

ECONNECT

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A BI-ANNUAL PUBLICATION OF THE DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING, NUS

Congratulations to our IEEE Fellows and Provost Chair Professor for bringing honour to the Department

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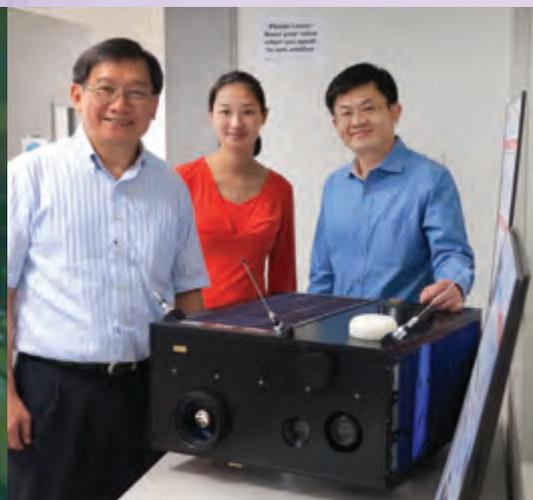
NUS ECE RANKED 6TH IN THE QS WORLD UNIVERSITY RANKINGS BY SUBJECT 2016 FOR ELECTRICAL & ELECTRONIC ENGINEERING



Light bulbs were set aglow with ideas by ECE teams at the recent Intel Singapore Invent 50 Competition held at Marina Bay Sands on 5 December 2015

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NUS ENGINEERING MAKES HISTORIC MARK IN SPACE



ECE community spirit: Students volunteer as peer tutors. The IEEE-Eta Kappa Nu (IEEE-HKN) NUS Chapter, together with the ECE Department and the ECE Undergraduate Student Council (USC), launched a new initiative called the NUS ECE Peer-Tutoring Scheme

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NUS Engineering sent two satellites – Galassia and Kent Ridge 1 (KR-1) into space. They were among six that were shot into space, piggy-backing on TeLEOS-1, the primary satellite by ST Electronics Satellite Systems Centre.

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HoD SPEAKS...



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

“ Our students have continued to garner awards at competitions and international competitions, and we are proud of them. ”

It was a tense moment in the evening of 16 December 2015 as the countdown progressed towards the launch of the 6 satellites from Singapore, as two of those piggybacking the main TeLEOS-1 satellite represented the culmination of more than 2 years of planning and hard work by staff and students from NUS Engineering, and from ECE in particular. Kent Ridge 1 (KR-1) is NUS' first foray into satellite development and this micro-satellite project provides a significant capability build-up to take on further R&D programs in satellite missions. Galassia, a nanosatellite, developed under the auspice of Engineering's Design Centric Programme, provided a team of undergraduate students the opportunity to design and build a satellite from scratch, and also the satisfaction of seeing it launched and working according to design.

In each issue, we give due recognition to the achievements of staff member, students, and alumni. We are delighted that Associate Professor Massimo Bruno **Alioto** has been elevated to IEEE Fellow, as has been our alumna and adjunct staff, Adjunct Associate Professor **Sun Sumei**. Professor Ben **Chen** has been appointed NUS Provost's chair in recognition of his scholarly achievements as well as impactful research in Unmanned Aerial Vehicles (UAVs). Also in this issue, we feature some of the high-impact research that our faculty have been working on, showing the reach of the ECE discipline in diverse areas from understanding the brain to enabling cyber-security.

Our students have continued to garner awards at competitions and international competitions, and we are proud of them. You can read their stories in pages 13 – 16. But such achievements only represent one facet of the pride our students bring. On page 17, we report a peer tutoring initiative in which senior undergraduate students volunteer as peer tutors to provide additional learning support to their juniors. We hope that this scheme, which has been very well received, will kindle a greater spirit of community giving. It is also gratifying to see the student body taking the initiative to enrich student life through the organisation of events, the latest being a “Welcome Back Party”. We trust that these achievements and the fostering of a sense of community go some way in engendering a memorable educational experience at ECE NUS in our future alumni.

CONGRATULATIONS TO OUR IEEE FELLOWS & PROVOST CHAIR PROFESSOR FOR BRINGING HONOUR TO THE DEPARTMENT



**IEEE FELLOW
ASSOCIATE
PROFESSOR
MASSIMO
BRUNO ALIOTO**

Elevated to IEEE Fellow (2016) is Assoc Prof Massimo Bruno **Alioto**. He is being honoured for his contributions to energy-efficient VLSI circuits.

The IEEE Grade of Fellow is conferred by the IEEE Board of Directors upon a person with an outstanding record of accomplishments in any of the IEEE fields of interest. The total number selected in any one year cannot exceed 0.1% of the total voting membership. IEEE Fellow is the highest grade of membership and is recognised by the technical community as a prestigious honour and an important career achievement.

Assoc Prof Massimo was also elected to join the board of governors (BoG) of the IEEE Circuits and Systems Society (CAS). He is currently serving a three-year term as a BoG member that ends in December 2017. The BoG manages and directs the IEEE CAS and is responsible for all operations as the final authority for the society's actions.



**PROVOST CHAIR
PROFESSOR
BEN CHEN**

Professor Ben **Chen** has been appointed NUS's Provost Chair, with effect from 1 April 2016, for a period of three years.

An internationally recognized researcher, Prof Chen is honoured for his scholarly accomplishments and impactful research in the areas of linear systems, robust control, and unmanned aerial vehicles (UAVs).

His work in linear systems has given rise to new structural decompositions, which led to deeper insights into feedback control effects on a system, and to the construction of effective feedback control laws. The practicality of his theories allows them to be applied to solve many real-life problems including UAV issues.

Prof Chen has received numerous international and national research honours and awards. He was elevated to IEEE Fellow in 2007, and was awarded a Changjiang Guest Professorship at China's Nanjing University of Science and Technology in 2010.

He runs a UAV team that is often called upon to serve the needs of the nation. His technical leadership and contributions have resulted in his receiving many formal recognitions from both Ministry of Defence and Defence Science Organisation. His team is recognized as one of the top UAV groups globally. The team has consistently won top prizes in international competitions.

IEEE FELLOW ADJUNCT ASSOCIATE PROFESSOR SUN SUMEI



Effective from 1 January 2016, **Sun Sumei**, Ph.D. graduate from ECE, has been named an IEEE Fellow, class of 2016. She is being recognised for her leadership in design and standardisation of wireless communication systems. A Department Head at the Institute for Infocomm Research (I²R), Agency for Science, Technology, and Research (A*STAR), she is the first Singaporean female scientist to receive this recognition.

Dr Sun's key research focus has been on advanced wireless communication systems since she started her career in the 1990s. Many of her inventions have been adopted by industry for application in 3G/4G cellular and high-throughput Wi-Fi systems. Her significant contributions to bridging theory and implementation, and academia and industry, have also been recognised with

A*STAR's Scientist-Entrepreneur Award in 2008 and the Royal Society of Engineering's Distinguished Visiting Fellowship in 2014. Her current interest lies in cognitive communications for a connected society, machines and 5G systems.

NEW APPOINTMENTS AND PROMOTIONS

FACULTY / ACADEMIC PROMOTIONS

- DR **ZHANG** RUI – promoted to Associate Professor on 1 January 2016

EXECUTIVE AND NON-ACADEMIC PROMOTIONS

- MS **CHUA** WEI NEE, WINNIE – to Manager
- MS **WONG** YOKE CHENG, EUNICE – to Senior Manager

- MR **BOEY** KUM TONG, FRANCIS – to Lab Technologist 3
- MR **NEO** HONG KEEM, ANDERS – to Lab Technologist 2
- MR **TAN** BENG HWEE – to Lab Technologist 2
- MR **UH** CHOON LENG – to Lab Technologist 2

- MS **CHUA** HUI SUAN, CINDY – to Management Assistant 1
- MS **LAM** WAI LENG, MELISSA – to Management Assistant 4
- MS **WONG** SUK MIN, SOEARTI – to Management Assistant 2

FACULTY / ACADEMIC NEW APPOINTMENTS

- DR **FENG** JIASHI joined the Department as an Assistant Professor on 26 October 2015. He was a Postdoctoral Fellow at the University of California, Berkeley, USA, before joining NUS. Dr Feng obtained his Ph.D. degree in Electrical and Computer Engineering from NUS in 2014, a Master's degree in Engineering from the Institute of Automation, Chinese Academy of Sciences in Beijing, China, in 2009, and a B.Eng. in Automation from the University of Science and Technology of China in 2007. Dr Feng's research interests are in the areas of Computer Vision, Deep Learning, Machine Learning, Robust Inference and Big Data Analysis.
- DR **JIANG** NIANJUAN joined the Department as an Adjunct Assistant Professor on 4 January 2016. Dr Jiang is currently a Researcher at the joint A*STAR-UIUC Advanced Digital Science Centre. She received her Ph.D. and B.Eng. degrees in Electrical and Computer Engineering from NUS, in 2012 and 2007 respectively. Dr Jiang's research areas include Structure-from-Motion, Image-based 3D Reconstruction and Modelling, and Sensor-Aided SLAM (Simultaneous Localisation and Mapping).
- DR **YU** XIA joined the Department as an Adjunct Assistant Professor on 25 January 2016. Dr Yu is currently a Scientist and Optics Team Leader at the Singapore Institute of Manufacturing Technology, A*STAR. Dr Yu received her Ph.D. and B.Eng. degrees from the Nanyang Technological University, Singapore, in 2006 and 2003 respectively. Her research focus are in the areas of Photonic Devices and Laser Systems.

ADJUNCT APPOINTMENTS

- DR **AKASH KUMAR** joined the Department as an Adjunct Assistant Professor on 1 October 2015. Dr Kumar is currently the Chair for Processor Design at the Centre for Advancing Electronics Dresden, Technische Universität Dresden, Germany. Prior to that, he was an Assistant Professor with the Department.
- DR **YU** CHANGYUAN joined the Department as an Adjunct Assistant Professor on 4 January 2016. Dr Yu is currently an Associate Professor at the Hong Kong Polytechnic University. Prior to that, he was an Assistant Professor with the Department.

ECE DEPARTMENT PAYS TRIBUTE TO OUR LATE PROFESSOR CHOI WEE KIONG

Colleagues and staff at the Department of Electrical & Engineering (ECE) at NUS are saddened by the passing of Professor **Choi** Wee Kiong on Friday, 13 November 2015.

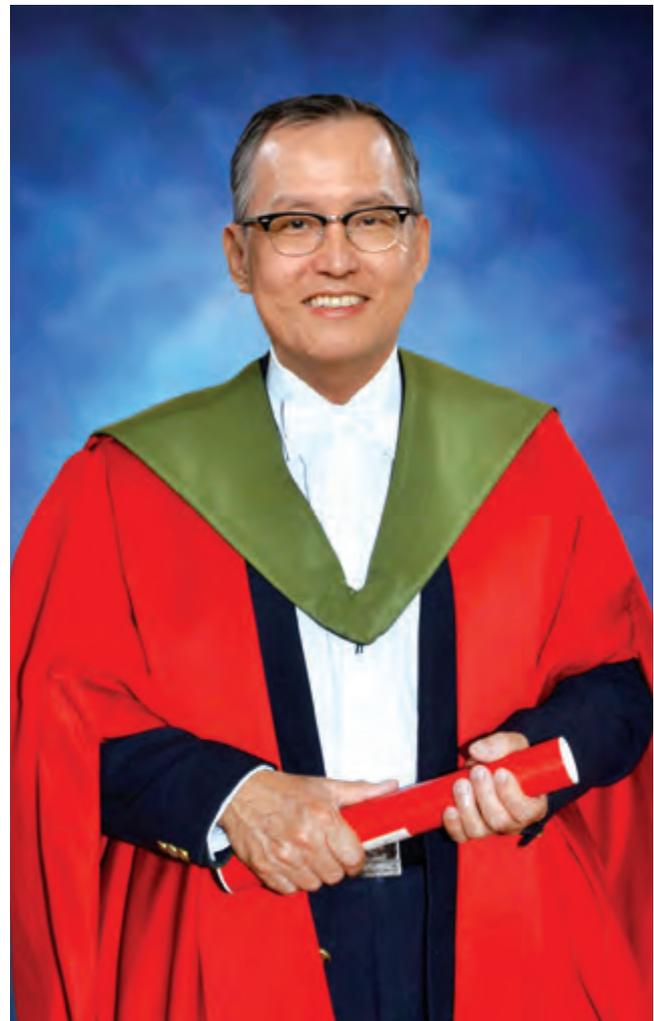
The late Prof Choi Wee Kiong joined the ECE department at NUS in 1991. In his early years at NUS, he was involved in teaching a third year “Materials and Devices” module and collaborated with Prof **Ling** Chung Ho (who has since retired) in Microelectronics fabrication and characterization research at the Microelectronics Laboratory in the Department.

In 1999, Prof Choi joined the Singapore-MIT Alliance (SMA) as a Faculty Fellow in the Advanced Materials program (name later changed to Advanced Materials for Micro- and Nano-Systems, AMM&NS).

In 2002, he was appointed as the Co-chair of the AMM&NS program in SMA, and worked closely with the other Co-chair, Prof Carl Thompson, from MIT. He served as the Program Co-chair from 2002 until 2014 when the SMA completed its term of operation. As a Faculty Fellow in SMA, he was involved in Microelectronics materials research and collaborated extensively with MIT and Singapore faculty in areas such as germanium nanocrystals, interconnect materials reliability and contacts to silicon-germanium devices. Over the years, Prof Choi has trained and inspired many graduate students, both in SMA and ECE.

In 2004, he was awarded the inaugural NUS Nanoscience and Nanotechnology Initiative (NUSNNI) Research Achievement Award for research work on “memory device structure based on germanium nanocrystals”.

Besides teaching and leading an active research program in Microelectronics, Prof Choi also served with dedication as the Deputy Head for Administration in the ECE Department from 2008 to 2012.



Prof Choi was conferred a Doctorate of Science (D.Sc.) by the College of Science and Engineering, University of Edinburgh, UK, on 26 November 2015. This degree was earlier awarded to him on 6 August 2015. He was honoured for his work on “Synthesis, Characterisation and Applications of Silicon-, Germanium-, Carbon- and Polymer-Based Materials and Devices: From Thin Films To Nanostructures”.

The Department will miss him dearly.

Rest in peace, Prof Choi.

RETIREMENT OF TUAN HAJI SULAIMAN BIN KASSIM

We bade farewell to Mr **Sulaiman**, who retired from the Department on 31 Dec 2015. At 81 years of age, he was our oldest colleague. Known as “Uncle Sulaiman” to many of us, he joined the Department on 21 Jan 1993, and has been with us for almost 22 years.

A longtime Clementi resident, Uncle Sulaiman also served as a community mentor in the West Coast division, offering advice to current grassroots leaders. This South West district resident and grassroots leader is undeniably the subject expert in this area, having been a grassroots leader himself for close to 34 years since he moved into the estate.

We thank him for his many years of service to the Department and wish him all the best.



At the buffet table



Uncle **Sulaiman** with management



With Head of Department Prof John **Thong**



With colleagues



Gift for uncle



With photographer Mr **Jalil**

WELCOME 2016 AND APPRECIATION LUNCH

On 2 February 2016, the non-academic social committee organised a “Welcome 2016 and Appreciation Lunch” at LT6. This event was attended by the ECE management committee and non-academic staff.



The happy faces of our balloon artists!

The event started with a sumptuous Asian fusion buffet lunch. It was a great opportunity for staff to mingle, catch up with colleagues and simply enjoy one another's company in a casual and relaxed atmosphere.

The lunch was followed by a balloon sculpting session. As this year is the lunar Year of the Monkey, the non-academic social committee decided to make balloon monkeys and mandarin oranges to usher in the New Year.

The committee's treasurer, Ms **Sim** Mong Choon, taught the participants how to make simple yet cute little balloon monkeys. Two different colours of balloons, light brown and beige, were used. The participants were attentive and eager to learn the technique of twisting and shaping the balloons. Braving the noisy squeaks of balloon sculpting and for some, the fear of bursting balloons, all the participants managed to make cute little balloon monkeys. Everyone agreed it was a thoroughly enjoyable session.



Ms **Sim** Mong Choon teaching participants how to do balloon sculpting

At the end of the event, each participant was given a pair of mandarin oranges for prosperity and good luck. What a memorable way to usher in the active year of the monkey!

The committee was much encouraged to hear from participants that they were looking forward to the next gathering. We thank the non-academic committee for organising the event and the Department's management for its support.



Participants queuing up for the sumptuous lunch



ECE Management

ECE SOCIAL EVENT: THE VINTAGE HIGH TEA

The ECE social event was held on 4 March 2016 at the Royal Plaza on Scotts' Balmoral Hall, a glass-walled function room overlooking the pool and lush greenery along Orchard Road.

The theme of the event was "Vintage". Guests were greeted upon arrival with a photo booth and mini games at the open pool area of the hotel. The games included bean separating, sugar cube stacking, and other Sisyphean tasks for prizes and glory. Prof **Zhang** Rui emerged as the undisputed tea bag throwing champion. Such hidden talents he has!



Colleagues having fun at the games

The high tea featured an international gourmet buffet with a wide array of finger foods, hot chaffers, dim sum, fruit tarts, cakes, and non-alcoholic drinks.



Colleagues ready for tea



Delicious high tea spread



Lucky draw & bingo coupons

Keeping guests engaged were performances by a stage magician and a memorable fire-breathing act. An emcee hosted the remainder of the events that thoroughly kept the guests entertained. A lavish multi-round lucky draw rounded up the day's stage entertainment. Everyone left a winner as the lucky draw had something for everyone and the only ones who did not win were those who did not show up.



Magic performance

The finale of the day was a table game in which each table selected an unwitting male member to receive a makeover using newspapers, makeup and accessories. Among a diverse cohort ranging from the gorgeously dressed to the fatally wounded, Prof **Chen** Xudong was crowned "Miss (Mr) ECE 2016". The best dressed and dancer couple prize was bagged by Ms Cindy **Chua** Hui Suan and Mr **Seow** Hung Cheng.



Our beautiful fashion models

Guests left in the late afternoon on a high note, bearing home their gifts, past a motivational sign on the photo booth that read, "I make things possible".

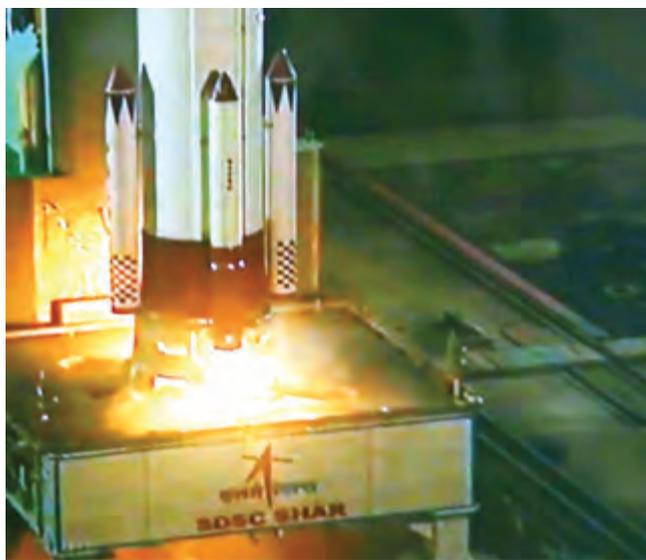


Happy faces of staff

NUS ENGINEERING MAKES HISTORIC MARK IN SPACE

SINGAPORE 8.30pm, 16 December: NUS Engineering sent two satellites, Galassia and Kent Ridge 1 (KR-1), into space. They were among six that were shot into space, piggy-backing on TeLEOS-1, the primary satellite by ST Electronics Satellite Systems Centre.

Launched from the Satish Dhawan Space Centre in Andhra Pradesh, India, the event was the climax of a Memorandum of Understanding signed between NUS Engineering and ST Electronics at the Global Space & Technology Convention 2013.



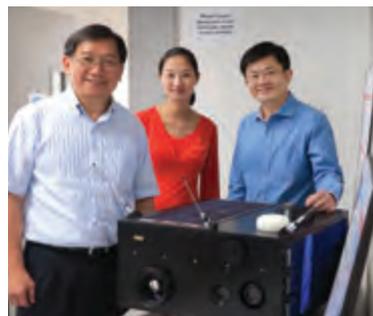
The blast-off in India, on 16 December, 8.30pm Singapore time

The satellites are orbiting around the equator to gather data that will benefit those in the equatorial region. The event marked a milestone in the history of Singapore's nascent space industry.



All eyes on the screen during the live webcast of the launch at NUS Engineering

KR-1 is a hyper-spectral imaging microsatellite designed to conduct scientific experimentation and analysis of the earth's surface. Galassia, a Design-Centric Programme project, will test out a quantum-based communication concept besides carrying a payload that measures the total number of electrons in the ionosphere above Singapore. The information obtained will help to improve GPS navigation and radio communication.



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

and challenges them to innovate and push boundaries."

Said ECE's Professor **Goh** Cher Hiang, Project Director, NUS Satellite Programme, "Creating a space-ready engineering system goes beyond nuts and bolts. The Galassia project brings together students from various engineering disciplines to apply what they have learnt in a real-life setting,

"The successful launch of Galassia is a strong endorsement of NUS' space engineering education and we hope that this will inspire more talented students who are passionate about space R&D to pursue their interest in this field," added Prof Goh.

Prof Goh's team is flying high, already planning to develop the second generation of Galassia and Kent Ridge 2.

These new models will boast a six-unit nanosatellite with enhanced capability such as propulsion and attitude control together with an optical mission for high resolution imaging. The propulsion feature would have the potential to undertake interplanetary missions such as flying a nanosatellite to explore the moon.

NUS SCIENTISTS CREATE ULTRA-SENSITIVE GRAPHENE SENSOR

A NUS-developed graphene-boron nitride sensor is 200 times more sensitive than commercial products, promising applications for smaller and cheaper electronics.

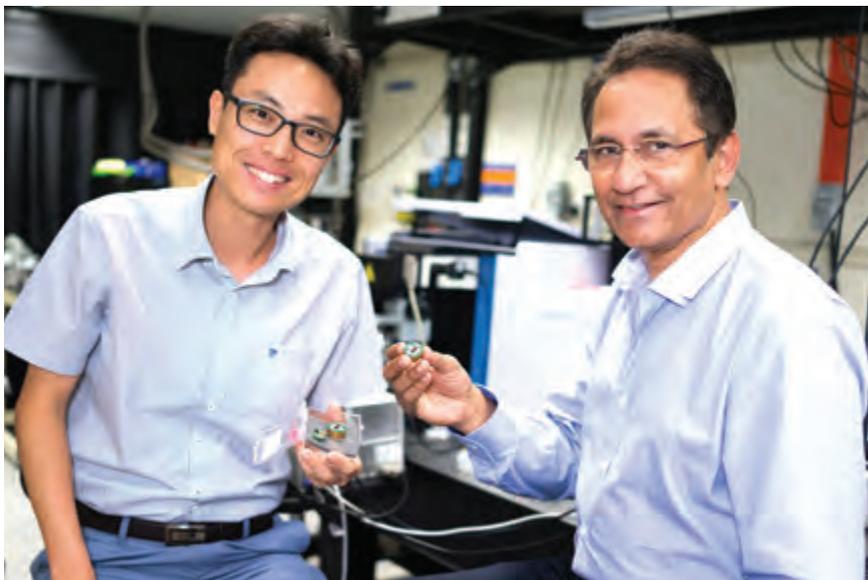
NUS scientists have created a magnetic sensor 200 times more sensitive than most commercially available products. These smaller and lower-cost sensors can potentially be used in areas such as consumer electronics, information and communication technology, biotechnology and automotive applications.

Headed by ECE's Associate Professor **Yang** Hyunsoo, the research team developed the new sensor from graphene and boron nitride. Comprising a few layers of carrier-moving channels controlled by a magnetic field, the hybrid sensor shows much higher sensitivity than current silicon and indium antimonide products.

When measured at 127 degrees Celsius – the maximum temperature at which most electronics products can operate – the hybrid sensor recorded a more than eightfold sensitivity gain over other reported laboratory results, and more than 200 times that of sensors in the market. It also showed little temperature dependence when tested at room temperature and temperatures as high as 127 degrees Celsius, making it an ideal sensor for hot environments.

Another major discovery is that the mobility of the graphene multilayers enables the sensor's characteristics to be optimised by tuning the voltage across it. This control gives the material an advantage over existing sensors.

The team's breakthrough work, which promises cheaper sensor production by eliminating expensive wafers, was published in *Nature Communications* in September.



Assoc Prof **Yang** (left) and Prof **Venkatesan** with the innovative sensor

Assoc Prof Yang, who is also attached to the NUS Nanoscience and Nanotechnology Institute (NUSNNI) and the Centre for Advanced 2D Materials (CA2DM), pointed out that magnetic sensors are everywhere, from home appliances to counters that track the number of vehicles in parking lots and drive-throughs. For instance, a car alone can have up to 30 magnetic sensors to monitor speed, pressure and position, as well as other functions.



The invention promises smaller and cheaper sensors for many potential applications

"Current sensors' properties can change due to air-conditioning or heat from the sun, requiring a temperature correction mechanism which incurs more cost. Our NUS innovation avoids these issues, allowing for tinier and cheaper electronics," explained Prof Yang.

He added, "Our sensor is perfectly poised to pose a serious challenge in the magnetoresistance market by filling the performance gaps of existing sensors, and finding applications as thermal switches, hard drives and magnetic field sensors. Our technology can even be used for flexible applications."

Other members of the team include Dr Kalon **Gopinadhan**, Research Fellow at NUSNNI; Professor Thirumalai **Venkatesan**, Director of NUSNNI; Professor Andre Konstantin **Geim** of the University of Manchester; and Physics Professor Antonio Helio **De Castro Neto**, the Director of CA2DM.

The researchers have filed a patent for the product, with plans to scale up their studies and manufacture industry-size wafers for industrial use.

ENERGY-EFFICIENT INFORMATION PROCESSING FOR SPINTRONIC DEVICES

A team of ECE researchers led by Professor Adeyeye **Adekunle** has developed energy-efficient information transmission and manipulation for spintronic devices.

While the development of CMOS technology is expected to continue well into the next decade, inevitably a point will be reached where today's semiconductor circuits meet their physical limits. It is widely believed that further shrinkage will be inefficient due to power dissipation problems.

Devices that make use of the spin degree of freedom of electrons have the potential to offer more than Moore of CMOS technology including low power, high speed and quantum capability.

A spin wave, which is the focus of this invention, represents a phase-coherent precession of microscopic vectors of magnetisation in magnetic medium and can be considered as a magnetic analogue of a sound or light wave.

Interest in propagating spin-wave-based devices has grown in the last few years. This is largely due to advances in nanotechnology which allows shapes of geometrically confined magnonic elements to be fabricated.

Other reasons for growing interest in spin-wave-based devices are the development of new advanced experimental techniques for studying high-frequency magnetisation dynamics and the potential use of spin waves as information carriers in spintronic applications.

The ECE researchers have developed a new waveguide that does not require stand-by power during operation. In their study, instead of using a magnetic wire, the team used a physically separated but dipolar-coupled rhombic shaped nanomagnetic chain.

To retain their correct magnetic states once initialised, the sizes of the nanomagnets were kept small (few 100 nanometer ~ 1/10,000 of a millimeter).



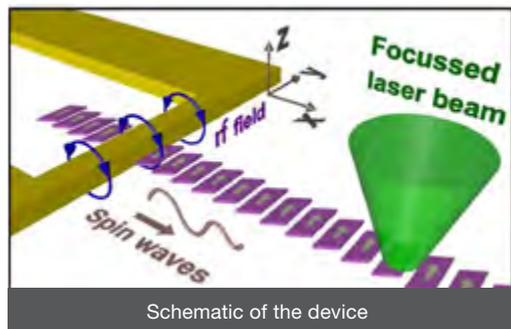
Professor Adeyeye **Adekunle** (right) with his team members – Research Fellows Dr Arabinda **Haldar** (center) and Dr Dheeraj **Kumar** (left)

For the proof-of-concept device demonstration, the signal was measured using micro-focused Brillouin light-scattering technique with a laser spot diameter of 250nm, the best-known tool for spatial imaging of spin waves.

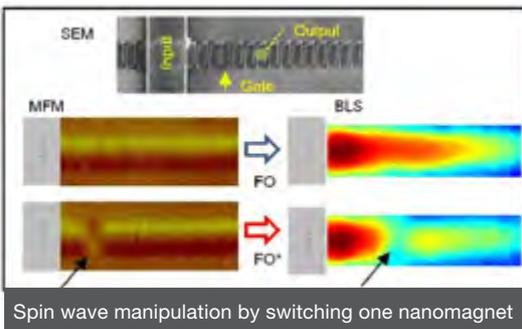
The team also showed that its waveguide could be used to send spin wave signal around a corner without any stand-by power, a previously unheard-of feat.

Another important parameter for device operation is the manipulation of the output signal which is similar to a gating operation in a transistor. In their invention, gating operation was achieved by switching the magnetisation of single/multiple nanomagnets in the waveguides in order to manipulate the spin wave amplitude at the output.

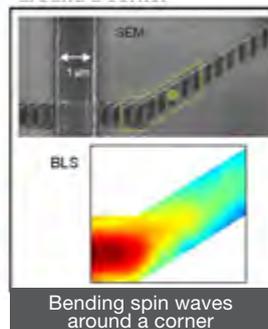
The team's findings were published online in *Nature Nanotechnology* (1 February 2016) titled, "A reconfigurable waveguide for energy-efficient transmission and local manipulation of information in a nanomagnetic device".



Schematic of the device



Spin wave manipulation by switching one nanomagnet



Bending spin waves around a corner

No stand-by power is required for information transmission using spin waves

NUS ENGINEERING TEAM MAKES THE INTERNET OF THINGS (IoT) UBIQUITOUSLY CYBER-SECURE

The unprecedented silicon-chip energy efficiency permits full data protection in any IoT node despite extremely tight energy budget.

An ECE research team led by Associate Professor Massimo Bruno **Alioto** has paved the way for making the Internet of Things (IoT) ubiquitously secure through a tiny but powerful silicon-chip for IoT nodes.

When used in smart buildings and cities, such nodes are dispersed in massive quantities to sense physical data, perform simple computation and infrequently communicate with the cloud wirelessly. Being at the interface between the Internet and the physical world, IoT nodes are effectively the “senses” of the IoT.

Due to their aggressively small size (a few millimetres), the power budget of IoT nodes is extremely small, typically about a few microwatts. This is approximately the power that would be generated by a photovoltaic panel with a size of less than a millimetre on a sunny day in Singapore.

With such a tight power budget, IoT nodes were previously unable to perform relatively complex functions such as those necessary to protect themselves from cyber-attacks. Examples of such functions are data encryption and chip authentication, which protect the sensed data and the identity of the IoT node, respectively.

ECE's research team has recently demonstrated innovative integrated circuit techniques that drastically reduce the energy consumption entailed by cryptography and chip authentication. The innovative techniques are suitable even for the tiny power budget of IoT nodes, and, hence, can be applied ubiquitously in the Internet of Things.



The NUS ECE team (from left): Dr **Ha** Yajun (I²R and ECE Adjunct Assoc Prof), **Zhao** Wenfeng (Research Fellow), Anastacia **Alvarez** (Ph.D. student) and Assoc Prof Massimo Bruno **Alioto**

In collaboration with Dr **Ha** Yajun from I²R, the ECE team is studying circuit techniques that allow an Advanced Encryption Standard (AES) cryptographic core to run on a silicon-chip at the unprecedented power of only 0.2 microWatts under typical IoT data transfer rates. This is seven times lower than that of any other existing competitor. Thus, ECE's novel techniques can continuously protect IoT data through well-established cryptographic standards (e.g., AES).

As a side benefit, such security improvement does not require any disruption in cryptographic standards and is fully compatible with existing Internet infrastructure. For example, existing UHF Radio RFIDs with a power budget of around 2-3 microwatts can now incorporate AES to prevent cyber-attacks.

To fulfil the vision of ubiquitously secure Internet of Things, the ECE team also introduced innovative circuit techniques for silicon-chip biometrics which allow unique identification of each IoT chip to prevent hardware piracy, chip counterfeiting, and malicious hardware.

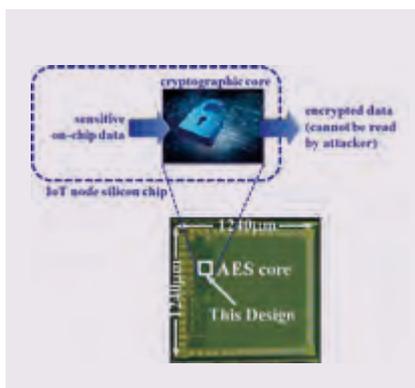
Such biometrics is the equivalent of a chip-unique fingerprint that is generated by circuits called Physically Unclonable Functions (PUFs).

PUFs generate unique digital keys from the unique pattern of manufacturing variations that occur in each chip. The ECE team recently proposed a novel type of PUF that has an unprecedented level of security and energy efficiency. In terms of security, the degree of PUF randomness, uniqueness and other security metrics were all improved by 10 to 15 times compared to earlier PUFs. At the same time, the energy per access was reduced by 12 times.

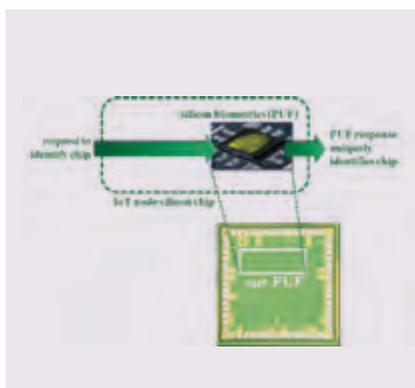
With the proposed circuit technique, continuous PUF operation at typical IoT data rates and 256-bit key now have a power consumption of only 0.3 microWatts, thus making it affordable in IoT nodes for the first time. The chip that was designed to demonstrate this new class of PUFs was premiered at the prestigious ISSCC conference held in San Francisco, 31 January to 4 February 2016.

Today, the outcome of the research work of the ECE team has redefined the state of the art in the field. With its new capability to counteract cyber-attacks ubiquitously and continuously, ECE has taken a major step forward in its journey towards making Singapore a smart nation.

Indeed, given the ubiquitously large numbers of IoT nodes presenting several potential points of cyber-attack, ECE's innovative chip addresses the very fundamental challenge of preserving cyber-security.



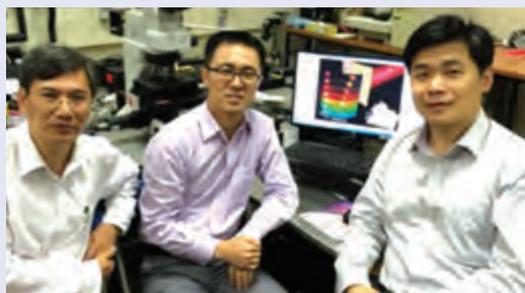
A cryptographic core in IoT node encrypts and protects on-chip sensitive data to make it unreadable from an off-chip attacker (our crypto-core chip demonstrator is shown at the bottom).



"Silicon-chip biometrics" (PUF) in IoT node allows unique identification of the chip, preventing chip counterfeiting and malicious hardware (our PUF chip demonstrator is shown at the bottom).

NUS RESEARCHERS MAKE A BREAKTHROUGH WITH PLASMONIC METASURFACE

Metasurface is a type of artificially structured two-dimensional (2D) material for manipulating the propagation of electromagnetic waves with a thickness far less than the operational wavelength. It may allow the realisation of exotic and intriguing effects which cannot be obtained by natural materials or 3D metamaterials. The concept is, however, still in its infancy due to either low manipulation efficiency or extreme complexity in sample fabrication, especially in visible light.



(From left) Prof **Hong**, Dr **Qin** Fei, and Prof **Qiu**

An ECE team led by Assistant Professor **Qiu** Cheng Wei has developed a new metasurface configuration that may fill the gap between laboratory proof-of-concept demonstrations and practical devices. Their finding

was published in *Science Advances* [*Sci. Adv.* 2, e1501168 (2016)], entitled "Hybrid bilayer plasmonic metasurfaces efficiently manipulates visible light", and selected as Research Highlights by *Nature Physics* [*Nat. Phys.* 12, 111 (2016)] in February 2016, entitled "Metasurfaces: Double up".

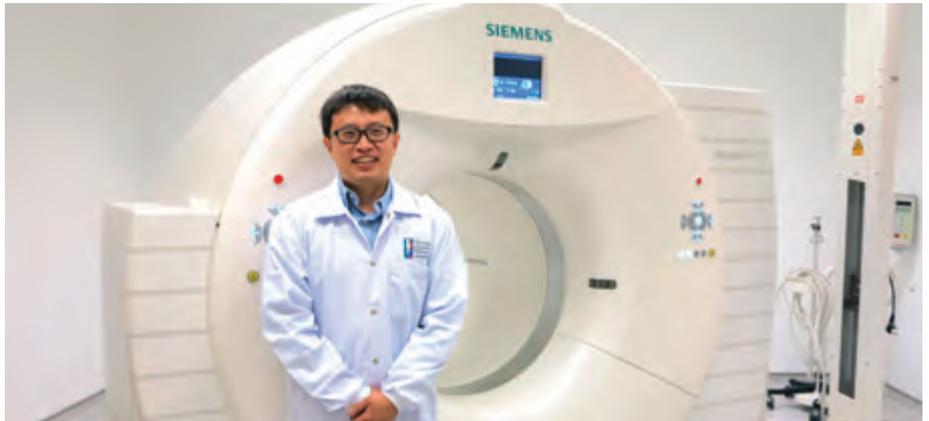
They proposed and experimentally demonstrated a novel design of bilayer metasurface configured by marrying 2D array V-shape nano-antennas with its babinet-inverted complementary counterpart. The bilayer metasurface could manipulate transmitted visible light with very high efficiency without sacrificing its ultra-thin property. Overturning a widely accepted perception, the bilayer metasurface shows that coupled plasmonic metasurfaces could surprisingly beat silicon metasurfaces although the ohmic loss of the metal is much higher than dielectrics. What's more, the required sample fabrication is even simpler than the existing single metasurface designs.

Said Dr Qiu, "While the one-step fabrication process of the bilayer metasurfaces presents challenges in sample preparation, there is significant improvement of efficiency which will facilitate viable commercialisation and mass production of the metasurface concept. This further translates into the miniaturisation and integration of optical components and systems."

Kudos to Dr Qiu and his team!

HOW DOES BRAIN MANAGE COMPLEX ACTIVITIES?

Our brain is a heavyweight, a hefty 1.5kg of mysteries. So far no one has come up with an ultimate model of the brain that solves all its mysteries. Neuroscientists are still at a loss, for example, to explain how incoming sensations get routed around in the brain so that they result in different responses or behaviour by different individuals.



Brain sleuth, Dr Thomas **Yeo**, co-author of the PNAS paper, “Modular and integrative functional architecture of the human brain”, is an ECE faculty member. He is also affiliated to the Clinical Imaging Research Centre, Singapore Institute for Neurotechnology, Duke-NUS Graduate Medical School and Harvard Medical School.

Another baffling question is whether the brain possesses innate properties that influence individuals in their cognition and, hence, their behaviour. Understanding the brain may shed more light on disorders such as autism which causes patients to have different visual interpretations and social norms from most people.

NUS Engineering researchers are closer to finding out some of these answers. Assistant Professor Thomas **Yeo** from ECE, working with a team (Maxwell **Bertolero** and Professor Mark **D’Esposito**) at the University of California, Berkeley, has come up with a model to explain how cognition takes place. Their paper, “Modular and integrative functional architecture of the human brain” recently published in the Proceedings of the National Academy of Sciences (PNAS, online) points towards findings that the brain consists of distinct modules connected by special brain nodes or regions. The team found indications that each of these modules are autonomous, responsible for a single function or a set of functions. The team also discovered that connector nodes play a crucial role as messengers, enabling modules to coordinate with each other and enable the brain to function as an entity.

Their findings were the result of almost 10,000 experiments involving 77 cognitive tasks to compare activity in the modules and connector nodes. Using MRI to monitor brain activity, they found that the level of activity within modules remain constant during various cognitive tasks. However, activity level at connector nodes increased with task complexities, suggesting that the connector nodes are working harder to coordinate more brain functions.

“This suggests that modules function autonomously of each other. Connector nodes, which are situated in regions associated with many different cognitive functions, are probably the key points of communication across specialised brain networks,” said Dr Yeo.

Added Bertolero, “The results also suggest that although single-function modules appear to operate autonomously, modules with diverse functions may be key to sustaining the cognitive network.”

Currently, Dr Yeo and his team at NUS are working with neuroscientists to see how much of the brain functions are based on innate properties and how modules can evolve with new inputs. For example, they hope to find out what happens when they are damaged by a stroke.

Related link:

Dr Thomas Yeo's homepage:

<https://sites.google.com/site/yeoyeo02/>



Understanding how the brain works will help clinicians come out with better treatment for patients with neurological impairment.

WINNERS AT INTEL SINGAPORE INVENT 50 COMPETITION

Light bulbs were set aglow with ideas by ECE teams at the recent Intel Singapore Invent 50 Competition held at Marina Bay Sands on 5 December 2015. The competition was held in conjunction with the dual celebrations of Singapore's 50th anniversary of independence and Intel's own Moore's Law turning 50. The event aimed to encourage the development of innovative solutions with significant social impact, leading to the enhancement of health, well-being and lives within the local community.



Team PD Loggers (supervised by Dr **Yen** Shih-Cheng, Assoc Prof **Heng** Chun Huat and Assoc Prof Arthur **Tay**) with their top prize at the Intel Singapore Invent 50 Competition held at Marina Bay Sands

A total of 18 teams underwent a two-day boot camp where they were acquainted with the Intel Edison and Intel RealSense. Subsequently, they underwent mentorship from Intel over three months to develop their respective prototypes.

Final-year ECE students Daniel **Lee** (Computer Engineering), **Teo** Yew Shen (Electrical Engineering) and Mikos **Val** (ECE Ph.D. student) made up the team, PD Loggers. The trio put their heads together and developed a wearable monitoring device for patients suffering from Parkinson's disease.

Powered by Intel® Edison technology, this wireless device provides biofeedback and automated monitoring of gait movements. The team received the first prize, taking home \$10,000, a laptop with Intel Sense camera and Intel internship opportunity.



PD Loggers at the award ceremony



Team Hydrone

The 1st runner-up went to team Hydrone, a multidisciplinary Design-Centric Programme (DCP) team comprising Mervyn **Wee** Yan Ru, Luigi Marshall Chua **Cham** (both Computer Engineering) and **Chong** Yue Linn (Mechanical Engineering).

The team developed a waterproof, recoverable drone with computer vision for efficient water monitoring, via the collection of water samples and detection of various chemicals in the solution. Hydrone hoped that their device can potentially automate some of the existing manual maritime operations. This drone has the ability to stream a live camera feed to a website for faster data analysis and response, and subsequent receipt and transmission of data to a ground control station.

Another NUS Engineering team was selected into the finals. Sinapse Swarm Sense, a team comprising students Kush **Agarwal**, Abhishek **Mishra** (both ECE Ph.D.) and Mahdi **Rasouli** (NGS Ph.D.), worked on smart robots for defence use. These semi-autonomous robots can navigate in an environment while avoiding obstacles using Intel® RealSense™ technology.

Congratulations to our teams who did ECE proud!

BEST STUDENT PAPER AT INTERNATIONAL CONFERENCE

ECE shone at an international conference devoted to research on underwater networks and network-related signal processing, communications, systems, and applications.

A team comprising V Prasad **Anjangi** (Ph.D. student) and Dr **Mandar** Anil Chitre, won the Best Student Paper on Underwater Systems with Experiments in Memory of Giovanni **Toso**, at the 10th ACM International Conference on Underwater Networks & Systems (WUWNet) at Washington DC, USA, on 22 October 2015.

ECE's winning entry is entitled "Design and Implementation of Super-TDMA: A MAC Protocol Exploiting Large Propagation Delays for Underwater Acoustic Networks".

The prize comprises a certificate and USD 500.

The special award was presented at the conference to a best student paper dealing with experiments on underwater systems in memory of Giovanni Toso.

Giovanni Toso, a young student at the University of Padova, Italy, where he was pursuing his Ph.D. degree, died in a car accident on August 10 2014. After this tragic event, Giovanni's family decided to employ the offers received from relatives and friends for something that other young students could benefit from.

Papers accepted for presentation at WUWNet 2015 were evaluated by a committee formed by Carrick **Detweiler** (University of Nebraska-Lincoln, Chair), Paolo **Casari** (IMDEA Networks Institute), Jun-Hong **Cui** (University of Connecticut) and Zhaohui **Wang** (Michigan Technological University).



V Prasad at the award ceremony

CHAMPIONS AT FIRST FACIAL LANDMARK TRACKING COMPETITION

A team comprising Ph.D. student **Xiao** Shengtao, Associate Professor **Yan** Shuicheng and Professor Ashraf **Kassim** has made the Department proud!

They clinched the winning titles of both Categories 2 and 3 [300 Videos in the Wild (300-VW): Facial Landmark Tracking in-the-wild Challenge and Workshop (ICCV 2015)] at the First Facial Landmark Tracking Competition, IEEE International Conference on Computer Vision Workshops (ICCVW), held on 18 December 2015 in Santiago, Chile.

Their winning entry, entitled "Facial Landmark Detection via Progressive Initialisation", won the team a prize comprising US\$200 and certificates.

Well done to our teams for doing ECE proud!



CHAMPIONS AT INTERNATIONAL UAV INNOVATION GRAND PRIX

Team AeroLion has roared to victory again!

NUS UAV Team AeroLion, jointly formed by members from NUS UAV Research Group and AeroLion Technologies (an NUS spin-off), claimed the championship in the Rotary-Wing Competition at the 3rd AVIC Cup, an International UAV Innovation Grand Prix, held in Anji, Zhejiang, China, on 30 October 2015.



Team AeroLion with their sophisticated drone BlackLion 168

The competition attracted 108 teams. The rotary competition task simulated the vertical replenishment task on the sea, which required drones to automatically transport cargo buckets from one moving platform to the other. The unmanned system used in the competition consisted of a sophisticated drone - BlackLion 168, developed by AeroLion Technologies, and advanced intelligent algorithms developed by NUS UAV Group for robust vision tracking, intelligent mission planning and precise positioning control.

The team comprising **Wang** Kangli, **Ke** Yijie (ECE Ph.D. students), **Shan** Mo (Temasek Lab), **Li** Xiang and Dr **Wang** Fei (AeroLion Technologies) took home a cash prize of CNY100,000.

The team was supervised by Professor Ben M. **Chen** and Professor **Lee** Tong Heng.

Our heartiest congratulations to the team!



Team AeroLion at award ceremony

TEAM WON TRIPLE AWARDS AT NATIONAL INSTRUMENTS COMPETITION

Du Xinxin and **Kyaw** Ko Ko Htet (Ph.D. students supervised by Assoc Prof **Tan** Kok Kiong) won the 2015 Engineering Impact Awards at the ASEAN Regional Contest, National Instruments (NI), Singapore. The award ceremony was held on 16 October 2015.

Their winning entry, "Solution to an Autonomous Vehicle Platform Integrated with Remote Human Intervention and Supervision", won the duo the following three awards:

- a** Academic Honorary Mention comprising \$500 cash and a plaque
- b** Advanced Research Award comprising \$300 cash and a plaque
- c** Editor's Choice comprising \$300 cash and a plaque.

The NI Engineering Impact Award is a technical application contest, showcasing the most innovative projects based on NI software and hardware from both academics and industries. It provides opportunities to share innovations with the NI community and network with NI leadership, trade press and industry leaders. An anonymous panel of judges consisting of NI experts evaluated all the entries based on how excellent the graphical system design is, how technically challenging the solution is and how positive the impact of the project on the world is. For this contest, there were more than 50 entries from six countries.

Congratulations to Xinxin and Ko Ko Htet!



Students **Kyaw** Ko Ko Htet and **Du** Xinxin with the electrical vehicle



Du Xinxin at award ceremony

PEER TUTORING

ECE community spirit: Students volunteer as peer tutors. The IEEE-Eta Kappa Nu (IEEE-HKN) NUS Chapter, together with the ECE Department and the ECE Undergraduate Student Council (USC), launched a new initiative called the NUS ECE Peer-Tutoring Scheme.



A group picture of Mr **Hong** Wei Shian (Peer Tutor of Semester 1, AY 2015/2016), Mr Edward Elson **Kosasih** and Mr Danny **Lim** Chai Hou (Current and Past Presidents of the IEEE-HKN NUS Chapter, respectively)

The scheme aims to provide an avenue for ECE students to seek academic help from passionate seniors who have done well in their Year 1 and 2 core modules. It also provides additional learning support for students who had expressed interest to participate in this scheme.

In Semester 1 of AY 2015/2016, 10 highly motivated senior undergraduate students volunteered to be peer tutors. After interviews by the IEEE-HKN NUS Chapter and ECE Department to ensure that they could manage their time, these peer tutors are committed to helping their juniors and to providing a good standard of tutoring throughout the semester.

Paired with 12 junior students, the peer tutors focused on concepts that their juniors had difficulties with to help them gain a better understanding. The peer tutors also served as mentors with the objective of empowering their tutees to help themselves such as by improving their self-confidence.

This scheme has achieved notable results since its inception one semester ago. Many junior students have given feedback that they have benefitted from the scheme. In fact, the majority of tutees have passed the modules for which they received peer tutoring. These students appreciate how their tutors often strive to focus on their tutees' concerns to prepare well for the tutoring sessions even though they have multiple deadlines and commitments themselves. These heartwarming and inspiring experiences have given our junior students renewed determination to persevere in their learning journeys.

Said presidents of the IEEE-HKN NUS Chapter, Mr Danny **Lim** Chai Hou and Mr Edward Elson **Kosasih**, "We saw this scheme as an opportunity to give back to the NUS ECE community. The peer tutoring scheme has provided us an alternative teaching and learning approach in which students take a pro-active role in thinking, questioning and knowledge-sharing."

The generosity and motivation of these peer tutors certainly deserve to be commended! The ECE community spirit is thriving indeed.

WELCOME BACK PARTY

Mondays are usually boring for ECE students, but 1 February 2016 was especially festive, as the ECE Undergraduate Student Council (USC) had organised a Welcome Back Party on that evening at the Shaw Foundation Alumni House.



Prof John **Thong** enjoying a light moment with colleagues while waiting for the start of the second part of the program

To welcome academic staff and students back to the new semester of AY2015/2016 Semester 2, party activities were held for them to get to know one another and prepare them for the rest of the academic year.

The event began with a generous spread of international cuisine. Participants then streamed into the auditorium to kick off the second part of the programme with a game of “charades”. Academic staff, such as Professor John **Thong**, Associate Professors Vivian **Ng** and Ashwin M **Khambadkone**, were invited on stage to act out the different ECE concepts. Their impressive performance had the crowd laughing and smiling.



A student (centre) chatting with (from left) Assoc Prof Arthur **Tay**, Dr Justin **Pang** and Dr **Ang** Kah Wee



Sumptuous dinner before start of program

Next the audience was treated to a screening of the Hollywood action-comedy film, ‘The A-Team’, a remake of an old favourite that had received good reviews. The evening was a perfect start to the week as participants enjoyed the time to unwind with friends over great entertainment. By the end of the night, eight happy students had walked away with either movie tickets or Starbucks gift cards as lucky draw prizes.

All in all, it was a great night for everyone to have loads of fun catching up with one another. Here’s to another good start to a challenging learning journey in the new semester!



Hanging out with pals before the start of the event



Current PhD student Alex **Toh** sharing his undergraduate experience with fellow students



Assoc Prof Vivian **Ng** chatting with student