation by a judging panel

consisting of experts from the marine industry and research institutes.



Participants at the project showcase held at NTU

# 2016 FACULTY TEACHING AWARDS

The awards were presented to the faculty recipients by Head of ECE Department, Prof John **Thong**, during the Department Faculty Meeting on 18 November 2016. Our congratulations to all the awardees. Keep up the good work!

## Honours List

- Assoc Prof Mehul **Motani**
- Dr Rajesh C **Panicker**

## Commendation List

- Assoc Prof Anjam **Khursheed**
- Dr **Chua** Dingjuan
- Assoc Prof **Heng** Chun Huat
- Assoc Prof **Loh** Ai Poh
- Dr **Luo** Sha
- Dr Sangit **Sasidhar**
- Assoc Prof **Tan** Kay Chen
- Dr **Tan** Yan Fu, Vincent
- Dr **Yeo** Boon Thye, Thomas

## Innovative Teaching Award (Bronze)

- Dr **Zhang** Jianwen



# WELCOME 2017 APPRECIATION LUNCH

On 24 January 2017, the non-academic social committee organised a "Welcome 2017 Appreciation Lunch" at LT6. The event was attended by the ECE management committee and non-academic staff.

Staff hoping to interact and catch up with one another in a relaxed atmosphere had a lot to look forward to at the appreciation lunch.



The ECE Management Committee at the lunch

Attendees of the event were treated to a delicious Nonya cuisine buffet lunch. Staff also enjoyed a balloon sculpting session. With the event organised during the lunar new year period, balloon lanterns were made

and mandarin oranges distributed to staff to symbolise good luck for the new year.

A committee member, Ms **Sim** Mong Choon, taught participants how to make Chinese lanterns using red and yellow balloons. Participants were very engaged in the lesson, eager to make their very own lanterns.



Participants queuing up for the sumptuous lunch

While some people were slightly apprehensive of bursting balloons, they managed to brave through the session.

The lunch received a thumbs-up from several staff. The committee was pleased to hear from participants that they looked forward to the next gathering. Kudos to the non-academic committee for organising a successful lunch and to management for their support.



The happy faces of our balloon artists

# HIGH TEA AT GARDENS BY THE BAY

More than 70 ECE staff members joined a fun-filled social event at Gardens by the Bay on Friday, 24 February 2017. Besides enjoying delectable Chinese dim sum at the award-winning Majestic Bay restaurant, participants played team-building games and won shopping vouchers at a lucky draw.



In the first game, each table worked together to build a tower out of straws, duct tape and glossy paper. Our discerning judges, Head of Department Prof John **Thong**, Assoc Prof **Chor** Eng Fong, and Assoc Prof Vivian **Ng**, evaluated these creative straw towers based on height, beauty, and robustness. The winning table won not only bragging rights but also great prizes.



In the second game, participants competed to make the best terrariums. Guided by our resident expert, Miss Sim Mong Choon, participants turned raw materials including soil, coloured stones, plants, and figurines into mini worlds of wonder and fantasy. Our judges had a tough time selecting the best creation but eventually decided on three.



The three proud winners, Mdm **Ah** Lian Kiat, Mr Eric **Siow** and Ms Melissa **Lam**, took home vouchers for their fantastic efforts.

Of the top 10 prizes given out

at the lucky draw, Mr Joseph **Ng** won the first prize, a whopping \$300 voucher. Participants who did not win prizes at the lucky draw still received \$20 vouchers while those interested were given free tickets to visit the world-famous Flower Dome after the event.





# HYBRID FLEXIBLE ELECTRONICS – OVERCOMING THE LIMITATIONS OF RIGID AND PRINTED ELECTRONICS

Over the last 50 years, microelectronic advances have transformed our experience and lifestyle. Box televisions have become ultra-thin curvy high-resolution displays. Brick phones have given way to slick mobile phones and smart watches. Electronic devices are becoming increasingly light-weight, conformal and more intimately integrated with us.



Prof **Thean** (front) with (standing from left) Prof Nitish **Thakor**, Assoc Prof **Yang** Hyunsoo, and Prof **Lim** Chwee Teck, whose projects involve the use of flexible technology

Flexible electronics are emerging over the last decade to enable this evolution in form factor. Unlike rigid semiconductor chips, ink-printed organic and inorganic electronics enable low-cost components and circuits that can be made in large area format and even on paper. However, for certain printed components, performance and reliability may be poor compared with their rigid complementary metal oxide semiconductor cousins. Hence, enabling sophisticated electronic systems with flexible electronics is highly challenging. An emerging field of hybrid flexible electronics where printed and rigid semiconductor technologies combine to overcome their respective limitations has become very promising over the last few years.

A new multi-team research programme at NUS, headed by ECE's Prof Aaron Thean has been formed to spearhead innovations in Hybrid Flexible Electronics. This Hybrid Integrated Flexible Electronic Systems (HiFES) programme proposes system approaches to flexible electronics by integrating materials, device fabrication and design through co-design. This brings together multi-disciplinary expertise across the

campus with clear goals towards realising more functionally capable devices. The mission of the programme is to push the frontier of the technology to address three broad areas of application: smart human machine interfaces and wearables; autonomous robotics; and diagnostic and medical applications.

Smart human interfaces and wearables are anticipated to be the next driving force for consumer electronics while autonomous robotics include smart skin applications where machines are integrated with flexible and stretchable factors to allow them to take on human forms or attributes. For example, Prof Nitish **Thakor** and his team are working on an "electronic skin" embedded with minute pressure sensors that measure changes due to contact. This can someday lead to sophisticated robotic limbs capable of intricate operations with tactile feedback like human hands.

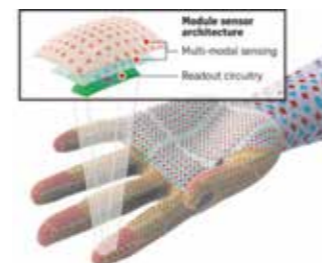


Fig. 1 Illustration of Smart Skin (photo credit: The Straits Times)

Another area of diagnostic and medical applications involves new monitoring sensors for health science and conditions that are not only portable but can be attached to or wrapped around a human body. NUS Engineering already has a few projects in the works that will kick off this initiative. An existing project from Prof **Lim** Chwee Teck's research team has already demonstrated a pressure-sensing insole for shoes that is applied to assist diabetics who have lost their sense of touch in their feet. The liquid metal fills the sensors and transmits foot pressure information that medical doctors and patients use to analyse foot motion. In this way, corrective actions can be implemented to avoid diabetic foot ulcers. The device is undergoing clinical trials in partnership with a hospital and has also been commercialised by an NUS startup, Flexosense.

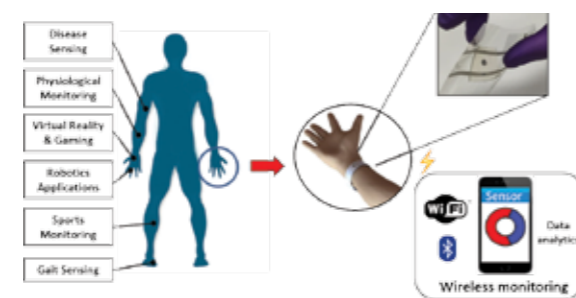


Fig. 2 Liquid Metal-Based Sensor for on-body pressure sensing from Prof **Lim** Chwee Teck

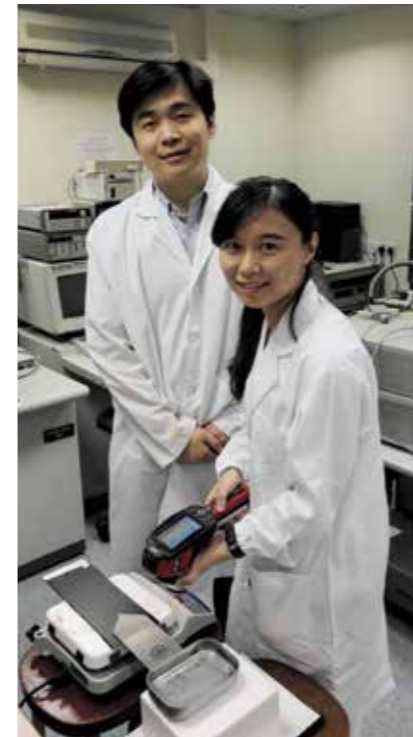
several local and overseas companies and institutes have expressed interest in the facility and programme while discussions are ongoing with these potential partners. "The Principal Investigators (of each project) will be interacting with some of the companies who may be on the receiving side of the technology in the future to get feedback on what they would find interesting," he added.

To push the technology and enable innovation that extends from materials to design, a new state-of-the-art research facility will be built. The centre will include world-class fabrication technologies and serve as a hub to further develop and enhance heterogeneous electronic systems.

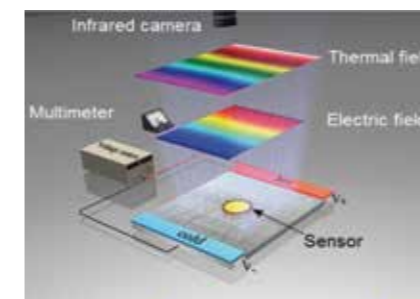
Prof Thean shared that

# MAKING UNDETECTABLE SENSING POSSIBLE

FOR their innovative discovery, Assoc Prof **Qiu** Cheng Wei and his team have the humble chameleon to thank. The lizard's camouflage shell provided inspiration for the ECE team.



(From left) Assoc Prof **Qiu** Cheng Wei and Ph.D. student **Bai** Xue with the results of their research



This is the first time that a sensor has been proven (theoretically and experimentally) to operate undetected in multi-physical fields simultaneously. The figure shows the schematics of multi-field operations for one physical design

The team has developed the world's first innovative camouflage shell that hides both thermal and electronic sensors simultaneously and effectively without compromising performance.



A piece of metal with the shell-coated material

The same technologies available today that make sensors 'invisible' also make them ineffective in certain circumstances: the sensors only work in either thermal or electrical environments. The ECE team developed an ideal 'invisible' sensor by covering it with a thin shell made of pure copper, designed to significantly reduce the perturbation of heat flux and electric current simultaneously. The thickness of the shell is manufactured based on detailed calculations to allow precise manipulation of external multi-physical fields to insulate the sensor. Hence, once the shell is wrapped around the sensor, the coated sensor becomes 'invisible' in both thermal and electric environments while it continues to receive incoming signals from outside.

**Explained Assoc Prof Qiu, "After conducting numerous research experiments in the past 14 months, we came up with a design of a camouflage shell that not only mimics surrounding thermal fields but electric fields too at the same time. The object under the camouflage shell becomes truly invisible as its shape and position cannot be detected as either thermal or electric images. While remaining invisible, the object can continue to probe the temperature and voltage in the environment that it is located."**

Assoc Prof Qiu added that their innovative camouflage shell could open up new avenues for advanced sensing and security systems. "Sensors which are used to monitor current and heat flow in strong voltage or high temperature environments are easily damaged. Our camouflage shell can protect the sensors from harsh environments and enhance the accuracy of the invisible sensors as they eliminate any distortion around the sensors. This feature is key to our study of other applications, such as the use of the camouflage shell on special mission fieldtrips."

The team is also working on developing multifunctional invisible sensors that have instantaneous stealth ability. Drawing a comparison with the chameleon, Assoc Prof Qiu said, "The skin of a chameleon is made up of several layers of specialised cells containing various pigments while the outermost layer is transparent. The cells beneath the skin change colour based on light intensity, temperature and the chameleon's mood. Our team's creation is like an improved 'skin' for the chameleon such that it can become invisible when it appears in front of thermal and electric signal detectors!"

The researchers estimate that a palm-size camouflage shell will cost less than S\$80, as the shell is fabricated from naturally available materials such as pure copper and stainless steel. The team is in talks with power companies and funding agencies to explore the fabrication potential of the camouflage shell.

## Related links:

Experimental Video on Youtube:



<https://www.youtube.com/watch?v=102OJmDcK2M>



# VEHICULAR WIRELESS MESH NETWORK PILOT

In collaboration with StarHub, Veniam and ComfortDelGro, the pilot of Singapore's first wireless mesh network for connected vehicles was launched on 23 September 2016. Unlike traditional wireless network infrastructure, the mesh platform leverages on vehicles as mobile Wi-Fi access points that connect to one another and to fixed points in buildings or bus-stops within the NUS campus. This approach helps extend overall Wi-Fi network coverage and enable a myriad of Internet of Things (IoT) devices to be connected seamlessly. The wireless mesh access points are powered by a combination of Dedicated Short Range Communications (DSRC) connected vehicle technology, 4G and Wi-Fi, providing seamless handovers and continuous connectivity.

With this deployment, NUS staff and students can access seamless Wi-Fi while travelling on NUS campus shuttle buses. It also allows NUS and external partners to leverage on the data generated from this network to analyse and address mobility trends and challenges. Such mobility trends and challenges shed light on efficient commuting patterns within NUS and provide insights for transportation and logistics companies in Singapore.

The year-long project at NUS is part of the NUS Living Lab initiative led by NUS' ECE and the Interactive and Digital Media Institute (IDMI). The project aims to transform the university into a major test-bed or large living laboratory for new technologies so that start-ups, firms or multi-national companies can use NUS as a real-world setting to test new services before they are commercialised. Also part of StarHub's Connected Labs initiative, the pilot collaboration aims to build an extensive test-lab for developers and researchers to validate their solutions in a real-life environment through the use of real actionable data and deep analytical insights.



NUS bus with mobile hotspot

Prof Lawrence **Wong**, Deputy Director of IDMI, indicated that the trial will allow NUS to conduct research into wireless mesh vehicular enhancements, commuting and mobility trends, as well as other technologies that will drive Singapore towards becoming a Smart Nation. He added that since the network deployment, 39 ComfortDelGro buses have been connected along with 15 fixed access points around the campus, with a whopping 78,000 unique Wi-Fi users tapping onto the network. This has resulted in more than two million internet sessions culminating in 580 gigabytes of online traffic exceeding 175,800 hours of surfing.

The data generated from this network will also facilitate usage by NUS to better understand transport trends on campus and provide insights into its management of campus operations and services. For instance, the network can track exactly where shuttle buses are on campus and determine the number of passengers on the buses in real-time. This is useful in refining vehicular fleet surveillance, scheduling and management so that buses can be deployed accordingly to meet demand. In the longer term, NUS start-ups could also leverage the information gathered through the technology to come up with solutions and create applications that will benefit both commuters and the transportation industry.



DSCR Antenna



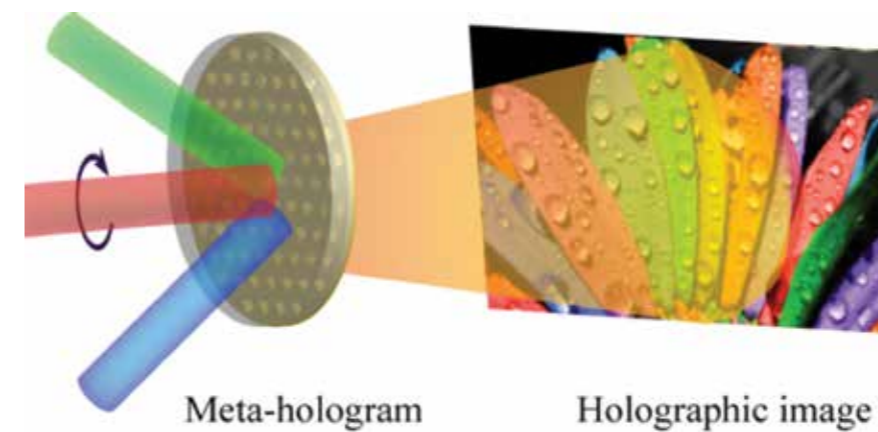
The wireless mesh access points are powered by a combination of DSRC connected vehicle technology, 4G and Wi-Fi, providing seamless handovers and continuous connectivity

# FULL-COLOUR 3D META-HOLOGRAPHY FOR NEXT GENERATION VR/AR DISPLAYS

Holography technology offers a powerful way to manipulate light properties such as phase and amplitude. It can be used in many important applications including beam shaping, authentication and advanced display techniques.

Holography technology enables 3D imaging to be seen by the naked eye, a key technique used in Augmented Reality (AR) and Virtual Reality (VR). However, the performance of conventional hologram techniques is highly limited: the viewing angle is small and the imaging quality for 3D patterns is poor.

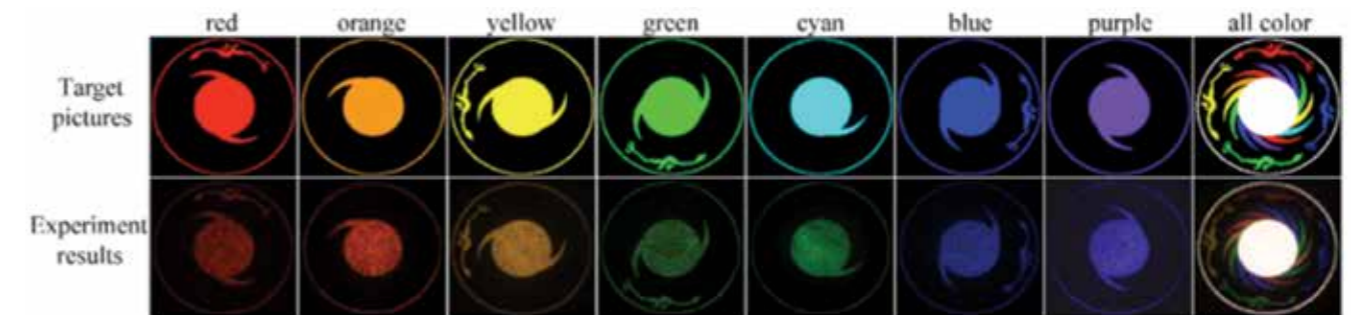
To overcome these limitations, ECE's Prof **Hong** Minghui's team collaborated with Prof Xiangang **Luo's** team from the State Key Laboratory of Optical Technologies on Nano-fabrication and Micro-engineering (SKLOTNM), Institute of Optics and Electronics, Chinese Academy of Sciences. They recently demonstrated the world's first full-colour spectrum 3D imaging with a broad viewing angle which was realised with just a single layer of optical nano-antenna, novel meta-surface structure. This technique enables the fabrication of 3D projectors for the naked eye with a broad range which breaks the barrier between real and virtual worlds. For instance, figures in movies or cartoons can be projected into our living space. We can also make a phone call to a faraway friend with his virtual figure just sitting in front of us.



An illustration of full-colour meta-holography

**More importantly, the teams' meta-hologram technique is highly compact, enabling integration into mobile phones, thus turning them into portable 3D projectors. Despite being at an early stage, this breakthrough not only produces remarkable image quality, with a signal-to-noise ratio (SNR) five times better than previous meta-hologram designs, it also paves the way for new meta-hologram devices, an achievement not seen before. For example, the seven-colour meta-holography and multi-colour 3D imaging demonstrated by the teams for the first time in the world is a big advancement in 3D imaging techniques. It shows huge potential for a broad range of applications, such as data storage, security, and authentication.**

The teams' research was published in Science Advances, which was founded by the American Association for the Advancement of Science (AAAS).



Seven-colour meta-holographic image of the Sun Phoenix, a pattern discovered on an ancient artefact – a gold coil from the Chinese Shang dynasty 3000 years ago



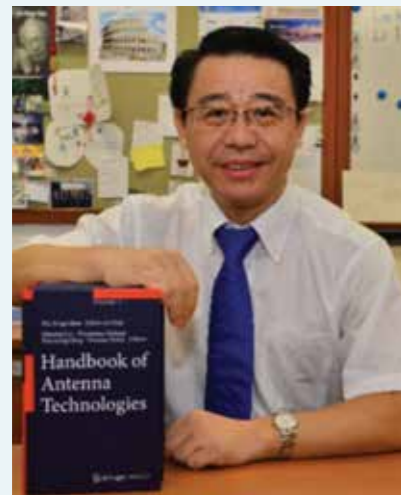
# HANDBOOK OF ANTENNA TECHNOLOGIES

ECE's Prof **Chen** Zhining is the editor-in-chief of a comprehensive handbook which provides quick reference to antenna technologies and applications.



The "Handbook of Antenna Technologies" in four volumes

Prof Chen, together with four other editors (Dr Duixian **Liu** from IBM Research Center, US, Prof Hisamatsu **Nakano** from Hosei University, Japan, Dr Xianming **Qing** from the Institute for Infocomm Research, A\*STAR, Singapore, and Prof Thomas **Zwick** from the Karlsruhe Institute of Technology, Germany), have published the "Handbook of Antenna Technologies" in four volumes.



Prof **Chen** Zhining is the editor-in-chief of the new handbook

Spanning 3,473 pages, the handbook was published by Springer on 17 September 2016. It is the most comprehensive in the field of antenna technologies. Featuring topics ranging from fundamentals, basic design, performance-enhanced technologies to applications, the handbook covers almost all areas in antenna technologies.

It took the team two years to complete the huge project. The team led by Prof Chen worked with 140 experts in the field from all over the world. The editorial team from Springer put in much effort to publish the 76 chapters of the handbook on schedule.

The handbook aims to capture the rapid development of antenna technologies, particularly in the past two decades. Also showcasing newly developed technologies and the latest applications of antenna technologies, the handbook provides readers with a comprehensive updated reference covering theory, modelling and optimisation methods, design and measurement, new electromagnetic materials, and applications of antennas. Covering not only key antenna design issues, the handbook also delves into fundamentals and issues related to antennas such as transmission, propagation, feeding structure, materials, fabrication, measurement, system, and unique design challenges in specific applications.

Offering a high-level historical review of technology, detailed technical descriptions and the latest practical applications, the handbook is useful as a quick and complete technical reference.

More information can be found at:



<http://www.springer.com/gp/book/9789814560436>



<https://www.youtube.com/watch?v=IKuf1922ih4>

# OUR DISTINGUISHED ENGINEERING ALUMNUS MR MASAGOS ZULKIFLI

The Department extends our heartiest congratulations to our distinguished alumnus, Mr **Masagos** Zulkifli, Minister for the Environment and Water Resources. Minister Masagos was conferred the Distinguished Engineering Alumni Award (DEAA) in recognition of his significant contributions to our nation. The award ceremony was held in conjunction with the NUS Engineering Alumni Gala Dinner 2016, on 2 September 2016, at the Kent Ridge Guild House.



Mr **Masagos** Zulkifli, Minister for the Environment and Water Resources (third from left) was the 2016 DEAA recipient. With him were his family members. Also in the picture were NUS Senior Management: (from left) Prof Victor **Shim** (Vice Dean - External Relations & Outreach), Prof **Tan** Chorh Chuan (NUS President), Prof **Chua** Kee Chaing (NUS Engineering Dean, second from right) and Mr Victor **Nian** (President of the Engineering Alumni Singapore, first on right)

Mr Masagos graduated from the Department with a Bachelor's degree (First Class Honours) in 1988, and a Master of Science in 1994. He began his career with Singapore Telecommunications Limited in 1988 and subsequently became the Chief Executive Officer of SingTel Global Offices.

He believes in doing things with a heart, taking a keen interest in the welfare of Singaporeans. He joined the Public Service in 2006 where he focused on his interests and passion. Minister Masagos is actively involved in Muslim community affairs and grassroots activities where he tirelessly engages Tampines residents as adviser to Tampines Grassroots Organisations. He also played a key role in the formation of Mercy Relief which has since evolved into one of the organisations at the forefront of disaster relief in the region.

**The Engineering Faculty alumni strength has grown through the years. There are more than 51,000 alumni today, with many having excelled in their respective careers or are making their mark in various capacities.**



(From left) Minister Masagos and NUS President Prof Tan Chorh Chuan at the Alumni Gala Dinner



Minister Masagos (right) receiving his award from NUS Engineering Dean, Prof Chua Kee Chaing



# NEW EDUCATIONAL FRAMEWORK

The Department, NUS Research Institute (NUSRI), Suzhou and Partner Chinese Universities are working together to offer a new educational framework.

Based on their existing admission criteria and academic standings, the 3+1+1 framework leads to a Bachelor's degree at the Partner Chinese universities after four years of study (with one year to be spent at NUSRI, the first "+1 year"). The NUS Masters of Science (Electrical Engineering) degree is then offered at NUS after a further one year (the second "+1 year") on course/project work. Conceptualised in 2016, the proposal has now been approved by the university senate.



Trips are organised regularly for the class and have so far included a visit to the old town of Luzhi, the Pingjiang historical District and Guanqian Street; and feasting on the famous crabs on the beautiful Yangcheng Lake

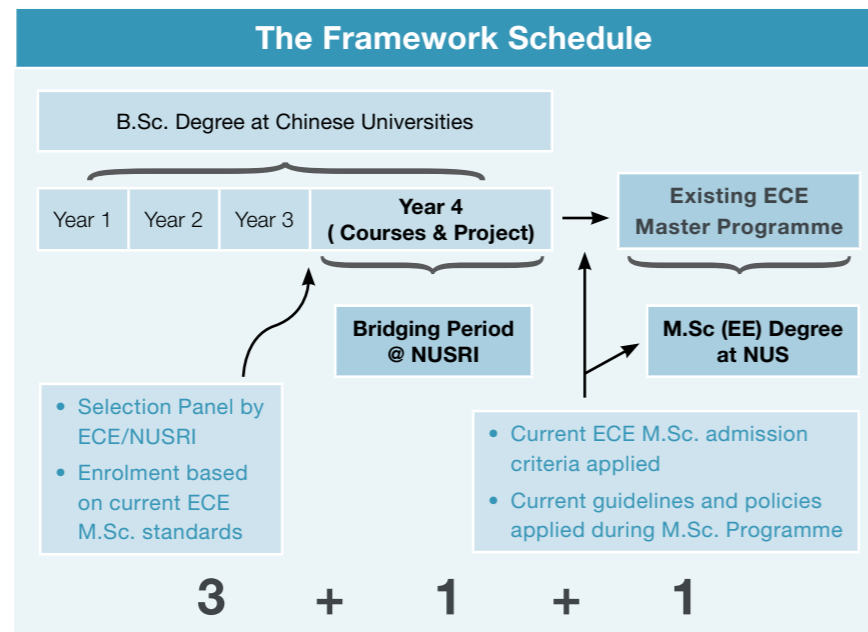
The framework schedule is summarised in the figure below. Students at the partner Chinese universities can apply to join the program at the end of Year 3. Applications undergo a selection panel before enrolment. Students enrolled in the program will continue their studies at NUSRI at Suzhou for their 4th year as the bridging period. Upon completion of the bridging period, students will be awarded the B.Sc. Degree by their home universities in China.

Students can then apply to enrol into the M.Sc. (EE) programme for their 5th year. Upon completion of the M.Sc. (EE) programme, students will be awarded the M.Sc. (EE) degree by NUS.

In the new framework, NUSRI offers two modules on technical communication, writing and seminars, four elective EE modules (taught by ECE staff) and the final year project module. Currently, six Chinese partner universities are participating in the framework, and 24 students have enrolled in the first batch.

**Besides academic activities at NUSRI, social programmes and team-building activities are arranged for students to visit cultural places in Suzhou. Other activities, such as dinner parties, are held every month at restaurants for everyone to interact and share experiences over food in a relaxed environment.**

The department envisages the number of students enrolled in the framework to increase by 30% each year for the next three years.



(Front row, centre) Prof **Tan** Eng Chye, (Deputy President of Academic Affairs; and Provost of NUS) visited the students under this program in NUSRI. Together with Prof Tan are Prof **Xu** Guoqin, Director of NUSRI and Dr **Zhou** Zhiying, Associate Director of NUSRI (fourth and third from right, respectively). Prof Tan chatted with the students regarding their living conditions and study progress

# OLIN: MY ONE YEAR JOURNEY

By **Ang** Wei Jian Anderson ('17, Electrical Engineering)

"The early millennials," a wistful F. Scott Fitzgerald might have written today, "are different from you and me." The experiences I had in America corroborated with that thoroughly. As a premillennial, aged well and wistfully by my army days, I went into America wide-eyed, hoping to find new ways to learn, and new perspectives to glean.

My Student Exchange Programme (SEP) adventure was a little different from the normal. For almost a year, I was based in a tiny suburb outside of Boston, in a college that numbered no more than 370 students.

It was here I realised that I was probably the oldest student. I was also a racial minority, in a state that was heavily populated by a single ethnic demography.

Beleaguered as it sounds, my new context allowed me new lenses, through which I could unravel many learning points. Being a Y-generation person in a generation-Z ecosystem, a true national and ethnic minority in a cosmopolitan, but mostly white demography, a few of many shoes/boots I walked in.

Olin was founded in 1997, with a vision to revolutionise engineering education. There, I was exposed to a deeply liberal learning environment - projects were open-scoped, machine shops and scrap materials lined the hallways, and hack culture was embedded in the college's DNA. Mailing lists were populated with collaboration requests, and young Americans used their virtual platforms as idea exchanges for schoolwork, political viewpoints, and more.

A millennial-driven culture underpinned the school's identity; undergraduates were co-teaching specialised classes in upcoming



Photograph by Anderson Ang



Photograph by Sarah Bassagal Delrieu

topics like Node.js and EV design instead of professors, and the relationship between staff and student was a colloquial one - it felt like a partnership, than a hierarchy. Terms like the Internet of Things (IoT) were not merely ideas, but a culture lived out everyday. Our tools were in the cloud, and students were constantly striving to be on the latest platforms; unreleased, betas, or otherwise. This was a microcosm of what the future of engineering was, a force of unstoppable change.

I was amazed, but also terrified at the same time - the culture and efficiency of this educational experiment left me deeply inspired, but there was a fear of irrelevancy and conventionality in my blood, that I couldn't quite seem to shake away. A once-in-a-lifetime opportunity at my doorstep, but I was fearful of change.

Innovation would have its way. Before I knew it, I began to approach life at Olin with an empty cup, hoping to fill it anew by my experiences. And I surely did. Over the course of the semester, I worked with Agastya International Foundation and the African Women Advocacy Project to create a rugged and miniaturised optics science kit, for lessons on the go. Our project was



Photograph by Anderson Ang

crowdfunded, just like many of the Olin projects.

I also had the privilege to compete in Formula SAE Hybrid 2016 as an engineering member of Revo, Olin's electric motorsport team. It was the college's first outing at the league, and our first time building an electric vehicle (EV) from scratch. It was truly a groundbreaking experience. We even walked away with 2nd prize in design!

I would like to thank the ECE Department for giving me this incredible opportunity, and to Olin, thank you, for allowing me to view engineering in a different light.



# WELCOME BACK PARTY 2017

ECE students and staff were treated to a fun and activity-packed afternoon just four weeks into the semester. Held on 3 February 2017, the carnival theme of the party was chosen by the Undergraduate Student Council (USC) with the objective of bringing professors and students together to get into the swing of Semester II of Academic Year 2016/2017.



Final year students contributing their feedback and concerns to Dr **Luo Sha** (middle of photo), Ms Elyn **Yip** and Ms Susan **Silva** (front row second and third on right respectively)

The event was kicked off by Head of ECE, Prof John **Thong**. He gave a few words of encouragement to the students who had gathered outside LT6 and updated them on the department's upcoming plans. Shortly after, the students were invited to enjoy a tasty spread of local cuisine.

In true carnival style, the attractive prizes promised by USC enticed students to rival one another in breaking the high-score record at the six game stalls. Archery, Darts and Shoot-Them-Down were among some of the hot favourites. Academic staff joined in the fun as they too tried their hand at beating high scores. The lucky winners were rewarded with a premium pair of Klipsch earphones.

Amidst the music, laughter and chatter, it was heartening to see



students dip into their pockets to offer generous donations when told of a fellow student in need. That's the ECE spirit!

**Concurrently, several cohorts from the ECE programmes also conducted their individual Meet the Year Coordinator events. This provided an informal platform for students to discuss with their year coordinators their curriculum and student life experiences. It was a helpful session as students shared their hopes and wishes.**

All in all, the Welcome Back Party was a great way for students to kick-start the semester.



Students competing to beat the high score of the six stall games

# NOVEL HYBRID UAV WITH SPECIAL FEATURES

Two ECE Ph.D. students, **Wang Kangli** and **Ke Yijie**, supervised by Prof Ben M. **Chen**, spent four years developing a novel hybrid unmanned aerial vehicle (UAV). The U-Lion is a hybrid UAV capable of taking off and landing vertically like a helicopter. It is also able to transit to cruise flight like normal airplanes.

The wings can be fully retracted or expanded, to enhance stability in VTOL mode or to provide efficient lift at cruise flight. The U-Lion's flying capabilities include vertical take-off and landing, cruise flight and autonomous transitions. Its novel technology means that this special UAV is able to endure long flight distance and duration.

The team's research results, published in Science China Information Sciences, (Volume 60, March 2017) have also appeared in the news media of professional societies, such as American Association for the Advancement of Science (AAAS) EurekAlert! Association for Computing Machinery (ACM); Phys. Org; sUAS News; Institute of Mechanical Engineering and AZoRobotics.

The three flying modes of the hybrid UAV U-Lion



Wings closed while hovering      Wings open while hovering      Cruise flight

# CHAMPIONS AT THE SINGAPORE AMAZING FLYING MACHINE COMPETITION

The ECE UAV Team, U-Lion, won again the overall championship and the best platform design award in the fully autonomous category at the 2017 Singapore Amazing Flying Machine Competition (SAFMC 2017) held on 17 March 2017.

The proud U-Lion team was led by research fellow Dr **Lai Shupeng** with members comprising scholars from the NUS Graduate School for Integrative Sciences and Engineering, **Bi Yingcai**, **Lan Menglu**, **Li Jiaxin** and ECE research engineers, **Qin Hailong** and **Zhang Kun**.

The U-Lion team is associated with ECE's NUS Unmanned Systems Research Group under the supervision of Prof Ben M. **Chen**.



<http://uav.ece.nus.edu.sg/index.html>



It's medals galore for ECE!



Team U-Lion members (from left), Qin Hailong, Zhang Kun, Bi Yingcai, Lan Menglu, Li Jiaxin, posing with the Guest of Honour at the award ceremony, Dr Mohamad **Maliki** bin Osman, the Senior Minister of State, Ministry of Defence and Ministry of Foreign Affairs



# GRADUATE STUDENT AWARDS

ECE's graduate students keep the NUS flag flying high with these awards.

## IECON 2016 AWARDS

Congratulations to ECE Ph.D. students Mr Amit Kumar **Singh** and Ms Satarupa **Bal**. They won the Best Session Presentation Awards at the 42nd annual conference of the IEEE Industrial Electronics Society (IECON 2016), held from 24 to 27 October 2016 in Firenze (Florence), Italy. In addition, Ms Bal received the "IES Student Paper Travel Assistance" at the conference.

Ms Bal's prize includes a certificate and up to US\$2,000 travel cost reimbursement for her paper, "Comprehensive Study and Analysis of Naturally Commutated Current-fed Dual Active Bridge PWM DC/DC Converter". She is supervised by Prof Dipti **Srinivasan** and Dr Akshay K **Rathore**.



Mr Singh, under the supervision of Assoc Prof Sanjib K **Panda** and Dr Pritam **Das**, presented on "A Novel Matrix Based Non-Isolated Buck-Boost Converter for More Electric Aircraft" at the conference.



## IEEE-ICSET 2016 AWARDS



International Conference on Sustainable Energy Technologies (IEEE-ICSET 2016).

Mr Radhakrishnan's paper, "GIS Integrated Automation of a Near Real-Time Power-Flow Service for Electrical Grids", won a certificate and US\$100 at the conference held from 14 to 16 November 2016 in Hanoi, Vietnam.



Congratulations too to Mr Krishnanand Kaippilly **Radhakrishnan** (Ph.D. student supervised by Assoc Prof Sanjib Kumar **Panda**) who won the Best Paper Award at the 4th IEEE

Also doing ECE proud at IEEE-ICSET 2016 was Mr Rodriguez Gallegos Carlos **David** who won the Best Presentation Award. He is supervised by Assoc Prof Sanjib Kumar Panda and Dr Thomas Gunter **Reindl**.

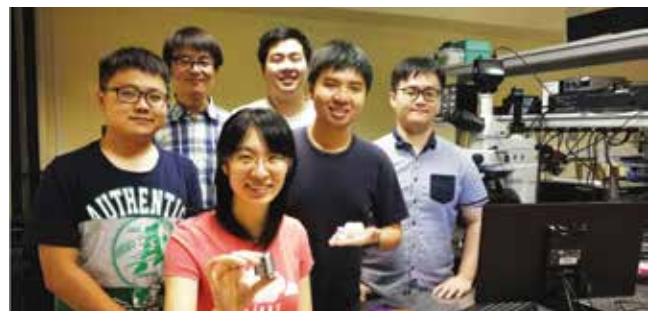
Mr David's presentation entitled "Placement and Sizing Optimisation for PV-Battery-Diesel Hybrid Systems", received a certificate.

## PRACTICUM AWARD, NUS ENTERPRISE

Ms **Wu** Mengxue (Ph.D. student supervised by Prof **Hong** Minghui) won glory for ECE by clinching the Innovation/Entrepreneurship Practicum Award offered by NUS Enterprise.

Ms Wu, who led the Microsphere Nanoscope project team under the mentorship of Prof Hong, received the award at the ENTERprise House (N-House) pitching competition on 18 November 2016. The team was also given S\$10,000 from NUS Enterprise to further develop their prototypes.

Ms Wu and her project team are looking forward to taking their technique further in science and into the commercialisation of their product.



The Microsphere Nanoscope project team members with their prototype. (From left) **Gao** Hui, Dr **Ling** Jinzhong, **Wu** Mengxue (team leader), **Ji** Jiahao, **Chion** Jet Chun and **Zhou** Yan