Department of Electrical and Computer Engineering
National University of Singapore

PROCEEDINGS

8th NUS ECE
GRADUATE STUDENT SYMPOSIUM
17 – 18 May 2018

Venue:
LT4, LT6 & Seminar Rooms
Faculty of Engineering
National University of Singapore

MESSAGE FROM THE HEAD OF ECE DEPARTMENT

I would like to thank the ECE Graduate Student Council for organizing the 2018 ECE Graduate Student Symposium, the eighth in a series of annual symposia inaugurated in 2011. A total of 40 oral papers will be presented over two days in 7 oral sessions, covering six areas of research within the Department. Run like a typical IEEE technical conference, the symposium provides a real platform for students to present their research results and engage with one another through interactions throughout the event. The ability to present their work well in such a public forum is an important part of their overall education as researchers.

The symposium is supported by many parties who contributed in various ways. On behalf of the Department, I would like to thank everyone for their generous support. In particular, I thank Prof. Subodh G. Mhaisalkar, Dr. Yeo Wee Loon, Mr. Sam Witteveen for delivering our keynote speeches and Mr. Aneesh Sathe, Mr. Kaveh Taghipour for leading the fireside chat session. I also thank Prof. Haizhou Li, Mr. Benjamin Anthony, Mr. Adhiraj Saxena and Mr. Ujjwal Kumar for their participation in the panel discussion.

I would also like to acknowledge the support of all our sponsors including the IEEE Rel/CPMT/ED society, COLiPS, IEEE ComSoc, IEEE Circuits and Systems society (Singapore chapter) and NUS ECE Department for their contributions to the symposium; and my colleagues who provided valuable advice to the students in the planning and organization of the symposium, and who will be acting as judges for the paper awards.

I wish you all a very fruitful and stimulating meeting.

John Thong

Professor and Head of Department
Department of Electrical & Computer Engineering
*National University of Singapo*re

MESSAGE FROM THE GSS COMMITEE

Thank you for being a part of this Graduate Student Symposium (GSS)-2018. We, the GSS 2018 committee, are greatly honored to welcome all the participants for our annual symposium.

The ability to make an effective presentation is a researcher's most valued skill both in academia and as well as industry. The core vision of GSS is to facilitate a platform for the graduate students to hone such skills. GSS, as its tradition goes has being providing ECE graduate students with an opportunity to present their research findings and enhance their presentation skills in a more conducive environment. Through GSS, graduate students are given constructive feedback by the ECE professors and their peers. We are proud to announce that ECE GSS started in 2011, and is running in its eighth year now.

The format of the symposium is same as previous years where every participant is encouraged to present their research findings in front of the judges and share their ideas with their peers on the site. This is followed by a Q & A session. This way, participants get the chances to practice their presentation skills and ability to think on their feet, which is very important for their M.Eng./PhD study and future career building. Like the previous year, we will only have oral presentations instead of both oral and poster presentations.

This year, we have three eminent keynote speakers addressing the conference over both days. We have Prof. Subodh G. Mhaisalkar from Nanyang Technological University who will give us a talk on "**Less than 2°C at 1°N?: Paris Agreement, Energy Efficiency, and Solar Cells Deployment Considerations for Tropical Megacities**", Dr. Yeo Wee Loon from NUS Centre for Future-ready Graduates who will deliver a keynote on "**Career Preparation Begins Now**", and Mr. Sam Witteveen from Red Dragon AI, who will be talking on "**Building AI Products: From Paper to Prototype to Production**". On the first day, we have a 'fireside' chat session for the first time in GSS, entitled "**Building the Plane While Flying It : An Entrepreneurial Journey**" which will be led by our guests Mr. Aneesh Sathe and Mr. Kaveh Taghipour, both co-founders of the med-tech AI company, Qritive. Finally, there will be panel discussion on "**Upskill 2.0: The skills essential for Engineers and Researchers to thrive in the world of Data and Machine Intelligence**" held on the first day. Our distinguished panel will include Prof. Haizhou Li , Mr. Benjamin Anthony, Mr. Adhiraj Saxena and Mr. Ujjwal Kumar.

We would like to extend our gratitude to ECE department for their support and cooperation for this event, in particular, Prof. Yung C. Liang, Deputy Head of the Department (Research & Graduate Programmes), without his advice we wouldn't have been able to pull this off, and Ms. Eunice Wong and Ms. Hemamalini for their kind guidance. Moreover, we would like to thank all the professors who helped us in judging the presentations and evaluating the research works. We would also like to express our sincerest appreciations to our fellow colleagues who volunteered to constitute and organize this symposium for their relentless and passionate call to duty that has made this event come this far. We all have enjoyed the very good experience in organizing an IEEE-like conference.

Finally, we appreciate your attendance and participation to make the eighth NUS ECE Graduate Student Symposium (GSS 2018) a great success.

GSS Organizing Committee

COMMITTEE MEMBERS

Assoc. Prof. Yung. C. Liang
Program Advisor

Krishanu Dey
General Co-chair & GSC Chair

Gurupraneesh Raman
General Co-chair

Naveen Punnose
Finance Chair

Gururaghav Raman
Program Chair

Rethnaraj Rambabu
Webmaster & Publicity Co-chair

Sivam Pillai
Sponsorship Co-chair

Arash Nemati
Sponsorship Co-chair

Ayush Kumar
Technical & Proceedings Chair

James Ranjith Kumar Rajasekaran
Publicity & Logistics Co-chair

Xie Hang

Publicity Co-chair

Jayendhar Gautham Mohanasundaram
Public Relations Co-chair

Hein Htet
Public Relations Co-chair

Xu Ruolei
Logistics Co-chair

KEYNOTE SPEECH 1

Day 1, May 17, 2018, Time: 10:30 am – 11:30 am, Venue: Lecture Theatre 4 (LT4)

Topic: Career Preparation Begins Now

Dr. Yeo Wee Loon
Careers Advisor, NUS Centre for Future-ready Graduates

Abstract:
Graduate studies are often seen as the epitome of intellectual pursuit. Many students pursue PhD studies because of deep passion in research and a strong interest in a specific subject area. Students also hope this pursuit will eventually lead to a fruitful and meaningful career, but what sort of career options await after thesis submission? When and how should a graduate student think about career preparation? This talk seeks to address these questions, and provide some tips on how you can start preparing for working life now.

Biography:
Wee Loon has worked in the education field for more than 12 years as both an educator and researcher. His teaching experience ranges from high school to University, both in Singapore and overseas. He completed his Ph.D. in Anthropology in and published articles in peer-reviewed journals in the area of educational research and youth identity. He is now a Careers Advisor at the NUS Centre for Future-ready Graduates, working mainly with NUS Postgraduate students. On the personal front, Wee Loon adores his wife and 2 young daughters, constantly amazed by how quickly the kids are growing. He also enjoys reading Non-Fiction books, and going for Reservist duty.

KEYNOTE SPEECH 2

Day 2, May 18, 2018, Time: 11:15 am – 12:15 pm, Venue: Lecture Theatre 6 (LT6)

Topic: Building AI Products: From Paper to Prototype to Production

Sam Witteveen
Deep Learning Engineer / Google Developer Expert for Machine Learning, Red Dragon AI

Abstract:
In this Keynote talk we will learn about some of the latest and greatest technology that is being used in developing and creating real-world AI products. It's one thing to see people talk about the emergence of these technologies and another to see industry experts break down how some of these products are being made with tips and tricks of the trade.

Biography:
Sam is a serial entrepreneur who has built multiple startups in diverse industries. He is Google Developer Expert for Machine Learning and Deep Learning as well as being the co-organizer of the TensorFlow & Deep Learning Singapore meetup group and regularly shares his knowledge in training sessions on TensorFlow, applied Deep Learning and AI. Sam is especially passionate about deep learning in the field of natural language understanding and conversational agents and is currently CEO of Red Dragon AI.

Sam has used Machine Learning and Deep Learning to build multiple tech startups, including a children's educational app provider which has over 4 million users worldwide. His current focus is AI for conversational agents to allow humans to interact easier and faster with computers.

KEYNOTE SPEECH 3

Day 2, May 18, 2018, Time: 12:15 pm – 1:00 pm, Venue: Lecture Theatre 6 (LT6)

Topic: Less than 2°C at 1°N?: Paris Agreement, Energy Efficiency, and Solar Cells Deployment Considerations for Tropical Megacities

Prof. Subodh G. Mhaisalkar
Assoc. Vice President (Strategy & Partnerships) President's Office, NTU
Tan Chin Tuan Centennial Professor
Executive-Director, Energy Research Institute @ NTU (ERI@N)

Abstract:

The successful implementation of the Montreal Protocol (1987), on substances that deplete the ozone layer, is a shining example of what one can achieve by a combination of science and political-will to reverse the harmful effects of anthropogenic activity on the environment. The Kyoto Protocol (1992) and the recently signed Paris agreement (2015), addresses the present and imminent need for a transition towards a more carbon free economy, while considering a holistic approach towards addressing the energy trilemma of energy security, environmental sustainability, and economic development. In this perspective, the large-scale development of Renewable Energy (RE) technologies is considered as a significant leverage for reducing anthropogenic emissions of Greenhouse Gases (GHGs), and "Holding the increase in the global average temperature to well below 2°C," as one of the explicit aims of the Paris agreement.

Singapore, situated at the equator (1.35°N, 103.8°E), is a self-acknowledged alternative-energy disadvantaged nation that has very limited wind or marine resources; and a solar resource which is only 30% more than southern Germany. Additionally, Singapore may be considered to be a blend of Manhattanesque dense Urban Megapolis and Houston Ship Channel-like dense Petrochemical complex. Despite these considerable constraints, Singapore has set the target of stopping any increase to its greenhouse gas emissions by 2030. It also pledged to reduce its energy intensity by 36 per cent from 2005 levels by 2030 by pursuing energy efficiency in both industrial and residential sectors, improving public transport, and increasing renewable energy deployment.

In this context, nanomaterials are poised to play a transformative role in providing solutions that range from heat rejection materials, materials that can cut the solar thermal gain through

glass windows, to next generation thin film and tandem solar cells. Opportunities that energy efficiency measures offer to reduce Singapore's energy intensity are thought to be higher than deployment of solar photovoltaics. However, emerging perovskite thin film solar cells promises to deliver solar cell efficiencies beyond what is possible with conventional solar cells; thus promising to boost the solar-output/unit area; a measure essential in real-estate constrained megacities like Singapore.

This presentation while broadly outlining challenges for Singapore to meet our Paris Agreement targets will focus also on perovskite solar cells, tandem solar cells, and new materials and concepts that promise to deliver efficiencies beyond the Shockley–Queisser limit.

Biography:

Subodh Mhaisalkar is the Associate Vice President (Strategy & Partnerships) and the Tan Chin Tuan Centennial Professor in the School of Materials Science & Engineering at the Nanyang Technological University (NTU), Singapore. Subodh is also the Executive Director of the Energy Research Institute @ NTU (ERI@N), a pan-University multidisciplinary research institute for innovative energy solutions. Comprising more than 220 researchers and 105 post graduate students, ERI@N has built up a critical mass of expertise in Energy Systems, Grid Systems, and Urban Solutions; and has set up more than 60 Industry partnership projects, with global industry leaders BMW, Johnson Matthey, Rolls-Royce, and BMW. Prior to joining NTU in 2001, Subodh has over 10 years of research and engineering experience in the microelectronics industry and his areas of expertise and current research interests includes semiconductor technology, perovskite solar cells, and printed electronics. Subodh received his Bachelors' degree from IIT-Bombay and his MS/Ph.D. degrees from The Ohio State University.

FIRESIDE CHAT SESSION

Day 1, May 17, 2018, Time: 12:00 pm – 1:00 pm, Venue: Lecture Theatre 4 (LT4)

Topic: Building the Plane While Flying It: An Entrepreneurial Journey

Guests

Aneesh Sathe

CEO & Co-founder, Qritive

Aneesh completed his Ph.D. from the Mechanobiology Institute (MBI), where he last worked on finding cancer cells in microscopy images using AI. At Qritive, he is the CEO, overseeing the business development and expansion. Aneesh's entrepreneurial journey started in PhD when he built (and broke) his first company. The lessons learnt have had a huge impact and he believes that without taking a risk, you can never achieve your full potential.

Kaveh Taghipour

CTO & Co-founder, Qritive

Kaveh completed his Ph.D. from the Computer Science department in the field of machine learning, where his technology has been used in hospitals for improving patient outcomes. At Qritive, he is the CTO, in charge of all the technology development. Kaveh takes incredibly difficult problems in healthcare and translates them into machine learning solutions. Kaveh's desire to make a change is rooted in a personal belief that ordinary people taking on impossible tasks change the world.

PANEL DISCUSSION

Day 1, May 17, 2018, Time: 4:15 pm – 6:15 pm, Venue: Lecture Theatre 4 (LT4)

Topic: Upskill 2.0: The skills essential for Engineers and Researchers to thrive in the world of Data and Machine Intelligence

Panel members

Prof. Haizhou Li
Department of Electrical and Computer Engineering
Department of Mechanical Engineering
National University of Singapore

Fellow of the IEEE
President, Asian Federation of Natural Language Processing

Prof. Haizhou Li is currently a Professor at the Department of Electrical and Computer Engineering, National University of Singapore (NUS). Prior to joining NUS, he was the Principal Scientist and Department Head of Human Language Technology in the Institute for Infocomm Research, A*STAR, Singapore. Dr Li has served as the Editor-in-Chief of IEEE/ACM Transactions on Audio, Speech and Language Processing (2015-2018), the President of the International Speech Communication Association (2015-2017), the President of Asia Pacific Signal and Information Processing Association (2015-2016), and the President of Asian Federation of Natural Language Processing (2017-2018). Dr Li is a Fellow of the IEEE. He was a recipient of the National Infocomm Award 2002 and the President's Technology Award 2013 in Singapore. Dr Li received the B.Sc., M.Sc., and Ph.D degree in electrical engineering from South China University of Technology, Guangzhou, China in 1984, 1987, and 1990 respectively.

Mr. Benjamin Anthony

Vice President, Digital Buildings, Middle-East & Asia-Pacific
Building Technologies, Siemens Pte. Ltd.

Benjamin has an extensive 29 years IT experience in operations, management and P&L leadership position with 18 years of working experience in global MNC with Siemens and Atos. Previous international posting was in Malaysia, Singapore and short stints in Germany, Shanghai and Mumbai. For the past 9 years based in Dubai managing GCC IT business. Recently relocated back to Singapore to head the Siemens Digital Buildings business for Middle East-Asia Pacific region.

Mr. Adhiraj Saxena

Manager of Industry Innovation
AI Singapore

Adhiraj is the manager of industry innovation in 'AI Singapore', a national initiative to anchor deep AI capabilities in Singapore. He oversees AI Singapore's '100 Experiments' programme with a mission to proliferate the adoption of AI among Singapore-based enterprises and start-ups. He is a Singaporean, graduated from National University of Singapore and served in Public Service for 7 years. Before joining AI Singapore, he was a project manager in the Ministry of Finance. He is also an Executive Committee member of the EDB Society, the alumni association for the Economic Development Board of Singapore.

Mr. Ujjwal Kumar

Principal Technical Evangelist
Systems of Intelligence (AI, Blockchain, Bots, IoT, ML)
Microsoft

Ujjwal Kumar is a Principal Technical Evangelist at Microsoft's Commercial Software Engineering (CSE) group based out of Singapore. He is a digital transformation ninja and works on system of intelligence (A.I., Blockchain, Bots, Cloud, IoT) with customers and partners to enable them realize their potential through architecture design and code development.

In the current role he works with enterprise businesses, global SI's, partner organizations, startups, top universities - faculties and students. He is also founder of "India Gamers Community", co-founder of "IoT community", an avid technologist and a prominent speaker.

Prior to current role, he worked as Partner Consultant and development platforms Worldwide Specialization Lead at Microsoft. He has 15 years of industry experience and he has been with Microsoft for 11.5 years. He has extensively worked on Microsoft Azure, Bots, Blockchain, IoT, Windows Internals, Robotics Studio, Modern Apps and Game development.

SYMPOSIUM STATEMENT & TECHNICAL HIGHLIGHT

The main objective of the Symposium is to further enhance the quality of graduate seminar as well as providing a platform for undergraduates & graduates students, faculty to exchange the latest research findings and ideas. This symposium provides a unique networking opportunity for students and faculty from NUS with leading industry experts in the field.

Thus, it will focus on research works and progress under six research areas- namely, Communications & Networks, Control, Intelligent Systems & Robotics, Microelectronic Technologies & Devices, Microwave & RF, Power & Energy Systems and Signal Analysis & Machine Intelligence. These works reflect the students' efforts in the state-of-the-art R & D.

PROGRAM SCHEDULE

Day 1: 17th May, 2018

TIME	EVENT	DESCRIPTION		
9.00 - 10.00 AM	**Registration** (Outside LT-4)			
10.00 - 10.30 AM	**Inaugural ceremony** (LT- 4)			
10.30 - 11.30 AM	**Keynote Speech 1** (LT -4)	Dr. Yeo Wee Loon, NUS CFG **Topic: Career Preparation Begins Now**		
11.30 AM - 12.00 PM	Tea& Snacks (Outside LT-4)			
12.00 - 1. 00 PM	**Fireside chat session** (LT - 4)	Dr. Aneesh Sathe and Dr. Kaveh Taghipour, Qritive **Topic: Building the Plane While Flying It: An Entrepreneurial Journey**		
1.00 - 1.45 PM	Lunch (Outside LT-4)			
1.45 – 3:45 PM	**Technical Sessions**	**Session 1** Microwave and RF (E3-06-01)	**Session 2** Microelectronic Technologies and Devices (E3-06-02)	-
3.45 - 4.15 PM	Tea& Snacks (Outside LT-4)			
4:15 - 5.15 PM	**Panel Discussion** (LT - 4)	**Topic: Upskill 2.0: The skills essential for Engineers and Researchers to thrive in the world of Data and Machine Intelligence**		
5.15 - 5.30 PM	Networking Reception&Heavy Snacks (Outside LT-4)			
5.30 – 6.15 PM	**Panel Discussion** (LT - 4)	Upskill 2.0 (contd.)		

Day 2: 18th May, 2018

TIME	EVENT	DESCRIPTION		
8.45 – 9.30 AM	**Registration** (Outside LT-6)			
9.00 - 11.00 AM	**Technical Sessions**	**Session 3** Communication and Networks (E3-06-04)	**Session 4** Microelectronic Technologies and Devices (E3-06-05)	**Session 5** Power and Energy Systems (E3-06-06)
10.55 - 11.15 AM	Tea& Snacks (Outside LT-6)			
11.15 AM - 12.15 PM	**Keynote Speech 2** (LT - 6)	Sam Witteveen, Red Dragon AI **Topic: Building AI Products: From Paper to Prototype to Production**		
12.15 – 1.00 PM	**Keynote Speech 3** (LT - 6)	Prof. Subodh G Mhaisalkar, NTU **Topic: Less than 2°C at 1°N?: Paris Agreement, Energy Efficiency, and Solar Cells Deployment Considerations for Tropical Megacities**		
1.00 - 2.00 PM	Lunch (Outside LT-6)			
2.00 - 4.00 PM	**Technical Sessions**	**Session 6** Control, Intelligent Systems, Robotics & Signal Analysis and Machine Intelligence (E3-06-04)	**Session 7** Microelectronic Technologies and Devices (E3-06-05)	-
4.00 - 4.30 PM	Tea& Snacks (Outside LT-6)			

TECHNICAL SESSIONS

SESSION 1

MICROWAVE & RF

PRESENTERS :		
1	**Lei Jin**	Non-interleaved full-colour meta-hologram
2	**Arash Nemati**	Tunable Metasurfaces
3	**Guang-Wei HU**	Metadevices via the Incorporation of Geometric Phase and Dynamic Phase
4	**Lei Jin**	Selectively Plasmon-Enhanced Second-Harmonic Generation from Monolayer Tungsten Diselenide on Flexible Substrates
5	**Menghua Jiang**	Etch-free Narrowband Metasurface

Non-interleaved full-colour meta-hologram

PRESENTER: **Lei Jin**

Abstract:
Metasurfaces with engineered nanostructures hold the promise for compact holograms that reconstruct vivid images due to their superior control of optical beams. As an excellent candidate to realize multifunctional devices, metasurfaces can be applied to control multi-wavelength wave-fronts to realize wavelength-multiplexed meta-hologram. However, the existing wavelength-multiplexed meta-hologram are based on the interleaved pixels to overcome the cross-talk among different wavelengths, which can degrade image quality, restrict the efficiency and produce high order diffractions. Here, we design and implement a non-interleaved full-colour Titanium Dioxide (TiO2) meta-hologram using a minimalist design with single-sized TiO2 elements. A dispersionless phase profile is utilized and coded on to the metasurface based on the Pancharatname-berry (PB) phase design. According to the nature of the PB phase and dispersion relationship, the designed metasurface controls three primary colour incident beams with right hand circular polarization to reconstruct three wavelength-dependent images at one observation plane. When 3 primary colour beams simultaneously illuminate this metasurface, the designed metasurface can reconstruct the image with both primary colours (red, green and blue) and the secondary colours (cyan, magenta, yellow and white). We believe that the reported meta-hologram with high capability will open a venue for future applications with versatile wavelength-multiplexed optical devices.

Tunable Metasurfaces

PRESENTER: **Arash Nemati**

Abstract:
Metamaterials are artificial media in which the propagation properties of an electromagnetic wave are mainly defined by their underlying structures with the feature size far smaller than the operational wavelength. Metasurfaces are the two-dimensional equivalent of metamaterials, composing discrete subwavelength structures in an ultrathin film at the interface and possessing the capability of full control of light properties in terms of amplitude, phase, dispersion, momentum and polarization. Metasurfaces have attracted huge attention for its versatile functionality, ultra-thin feature and easy integration compared with conventional refractive optics. There has been intensive research on different types of metasurfaces such as frequency selective metasurfaces, high-impedance metasurfaces, perfectly absorbing metasurfaces, and wave-front shaping metasurfaces, holograms, etc. The importance of active, tunable, or reconfigurable devices in modern electromagnetic and photonic systems is undebatable. It is highly desired to create such metasurfaces capable of dynamic manipulations of the incident wave. For example, tunable frequency selective or perfectly absorbing metasurfaces allow accurate resonance tuning to perfectly match the operational condition or switching of operational frequency in signal modulation. Making a tunable metalens, one of the wave-front shaping metasurfaces acting as a flat optical lens, allows fine tuning of focal length which is very desirable in the imaging process.

Metadevices via the Incorporation of Geometric Phase and Dynamic Phase

PRESENTER: **Guang-Wei HU**

Abstract:
In this talk, I will present my recent progresses of the metasurface and metadevice design based on the incorporation of dynamic phase and geometric phase. In particular, the dynamic phase is the optical phase due the resonance or the optical path difference, such as concave lens or V-shape antenna array; the geometric phase is due to the spin-orbit interaction and intrinsically spin-dependent, such as Pancharatnam-Berry phase. In this presentation, I will show that by judiciously designing the meta-atoms, the functional metadevices with the auxiliary degree of freedom (DoF) and more flexibility can be achieved. More specifically, the broadband photonic spin Hall metalens (PSHM) and the arbitrary generation of angular momentum (AM) of light (both spin-dependent and -independent) will be shown. PSHM can achieve the splitting and focusing of light with different spin angular moment (SAM) simultaneously in the same side via designing the metasurface on curved silica glass. We also demonstrated the PSHM can also be utilized for information encryption and many other purpose. In addition, we showed that patterning the nanoslit array in the gold surface can help to generate orbit angular momentum (OAM) with arbitrary order thanks to the co-contribution of the geometric phase and dynamic phase, which can also break the spin-dependence for the traditional OAM generation like the Archimedean spiral or synthetic array. We also revealed the dynamic and static characteristics of OAM in the experiment via photon-emission electron microscopy. We believe that our work can provide an alternative approach to design the functional, miniaturized metadevices with more DoF.

Selectively Plasmon-Enhanced Second-Harmonic Generation from Monolayer Tungsten Diselenide on Flexible Substrates

PRESENTER: **Lei Jin**

Abstract:
Monolayer two-dimensional transition-metal dichalcogenides (2D TMDCs) exhibit promising characteristics in miniaturized nonlinear optical frequency converters, due to their inversion asymmetry and large second-order nonlinear susceptibility. However, these materials usually have very short light interaction lengths with the pump laser because they are atomically thin, such that second-harmonic generation (SHG) is generally inefficient. In this paper, we fabricate a judiciously structured 150 nm-thick planar surface consisting of monolayer tungsten diselenide and sub-20 nm wide gold trenches on flexible substrates, reporting ∼7000-fold SHG enhancement without peak broadening or background in the spectra as compared to WSe2 on as-grown sapphire substrates. Our proof-of-concept experiment yields effective second-order nonlinear susceptibility of 2.1 × 104 pm/V. Three orders of magnitude enhancement is maintained with pump wavelength ranging from 800 to 900 nm, breaking the limitation of narrow pump wavelength range for cavity-enhanced SHG. In addition, SHG amplitude can be dynamically controlled via selective excitation of the lateral gap plasmon by rotating the laser polarization. Such a fully open, flat, and ultrathin profile enables a great variety of functional samples with high SHG from one patterned silicon substrate, favoring scalable production of nonlinear converters. The surface accessibility also enables integration with other optical components for information processing in an ultrathin and flexible form.

Etch-free Narrowband Metasurface

PRESENTER: **Menghua Jiang**

Abstract:
Narrowband metasurface generally receives fewer attention than its broadband variation. Common metallic narrowband metasurface employs metal-insulator-metal (MIM) structures with etching processing. Here we present a narrowband metasurface with full-width-half-maximum (FWHM) of its reflection spectrum being about 20 nm, and an etch-free fabrication recipe. The metasurface exhibit highly saturated structural color upon white illumination. Several possible variations of the design are proposed, including phase-variation design for color hologram. This is by far the metasurface design with the narrowest reflection band and simplest fabrication recipe.

SESSION 2

MICROELECTRONIC TECHNOLOGIES AND DEVICES

PRESENTERS :		
1	**Lingfei Wang**	Percolation Theory based Statistical Resistance Model for Resistive Random-Access Memory
2	**Serene Wen Ling Ng**	One-step activation towards spontaneous etching of hollow and hierarchical porous carbon nanospheres composite with TiO2 for enhanced pollutant adsorption and degradation
3	**Lingfei Wang**	A Physics-Based Compact Model for Transition-metal Dichalcogenides Transistors with the Band-Tail Effect
4	**Xinhang Li**	P-type silicon solar cells with laser fired contacts for tandem applications
5	**Chen Nan**	Graphene Tunable Plasmon-Phonon Coupling in Mid-IR Complementary Metamaterial

Percolation Theory based Statistical Resistance Model for Resistive Random-Access Memory

PRESENTER: **Lingfei Wang**

Abstract:
Comprehensive understanding of the disorder induced transport characteristics in Resistive Random-Access Memory (RRAM) is critical for its thermal stability analysis and analog switching in neuromorphic computing application. In a wide temperature range from 4 K to 300 K, the previous reports have shown that the RRAM characteristics are dependent on its structural disorders (i.e., Oxygen vacancy, Poole–Frenkel defects etc.). Such disorders are invariably induced by the fabrication and will lead to different transport mechanisms in low temperature region, such as Poole-Frenkel (PF) conduction for 213 K, trap-assisted-tunneling conduction for 50 K and metallic conduction in low resistance state for 10 K. Therefore, the models disable distinguishing the statistical transport mechanisms in different temperature regions (below 300 K), which hinders the thermal stability analysis in low temperature region. In addition, to provide accurate predictions for potential applications in ultra-low temperature region, a more universal and accurate physical model of RRAM considering structural disorders is highly required In this work, by utilizing percolation theory and Fermi Golden Rule, the probability distributions for both tunnel junction energy barrier and gap distance based statistical resistance model is proposed. The low temperature transport mechanism transition has been studied under different programming cycles and resistance states. Moreover, the model enables the investigation of the dependence of electrical characteristics on temperature and defect generation (i.e., radiation damage). The good agreement between the simulation and experimental results indicates the capability of our physics-based model to provide an accurate prediction of disorder effects in RRAMs.

One-step activation towards spontaneous etching of hollow and hierarchical porous carbon nanospheres composite with TiO2 for enhanced pollutant adsorption and degradation

PRESENTER: **Serene Wen Ling Ng**

Abstract:
Traditionally, porous carbon can be realized through chemical activation as well as templating with different materials for generation of hierarchical pores. However, the former method often results in the loss of the carbon's initial structure, while the latter is known to be complex and requires additional procedures to remove the templates. This work demonstrates one-step activation-excavation approach towards simultaneous etching of hierarchical pores with the preservation of its hollow framework for enhanced volatile organic compounds (VOCs) adsorption. The improvement in activity stems from the micropores, mesopores and hollow interior for containment, selectivity of larger adsorbents and enhanced transport diffusion respectively for VOCs adsorption. In addition, growth of TiO2 nanosheets on the as synthesized carbon leading to improved photocatalytic degradation has also been demonstrated. Thus, this facile and effective approach of producing hollow interior and hierarchical pores carbon nanostructures composite with TiO2 is promising for functional pollutant removal.

A Physics-Based Compact Model for Transition-metal Dichalcogenides Transistors with the Band-Tail Effect

PRESENTER: **Lingfei Wang**

Abstract:
Due to structural disorder effects, variable range hopping (VRH) transport via band-tail states has been widely observed in transition metal dichalcogenide field-effect transistor (TMD FET). For TMD-FETs, the band-tail effect is of great significance for mobility reduction, due to variable range hopping (VRH) transport via localized states. Such band-tail effect is inevitably induced by the intrinsic defects in TMD or during device fabrication. However, this mechanism was not incorporated in the previous compact models which use the drift-diffusion model. Therefore, they cannot accurately predict the temperature and carrier density dependent transport behaviors, especially in sub-threshold region. In this work, a continuous physics-based compact model considering VRH in TMD FET is developed. The voltage dependent carrier density and temperature dependent current characteristics are physically predicted by utilizing transport energy theory, general percolation theory and generalized Einstein relation. In addition, this model is unified to explain the similar behaviors in both TMDs and other 2D materials like black phosphorus. Key parameters are extracted by calibration to experimental molybdenum disulfide FET. Our model is validated by the good agreement between the simulation and experimental results. Furthermore, the relationship between disorder effects and circuit-level performances are presented. This work is significant for material engineering and device optimization of TMD FET.

P-type silicon solar cells with laser fired contacts for tandem applications

PRESENTER: **Xinhang Li**

Abstract:
Today, crystalline silicon wafer solar cells are approaching their practical efficiency limit of about 26%. Higher efficiency can be achieved by applying a tandem approach that incorporates a high bandgap top cell on top of a silicon bottom cell. In this configuration, the design considerations for the silicon bottom cell will be different from that of a standalone single-junction silicon cell operating under AM1.5G 1-sun standard spectrum. In a conceptual 2-terminal tandem integration of a perovskite on silicon tandem device, the two sub-cells could be connected in series by a tunnelling layer of Bragg transmitter. Since the Bragg transmitter layers are sensitive to both heat and metal contaminations, low temperature rear-side metallization could only be applied after its deposition. Bearing this process limitation in mind, silicon bottom cell with full area sputtered aluminium and laser fired contacts (LFCs) was designed. To investigate the effect of ARC thickness on cell performance, cells with 120nm and 70nm silicon nitride (SiNx) anti-reflective coating were fabricated. When illuminated under AM1.5G 1-sun standard spectrum, the efficiency of the group with 120nm SiNx was only 13.9% while the group with 70nm SiNx achieved 17.4%. However, when 915nm single wavelength laser illumination was used, the efficiency increased to 30.9% and 31.8% for the respective group. This effect could be explained through external quantum efficiency measurement. Other characterization methods were also employed to further explain the current-voltage characteristics of the solar cells.

Graphene Tunable Plasmon-Phonon Coupling in Mid-IR Complementary Metamaterial

PRESENTER: **Chen Nan**

Abstract:

Metamaterial-based plasmonics has become an overwhelming research field due to its enormous potential and versatility in molecular sensing, imaging and non-linear optics. This work presents a new tunable plasmonic platform on which the metamaterial resonance is coupled with infrared vibrational bond in the presence of graphene electrostatic modulation. The maximum electric field enhancement factor induced by mode coupling is 14 and the quality factor (Q-factor) of phonon mode is increased approximately by 4 folds. The graphene electrostatic modulation based on the parallel-plate capacitor configuration enables the wavelength shift of 1.57 nm/V, resonance intensity and Q-factor modulation depth of 103.34% and 70%, respectively. Metamaterial based plasmon polariton perfectly matched with phonon mode yields the highest Q-factor of 40. However, this perfectly-matched resonance appears to be prohibitively "switched off" in the electrostatic tuning, which is reported for the first time. Mode splitting investigation reveals the largest coupling strength of 8.1 meV (1.96 THz) that results in the insensitivity to the perturbation caused by graphene modulation. Finally, we report an averaged sensitivity of 1.677 μm/RIU and a tunable figure of merit depicting the versatility of this platform for multiplexed sensing applications in various conditions.

SESSION 3

COMMUNICATIONS AND NETWORKS

PRESENTERS :		
1	**Rajarshi Chattopadhyay**	Distributed Incentive Mechanism for a Mobile Edge Computing Network
2	**Shandong Dong**	Simultaneous Measurement of Refractive Index and Temperature with a Dual Core Photonic Crystal Fiber Interferometer
3	**Ayush Kumar**	Detecting Internet-of-Things Malware Bots: A Practical Algorithm Using Packet Sub-Sampling
4	**Bikalpa Upadhyaya**	Jamming Detection in Indoor Environment based on Received Signal Strength
5	**Jingwei Zhang**	UAV-Enabled Radio Access Network: Multi-Mode Communication and Trajectory Design
6	**Nalam Venkata Abhishek**	An Intrusion Detection System for Detecting Compromised Gateways in Clustered IoT Networks
7	**Chua Yu Han**	The impact of shipping bubbles towards underwater acoustic communication

Distributed Incentive Mechanism for a Mobile Edge Computing Network

PRESENTER: **Rajarshi Chattopadhyay**

Abstract:
The increasing use of edge devices and edge computing has become a major trend in networking research. The rapid growth in the amount and variety of sensing data coupled with the growing number of data analytics based mobile applications, has resulted in an exponential rise in processing demand. One way to cope up with this increased processing demand is to use edge networks, which is a wireless ad-hoc network of mobile cloudlets, vehicular cloudlets, dedicated edge devices and cloud platforms. Typically these devices are owned and managed by different users and service providers, with no central authority governing them. In this work, we propose a distributed incentive mechanism for such a network, which does not require a trusted third party (TTP) and helps to increase device participation, which is crucial for the success of this approach. Essentially, a user's mobile device offloads tasks to neighboring nodes in an edge network and provides incentives for completing them. Our scheme is computationally efficient and takes into account the processing cost of each node, helping them decide on the incentives and workload distribution, and requires each node to communicate only with its direct neighbours. We conducted simulations to study the workload distribution and incentives received by nodes, including scenarios of untruthful behavior by some nodes. Results show that our proposed scheme successfully assigns more workload to efficient (in terms of per unit processing cost) nodes and lower workload to untruthful nodes.

Simultaneous Measurement of Refractive Index and Temperature with a Dual Core Photonic Crystal Fiber Interferometer

PRESENTER: **Shandong Dong**

Abstract:
A compact and small modal interferometer for simultaneous measurement of temperature and refractive index is demonstrated. The coupling and interference of the sensor were investigated mathematically and experimentally. The interferometer with structure of single mode fiber (SMF)-dual core photonic crystal fiber (DCPCF)-SMF has very weak interference, due to the small difference between two core modes in the DCPCF. To improve the interference depth and enhance the refractive index sensitivity, a finely core-offset at one splicing point between DCPCF and SMF is necessary to excite cladding modes. By using the core-offset, cladding modes can be highly excited. As a result, modal interference between dominated cladding mode and core mode dominates the transmission spectrum, while weak interferences (including interference between two core modes, interference between core mode and weak cladding modes) can modulate the interference pattern. The proposed sensor can have much higher RI sensitivity than the structure without core offset since the excitation cladding mode can be directly affected by the ambient RI. We further experimentally perform simultaneous measurements with a measurement resolution of ±2.3196 °C in temperature and resolution of ±0.0005 RIU in RI for temperature and RI by just one sensing head. Moreover, the proposed sensor owns advantages of small size, simple structure, good repeatability, low cost, etc.

Detecting Internet-of-Things Malware Bots: A Practical Algorithm Using Packet Sub-Sampling

PRESENTER:**Ayush Kumar**

Abstract:
The widespread adoption of Internet of Things has led to many security issues. Recently, there have been malware attacks on IoT devices, the most prominent one being that of Mirai. IoT devices such as IP cameras, DVRs and routers were compromised by the Mirai malware and later large-scale DDoS attacks were propagated using those infected devices (bots) in October 2016. In this research, we aim to develop a practical algorithm which can be used to detect IoT bots infected by Mirai and similar malwares in a real-world large networks (e.g. ISP network). We analyze the unique signatures of the Mirai malware to identify its presence in an IoT device. Further, we use a two-dimensional (2D) packet sampling approach, wherein we sample the packets transmitted by IoT devices both across time and across the devices. Leveraging the Mirai signatures identified and the 2D packet sampling approach, a practical bot detection algorithm is proposed. We use testbed measurements and simulations to study the relationship between bot detection delays and the sampling frequencies for device packets. We derive insights from the obtained results and use them to design our proposed bot detection algorithm. Finally, we discuss the deployment of our bot detection algorithm and the countermeasures which can be taken post detection.

Jamming Detection in Indoor Environment based on Received Signal Strength

PRESENTER: **Bikalpa Upadhyaya**

Abstract:
Wireless Sensor Networks are prone to cyber-attacks that causes Denial of Service (DOS), increase in latency and decrease in throughput, ultimately causing fatal damages in real-time applications. Such DOS attacks can be handled by designing an Intrusion Detection System (IDS) that monitors the operation of the network or the host to detect security violations in the system. It is important to design a detection scheme that uses minimal resources and yet has a wide range of detection. This paper demonstrates the design of an IDS that detects any jammers in the network passively by monitoring Received Signal Strength (RSS) with the help of anchor nodes in the network and classifies them either as a registered node or a jammer node. The network assumes that the nodes are stationary, and the simulation is carried out in an indoor environment. The simulation results indicate accuracy for increasing number of anchor nodes used in the network.

UAV-Enabled Radio Access Network: Multi-Mode Communication and Trajectory Design

PRESENTER: **Jingwei Zhang**

Abstract:
We consider a unmanned aerial vehicle (UAV)-enabled radio access network (RAN) with the UAV acting as an aerial platform to communicate with a set of ground users (GUs) in a variety of modes of practical interest, including data collection in the uplink, data transmission in the downlink, and data relaying with both uplink and downlink involved. Under this general framework, two UAV operation scenarios are considered: \emph{periodic operation}, where the UAV serves the GUs in a periodic manner by

following a certain trajectory repeatedly, and one-time operation where the UAV serves the GUs with one single flying and then leaves for other missions. In each scenario, we aim to minimize the operation period or mission completion time, respectively, while satisfying the target rate requirement of each GU via a joint UAV trajectory and communication resource allocation design approach. Iterative algorithms are proposed to find efficient locally optimal solutions by utilizing successive convex optimization and block coordinate descent techniques. Moreover, as the quality of the solutions obtained by the proposed algorithms critically depend on the initial UAV trajectory assumed, we propose new methods to design the initial trajectory by leveraging the results for solving the classical Traveling Salesman Problem (TSP) and Pickup-and-Delivery Problem (PDP) in the literature. Numerical results show that the proposed trajectory initialization designs lead to significant performance gains compared to the benchmark initialization with circular trajectory.

An Intrusion Detection System for Detecting Compromised Gateways in Clustered IoT Networks

PRESENTER: **Nalam Venkata Abhishek**

Abstract:
It is well known that clustering IoT devices will help to alleviate the network scalability problem in IoT networks. However, clustering also provides an opportunity for an adversary to compromise a set of nodes by simply compromising their gateway. In such scenarios, one of the strategies available to an adversary to degrade the performance of a network is by corrupting the packets to be forwarded by the gateway. In this paper, a centralized detection system for detecting the presence of such a malicious gateway is proposed. The proposed system uses the packet drop probability as a means to monitor the gateways. An algorithm is presented to design the key parameters of the proposed system, and its performance is evaluated through extensive simulations.

The impact of shipping bubbles towards underwater acoustic communication

PRESENTER: **Chua Yu Han**

Abstract:
Underwater water acoustic communication is highly susceptible to the effects of bubbles. One of the primary causes of these bubbles is the shipping activity in the vicinity. To understand the effect of these shipping bubbles, we conducted an experiment where communication signals were sent across a channel with a boat hovering around the channel. We present the experimental data and show the performance of various channel estimation methods in such channels.

SESSION 4

MICROELECTRONIC TECHNOLOGIES AND DEVICES

PRESENTERS :		
1	**Xue Zheng**	Characterization of Cu(In,Ga)Se2 solar cells fabricated by two-step sequential process: selenization temperature influences
2	**Chi Sun**	Effect of capping layer on spin-orbit torques
3	**Li Chen**	Monolithic Complementary Transistors and Integrated Circuit Based on Black Phosphorus/HfO2 Heterostructure
4	**Pranesh Balamuniappan**	3D Scanning Electron Microscopic image using a dual focusing electron beam column design.
5	**S M Rafi Ul Islam**	Strain induced valley filtering in Weyl-semimetal

Characterization of Cu(In,Ga)Se2 solar cells fabricated by two-step sequential process: selenization temperature influences

PRESENTER: **Xue Zheng**

Abstract:

Chalcopyrite Cu(In,Ga)Se2 (CIGS) based CIGS thin film solar cells have achieved a conversion efficiency of 22% recently. The advantages such as cost-effective, high throughput and flexible production method make the technology even more attractive for photovoltaic (PV) module fabrication. In this contribution, CIGS thin film solar cells are fabricated by metal precursor deposition and the subsequent rapid thermal annealing using elemental selenium. The influences of the selenization temperature, ranging from 550 to 650 °C, on the chemical composition, crystal structure as well as the electrical properties of the devices are investigated. Micro-Raman spectroscopy measurements reveal the dominant chalcopyrite CIGS phase for all absorbers under investigation. The compositional profile obtained by energy dispersive X-ray spectroscopy demonstrates that higher selenization temperatures enable improved Gallium diffusion into the front surface region of the CIGS absorber, reducing the recombination in the depletion region and improving the open-circuit voltage. However, the solar cell series resistance is increased by higher selenization temperatures due to the increased thickness of the MoSe2 layer formed at the Mo/CIGS interface. A fill factor loss analysis shows that junction shunting problems occur in low-temperature selenized CIGS absorbers, due to In accumulation near the front surface of the absorber. For the chosen deposition method, the optimized selenization temperature is 580 °C.

Effect of capping layer on spin-orbit torques

PRESENTER: **Chi Sun**

Abstract:

In order to enhance the magnitude of spin-orbit torque (SOT), considerable experimental works have been devoted to studying the thickness dependence of the different layers in multilayers consisting of heavy metal (HM), ferromagnet (FM) and capping layers. Here we present a theoretical model based on the spin-drift-diffusion (SDD) formalism to investigate the effect of the capping layer properties such as its thickness on the SOT observed in experiments. It is found that the spin Hall-induced SOT can be significantly enhanced by incorporating a capping layer with opposite spin Hall angle to that of the HM layer. The spin Hall torque can be maximized by tuning the capping layer thickness. However, in the absence of the spin Hall effect (SHE) in the capping layer, the torque decreases monotonically with capping layer thickness. Conversely, the spin Hall torque is found to decrease monotonically with the FM layer thickness, irrespective of the presence or absence of SHE in the capping layer. All these trends are in correspondence with experimental observations. Finally, our model suggests that capping layers with long spin diffusion length and high resistivity would also enhance the spin Hall torque.

Monolithic Complementary Transistors and Integrated Circuit Based on Black Phosphorus/HfO2 Heterostructure

PRESENTER: **Li Chen**

Abstract:
Black phosphorus (BP) has attracted enormous interest for logic applications due to its unique electronic properties. However, pristine BP exhibits predominant p-type channel conductance, which limits the realization of complementary circuits unless an effective n-type doping is found. Here, we propose a practical approach to transform the conductivity of BP from p-type to n-type via aluminum (Al) doping in the BP channel. Symmetrical threshold voltage for the pair of p-type and n-type BP field-effect transistors (FET) can be achieved by tuning the Al doping concentration. The complementary inverter circuit shows a clear logic inversion with a high voltage gain up to ~11 at a supply voltage (VDD) of 1.5 V. Simultaneously, a high noise margin of 0.27 VDD is achieved for both low (NML) and high (NMH) input voltages, indicating good immunity to input signal noise. In addition, a three-stage ring oscillator is theoretically examined by circuit modeling based on the device measurements, showing an oscillating frequency as high as 1.8 GHz and a voltage swing of 1.0 V at VDD = 1.5 V. Our study demonstrates a straightforward approach to fabricate complementary transistors and integrated circuits using a homogenous BP channel material, paving the way towards the realization of complex logic circuits on large scale substrate.

3D Scanning Electron Microscopic image using a dual focusing electron beam column design.

PRESENTER: **Pranesh Balamuniappan**

Abstract:
A scanning electron microscope (SEM) produces images of a sample by scanning the surface with a focused beam of electrons and produces planner information of the specimen surface. This paper proposes an electron beam column design that enables a stereoscopic 3D image of the specimen surface to be formed. The proposed electron beam column has 2nd order focusing in both geometric and chromatic ray distribution for a cold-field emission source. This would be achieved through a novel column design which consists of two 45o spherical deflectors and weak focusing Einzel lens. Through rotational symmetry, we were able to achieve a probe size of 8nm formed by multiple electron beamlets from different angles at the detection plane. Thus, the signals scattered from these different angles can be recorded for a stereoscopic 3D image. This image may provide vital information for various phenomenon observed in various scientific researches.

Strain induced valley filtering in Weyl-semimetal

PRESENTER: **S M Rafi Ul Islam**

Abstract:
In this paper, a valley filtering device based on strained Weyl-Semimetal(WSM) has been proposed. Strain can induce gauge vector potential in the effective Hamiltonian of WSM. It is found that both strain and barrier height can enable spatial separation of states of opposite valleys. WSM can be considered as the three-dimensional analogous of 2D graphene. Since energy equation of WSM consists of all three Pauli matrices, unlike

graphene it provides topological protection and robustness against perturbation. However, strain can shift the Weyl nodes and fermi surfaces for K and K' valley in opposite directions but still topologically preserved. When fermi circles for K and K' valleys have mutual common region with respect to fermi circle in unstrained region, transmission of electrons of both valleys prevails. However, larger strain parameter can shift valley dependent fermi circles such that they will be mutually exclusive to each other. This will cause the total backscattering for incident electrons at the interface. Therefore, a strain induced channel can guide valley dependent transport in WSM. A large value of strain can make the wavevector imaginary in strained region, which will provide total internal reflection instead of transmission for a selected valley. So, strained WSM can guide the carrier transmission with valley dependency and lead to many exotic transport phenomena. Moreover, 100% valley polarized current can be obtained by tuning proper combination of energy, barrier height and strain. So, performance and system properties of Weyl semimetal based valleytronic devices can be enhanced significantly by tuning strain.

SESSION 5

POWER AND ENERGY SYSTEMS

PRESENTERS :		
1	**Jaydeep Saha**	A Matrix-Based Solid-Sate-Transformer For A Hybrid Nanogrid
2	**Gururaghav Raman**	Residential microgrids for increasing the community acceptance of smart grid services
3	**Gurupraanesh Raman**	Sensitivity-based supervisory control scheme for multi-microgrid distribution systems
4	**Rohit Chandra**	Building Energy Management System for Transactive Energy Framework
5	**James Ranjith Kumar Rajasekaran**	Efficient detection of false data injection attacks on AC state estimation in smart grids

A Matrix-Based Solid-Sate-Transformer For A Hybrid Nanogrid

PRESENTER: **Jaydeep Saha**

Abstract:
A front-end Matrix-based Bidirectional Solid-State-Transformer (SST) is proposed for a nanogrid having both DC and AC buses (hybrid nanogrid). A front-end single-phase Matrix-Converter (MC) converts the Line-Frequency AC grid voltage to High-Frequency AC (HFAC) without using any intermediate DC-link Capacitor. The MC is modulated using a modified Sinusoidal Pulse-Width-Modulation (SPWM) scheme. The HFAC voltage passes through a compact High-Frequency Transformer. The HFAC voltage at the secondary side of the transformer is then rectified using a Bidirectional Current-Doubler-Rectifier (CDR) to form a stiff DC bus. The currents emerging out of the CDR in all the three phases (which are phase shifted by $2\pi/3$ each) meet at the common DC bus and produce a sixth harmonic ripple current, whose ripple content is lower than the individual current emerging from CDR in each of the 3 phases. This leads to a considerable reduction in size of the DC output filter capacitor. A bidirectional converter is used to facilitate energy interaction between AC and DC buses of the nanogrid. The topology has two configurations based on the direction of power flow – (i) step-up and (ii) step-down. Simulation of the proposed SST topology is performed using PLECS Standalone and MATLAB R2016b softwares and the results are presented to verify the theoretical analysis. A comparative analysis of the proposed topology with other relevant contemporary SST topologies along with STATCOM based Low-Frequency Transformer (LFT) technology is also presented. The proposed topology has high reliability, exhibits high power density and superior input side power quality (THD of 3.05%).

Residential microgrids for increasing the community acceptance of smart grid services

PRESENTER: **Gururaghav Raman**

Abstract:
Community-wide acceptance and implementation of smart grid services in the residential distribution system is key to modernizing the power grid. This paper addresses two main concerns that inhibit the residential community from embracing smart grids: lack of an ageless hardware topology that can adapt to future changes in the home appliance industry, and vendor-specific commercial home energy management systems (HEMS) that create a "walled garden" and hijack consumers for life. These concerns result in: inability of consumers to power efficient DC-based appliances directly from the current AC distribution system, lacklustre adoption rates of HEMS devices, incompatibility of home automation devices sold by various vendors with each other, and finally, the inability of the utility to coordinate the various flexible resources in the grid. We propose a scalable solution to these problems by proposing building-integrated smart sockets controlled by a building energy management system, amalgamated to form a futuristic topology and controlled in a decentralized manner. Targeting residential apartment buildings, we posit a shift from the voluntary installation of HEMS systems in just a few residences, to a building-wide implementation of demand response services so as to involve the whole community, and increase the flexibility of the demand. Owing to the simplicity of the proposed transitional topology and policy of central BEMS installation, this design would be attractive to contractors and builders of new residential buildings that are built in dense urban communities.

Sensitivity-based supervisory control scheme for multi-microgrid distribution systems

PRESENTER: **Gurupraanesh Raman**

Abstract:

Pockets of local generation, loads and storage elements are integrated to form microgrids at the distribution level. With increasing penetration of renewables and storage solutions, multiple microgrids are expected to be interconnected through the distribution infrastructure. These microgrids are typically controlled in a decentralized manner with P-f/Q-V droops, and the overall stable operation of the distribution system infrastructure comes under the purview of the Distribution System Operator. This paper presents a novel scheme to restore global system stability in the event of poorly damped power flows. The droop coefficients of the controllable inverters are manipulated in real-time based on a sensitivity criterion so as to obtain the maximum damping effort per unit of additional power injected. This prevents the overloading of any one inverter or group of inverters in the system. The proposed scheme is robust to failure of communication links, and further incorporates condition-based calls to the global stability assessment tool. During the contingency response process, this reduces the number of stability assessment calls, which are computation-intensive and un-scalable to system size, thereby reducing the response time. The proposed method was implemented in a simple 3-bus test case, as well as in the IEEE 123 bus distribution system test case. In either case, the simulation results indicate that the sensitivity-based supervisory control scheme can enable recovery of system damping above the desired threshold, while maintaining the power sharing disparity within prescribed limits.

Building Energy Management System for Transactive Energy Framework

PRESENTER: **Rohit Chandra**

Abstract:

In future smart grids, billing of electricity usage will be based on electricity plans such as time-of-use (TOU) tariffs. The price of electricity units would vary throughout the day based on demand-supply scenarios and congestion in power supply networks. This paradigm has been proposed to incentivise customers to align their electricity usage with availability patterns across the day to avoid demand peaks which cause additional losses and stresses on the power system. In this paradigm, automated Building Energy Management System (BEMS) participate in Transactive Energy (TE) markets to purchase electricity. In order to bid in TE markets, a value discovery mechanism for electricity consumption in households is required. A novel BEMS is presented which schedules the household appliances according to applicable TOU tariffs, expected distributed energy resource generation, and user preferences for economy. The appliances in the households are divided into four categories: uncontrolled (refrigerators), deferrable (like washing machine, rice cooker, etc), controlled (air-conditioning), and energy storage. Mathematical models are presented for electricity usage of each type of appliance, and their operation constraints. The proposed BEMS minimizes the cost of electricity used along with minimizing the virtual costs (i.e. maximize usage value of electricity) of ageing of storage appliance, thermal discomfort and waiting to operate deferrable appliances. The problem is formed as non-linear constrained optimization problem which is solved using a hybrid gradient descent algorithm. Simulations results are presented in MATLAB for different TOU tariffs and user preferences to verify the efficacy of the proposed algorithm.

Efficient detection of false data injection attacks on AC state estimation in smart grids

PRESENTER: **James Ranjith Kumar Rajasekaran**

Abstract:

This paper proposes a simple non-iterative technique for detecting false data injection attacks on alternating current (AC) state estimators. The proposed method uses the nodal power injections and line power flows from the supervisory control and data acquisition (SCADA) system and voltage magnitudes and angles from phasor measurement units (PMUs) to the detect the false data injection attack. As the proposed method is independent of the state estimation outputs and does not depend on any other energy management system (EMS) functionality, it can be used to test the quality of the data even before the execution of the state estimation algorithm. The proposed method has been tested in the IEEE 118 bus system where false data with a magnitude ranging from 1% to 10 % is injected in four pairs of line power flows and one voltage measurement. It has been demonstrated that the proposed method can detect such attacks even when the attack magnitude is as small as 1%, which is not able to be deducted by conventional bad data detection techniques.

SESSION 6

CONTROL, INTELLIGENT SYSTEMS AND ROBOTICS
&
SIGNAL ANALYSIS AND MACHINE INTELLIGENCE

PRESENTERS :		
1	**Shuhua Gao**	Efficient Boolean Modeling of Gene Regulatory Networks via Random Forest Based Feature Selection and Best-Fit Extension
2	**Zihan Pan**	An Event-Based Cochlear Filter Temporal Encoding Scheme for Speech Signals
3	**Jibin Wu**	A Spiking Neural Network Framework for Robust Sound Classification
4	**Shuhua Gao**	Mathematical Modelling Reveals the Role of Hypoxia in Promotion of Human Mesenchymal Stem Cell Long-Term Expansion
5	**Aashish Sharma**	Into the Twilight Zone: Depth Estimation using Joint Structure-Stereo Optimization
6	**Xiaoxu Zheng**	Human vision inspired multi-scale line segments merging and filtering
7	**Jingwei Li**	Global signal regression strengthens association between resting-state functional MRI and behavior in human
8	**Nanbo Sun**	Latent Factors Underlying Atrophy, Behavioral and Tau Heterogeneity in Alzheimer's Disease

Efficient Boolean Modeling of Gene Regulatory Networks via Random Forest Based Feature Selection and Best-Fit Extension

PRESENTER: **Shuhua Gao**

Abstract:
Gene regulatory networks play a critical role in cellular behavior and decision making. Mathematical modeling of gene regulatory networks can help unravel the complexity of gene regulation and provide deep insights into key biological processes at the cellular level. In this paper, we focus on building Boolean models for gene regulatory networks from time series gene expression data. Since the two classic methods, REVEAL and Best-Fit Extension, are both computationally expensive and cannot scale well for large networks, we propose a novel hybrid approach combining the feature selection technique based on random forest and the Best-Fit Extension algorithm. The feature selection step can effectively rule out most of the incorrect candidate regulators, and thereby can significantly decrease the workload of the subsequent Best-Fit Extension fitting procedure. The efficiency and performance of the proposed two-stage framework are analyzed theoretically and validated comprehensively with synthetic datasets generated by the core regulatory network active in myeloid differentiation.

An Event-Based Cochlear Filter Temporal Encoding Scheme for Speech Signals

PRESENTER: **Zihan Pan**

Abstract:
Spiking Neural Network (SNN), the third generation of neural networks, has been shown to perform well in pattern recognition tasks involving temporal information, such as speech recognition and motion detection. However, most neural networks, including the SNN, for speech recognition rely on short-time frequency analysis, such as the mel-frequency cepstral coefficients (MFCC), for low-level feature extraction. MFCC feature extraction works by analyzing a window of time signal in multiple frequency bands one window at a time, in a synchronous fashion. This is in contrast to the event-based principle of SNN, whereby electrical impulses are emitted and processed in an asynchronous fashion. Just as speech signals arrive at the human's cochlear filterbank concurrently, but spikes encoding the power in each frequency band are emitted asynchronously, we propose an event-based cochlear filter encoding scheme, whereby the power in each frequency band is directly extracted in the time domain and spikes encoded using the latency code are emitted asynchronously to represent the power of each frequency band. This replaces the traditional MFCC frontend used in most speech recognition models, and makes possible an end-to-end event-based SNN implementation for a speech recognition task. The proposed event-based neural encoding is not only biologically plausible, but also outperforms the MFCC as an encoding frontend for an SNN classifier in a speech recognition task, in terms of higher classification accuracy and lower latency. Such an end-to-end SNN model could be implemented on a neuromorphic chip to fully realize the advantages of event-based processing.

A Spiking Neural Network Framework for Robust Sound Classification

PRESENTER: **Jibin Wu**

Abstract:
Environmental sounds form part of our daily life. With the advancement of deep learning models and abundance of training data, the performance of automatic sound classification (ASC) systems has improved significantly in recent years. However, the high computational cost, thus high power consumption, has prevented such ASC systems from large scale deployment on mobile and wearable devices. Motivated by the observations that humans perform effortlessly and consume extremely low power to analyze complex audio scenes, we propose a biologically plausible ASC framework, namely SOM-SNN, which uses the unsupervised self-organizing map (SOM) for effective representation of frequency contents embedded within the acoustic signals, followed by an event-based spiking neural network (SNN) for spatiotemporal spiking pattern classification. We report experimental results on the RWCP sound dataset and show that the proposed framework outperforms all other deep learning and SNN-based models consistently. The SOM-SNN framework is shown to be highly robust to corrupting noise after multi-condition training, whereby the model is trained with noise-corrupted sound samples. Moreover, we discover the predictive capability of the proposed framework, whereby an accurate classification can be made with only partial presentation of the input.

Mathematical Modelling Reveals the Role of Hypoxia in Promotion of Human Mesenchymal Stem Cell Long-Term Expansion

PRESENTER: **Shuhua Gao**

Abstract:
Many experimental studies have found that human mesenchymal stem cells (MSCs) in long-term culture exhibited enhanced cell proliferation and prolonged lifespan under hypoxia (around 1%-7% oxygen) against the normoxic condition (about 21% oxygen). Inspired by the experimental findings, we aimed to investigate the hypoxic effects on MSC expansion quantitatively through mathematical modelling to elucidate the corresponding biological mechanism. A two-compartment model based on ordinary differential equations (ODEs), which incorporates cellular division and senescence via state transition, was developed to describe the MSC expansion process. Parameters of this model were fitted to experimental data and used to interpret the different proliferative capacity of MSCs under hypoxia and normoxia along with model sensitivity analysis. The proposed model was tested on data from two separate experimental studies and it could reproduce the observed growth characteristics in both conditions. Overall, this compartmental model with a logistic state transition rate was sufficient to explain the experimental findings and highlighted the promotive role of hypoxia in MSC proliferation. This in silico study suggests that hypoxia can enhance MSC long-term expansion mainly by delaying replicative senescence, which is indicated by the slowdown of the state transition rate in our model. Therefore, this explanatory model may provide theoretical proof for the experimentally observed MSC growth superiority under hypoxia and have the potential to further optimize MSC culture protocols for regenerative medicine applications.

Into the Twilight Zone: Depth Estimation using Joint Structure-Stereo Optimization

PRESENTER: **Aashish Sharma**

Abstract:
We present a joint Structure-Stereo optimization model that is robust for disparity estimation under low-light conditions. Eschewing the traditional denoising approach - which we show to be ineffective for stereo due to its artefacts and the questionable use of the PSNR metric, we propose to instead rely on structures comprising of piecewise smooth regions and principal edges in the image, as these are the important regions for extracting disparity information. We also judiciously retain the coarser textures for stereo matching, discarding the finer textures as they are apt to be inextricably mixed with noise. This selection process in the structure-texture decomposition step is aided by the stereo matching constraint in our joint Structure-Stereo formulation. The resulting optimization problem is complex but we are able to decompose it into sub-problems that admit relatively standard solutions. Our experiments confirm that our joint model significantly outperforms the baseline methods on both synthetic and real noise datasets.

Human vision inspired multi-scale line segments merging and filtering

PRESENTER: **Xiaoxu Zheng**

Abstract:
A novel method for merging and filtering line segments which is designed based on line segments detector (LSD) is proposed. Compared to state-of-the-art, our algorithm reduces the complexity of the algorithm by implementing the property of cross product between two vectors, thus improves the speed. And inspired by human vision, a further multi-scale filtering step is conducted to capture predominant line segments and leave out trivial segments in different scaled images. Experiments on both synthetic and real images show that the merging and filtering line segments are closer to human-marked ground-truth and consistent with that of human vision system.

Global signal regression strengthens association between resting-state functional MRI and behavior in human

PRESENTER: **Jingwei Li**

Abstract:
Little agreement has been achieved for preprocessing strategies of resting-state functional MRI (rs-fMRI). Global signal regression (GSR) is one of the most debated strategies. GSR effectively removes global artifacts driven by motion and respiration, but also discards globally distributed neural information and introduces negative correlations between brain regions. The majority of previous studies have focused on the effectiveness of GSR in cleaning imaging artifacts, and its potential biases. Given the growing importance of individual-specific fingerprinting (i.e. how do participants differ from each other in neural imaging, cognition, etc.), here we considered the utilitarian question of whether GSR strengthens or weakens associations between rs-fMRI and multiple behavioral measures across cognition, personality and emotion. Among the 862 young healthy adults in the Genomics Superstruct Project, behavioral variance explained by whole-brain resting-state functional connectivity (RSFC) increased by an average of 58% across 23 behavioral measures after GSR. Among 419 unrelated healthy young adults in the Human

Connectome Project, the behavioral variance explained by RSFC increased by an average of 51% across 58 behavioral measures when GSR was applied after ICA-FIX de-noising. Improvements were observed for 58 of the 81 behavioral measures examined in total. Since GSR was more effective at removing motion-related and respiratory-related artifacts, these improvements were unlikely to be the result of imaging artifacts. Overall, our results suggest that at least in the case for young healthy adults, GSR strengthens the associations between RSFC and most (although not all) behavioral measures.

Latent Factors Underlying Atrophy, Behavioral and Tau Heterogeneity in Alzheimer's Disease

PRESENTER: **Nanbo Sun**

Abstract:

Individuals with Alzheimer's disease (AD) have shown significant heterogeneity in clinical symptoms, atrophy patterns and spatial distribution of tau depositions. In this study, we utilized a Bayesian model to identify distinct latent factors of atrophy patterns and cognitive deficits. Application of the model to structural MRIs and cognitive scores from AD dementia patients revealed three factors. The first factor was associated with atrophy of the medial temporal lobe, episodic memory deficits and disorientation to time and place. The second factor was associated with lateral temporal atrophy and language deficits. The third factor was associated with posterior lateral cortical atrophy and visuospatial executive function deficits. To explore the influence of each factor in early AD, atrophy and cognitive loadings of each factor were inferred in participants with mild cognitive impairment (MCI). We found that MCI participants with higher tau deposits in posterior lateral cortex exhibited greater posterior lateral cortical atrophy. MCI participants with greater tau deposits in medial temporal regions exhibited worse episodic memory deficits, as well as disorientation to time and place. MCI participants with greater tau deposits in posterior lateral cortex (relative to medial temporal lobe) exhibited worse visuospatial executive function. Finally, subjects with higher expression of the lateral temporal atrophy factor showed a faster progression from MCI to AD dementia. These results suggest that distinct patterns of atrophy, cognitive deficits and regional tau exist in 'typical' Alzheimer's disease. Quantification of Alzheimer's disease heterogeneity may be exploited for individual-specific diagnosis, disease monitoring and customized therapies.

SESSION 7

MICROELECTRONIC TECHNOLOGIES AND DEVICES

PRESENTERS :		
1	**Maheswari Sivan**	Thickness dependent electronic properties in 2-D WSe2 Nano-sheet field effect transistor
2	**Wei Wei**	Dual-Gated MoS2 FETs with PMMA as top gate insulator interlayer
3	**Yanjun Xu**	Magnetic sensor using spin-orbit torque effective field as transverse bias
4	**Divya Ananthanarayanan**	Determination of metal induced recombination of n-type bifacial Si solar cells
5	**Maverick Chauwin**	Strained graphene in transistor applications

Thickness dependent electronic properties in 2-D WSe2 Nano-sheet field effect transistor

PRESENTER: **Maheswari Sivan**

Abstract:
Transition Metal Dichalcogenides (TMDs) have gained enormous attention, owing to their tunable electronic and optical properties – layer dependent bandgap, as well as its intrinsic material quality – pristine surface with zero dangling bonds. In this work, we investigated the thickness dependent electronic properties and transport mechanism in 2-D WSe2 Nano-sheet field effect transistor (FET). Our results reveal a strong thickness dependence of the WSe2 device's field effect mobility due to the competition of Coulomb impurity scattering and phonon scattering effect. Also, the larger c-access resistance provided by the Vandal Waals gap between different layers plays a part in determining the mobility of the WSe2 FET. In addition, the electronic characteristics is correlated with a careful material study using Raman and Photoluminescence spectra. This interesting thickness dependent electronic property change in WSe2 devices prompted study to devise a technique that allows the control of the WSe2 thickness accurately. This is necessary in building large scale, high performance WSe2 circuits because high quality WSe2 flakes obtained from mechanical flaking does not allow for thickness selection. We propose a surface plasma oxidation technique on WSe2 as a promising thickness control approach. We are able to achieve a self-limiting, 3 layer per cycle consumption of WSe2, thus demonstrating itself as a viable thickness control approach.

Dual-Gated MoS2 FETs with PMMA as top gate insulator interlayer

PRESENTER: **Wei Wei**

Abstract:
Two-dimensional (2D) material based field effect transistors (FET) have been the focus of research worldwide recently owing to their unique features, including ultrathin thickness, excellent scalability, high carrier mobility and variable bandgap. Among them, molybdenum disulphide (MoS2) is one of the most popular 2D materials used in FETs for low-power application. Development of high quality gate stack on MoS2 is one approach to increase the electron mobility. In this work, the stack of PMMA and Al2O3 used as the top gate dielectric is demonstrated in dual-gated MoS2 based FETs. Electrical performance of MoS2 FETs are characterized and compared between two independently driven top- and back-gate. A high electron mobility of 30-40 cm2V-1s-1 and high on/off current ratio of 107 to 109 are obtained in both top- and back-gated FETs, while the top-gated configuration provides a smaller sub-threshold swing of 160-180 mV/dec compared to the back-gated configuration (1.6 – 1.7 V/Dec) due to the thinner top dielectric thickness and better interface quality. The threshold voltage of back-gated (top-gated) configuration depends on the top-gate (back-gate) bias. A small change in top-gate bias causes a large shift (3.3x) in threshold voltage of the back-gated FETs. All this suggests the high potential of the dual-gated MoS2 FETs for sensing applications.

Magnetic sensor using spin-orbit torque effective field as transverse bias

PRESENTER:**Yanjun Xu**

Abstract:
Magnetic biasing is commonly used to enhance the linearity, sensitivity and dynamic range of magnetic sensors, For anisotropic magnetoresistance (AMR) sensor, the most commonly used biasing schemes is barber pole biasing, in which the local current is directed away from the ease axis direction by patterned conducting strips deposited directly atop the sensing layer, instead of changing the magnetization direction. The strips are aligned at an angle of 45o from the ease axis direction of the sensing element, leading to a linear response to transverse field. It is apparent that the barber pole design suffers from requirement of additional process steps and current shunting by the conducting strips.

Determination of metal induced recombination of n-type bifacial Si solar cells

PRESENTER: **Divya Ananthanarayanan**

Abstract:
Bifacial n-type silicon solar cells are becoming increasingly popular in the PV world due to its high efficiency potential, stable electrical performance and cost-effective manufacturing techniques. However, metal induced recombination losses due to screen printing is a factor that limits the device voltage and hence the efficiency of the solar cell. The degree of surface recombination greatly depends on the emitter dopant profile and the metal paste used. Unlike the dark saturation current density under the passivated region (J0e), the metal induced recombination density (J0e,met) cannot be easily measured and requires a standardized method. This paper provides a systematic routine to determine the front and rear metal induced recombination losses of bifacial silicon solar cells using an automated fit procedure by Griddler AI, a finite element method based 2D solar cell simulator. In this, Griddler performs rigorous analysis of the photoluminescence images of special easy to prepare test patterns printed on the front and rear side of the cells along with the non-metallized life time samples. The various fit statistics are intensively examined to ensure the discerning capability of Griddler between the front and rear recombination parameters. Eight different samples with similar front boron emitter and different phosphorus back surface fields were analyzed and it was observed that choosing the optimum BSF would lead to an efficiency gain of up to ~0.4%.

Strained graphene in transistor applications

PRESENTER: **Maverick Chauwin**

Abstract:
Graphene materials have been intensely studied in the past years for their theoretical high potential. Their huge conductivity makes them candidates to be the basis of high-efficient electric circuits based on transistors. Nonetheless, due to the particularities of graphene materials, electrons in graphene experience a slight different tunneling effect known as Klein tunneling. Indeed, electrons with a normal incidence will go through the electric barrier with a 100% chance. After briefly explaining what the Klein tunnelling in graphene is, I will consider two solutions to make graphene transistors: one by adding a magnetic field and another with a strain force acting on the graphene sheet. In this case, the Dirac cones are shifted and tilted. These two effects have huge impacts on the electron

conductivity and may be used to design graphene-based transistors. Eventually, the next step of this study would be to consider a Silicene sheet which experiences some strain. Its behaviour will mostly follow the graphene sheet one however while its stronger spin-orbit coupling may have some interesting impact on the electron conductivity.

Sponsored by

NUS National University of Singapore
Department of Electrical & Computer Engineering

COLIPS

IEEE
Reliability/Electronics Packaging/
Electron Devices Singapore Chapter

IEEE ComSoc™
IEEE Communications Society

CAS
IEEE Circuits and Systems
Singapore Chapter

ECE GSS 2018 Website

Scan me

https://www.ece.nus.edu.sg/gsc/GSS2018/