第３回シンガポール−日本研究交流会
The 3rd Singapore-Japan Research Exchange Seminar

平成 26 年（2014 年）12 月 8 日（月）〜9 日（火）
December 8 -9, 2014
国立シンガポール大学、シンガポール
NUS (National University of Singapore), Singapore

The 3rd Singapore-Japan Research Exchange Seminar

1. はじめに **Introduction**

一昨年 **11** 月シンガポール、昨年 8 月九大高原牧場（久住）での研究交流会に引き続き、第 3 回のシンガポール- 日本研究交流会をシンガポールにて開催します。農牧業と工業の融合を目指したバイオ電子デバイスの開発ならびにその応用の展開をしていきたいと思っております。奮って参加いただければ幸いです。

We will hold the third Singapore-Japan Research Exchange which follows the1st and 2nd Exchange Seminar held in Singapore (2012) and at Kuju in Oita prefecture, Japan (2013). Through this Seminar, we would like to promote the development of bioelectronic devices aimed at the integration of agriculture and stock farming and industry, and its applications. I sincerely invite you to join us.

2. アブストラクト投稿 **Abstract submission**

フォント **11** 程度で **A4** 用紙 **1** 枚。添付資料のひな形を参照願います。締め切りは **11** 月 **30** 日。以下のアドレスに **PDF** ファイルにて送付願います。
staff1@nano-micro.mech.kyushu-u.ac.jp

Font size 11、an A4 sheet (Please using the attached template). Deadline is 30/Nov/2014. Please submit this abstract in "PDF file" format by e-mail: staff1@nano-micro.mech.kyushu-u.ac.jp.

3.登録料：日本研究者は、会場にて シンガポールドル **145** 現金で支払い願います。
Banquet 等は別料金です。

Registration Fee: 250SGD cash to be paid at venue.

As the general chair, I would appreciate the valuable contribution from the authors. Particularly I want to thank Prof. C Lee and his team in organizing this seminar. I would like to also express my appreciation for attendee. Without your support, we will not have a fruitful discussion and valuable information exchange.

General Chair
Renshi Sawada
Professor
Kyushu University

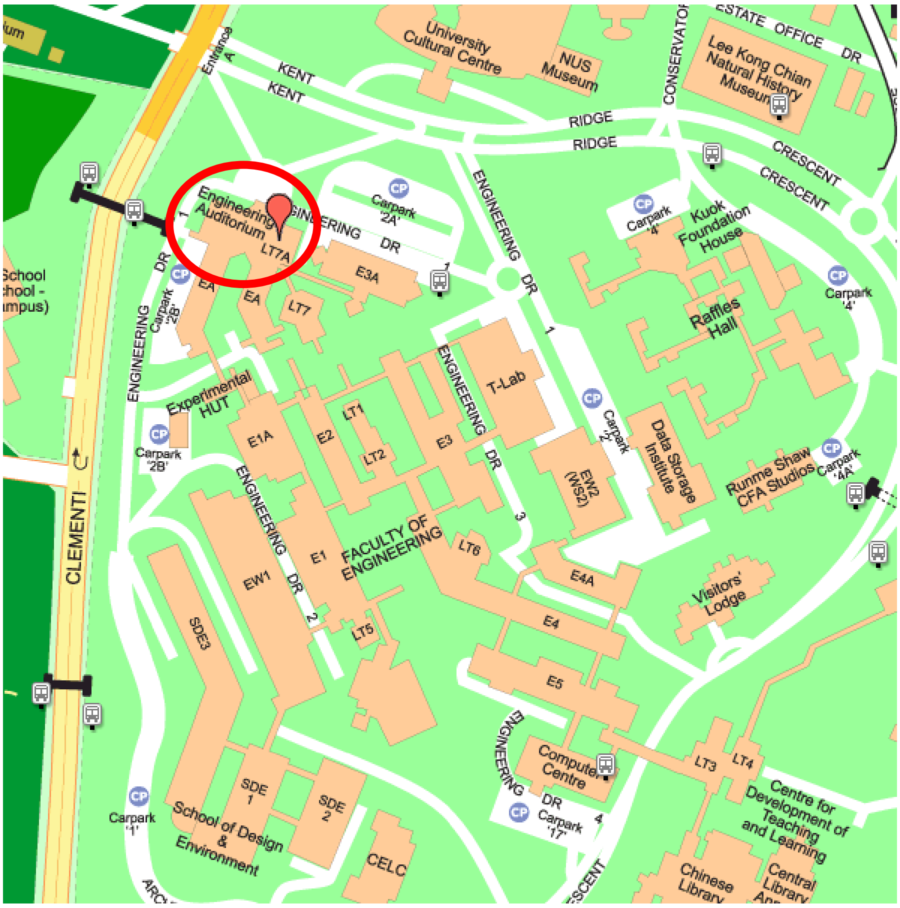
The 3rd Singapore-Japan
Research Exchange Seminar Information

Details of the seminar are available at:
http://www.ece.nus.edu.sg/stfpage/elelc/share_file/3rd_SJ_seminar.pdf

When and Where

The conference will be held on Dec. 8 - 9th (Mon - Tue), 2014.

The venue will be the LT7A, Block EA, National University of Singapore (NUS).



Seminar Agenda – Day 1

LT7A, Block EA, NUS

Morning Session - Monday, December 8, 2014 Registration fee is required	
8:00 ~	**Registration**
9:00 to 9:15	**Opening Speech:** **Development of Wearable Micro Blood Flow Sensors for Livestock Breeding by A*STAR – JST JOINT PROJECT** Prof. Renshi Sawada Kyushu University, Japan
9:15 to 9:30	**Greeting Speech:** **Recently Hot Topics** Prof. Ryutaro Maeda Advanced Institute of Science and Technology (AIST), Tsukuba, Japan
9:30 to 9:50	**Keynote I:** **Shear Loading on Chondrocyte Cultured an Agarose Scaffold** Prof. Yoshinori Sawae[1,2], Seiji Omata[2] and Keisuke Fukuda[3] [1] Faculty of Engineering, Kyushu University, Japan [2] Research Center for Advanced Biomechanics, Kyushu University, Japan [3] Graduate School of Engineering, Kyushu University, Japan
9:50 to 11:30	**Talk 1:** **Polymer Based Triboelectrification for Enabling Flexible Energy Sources** Lokesh Dhakar[1, 2] , F. E. H. Tay[3] and Chengkuo Lee[2] [1] NUS Graduate School for Integrative Sciences and Engineering, National University of Singapore, Singapore [2] Department of Electrical and Computer Engineering, National University of Singapore, Singapore [3] Department of Mechanical Engineering, National University of Singapore, Singapore **Talk 2:** **Room-Temperature Wafer Bonding with smooth Au Thin Film for Thermal Management of High-Power Semiconductor Lasers** Ken Okumura[1], Eiji Higurashi[1], Tadatomo Suga[1], Kei Hagiwara[2] [1] School of Engineering, The University of Tokyo [2] NHK Science and Technology Research Laboratories **Talk 3:** **Handshaking Driven Non-linear Electromagnetic Energy Harvester** Gudla Sudeep[1], Lokesh Dhakar[1,2] and Chengkuo Lee[1], [1] Department of Electrical and Computer Engineering, National University of Singapore, Singapore [2] NUS Graduate School for Integrative Sciences and Engineering, National University of

	Singapore, Singapore **Talk 4:** **Fabrication Process of Patterned ZnO NWs / Thin Film for Energy Harvesting Application** Qiongfeng Shi and Chengkuo Lee Department of Electrical and Computer Engineering, National University of Singapore, Singapore **Talk 5:** **Pull-In Voltage and Yield Analysis of All-Metal-Based Nanoelectromechanical Switches** You Qian[1], Bo Woon Soon[1,2] and Chengkuo Lee[1] [1] Department of Electrical and Computer Engineering, National University of Singapore, Singapore 2 Institute of Microelectronics, Agency for Science, Technology and Research (A*STAR), Singapore
11:30 to 12:50	**Lunch break**

Afternoon Session - Monday, December 8, 2014 Registration fee is required	
12:50 to 13:20	**Keynote II:** **A New Project for Developing Next-Generation Precise Individually Livestock-Management System Utilizing Wireless Sensor Network** Prof. Toshihiro Itoh[1] and Shozo Arai[2] [1] National Institute of Advanced Industrial Science and Technology (AIST), Japan [2] National Institute of Animal Health, Japan
13:20 to 15:00	**Talk 6:** **Reliability Characterization of Si-to-Si Microswitches with Operation Range of -60 °C to 400 °C** Jeffrey B.W. Soon and Chengkuo Lee Department of Electrical and Computer Engineering, National University of Singapore **Talk 7:** **Temperature Sensor for An Early Diagnosis System of Pneumonia in Calves** Hirofumi Nogami Kyushu University, Japan **Talk 8:** **Advanced Fabrication Technology for Polymer Based Drug Delivery Devices and Neural Recording Cantilevers** Zhuolin Xiang[1,2], Hao Wang[1] , Giorgia Pastorin[2] and Chengkuo Lee[1] [1] Department of Electrical and Computer Engineering, National University of Singapore, Singapore [2] Department of Pharmacy, National University of Singapore, Singapore **Talk 9:** **Micropyramid Array Electrode for Electrochemical Detection** Wataru Iwasaki National Institute of Advanced Industrial Science and Technology (AIST), Japan **Talk 10:** **Flexible Epineural Strip Electrode for Neural Signal Recording** Sanghoon Lee, Shih-Cheng Yen and Chengkuo Lee Department of Electrical and Computer Engineering, National University of Singapore, Singapore
15:00 to 15:20	**Tea Break**
15:20 to 15:50	**Keynote III:** **Application of Piezoresistive Silicon Nanowires (SiNWs) in NEMS Technology** Songsong Zhang[1], Liang Lou[2], Renshi Sawada[3] and Chengkuo Lee[1] [1] Department of Electrical and Computer Engineering, National University of Singapore, Singapore [2] Institute of Microelectronics, Agency for Science, Technology and Research (A*STAR), Singapore [3] Department of Mechanical Engineering, Kyushu University, Japan

15:50 to 17:10	**Talk 11:** **Development of Broadband Piezoelectric Micromachined Ultrasound Transducers (pMUTs)** Tao Wang[1], Takeshi Kobayashi[2] and Chengkuo Lee[1] [1] Department of Electrical and Computer Engineering, National University of Singapore, Singapore [2] National Institute of Advanced Industrial Science and Technology (AIST), Japan **Talk 12:** **Control of Protein Crystal Growth in Microfluidic Chip** Masaya Miyazaki Measurement Solution Research Center, AIST Japan Department of Molecular and Material Sciences, IGES, Kyushu University, Japan **Talk 13:** **Long Range Dynamic Controllable Linear Gradient Generator** Hao Wang[1], Yan Wang[1], Zhuolin Xiang[1], Ming Wang[2], Chia-Huang Chen[2] and Chengkuo Lee[1] [1]Department of Electric and Computer Engineering, National University of Singapore, Singapore [2]Department of Biomedical Engineering, National University of Singapore, Singapore
18:00 ~	**Banquet Dinner -** **Swiss Merchant Courts Hotel** **20 Merchant Road, Singapore 058281** http://www.swissotel.com/hotels/singapore-merchant-court/dining/ellenborough-market-cafe/

Seminar Agenda – Day 2

Morning Session - Tuesday, December 9, 2014 Registration fee is required	
09:00 to 11:50	**Talk 14:** **Applying MEMS Micro-Scanner to Light-Section Sensor** Koji Okazaki[1], Kentaro Ikeda[1], Noriaki Ishikawa [1,2], Renshi Sawada [1] [1] Kyushu University, Japan [2] Fuji Electric Co., Ltd., Japan **Talk 15:** **Characterization of Nanometer-Thick Polycrystalline Silicon with Phonon-Boundary Scattering Enhanced Thermoelectric Properties and Its Application in Infrared Sensors** Huchuan Zhou and Chengkuo Lee Department of Electrical and Computer Engineering, National University of Singapore, Singapore **Talk 16:** **Fabrication of Micro Lens Using DMD Lithography Equipment** Toshihiro Takeshita[1], Wataru Iwasaki[2], Hiromasa Sibata[3], and Renshi Sawada[1] [1] Kyushu University, Japan [2] National Institute of Advanced Industrial Science and Technology (AIST), Japan [3] Nikon Corporation, Japan **Talk 17:** **Characterization of Polycrystalline Silicon Based Photonic Crystal Suspended Membrane for High Temperature Applications** Chong Pei Ho, Prakash Pitchappa and Chengkuo Lee Department of Electrical and Computer Engineering, National University of Singapore, Singapore **Talk 18:** **Application of Blood Flow Sensor in Doppler Velocimeter** Yao Peng and Renshi Sawada Graduate School of Systems Life Sciences, Kyushu University, Japan **Talk 19:** **Lateral Lattice Shift Engineered Slow Light in Elliptical Photonics Crystal Waveguides** Bo Li, Chong Pei Ho and Chengkuo Lee Department of Electrical and Computer Engineering, National University of Singapore, Singapore **Talk 20:** **A Micro-Laser Doppler Velocimeter for Slip Detection** N. Morita[1], T. Cargan[1], H. Nogami[1], E. Higurashi[2], T. Ito[3], R. Sawada[1] [1]Kyushu University, Japan [2]The University of Tokyo, Japan [3]Kyushu Institute of Technology, Japan

	Talk 21: **Infrared Metamaterial Absorbers for Gas Sensing Application** Prakash Pitchappa, Chong Pei Ho and Chengkuo Lee Department of Electrical and Computer Engineering, National University of Singapore, Singapore **Talk 22:** **Excitation of Magnetic Resonance in Bow-tie Nanoantenna Array by Plasmonic Inclusion** Dihan Hasan and Chengkuo Lee Department of Electrical and Computer Engineering, National University of Singapore, Singapore
11:50 to 13:00	**Lunch Break**
13:20 to 16:40	**NUS-A*STAR-AIST Joint Seminar** http://www.ece.nus.edu.sg/stfpage/elelc/Seminar_JPSG_Dec092014.html
17:30 ~	**Banquet Dinner -** **Stewords Riverboat** **31 Marina Coastal Drive, Berth 1, Marina South Pier, Singapore 018988** http://www.riverboat.com.sg

3rd SIN-JPN Research Exchange Seminar

Abstracts and Biographies of Speakers

Opening Speech:

Development of Wearable Micro Blood Flow Sensors for Livestock Breeding by A*STAR – JST JOINT PROJECT

Speaker:

Prof. Renshi Sawada
Kyushu University, Japan

Abstract

There are two targets of this project. One is to realize all around MEMS blood flow sensor by a combination of a Laser light waves using vertical cavity surface emitting laser (VCSEL) chip and Ultrasonic waves using phononic crystal. The other is to form the base for developing bio-electronic devices in Singapore and Japan.

Figure 1 visualizes the first target, all around blood flow sensor is made up of ultrasonic element, optical element, and diaphragm including a silicon nano-wire capable of measuring the contact pressure. This picture is three-dimensional ultrasound generating element, using the phononic crystal, which is made primarily in Singapore. By a combination of ultrasound and optical MEMS, a deep part and large flow rate can be also measured. Ultrasound and laser light can complement each other. Optical one enables measurement of peripheral vascular flow, and ultrasound one enables measurement of arterial and aortic flows.

As a countermeasure to an increasing population and aging, I want to aim to mass-produce safe and good-tasting food as well as calories and also provide quality medical devices, by application of ICT such as MEMS and electronic technologies to the medical devices and agriculture.

As for formation of Asian bio-industrial infrastructure centered at Singapore and Japan, through these seminars, we would like to promote the development of bio-electronic devices aimed at the integration of agriculture and stock farming and industry, and its applications. In Japan, we have already organized the Council for High Value-added Bioelectronics. Also, we want to increase young researchers and developers having awareness of issues or interested in this new fields by being triggered by this exchange meetings.

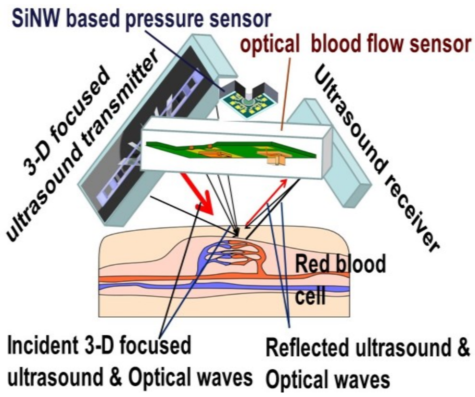


Fig.1 all around blood flow sensor

Renshi Sawada

Professor
Life Science Institute
Department of Mechanical Engineering,
Kyushu University, Japan

Biography

Renshi Sawada received the B.E., M.E., and Ph.D. degrees from Kyushu University, Fukuoka, Japan, in 1976, 1978, and 1995, respectively. In 1978, he joined the Electrical Communication Laboratories, Nippon Telegraph and Telephone, Tokyo, Japan, where he was engaged in the research on the polishing of Si substrates, gettering of Si crystalline defects, fabrication of dielectrically isolated Si substrates (silicon on insulator substrate process), and optical microelectromechanical systems, such as micromirror array, integrated optical displacement sensors, integrated optical blood flow sensor, integrated scanning microscope, and sensors attachable to animals and humans for network. Since January 2004, he has been at Kyushu University, Fukuoka, Japan. He is an Editor of the *Journal of Micromechanics and Microengineering* and have served as members of the board of trustees including JIEP in 2008-2010, the Society of Instrument and Control Engineers in 2006-2007, and Kyushu branch of Japanese Society for Medical and Biological engineering since 2009. He received the Japan Society of Precision Engineering awards in 1981 and 1991, the Okawa press prize in 2001, the ninth Microoptics Conference (MOC) paper prize in 2003, and the Japan Institute of Electronic Packaging Awards in 2010, and Best Paper Award in Sensor devices of International Academy, Research, and Industry Association (IARIA). He also served as conference chair for a number of international conferences, including IEEE International Optical MEMS Conference 2000 and 2001, was also involved in Program Committees of many conferences, and is a Fellow of Institute of Physics.

Greeting Speech:

Recently Hot Topics

Speaker:

Ryutaro Maeda
Advanced Institute of Science and Technology (AIST), Tsukuba, Japan

Ryutaro Maeda received Ph.D. degree in engineering in 2006 from Toyohashi University of Technology, Aichi, Japan. He was a post-doctoral researcher from 2006 to 2007, and joined the faculty of Toyohashi University of Technology from 2008 as an assistant professor. Since 2009, he has been an assistant professor in Nara Institute of Science and Technology. His current research interests focus on retinal prosthesis devices and bio-imaging with CMOS image sensors.

Keynote Speech I:

Shear Loading on Chondrocyte Cultured an Agarose Scaffold

Speaker:

Yoshinori Sawae [1,2], Seiji Omata [2], Keisuke Fukuda [3]
[1] Faculty of Engineering, Kyushu University, Japan
[2] Research Center for Advanced Biomechanics, Kyushu University, Japan
[3] Graduate School of Engineering, Kyushu University, Japan

Yoshinori Sawae received the degree of B.S. in 1991, M.S. in 1993 and Dr.Eng in 1996 in Mechanical Engineering from Kyushu University, Fukuoka, Japan. He joined Department of Mechanical Engineering, Kyushu University as a lecturer in 1996 and became a Professor of Machine Elements and Design Engineering Laboratory in 2011. Current research interests are primarily friction, wear and lubrication in artificial joints and natural synovial joints.

Abstract

Mechanical loadings on chondrocytes cultured within scaffold are essential to have mechanically matured regenerated cartilage tissue in the cartilage tissue-engineering context. Therefore, many previous studies have investigated deformation and subsequent mechanotransduction within chondrocytes compressed uniaxially or isostatically. However, the number of studies in which effects of shear deformation caused by the surface friction have been examined experimentally is quite limited.

In this study, chondrocytes isolated from bovine cartilage tissue were seeded in agarose gel to have chondrocyte-agarose constructs. Subsequently, effects of shear loadings on cultured chondrocytes were examined in a series of experiments by using cell-agarose construct as a tissue engineered cartilage model. First, certain amount of shear deformation was applied to the construct by mechanical loading machine mounted on confocal laser scanning microscope (CLSM) and deformation of a chondrocyte within agarose scaffold was monitored. Second, cell-agarose constructs were cultured under dynamic 5% shear strain applied at 1 Hz for 3 weeks and effects of the shear loading on the formation of regenerated cartilage tissue were evaluated. Finally, the cell-agarose construct was exposed to excessive shear strain up to 25% and cell viability under the harsh shear loading condition was examined.

Results of the first experiment indicated that chondrocytes could deform with agarose scaffold under shear up to 10% shear strain. However, the chondrocyte detached from agarose and deformed unevenly if the shear strain increased to 15%. Following culture experiments showed that the 5% shear strain could up-regulate the cartilage tissue formation while the excessive strain deteriorates cell viability significantly.

Keynote Speech II:

A New Project for Developing Next-Generation Precise Individually Livestock-Management System Utilizing Wireless Sensor Network

Speaker:

Toshihiro Itoh[1] & Shozo Arai[2]
[1] National Institute of Advanced Industrial Science and Technology (AIST), Japan
[2] National Institute of Animal Health, Japan

Toshihiro Itoh received the BE, ME, and Ph.D. degrees in precision engineering from the University of Tokyo, Japan, in 1988, 1990 and 1994, respectively. He is currently a deputy director of Research Center for Ubiquitous MEMS and Micro Engineering (UMEMSME) in National Institute of Advanced Industrial Science and Technology (AIST), Japan. Also he has been a director of Tsukuba Research Center, NEDO "Green Sensor Network System Technology Development" project since 2011. He had joined the faculty of the University of Tokyo in 1995 and was an associate professor at the Research Center for Advanced Science and Technology (RCAST) and the Department of Precision Engineering from 1999 to 2007. His research interests are in MEMS and wireless sensor nodes for sensor networks as well as large area MEMS.

Abstract

A new project "Next-Generation Precise Individually Livestock-Management System Utilizing Wireless Sensor Network" that has just started since October, 2014 will be introduced. The project is one of the Cross-ministerial Strategic Innovation Promotion Program (SIP) "Agri-Innovation" under the management of Cabinet Office, Japan. The research items can be divided to two categories, development of reproductive performance improvement system and system for high quality breeding management and prevention of production disease. The former includes the development and field tests of new types of sensors such as a wireless sensor of impedance and temperature inside the vagina, a wireless calf-tail body-surface temperature sensor and portable hormone sensor. Concerning the latter, to increase the productivity in cattle breeding, it is important to prevent calves and fattening cattle from contracting pneumonia and rumen acidosis, respectively. Therefore, in the project, continuous monitoring system of body temperature using the wireless calf-tail sensors will be developed and demonstrated in field tests. Also wireless sensor network system with novel bolus-type rumen pH and/or movement sensor nodes should be developed and demonstrated for breeding optimization and rumen acidosis prevention system.

Keynote Speech III:

Application of Piezoresistive Silicon Nanowires (SiNWs) in NEMS Technology

Speaker:

Songsong Zhang[1], Liang Lou[2], Renshi Sawada[3] and Chengkuo Lee[1]
[1] Department of Electrical and Computer Engineering, National University of Singapore, Singapore
[2] Institute of Microelectronics, A*STAR, Singapore
[3] Department of Mechanical Engineering, Kyushu University, Japan

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Songsong Zhang received the B.Tech and Ph.D degree in the Department of Electrical Engineering from National University of Singapore (NUS), Singapore, in 2009 and 2014, respectively. His research interests focus on piezoresistive NEMS sensor and MEMS brain neural prosthetic device.

Abstract

A new project "Next-Generation Precise Individually Livestock-Management System Utilizing Wireless Sensor Network" that has just started since October, 2014 will be introduced. The project is one of the Cross-ministerial Strategic Innovation Promotion Program (SIP) "Agri-Innovation" under the management of Cabinet Office, Japan. The research items can be divided to two categories, development of reproductive performance improvement system and system for high quality breeding management and prevention of production disease. The former includes the development and field tests of new types of sensors such as a wireless sensor of impedance and temperature inside the vagina, a wireless calf-tail body-surface temperature sensor and portable hormone sensor. Concerning the latter, to increase the productivity in cattle breeding, it is important to prevent calves and fattening cattle from contracting pneumonia and rumen acidosis, respectively. Therefore, in the project, continuous monitoring system of body temperature using the wireless calf-tail sensors will be developed and demonstrated in field tests. Also wireless sensor network system with novel bolus-type rumen pH and/or movement sensor nodes should be developed and demonstrated for breeding optimization and rumen acidosis prevention system.

Talk 1:

Polymer Based Triboelectrification for Enabling Flexible Energy Sources

Lokesh Dhakar[1, 2], F. E. H. Tay[3] and Chengkuo Lee[2]
[1] NUS Graduate School for Integrative Sciences and Engineering, National University of Singapore, Singapore
[2] Department of Electrical and Computer Engineering, National University of Singapore, Singapore
3 Department of Mechanical Engineering, National University of Singapore, Singapore

Lokesh Dhakar received his B.E.(Hons.) degree in Mechanical Engineering from Birla Institute of Technology and Science, Pilani in 2010. He worked in the industry as a design engineer from 2010 to 2011. He is currently pursuing his PhD degree from NUS Graduate School of Integrative Sciences and Engineering, National University of Singapore, Singapore. He is concurrently also pursuing his MBA from NUS Business School. He is keenly interested in entrepreneurship and technology commercialization. He is currently working on energy harvesting devices aimed at powering wireless wearable sensors for healthcare.

Triboelectrification or contact electrification phenomenon is charging of two dissimilar materials when put in contact. The charges generated are dependent on material properties and topography. Triboelectrification can be seen in various materials ranging from metals to polymers. Easy fabrication and patterning technologies for polymers enable them as a suitable material to realize triboelectric mechanism based energy harvesters. These polymer based devices can be used to convert mechanical energy generated from walking, running, heartbeat, muscle motion and wind blowing. The harvested mechanical energy from these sources can be used to power small electronics devices and sensors. Another important application of triboelectric mechanism based devices is in realizing self-powered sensors which can sense parameters e.g. movement, pressure, chemicals etc. without need of any external power source. We have developed flexible energy harvesting devices based on triboelectric mechanism which can also be adapted to use a self-powered sensors for activity/motion tracking.

Talk 2:

Room-Temperature Wafer Bonding with smooth Au Thin Film for Thermal Management of High-Power Semiconductor Lasers

Ken Okumura[1], Eiji Higurashi[1], Tadatomo Suga[1], Kei Hagiwara[2]
[1] School of Engineering, The University of Tokyo
[2] NHK Science and Technology Research Laboratories

Ken Okumura received B.E. degree from Tokyo University, Tokyo, Japan, in 2014. He is currently working toward the M.E. degree at the Department of Precision Engineering, School of Engineering, The University of Tokyo, Tokyo, Japan. His current research interests include room temperature wafer bonding and thermal management of high-power semiconductor lasers.

Compact and high power semiconductor lasers are key components in various scientific and industrial instruments including fluorescence analysis systems such as confocal microscopes and flow cytometers. Generally, the performance of the semiconductor lasers is limited by overheating. The temperature rise of the active region strongly affects the laser characteristics, such as output power, threshold current and slope efficiency. Furthermore, it causes degradation of the laser diode exponentially. Thus, Thermal management of high power semiconductor lasers is of great importance.

We have demonstrated room temperature wafer-scale bonding with smooth Au thin film in air using Ar radio frequency (RF) plasma activation. Quartz glass wafers with smooth Au thin film (thickness: 30 nm, surface roughness RMS: 0.43 nm) were successfully bonded in ambient air at room temperature after Ar RF plasma activation process, even when it was exposed to air for a long term (800 - 2000 h) after Au deposition. They showed high die-shear strength and the fractures typically occurred inside the bulk glass. Based on the experimental results of the glass bonding, the GaAs and SiC wafers (2 inch in diameter) with Au thin film (30 nm in thickness) were also successfully bonded at room temperature in air and strong bonding was also achieved. The application of this process to heterogeneous integration of GaAs on SiC enables improved thermal management in high power semiconductor lasers.

Talk 3:

Handshaking Driven Non-linear Electromagnetic Energy Harvester

Gudla Sudeep[1], Lokesh Dhakar[1,2] and Chengkuo Lee[1],
[1] Department of Electrical and Computer Engineering,
National University of Singapore, Singapore
[2] NUS Graduate School for Integrative Sciences and Engineering,
National University of Singapore, Singapore

Gudla Sudeep received his B.Tech degree in Electronics and Communication Engineering from SASTRA University, Thanjavur in 2012 and M.Sc degree in Electrical Engineering from National University of Singapore (NUS), Singapore in 2014. He is currently working as a Research Engineer in Electrical and Computer Engineering Department at National University of Singapore (NUS) and is keenly interested in energy harvesting mechanisms for wireless sensor networks and healthcare.

Electromagnetic energy harvesting is based on Faraday's law of induction which states that a change of magnetic flux linkage with a coil induces a voltage in the coil thereby resulting in a current flowing through the circuit. It can be implemented in two ways i.e. a moving magnet whose flux is linked with a fixed coil or a fixed magnet whose flux is linked with a moving coil. The nonlinear Electromagnetic Energy Harvester (EMEH) developed uses magnetic-spring configuration (a moving magnet with a fixed coil) is employed for generating sufficient power from hand shaking of irregular and low frequency vibrations. Based on the modeling, simulation and hand shaking testing the longer tube length of the EMEH device results in lower resonant frequency and stronger nonlinearity of the system and thus is more efficient for low frequency harvesting. The optimized device provided maximum power outputs of 825.36 μW at the hand shaking acceleration of 1.56 g and frequency of 6.7 Hz. Thus, a feasible design of nonlinear EMEH device is fabricated with impressive output performance from hand shaking.

Talk 4:

Fabrication Process of Patterned ZnO NWs / Thin Film for Energy Harvesting Applications

Qiongfeng Shi and Chengkuo Lee
Department of Electrical and Computer Engineering,
National University of Singapore, Singapore

Qiongfeng Shi received his B.Eng. degree from Department of Electronic Engineering and Information Science at University of Science and Technology of China in 2012. He is currently pursuing his Ph.D. in the Dept. of ECE, NUS under the NUS research scholarship since Jan. 2014. Before that, he had been working as a research engineer in Dept. of ECE, NUS for one year. His research interests are energy harvesters.

Energy harvesting from renewable and green energy resources, such as vibration, ultrasonic wave, wind and solar energy, has attracted considerable interest due to the energy crisis and global warming. Piezoelectric effect can convert very small-scale mechanical energy to electricity. ZnO nanowire (NW) is one of the most promising piezoelectric materials with wide direct band gap (3.37 eV) and large exciton binding energy (60 meV) at room temperature. Other advantages are non-toxicity, easy and low temperature fabrication process. Here we will discuss the fabrication process of patterned ZnO NWs and ZnO thin film by varying the growth conditions. Then we will use the ZnO thin film to form a novel dome-shape structure for ultrasonic wave energy harvesting and pMUT application.

Talk 5:

Pull-In Voltage and Yield Analysis of All-Metal-Based Nanoelectromechanical Switches

You Qian[1], Bo Woon Soon[1,2] and Chengkuo Lee[1]
[1] Department of Electrical and Computer Engineering, National University of Singapore, Singapore
[2] Institute of Microelectronics, Agency for Science, Technology and Research (A*STAR), Singapore

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You Qian received his B.Eng. degree from University of Electronic Science and Technology of China (UESTC), Chengdu, China, in 2009 and MSc degree from Department of Electrical and Computer Engineering at National University of Singapore in 2010. He is now a Research Engineer at ECE, NUS and pursuing his doctorate degree in the same department. He is also currently attached to Institute of Microelectronics (IME), A*STAR. His research interests are focused on NEMS switches.

Electrostatically actuated nanoelectromechanical system (NEMS) switches have been attracting attention for its excellent switching properties include zero-leakage current, abrupt switch behavior and potential to operate in harsh environments. Aiming to have a low cost and CMOS compatible process, we designed a one-mask process for all-molybdenum-based laterally actuated nanoelectromechanical switch. The Damascene-like process is designed to ensure a clean, high aspect ratio, metal-to-metal mechanical contact. Analytical solution for fixed-fixed beam and cantilever pull-in voltage is developed, showing very good agreement with finite element modeling. Single device measurement shows very good performance in reliability and contact resistance. A statistical study of 800 devices has been performed concentrating on the pull-in voltage and repeatability. Different device failure mode and pull-in voltage deviation are identified. Based on the accumulated data, we propose the suitable dimension range for laterally actuated NEMS switch design, where 100% process yield can be achieved from our measurement.

Talk 6:

Reliability Characterization of Si-to-Si Microswitches with Operation Range of -60 °C to 400 °C

Jeffrey B.W. Soon[1] and Chengkuo Lee[1]
[1]Department of Electrical and Computer Engineering, National University of Singapore

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Jeffrey B.W. Soon received his B.Eng. Degree in microelectronics engineering from Liverpool John Moores University, United Kingdom, in 2006. Currently he is a research engineer working in the Department of Microelectromechanical Systems Integration at Institute of Microelectronics, Agency of Science and Technology, A*STAR, Singapore. He is also actively pursuing his PhD degree in electrical and computer engineering at National University of Singapore. His research interests include microfabrication technologies, MEMS sensors and actuators.

Micro/nano-electromechanical (MEM/NEMS) switches have been reported to possess superior harsh environment reliability over the state-of-art complementary metal-oxide-semiconductor (CMOS) transistor technology. Using an ultra-clean vacuum sealing process, an encapsulated Si-to-Si contact micro switch is fabricated and characterized. This three-terminal micro switch relies on a curved beam (source) that actuates toward the contact terminal (drain) by charging the control terminal (gate). We report the temperature stability of this switch from -60 °C to 300 °C, which approximately yields a resistance drift of -200 Ω/K. Meanwhile, through continuous on-off cycles, the operating lifetime in high temperature environment is investigated. By reducing excessive Joule heating, preliminary results demonstrate at least 10^6 cycles longer lifetime at 400 °C. Subsequently, the failure mode is investigated and reported. The study of such Si-to-Si contact based micro switches provides a crucial guideline to the field of mechanical and electrical failure mechanisms for harsh environment applications.

Talk 7:

Temperature Sensor for An Early Diagnosis System of Pneumonia in Calves

Hirofumi Nogami
Kyushu University, Japan

He received the B.E (2005) degree in Faculty of Engineering from Kyushu University, M.E (2008) and Ph.D. (2011) degrees in graduate school of Systems Life Sciences from Kyushu University. He had worked at Advanced Institute of Science and Technology (AIST) since April, 2011 for 3 years. Now, he is assistant professor in Kyushu University. His research works are potentially in commercial development in animal health monitoring system and the wireless sensor node. Also, he have researched optical blood flow sensor using MEMS technology.

Calves are less able to fight virus or bacterium, and predisposed to respiratory disease such as pneumonia. The death and disease accidents caused by respiratory disease are the highest in all accidents. The effective means for early detection of the respiratory disease are to measure rectal temperature with a thermometer. However the mean cannot be frequently conducted on account of spending too effort in the farm. As a means of requiring little effort, we have developed wireless sensor nodes. The primary advantages of the sensor nodes are flexible and slightly temperature sensor pats. The temperature sensor was mounted on the flexible substrate, and the thickness was 0.8 mm. Thus, we can easily attach the sensor nodes to the base of the calf's tail, which is one of the highest skin temperature parts, and success to measure the skin temperature.

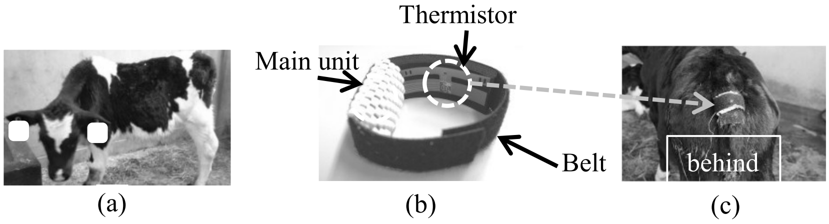

Fig. 1 Target (a), Wireless sensor node (b), Measurement part

Talk 8:

Polymer Based Drug Delivery Devices and Neural Recording Cantilevers

Zhuolin Xiang[1,2], Hao Wang[1] , Giorgia Pastorin[2] and Chengkuo Lee[1]
[1]Department of Electrical and Computer Engineering, National University of Singapore, Singapore
[2]Department of Pharmacy, National University of Singapore, Singapore

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Zhuolin Xiang received his B.Eng. degree from the Department of Information and Electronics, Beijing Institute of Technology, Beijing, China in 2011. He is now a Ph.D student in Electrical and Computer Engineering, NUS. His research interests focus mainly on BioMEMS Devices for drug delivery and neural interfacing.

Polymer-based microneedles have drawn much attention in transdermal drug delivery resulting from their flexibility and biocompatibility. Traditional fabrication approaches are usually time-consuming and expensive. Drawing lithography technology is a popular technique to fabricate 3-dimensional (3D) microneedles in recent years. The advanced fabrication technology to be presented can overcome limitations to fabricate dense, scale-up and small microneedles in conventional processes. The fabricated microneedles are demonstrated to penetrate skin samples in vivo and lower blood glucose levels in vivo, which suggests future possible usage for minimally invasive transdermal delivery of macromolecules. Meanwhile, neural probe embedded in the biodissolvable microneedles is also demonstrated to successfully penetrate the brain tissue and acquire neural signals.

Talk 9:

Micropyramid Array Electrode for Electrochemical Detection

Wataru Iwasaki
National Institute of Advanced Industrial Science and Technology (AIST), Japan

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Wataru Iwasaki received the B.E. degree in Mechanical Engineering from Kyushu University in 2008, M.E. and Ph.D. degrees in Graduate School of Systems Life Sciences in 2010 and 2013, respectively. He joined in AIST as a research scientist. His research interests are MEMS devices and biochemical sensors for animal health monitoring.

It is required that we can easily get information of optimum insemination and birthing period of cattle in the agricultural fields. Measurement of luteinizing hormones and sexual hormones such as estradiol, estrone and progesterone is quite a good way to guess the optimum period of doing artificial insemination and birthing. Rapid and simple measurement system of these biomarkers is required for farmer to use a sensor in the field. Immunochromatography is one of the rapid and simplest immunosensors available, however it is not suitable for quantitative detection of biomarkers. Recently some researcher have tried providing quantitative capability with electrochemical, fluorescence and other detection technique. In the case of electrochemical measurement, the contact between nitrocellulose membrane and electrode is very important for the sensitivity. Therefore, we tried to fabricate micropyramid array electrode using maskless lithography equipment. The micropyramid array electrode improves the contact area between the nitrocellulose membrane and electrode. The micropyramid array electrode is evaluated with ferricyanide ion as an electrochemical mediator by cyclic voltammetry.
This work was supported by Council for Science, Technology and Innovation (CSTI), Cross-ministerial Strategic Innovation Promotion Program (SIP), “Technologies for creating next-generation agriculture, forestry and fisheries” (funding agency: Bio-oriented Technology Research Advancement Institution, NARO)

Talk 10:

Flexible Epineural Strip Electrode for Neural Signal Recording

Sanghoon Lee, Shih-Cheng Yen and Chengkuo Lee
Department of Electrical and Computer Engineering,
National University of Singapore, Singapore

He received the B.S. degree at the Department of Electronic Material Engineering in Kwangwoon University, Seoul, Korea in 2009 and his M.Eng. degree at the Department of Electrical and Computer engineering in National University of Singapore in 2013. The research topic of M.Eng was the development of new functional superparamagentic nanoparticles for various cancer diagnosis/treatment modalities (MRI/hyperthermia agents for glioblastoma and liver cancer) in nanomedicine.
He is currently pursuing his Ph.D. under the supervision of Prof. Vincent C. Lee in Electrical and Computer Engineering in National University of Singapore. His current research efforts are focused on the development of MEMS based neuroprosthetics.

Many researchers have been focused on developing a reliable and stable neural interfacing for neuroprosthetics and neurotherapeutic applications. Accordingly, various types of electrodes have been reported in the past such as cuff, LIFE and TIME, which reveals tradeoffs between high selectivity and low invasiveness. Cuff electrodes have been widely used chronically in different clinical applications owing to their easy implantation and low invasiveness. However, most of them have been used for nerve stimulation instead of recording, where the low signal-to-noise ratio (SNR) is a major challenge. Even though snug-fitting nerve cuffs have been approved to obtain a high signal-to-noise ratio (SNR) for neural recording as well as to reduce the stimulus charge injection, nerves can be damaged by the presence of the cuff due to the delicacy of the nerve tissue and the physical properties of the electrode. Therefore, the development of new designs for reliable and biocompatible neural electrodes is still desirable. We have developed flexible epineural strip electrode for neural signal recording. This new design allow the electrode to put on the nerve so that it is free for nerve pressure as well as enables to closely contact on various sizes of nerves. To enhance electrical characteristics of electrode sites, Au-CNTs nanocomposite is coated on electrode surface. For in vivo test, sciatic nerve of a rat is used for neural signal recording. The result demonstrates that flexible epineural electrodes are promising electrode designs for an implantable neural interface.

Talk 11:

Development of Broadband Piezoelectric Micromachined Ultrasound Transducers (pMUTs)

Tao Wang[1], Takeshi Kobayashi[2] and Chengkuo Lee[1]
[1] Department of Electrical and Computer Engineering, National University of Singapore, Singapore
[2] National Institute of Advanced Industrial Science and Technology (AIST), Japan

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Tao Wang received his B.Eng. degree from the School of Microelectronics and Solid-state Electronics at the University of Electronic Science and Technology of China (UESTC), Chengdu, China, in 2010 and M.Sc degree from Department of Electrical and Computer Engineering at National University of Singapore in 2011. He is now a PhD candidate in Electrical & Computer Eng. Dept., NUS. His research interests are focused on piezoelectric MEMS based acoustic devices.

Broadband ultrasonic transducer is always preferred for diagnostic ultrasound imaging, because wide frequency bandwidth can reduce duration of ultrasonic pulse and enhance the axial imaging resolution. However, frequency bandwidth of both bulk piezoelectric ceramics based ultrasonic transducer and conventional piezoelectric micromachined ultrasonic transducer (pMUT) is quite limited. To overcome this limitation, a mode-merging pMUT is presented in this paper. By using a rectangular membrane with large length / width aspect ratio, numbers of resonant modes are excited within a narrow frequency range. When this pMUT works in largely damped medium, excited modes are merged together, forming an ultra-wide bandwidth. A -6dB bandwidth of over 94% is measured in water for the proposed pMUT without matching layer, which is significantly broader than that of conventional pMUT. Benefited from such ultra-wide frequency bandwidth, pulse duration of 1 μs is achieved at central frequency of 1.24 MHz. If this broadband pMUT is utilized to replace the conventional ultrasonic transducers for diagnostic ultrasound imaging, the axial resolution can be significantly enhanced without compromising the sensing range.

Talk 12:

Control of Protein Crystal Growth in Microfluidic Chip

Masaya Miyazaki
Measurement Solution Research Center, AIST Japan
Department of Molecular and Material Sciences, IGES, Kyushu University, Japan

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Dr. Masaya Miyazaki has a multidisciplinary background in the fields of Analytical Biochemistry, Microfluidics, and Bioorganic Chemistry. He graduated from Saga University with a B.Sc. and pursued his Ph.D. at the same University. Dr. Miyazaki was trained in the field of Biochemistry at Joslin Diabetes Center/Harvard Medical School, where he spent his postdoctoral training. After working as a researcher of ERATO project at RIKEN, he joined AIST. His current research interests include development of microfluidic reaction system and their application for analytical biochemistry.

Control in crystal shape is essential issue in protein crystal structure analysis and material chemistry field. We found that crystal growth can be controlled in small droplet generated in microfluidic chip [1-3]. This technique is based on decreasing the supersaturation by controlling the protein concentration gradient in a microdroplet after the first nucleation. By this method, we could control generated crystal number within the droplet.

We expand this approach to control the shape of protein crystal within small microfluidic chamber, because there is a demand on the controlling morphology and aggregation of protein crystals in order to obtain clear diffraction pattern via on-chip X-ray analysis. In particular, crystal habit of protein effects on the diffraction intensity. We found the potential of microfluidic chip for controlling crystal habit as well as aggregation of protein crystals by changing size and aspect ratio of microchamber on chip.

These results demonstrate that microfluidic chip is a suitable apparatus for controlling crystal habit.

[1] M. Maeki, et al., "A method for generating single crystals that rely on internal fluid dynamics of microdroplets." *Chem. Commun.*, **48**, 5037-5039 (2012)

[2] H. Yamaguchi, et al., "Controlling one protein crystal growth by droplet-based microfluidic system." *J. Biochem.*, **153**, 339-346 (2013)

[3] M. Maeki, et al., "A Controlling protein crystal nucleation by droplet-based microfluidics." *Chem. Eur, J.*, **20**, 1049-1056 (2014).

Talk 13:

Long Range Dynamic Controllable Linear Gradient Generator

Hao Wang[1], Yan Wang[1], Zhuolin Xiang[1], Ming Wang[2], Chia-Huang Chen[2] and Chengkuo Lee[1]
[1]Department of Electric and Computer Engineering, National University of Singapore, Singapore
[2]Department of Biomedical Engineering, National University of Singapore, Singapore

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Wang Hao received his B.Eng. degree in School of Optoelectronic Information from University of Electronic Science and Technology of China in 2010. He is currently a Research Engineer of ECE, NUS and pursuing his M.Eng degree in the same department. His research interests are focused on nanoneedle devices for transdermal drug delivery.

Nowadays, engineering various gradients has attracted extensive attention for biomedical applications because gradients play essential roles in many biological activities and regulate a number of cellular functions in vivo. Chemical gradients have been shown to affect various cell behaviors, such as migration, proliferation, and differentiation during development. Microfluidic devices offer the possibility of generating complex and well defined gradient profiles. One of the most popular method to generate the chemical gradient is to leverage the Christmas Tree design. But the major disadvantage is that the gradient profile is not linear. Another major direction is to leverage the diffusion to generate chemical gradient. The length of the gradient generated is limited and the profile is also not linear. Due to the static flow rate used for diffusion, dynamic control is not feasible to be applied. Here we report a novel gradient generator to achieve long range and linear chemical gradient with dynamic control function. The length of the gradient can be at centimeter scale. A channel network, which is different from the one in Christmas tree, is designed. This channel network could ensure a linear gradient profile which cannot be realized by Christmas tree design. The gradient profile can be tuned by changing the flow rates. The device can work in both high flow rate regime with large shear stress and low flow rate with minimum shear stress.

Talk 14:

Applying MEMS Micro-Scanner to Light-Section Sensor

Koji Okazaki[1], Kentaro Ikeda[1], Noriaki Ishikawa [1,2], Renshi Sawada [1]
[1] Kyushu University, Japan
[2] Fuji Electric Co., Ltd., Japan

Koji Okazaki was born in Japan, in August 1990. He received the B.E. degrees from Kyushu University, Fukuoka, Japan, in 2014, where he is currently working toward the M.E. degree.

A MEMS micro-scanner is applied to various applications, such as optical switches and projection displays. In this study, we applied MEMS micro-scanner to light-section sensor, and measured the surface shape of target object.
Fig.1 shows the experimental system. We irradiated the laser beam which was scanned into one dimension by MEMS micro-scanner to target object. The incident angle of laser beam was 45°. The reflected light from target object was detected by the CCD camera. Fig.2 shows the target object. It is composed of two mirrors and has a step. The height of the step is 1.65mm.
Fig.3 shows the measured result of the surface shape of target object. The measured and calculated results of the step on this image, which was detected by CCD camera, were 2.26mm and 2.33mm respectively. These results almost corresponded to each other. It turned out that the MEMS micro-scanner is applicable to light-section sensor.

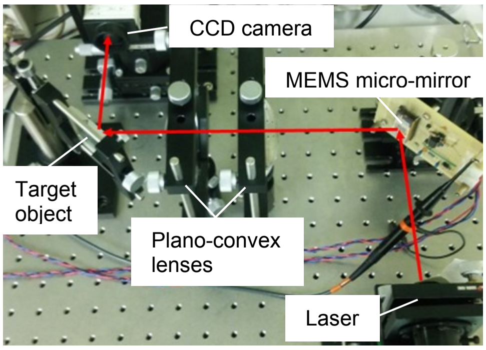


Fig.1 Experimental system

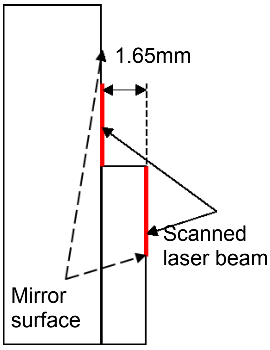


Fig.2 Target object

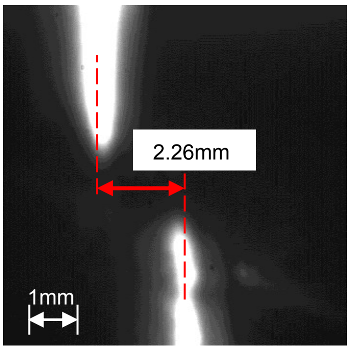
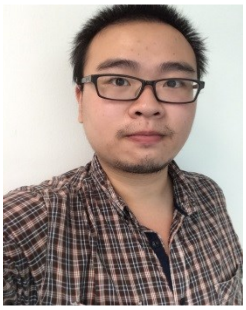


Fig.3 Image which was detected by CCD

Talk 15:

Characterization of Nanometer-Thick Polycrystalline Silicon with Phonon-Boundary Scattering Enhanced Thermoelectric Properties and Its Application in Infrared Sensors

Huchuan Zhou and Chengkuo Lee
Department of Electrical and Computer Engineering,
National University of Singapore, Singapore



Zhou Huchuan received his B.Eng. degree in School of Optoelectronic Information from University of Electronic Science and Technology of Chnia in 2010. He is currently pursuing his doctorate degree at NUS, Electrical and Computer Engineering and is attached to the Institute of Microelectronics (IME), A*STAR. His research interests include MEMS-based devices, focusing mainly on microbolometer and thermopile.

Although significantly reducing to thermal conductivity of silicon nanowires has been reported, it remains as a challenge about integrating silicon nanowires with structure materials and electrodes in the CMOS process. In this presentation, we investigated the thermal conductivity of nanometer-thick polycrystalline silicon (poly-Si) theoretically and experimentally. By leveraging the phonon-boundary scattering, the thermal conductivity of 52 nm thick poly-Si is as measured as low as around 12 W/mK which is only about 10% of the value of bulk single crystalline silicon. Thermopile infrared sensors comprising 128 pairs of thermocouple made of either n-doped or p-doped nanometer-thick poly-Si strips in series connection with aluminium (Al) metal interconnect layer are fabricated using microelectromechanical system (MEMS) technology. The measured vacuum specific detectivity (D*) of n-doped and p-doped thermopile infrared (IR) sensors are 3.00*10^8 and 1.83*10^8 cm*$Hz^{1/2}$*W^{-1} for sensors of 52nm thick poly-Si, and 5.75*10^7 and 3.95*10^7 cm*$Hz^{1/2}$*W^{-1} for sensors of 300nm thick poly-Si, respectively. The outstanding thermoelectric properties indicate our approach promising in diversified applications using ultrathin poly-Si technology.

Talk 16:

Fabrication and Applications of Micro Lens Using DMD Lithography Equipment

Toshihiro Takeshita[1], Wataru Iwasaki[2], and Renshi Sawada[1]
[1] Kyushu University, Japan
[2] National Institute of Advanced Industrial Science and Technology (AIST), Japan

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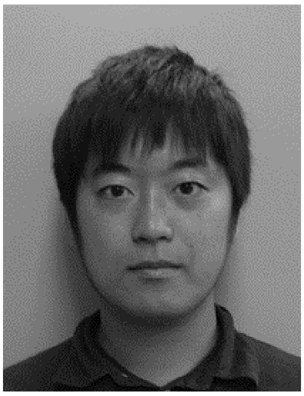


Toshihiro Takeshita was born in Japan, in October 1988. He received the B.E. degree and Master from Kyushu University, Fukuoka, Japan, in 2011 and 2014 and is a student Doctoral program of Kyushu University.

With development of a robot, medical machine, and mobile phone, miniaturization and high functionalization are required. Generally speaking, optical sensor is high performance. However, it is difficult to be miniaturized because optical sensor needs many optical elements.
We have researched about fabrication of micro lens which is one of the most important optical element for optical sensor. The micro lens is fabricated using of DMD (digital mirror device) lithography equipment. A DMD uses a light-switch array of thousands of individually addressable and tiltable micro mirrors. So, The DMD lithography equipment can maskless-photolithograph and grayscale-photolithograph.
Firstly, gray scale mask is designed, which is a picture of bitmap date. Next, photoresist spin-coated on glass wafer is formed into micro lens using DMD lithography equipment and gray scale mask. After that, the glass wafer is etched by dry etching equipment. As a result, micro lens is formed on glass wafer.
The micro lens will be applied to optical sensor we have developed.

Talk 17:

Characterization of Polycrystalline Silicon Based Photonic Crystal Suspended Membrane for High Temperature Applications

Chong Pei Ho, Prakash Pitchappa and Chengkuo Lee
Department of Electrical and Computer Engineering,
National University of Singapore, Singapore

Mr. Chong Pei Ho received his B.Eng. degree from Department of Electrical and Computer Engineering at National University of Singapore in 2011. He is currently a Research Engineer in the same department. He has also enrolled in NUS Ph.D. program since Jan. 2012. His research interests include applications involving nanophotonics especially in the area of photonic crystals.

We present the design and characterization of polycrystalline silicon (Si) based photonic crystal (PhC) suspended membrane, working in the mid-infrared (MIR) wavelengths. In order to facilitate transmission measurement, the PhC membrane is released by removing the underneath Si substrate. Around 97% reflection and 3% transmission at 3.58μm wavelength are measured at room temperature. Characterization is also done at 450^{o}C and it reveals that the peak reflection of the PhC membrane shifts by 75nm to higher wavelengths. This corresponds to a linear wavelength shift of 0.174nm/^{o}C and the thermo-optic coefficient is calculated to be +1.70×10^{-4} K^{-1}. By altering the dimension of the PhC air holes, it is also shown that such thermo-optic effect is compensated.

Talk 18:

Application of Blood Flow Sensor in Doppler Velocimeter

Y.Peng, R. Sawada
Graduate School of Systems Life Sciences, Kyushu University, Japan

Yao Peng was born in China, in February 1989. After graduated from Shanghai Jiaotong University, China, she came to Kyushu University, Japan, in 2010. Now she is studying in graduate school of systems life sciences, to pursuit for her doctor degree.

Nowadays as health care is drawing more and more attention from the public, wearable medical technology is becoming a hot commodity. Using these devices, multi kinds of vital signals could be sent to both doctors and patients. It could not only help doctors to monitoring patients' condition, but also be able to give advices or warnings directly to patients, based on collected data. It has already been known that nowadays there have already been lots of sensors redesigned to be wearable, such as: glucose monitors, pulse oximeters, blood pressure monitors and so on. In this paper we propose a method of small-sized Doppler velocimeter, able to be adapted into wearable devices, which is based on the principle of an existed blood flow sensor. In order to be applied into wearable devices, the sensor has to be small and light enough. By MEMS technology we succeed in designing a small-sized sensor, showed as figure 1(a). The size of sensor is only 2.0mm×2.7mm×0.9mm, with the weight of 0.06g. Using the sensor, we are capable of measuring the surface speed of a moving subject as figure 1(b). By this method, we could measure the speed in both x and y directions. We analysis the data collected by photodiode, while subject is moving in y direction. The results are showed in figure 1(c). Different from other common Doppler velocimeter, only one light beam is used in the principle, which make the sensor simpler and easier to be minimalized.

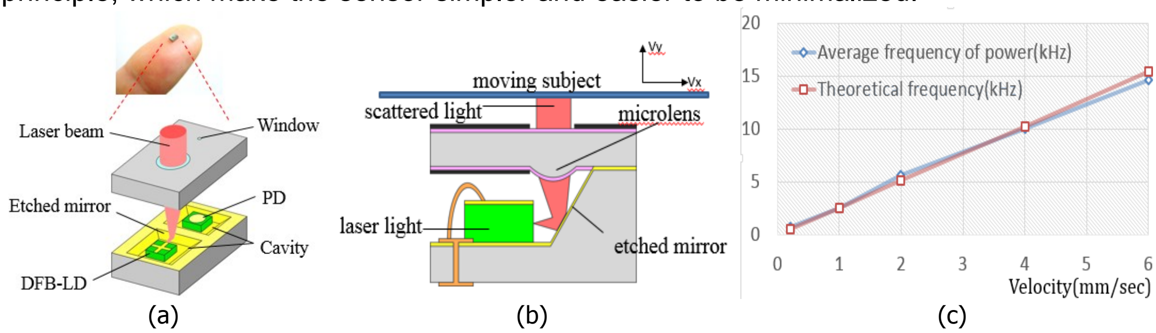


Figure 1 (a) Structure of Doppler Velocimeter (b) Principle of Sensor (c) Experimental and Theoretical Results

Talk 19:

Lateral Lattice Shift Engineered Slow Light in Elliptical Photonics Crystal Waveguides

Bo Li, Chong Pei Ho and Chengkuo Lee
Department of Electrical and Computer Engineering,
National University of Singapore, Singapore

Bo Li is a research fellow at Lab of Sensors, MEMS and NEMS, Department of Electrical & Computer Engineering, National University of Singapore, Singapore. Received his B.Eng. degree and PhD degree from the Department of Electrical and Computer Engineering, National University of Singapore in 2009 and 2013. His research interests include nanophotonics and its integration with MEMS for sensing applications.

A photonics crystal (PhC) waveguide which operates in the slow light regime is reported in this paper. A second line of circular air holes from the PhC waveguide in triangular lattice is replaced by a line of ellipse air holes. Based on three dimensional plane wave expansion (PWE), the lateral shift of ellipse air holes is conducted to enhance the slow light characteristics. Group index of 166 and a delay-bandwidth product of 0.1812 are derived from an optimized PhC using ellipse air holes with lateral shift of 160 nm according to the simulation results. A mach-zehnder interferometer (MZI) is integrated with the above-mentioned PhC waveguide with 17 μm length in one of its arms. The measured transmission spectrum of fabricated MZI embedded with PhC waveguide shows slow light interference patterns.

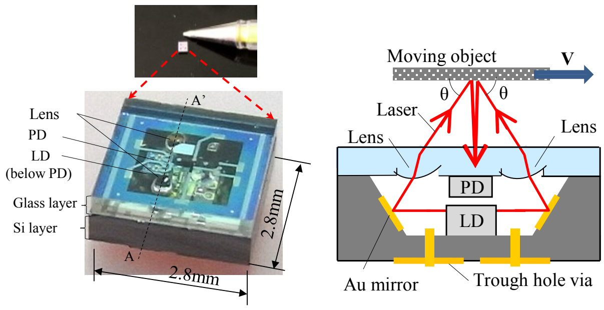
Talk 20:

A Micro-Laser Doppler Velocimeter for Slip Detection

N. Morita[1], T. Cargan[1], H. Nogami[1], E. Higurashi[2], T. Ito[3], R. Sawada[1]
[1]Kyushu University, Japan
[2]The University of Tokyo, Japan
[3]Kyushu Institute of Technology, Japan

Nobutomo Morita was born in Japan, in April 1987. He received his B.E. and M.E. degrees in 2010, and 2012, respectively, from Kyushu University, Fukuoka, Japan, where he is currently working toward his Ph.D. degree.

In the near future, many countries in the world will face the challenges of an ageing population, including an increase in the number of patients and a converse decrease in the labor force. Humanity needs robots to help us overcome these problems. To assist humans, robot hands must be capable of gripping various objects with appropriate force and without slipping, as humans do. Slip detection sensors are necessary to prevent slipping in robot hands, and they need to be very small to be embedded on robot fingertips. In this paper, we propose a method for slip detection that can measure slip velocity directly. The laser Doppler velocimeter (LDV) is known as a sensor that can measure the velocity of objects of various materials. However, even smaller commercial LDVs are a few cubic centimeters. We created a miniaturized laser Doppler velocimeter (micro-LDV) in order to enable it to be embedded on a robot fingertip for use as a slip sensor (Fig. 1). This sensor size is 2.8 × 2.8 × 1.0 mm thick, only 1/10,000th of the volume of commercial LDVs. Our micro-LDV was able to measure velocities of three types of moving objects ranging from 10 to 20,000 μm/s, as shown on Fig. 2. The output of this sensor was independent of the type of material measured, which included aluminum, cardboard, or black plastic. We anticipate our micro-LDV will be utilized as a slip sensor for various materials in the future.



(a) (b)

Fig.1 (a) Picture of micro-laser Doppler velocimeter and (b) schematic of A-A′ section.

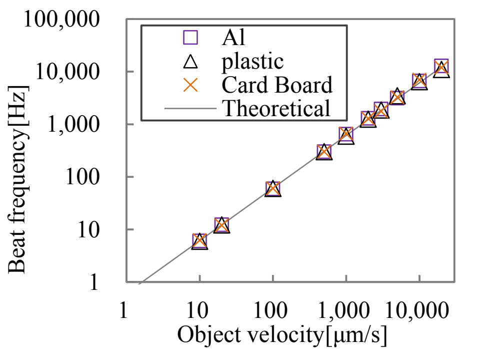


Fig. 2 Velocity measurement results for three materials.

Talk 21:

Infrared Metamaterial Absorbers for Gas Sensing Application

Prakash Pitchappa, Chong Pei Ho and Chengkuo Lee
Department of Electrical and Computer Engineering,
National University of Singapore, Singapore

Prakash Pitchappa is currently a research student at Lab of Sensors, MEMS and NEMS, Department of Electrical & Computer Engineering, National University of Singapore, Singapore. He received his M.Sc. degree from Department Electrical & Computer Engineering from National University of Singapore in 2011 and B.Eng. degree from Department of Electronics & Communication Engineering, College of Engineering, Guindy, India in 2008. He is expected to get his Ph.D. degree from National University of Singapore in Dec. 2015. His research interest is in MEMS integrated metamaterial devices. He is currently working on MEMS tunable THz and infrared metamaterial based filters and absorbers for gas sensing applications.

Low cost miniaturized gas sensing has been looked upon the next potential component to be integrated with the smart phones. However realization of such low cost miniaturized system is challenged due to presence of multiple components such as IR source, IR filter and IR detector. Hence the critical and costly component is the IR filter, which provides the wavelength selective information of the entire system. However recently metamaterial based absorbers have been reported for IR spectral region, which can provide narrowband IR absorption and can be integrated directly with the IR sensors and so the IR filter can be totally eliminated. This simple means can enable both low cost and miniaturized gas sensing systems that can be potentially used in mobile devices.

Talk 22:

Excitation of Magnetic Resonance in Bow-tie Nanoantenna Array by Plasmonic Inclusion

Dihan Hasan and Chengkuo Lee
Department of Electrical and Computer Engineering,
National University of Singapore, Singapore

Dihan Hasan is a member at Lab of Sensors, MEMS and NEMS, Department of Electrical & Computer Engineering, National University of Singapore, Singapore. He received his B.Sc. degree in Electrical Engineering from Bangladesh University of Engineering and Technology, in 2012. He is currently pursuing his PhD in the Dept. of Electrical and Computer Engineering at National University of Singapore. His research interests include Si Nanophotonics and Plasmonics.

In this work, we experimentally demonstrate magnetic resonance in a new class of bow-tie optical nanoantenna for the first time by inserting plasmonic inclusion. We also observe simultaneous enhancement of electric and magnetic field and report significant improvement of fano like dipolar characteristics occurring due to their strong interplay. We propose a unique parameter to control the plasmonic current density in bow-tie structure for strong modulation of optical characteristics across multiple bands. The high density plasmonic antenna array holds promise for potential applications in optical magnetism, magnetoplasmonics, optical trapping and ultrasensitive detection of molecular fingerprints