APCOT 2018

Asia-Pacific Conference of Transducers and Micro-Nano Technology 2018

24 – 27 June 2018
Hong Kong University of Science and Technology,
Hong Kong SAR

Sponsors:

Croucher Foundation 裘槎基金會

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Welcome Messages

We sincerely welcome you to attend the 9th Asia-Pacific Conference of Transducers and Micro-Nano Technology (APCOT 2018) at the Hong Kong University of Science and Technology, Hong Kong on 24–27 June 2018. Situated on China's south coast and, enclosed by the Pearl River Delta and the South China Sea, Hong Kong is known for its impressive skyline and deep natural harbor. APCOT will bring together the leading scholars and researchers from across the world to discuss their most recent and advanced findings in micro/nanotechnology and transducers. In addition, the international Contest of Applications in Nano-Microtechnologies (iCAN 2018) will be held in conjunction with APCOT 2018. The biannual APCOT meeting is a premier event with a history of eight successful conferences: The 1st APCOT was held in Xiamen, China in 2002, the 2nd APCOT in Sapporo, Japan in 2004, the 3rd APCOT in Singapore in 2006, the 4th APCOT in Tainan Taiwan in 2008, the 5th APCOT in Perth, Australia in 2010, the 6th APCOT in Nanjing, China in 2012, the 7th APCOT in Daegu, South Korea in 2014, and the 8th APCOT in Kanazawa, Japan in 2016. The APCOT 2018 has received **157** abstracts submitted from 21 countries/regions. TPC members have worked hard in refereeing the submissions. As a result, **87** papers have been selected for oral presentations and **56** papers have been selected for posters. In addition to that, distinguished experts including **6** plenary speakers and **10** keynote speakers are among the speakers for the 3-day Technical Program. The technical program contains the abstracts of all oral and poster presentations and is provided in USB flash drive. We thank all the authors who contribute their original works to APCOT2018 and help make this excellent conference possible.

We would like to thank all the people who have contributed to the conference. We especially appreciate the work of all the members in various committees and the student volunteers of APCOT 2018.

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HKUST

Conference Co-Chair
Ching-Hsiang Cheng
Hong Kong Polytechnic University

Technical Program Chair
Xuming Zhang
Hong Kong Polytechnic University

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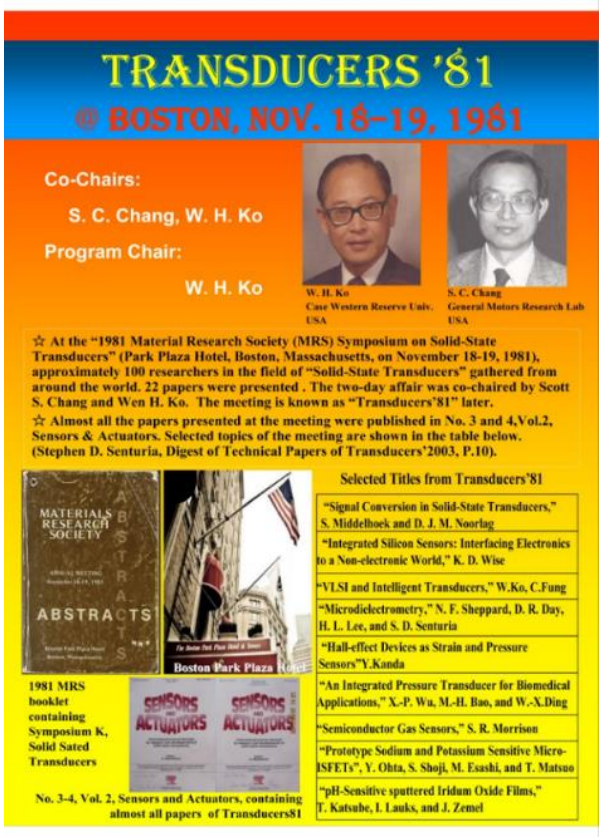
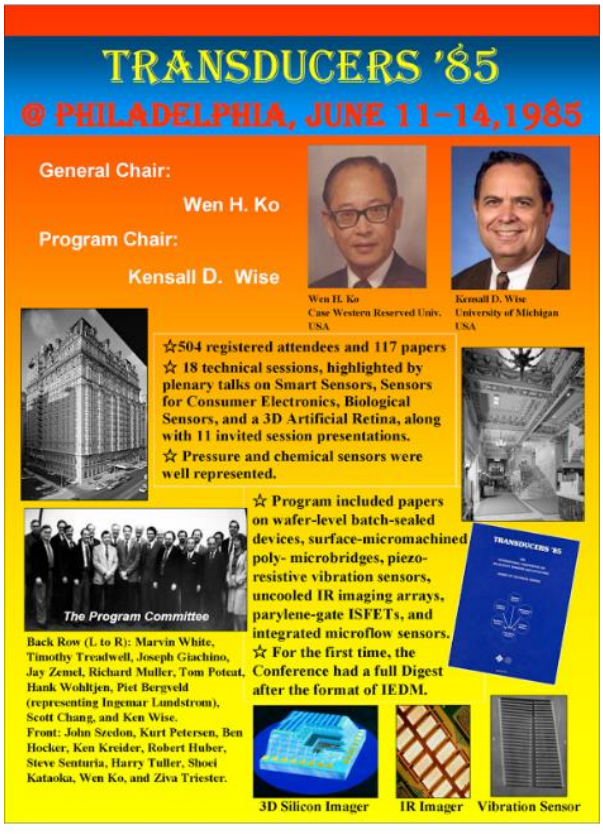
In Memory of Professor Wen Hsiung Ko (葛文勳教授)

Professor Wen H. Ko, the Professor Emeritus in Electrical Engineering at Case Western Reserve University, passed peacefully at home in Palo Alto, California at the age of 94 on 4 December 2017. He was a pioneer in MEMS and organized the first APCOT conference in Xiamen, China in 2002. He served as the chairperson of the steering committee of APCOT committee from 2002 to 2004. He served as the program chairman for the International Conference on Solid-State Sensors and Actuators, Transducers 1981, Boston, MA, USA, 18-19 Nov, 1981; as the general chairman of 1985 International Conference on Solid-State Sensors and Actuators (Transducers 1985), Philadelphia, PA, 11~15 June, 1985. He was the IEEE fellow and Fellow of the American Institute of Medical and Biological Engineering. He organized and was the President of the Transducer Research Foundation from 1986 to 2004.

Professor Ko received his B.S. degree in electrical engineering from Xiamen University of China in 1946, and the M.S. and Ph.D. degrees in electrical engineering from Case Institute of Technology, Cleveland, OH, in 1956 and 1959, respectively. He has been an Assistant, an Associate and a full Professor of electrical engineering and biomedical engineering, at Case Western Reserve University (CWRU), Cleveland, OH, since 1959, 1962, and 1967, respectively. Professor Ko published ~450 papers, supervised ~200 MS and Ph.D. theses, and was awarded 26 patents. He was active in technology transfer to industry throughout his career. He became a Professor Emeritus in electrical engineering at CWRU on July 1993 and is active in research on MEMS and biomedical implants including micropackage and thin film power supplies. He is interested in solid state electronics, micro-sensors and actuators, MEMS, biomedical instrumentation, and control system design. Reference: M. Mehregany, "Celebrating the legacy of Wen H. Ko (1923–2017)," Sensors and Actuators A, 277, p. 200, 1 July 2018).





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Exhibitor Booths

1. TSI Semiconductor Inc., Roseville, CA, USA
   http://www.tsisemi.com

2. BMF Material Technology Inc., Shenzhen, China
   http://bmftec.com

3. Hong Kong Applied Science and Technology Research Institute (ASTRI)
   http://www.astri.org

4. Asensing Electronics Co., Ltd, Guangzhou, Guangdong Province, China
   http://www.asensing.com

5. RX Microsystem, Wuhan, Hubei Province, China
   http://www.rxmicrosystems.com

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General Information

Conference Venue:

Lecture Theatres B, D and E
Lecture Theatre H (speakers' room)
1/F, Academic Building
Hong Kong University of Science and Technology
Clear Water Bay, Kowloon, Hong Kong
http://www.ust.hk

Registration Desk:

Location: The hallway outside the lecture theatres

24 Jun 2018: 15:00–18:00
25 Jun 2018: 8:00–18:00
26 Jun 2018: 8:00–18:00
27 Jun 2018: 8:00–12:00

Lunch on 25–26 Jun 2018

12:00–14:00 at G/F Chinese Restaurant, Academic Building

Conference Banquet on 26 Jun 2018

18:30–21:30 at Crowne Plaza Hong Kong Kowloon East (next to Tseung Kwan O MTR Station)

Wi-Fi Service at HKUST

1. Wi-Fi.HK via HKUST (SSID = Wi-Fi.HK via HKUST)
This service is a collaboration with Hong Kong Government to promote the common Wi-Fi brand. Visitors can surf the Internet in public areas of HKUST campus. The service is free of charge and does not require any registration. In order to use this service, the users must agree to HKUST's Acceptable Usage Policy.

2. eduroam Wi-Fi (SSID = eduroam)
Education Roaming (eduroam) is an international wireless service, which uses IEEE 802.1X technology to provide free, easy, and flexible Wi-Fi access among education institutions around the world.

Presentation Guidelines

Oral Session Guide

In each oral presentation lecture theatre, the computer projector and MS Window based desktop computer will be available. The presenters should prepare their presentation slides in the format of Microsoft powerpoint. Please use a minimum font size of 14 in your presentation slides. The presenters are encouraged to bring both their presentation files in USB memory sticks and their own laptop computer. Please test your presentation slides before session start to avoid potential format problems caused by the compatibility of different presentation software versions. VGA, HDMI connection cable and a laser pointer will be provided, if other connection cables are needed, presenters need to prepare themselves.

Lecture Theatre H has been arranged as the speakers' room. The presenters could use this room for the preparation and testing of their slides, as well as the practice of their oral presentations.

Poster Session Guide

(1) Poster session represents an effective and valuable means for authors to present their research results. There are two Poster Sessions to be held outside the **Lecture Theatre J** during the APCOT 2018 conference. Presenters need to be along with their poster during the entire presentation period. Your poster SHOULD have the following dimensions:

A0 Size, i.e., 841 mm wide × 1189 mm high / 33.1 inches × 46.8 inches.

Set-up Time:
Monday, 25 June 10:30 - 12:00
ALL posters are to be set-up by 12:00 on Monday and remain up during the entire Conference. This will give additional time to view posters during breaks and before the Conference sessions.

Take Down:
Wednesday, 27 June 10:00 - 12:00
All posters must be removed by 12:00 Wednesday. You are responsible for your poster. All posters left after 12:30 will be disposed. Please remove your poster promptly.

(2) For the presenters of exhibitor booths, please use the area outside of **Lecture Theatre B**.

Set-up Times:
Sunday, 24 June 18:00 - 20:00
Monday, 25 June 08:00 - 12:00

Take Down:
Wednesday, 27 June 10:00 - 12:00

LOCATION MAP

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

MTR Stations with bus or green minibus service to HKUST 提供往科大巴士或綠色專線小巴服務的港鐵車站		
Diamond Hill 鑽石山:	91, 91M, 91P*	
Choi Hung 彩虹:	91, 91M, 91P*	11, 11S#
Ngau Tau Kok 牛頭角:		104
Tiu Keng Leng 調景嶺:	792M	
Hang Hau 坑口:	91M	11, 11M, 11S#
Po Lam 寶琳:	91M	12, 11S#
Tseung Kwan O 將軍澳:	792M	

Transportation from airport to HKUST:

For passengers with bulky luggage, taking a taxi to HKUST direct is recommended. Those with simple luggage may take Airport Bus A22 to Lam Tin MTR station or A29 to Po Lam MTR station, and change for taxi to HKUST.

Bus Routes 巴士路線

Green Minibus Routes 綠色專線小巴路線

* Departing from Diamond Hill Station at 07:55 – 08:50 to North Bus Station (HKUST) Monday to Friday (except Public Holidays)
星期一至星期五（公眾假期除外），於07:55至08:50由鑽石山鐵路站前往北門巴士站（香港科技大學）

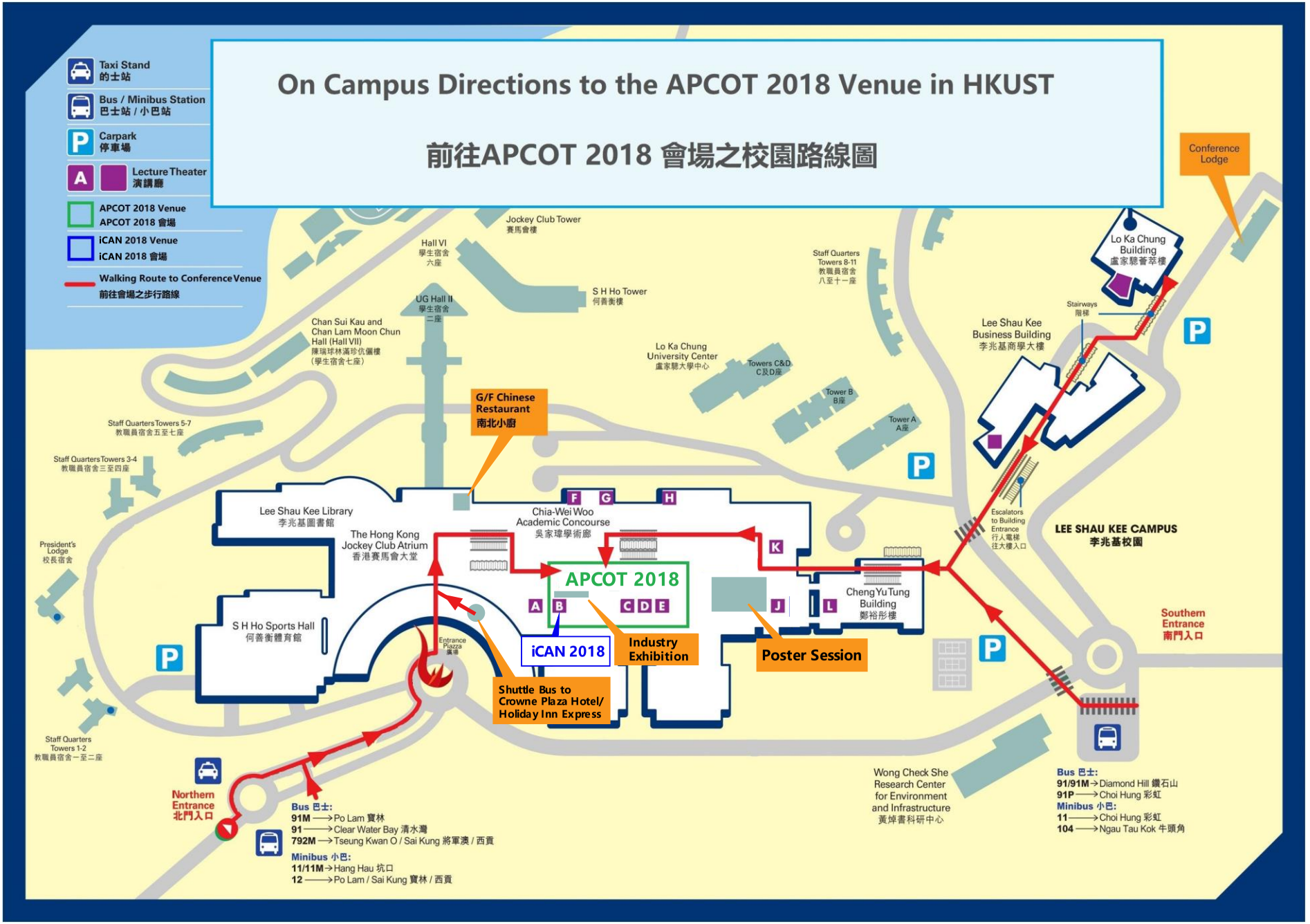
\# Departing from Po Lam (Public Transport Interchange) at midnight 12:00 to 05:00 to North Bus Station (HKUST)
午夜12:00至05:00由寶林（公共交通交匯處）前往北門巴士站（香港科技大學）

Tips for Travelling Between HKUST & Holiday Inn Express / Crowne Plaza Hotel with Bus No. 792M

Free Shuttle Bus between Crowne Plaza Hotel/Holiday Inn Express and HKUST

Date	Time	Direction
24 June	8:00am	Crowne Plaza Hotel to HKUST, for ICAN 2018
	6:00pm	HKUST to Crowne Plaza Hotel
25 June	8:00am	Crowne Plaza Hotel to HKUST
	6:15pm	HKUST to Crowne Plaza Hotel
26 June	8:30am	Crowne Plaza Hotel to HKUST
	6:15pm	HKUST to Crowne Plaza Hotel, for the banquet at 6:30pm~9:00pm
27 June	8:30am	Crowne Plaza Hotel to HKUST
	12:30pm	HKUST to Crowne Plaza Hotel

For more information, please refer to webpages:
http://www.ust.hk/about-hkust/about-the-campus/map-directions-2015/
http://library.ust.hk/about-us/contact-us/transportation/
http://www.ust.hk/hkust-campus-map/
https://join.ust.hk/admitted/jee/Campus_Map_Color.pdf


On Campus Directions to the APCOT 2018 Venue in HKUST
前往APCOT 2018 會場之校園路線圖
Taxi Stand 的士站
Bus / Minibus Station 巴士站 / 小巴站
Carpark 停車場
Lecture Theater 演講廳
APCOT 2018 Venue APCOT 2018 會場
iCAN 2018 Venue iCAN 2018 會場
Walking Route to Conference Venue 前往會場之步行路線
Conference Lodge
Jockey Club Tower 賽馬會樓
Hall VI 學生宿舍六座
S H Ho Tower 何善衡樓
Staff Quarters Towers 8-11 教職員宿舍八至十一座
Lo Ka Chung Building 盧家聰薈萃樓
Stairways 階梯
UG Hall II 學生宿舍二座
Chan Sui Kau and Chan Lam Moon Chun Hall (Hall VII) 陳瑞球林滿珍伉儷樓 (學生宿舍七座)
Lo Ka Chung University Center 盧家聰大學中心
Towers C&D C及D座
Tower B B座
Tower A A座
Lee Shau Kee Business Building 李兆基商學大樓
G/F Chinese Restaurant 南北小廚
Staff Quarters Towers 5-7 教職員宿舍五至七座
Staff Quarters Towers 3-4 教職員宿舍三至四座
Lee Shau Kee Library 李兆基圖書館
The Hong Kong Jockey Club Atrium 香港賽馬會大堂
Chia-Wei Woo Academic Concourse 吳家瑋學術廊
F G H
K
Escalators to Building Entrance 行人電梯往大樓入口
LEE SHAU KEE CAMPUS 李兆基校園
President's Lodge 校長宿舍
APCOT 2018
A B C D E
J L
Cheng Yu Tung Building 鄭裕彤樓
S H Ho Sports Hall 何善衡體育館
Entrance Plaza 廣場
iCAN 2018
Industry Exhibition
Poster Session
Shuttle Bus to Crowne Plaza Hotel/ Holiday Inn Express
Southern Entrance 南門入口
Staff Quarters Towers 1-2 教職員宿舍一至二座
Northern Entrance 北門入口
Bus 巴士:
91M → Po Lam 寶林
91 → Clear Water Bay 清水灣
792M → Tseung Kwan O / Sai Kung 將軍澳 / 西貢
Minibus 小巴:
11/11M → Hang Hau 坑口
12 → Po Lam / Sai Kung 寶林 / 西貢
Wong Check She Research Center for Environment and Infrastructure 黃焯書科研中心
Bus 巴士:
91/91M → Diamond Hill 鑽石山
91P → Choi Hung 彩虹
Minibus 小巴:
11 → Choi Hung 彩虹
104 → Ngau Tau Kok 牛頭角

ICAN 2018 Program

- **23 June 2018**

12:00 Registration

Exhibition set up

18:00 Welcome meeting

- **24 June 2018**

9:00 Opening ceremony

Exhibition

Guest lecture speech

10:30 Competition

12:00 Lunch break

13:00 Competition

18:00 Transfer to Crown Plaza Hotel

19:00 Banquet

- **25 June 2018**

9:00 Visiting

12:00 Activity finish

ICAN 2018 Team Information

Country/Region	Project name	University/Organization
Thailand	Cervical Cancer Cell Classification using Artificial Intelligent	King Mongkut's Institute of Technology Ladkrabang
Swiss	SLEEPIZ	ETH ZURICH
Swiss	WEARit	Interstate University of Applied Science Buchs NTB
Hong Kong	Executive Chef	HKUST
France & Egypt	Portable Air Quality Monitoring and Purification	Esiee Paris Université Paris-Est & Ain Shams University
China & New Zealand	Active Protection System Based on Visual Gesture Recognition	Army Academy of Artillery and Air Defense & The University of Auckland
China	Multi-perception robotic gripper	Nanjing Agricultural University
China	Electric skateboard with disk brake and Bluetooth remote control	Chongqing University
China	Aeroband Air Dial	University of Science & Technology Beijing
China	Single Camera Full-view Real-time Line Number Identification System	Aviation University of Air Force, Changchun University of Science and Technology, Jilin University
China	3D Gesture-based Remote Control Device	National University of Defense Technology
Germany	Chemical Cap	Technical University of Darmstadt
Germany	HEAT IT	Karlsruhe Institute of Technology (KIT)
Germany	Self Balancing Bicycle	Karlsruhe University of Applied Sciences
Germany	Smart Faraday	University of Freiburg
Taiwan	I HEALTH I CARE	Taipei Medical University
Japan	Intelligent Bottle Keeper	Ichikawa Gakuen Ichikawa Senior High School
France	NO'ZZ, the Morning Companion	Esiee Paris Université Paris-Est
Thailand	Smart Therapy for Osteoarthritis – Enhancing Chondrocytes with Innovative Mechanical Stimulation	King Mongkut's Institute of Technology Ladkrabang
Thailand	Agroribot: Robotics for Smart Agriculture	King Mongkut's Institute of Technology Ladkrabang
Thailand	HP Chatbot -Smart Hospital Patient Care and Customer Service	King Mongkut's Institute of Technology Ladkrabang
Thailand	Reducing the Usage of Antibiotics/Preservatives - Innovative Recombinant Human Peptide Production	King Mongkut's Institute of Technology Ladkrabang
Japan	TBT2	Kyoto University

APCOT 2018 Program Overview

Sunday, 24 June 2018

9:00am-6:00pm	**ICAN 2018** (Lecture Theatre B, Academic Building)
3:00pm-6:00pm	**APCOT 2018 Registration** (Hallway outside Lecture Theatre B, Academic Building)
6:00pm-8:00pm	**Reception (**Hallway outside Lecture Theatre B, Academic Building)

9:00 - 18:00

ICAN 2018 (Lecture Theatre B, Academic Building)

15:00 - 18:00

APCOT 2018 Registration (Hallway outside Lecture Theatre B, Academic Building)

18:00 - 20:00

Reception (Hallway outside Lecture Theatre B, Academic Building)

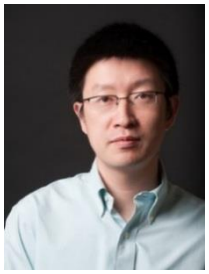
Monday, 25 June 2018

8:50am-9:00am	**Open Ceremony** (Lecture Theatre B, Academic Building)		
9:00am-9:40am	**Plenary Talk 1**: Nicholas X. Fang, Massachusetts Institute of Technology, USA (Lecture Theatre B, Academic Building		
9:40am-10:20am	**Plenary Talk 2**: Tarik Bourouina, ESIEE Paris, France (Lecture Theatre B, Academic Building)		
10:20am-10:35am	**Coffee Break** (Hallway outside Lecture Theatre B)		
10:35am-12:00pm	**A1: Theory, Design, Analysis, and Simulation** (Lecture Theatre B, Academic Building)	**B1: Material, Fabrication, and Packaging** (Lecture Theatre D, Academic Building)	**C1: Physical Sensors, Micro/Nano Fluidics** (Lecture Theatre E, Academic Building)
12:00pm-2:00pm	**Lunch** (G/F Chinese Restaurant, HKUST)		
2:00pm-3:00pm	**Poster Session I** (Outside Lecture Theatre J)		
3:00pm-4:30pm	**A2: Theory, Design, Analysis, and Simulation** (Lecture Theatre B, Academic Building)	**B2: Material, Fabrication, and Packaging** (Lecture Theatre D, Academic Building)	
4:30pm-4:45pm	**Coffee Break** (Hallway outside Lecture Theatre B)		
4:45pm-6:00pm	**B3: Material, Fabrication, and Packaging** (Lecture Theatre B, Academic Building)	**Industry Session** (Lecture Theatre D, Academic Building)	

8:50 - 9:00

Open Ceremony (Lecture Theatre B, Academic Building)

9:00 - 9:40



Plenary Talk 1: Nicholas X. Fang, Massachusetts Institute of Technology, USA (Lecture Theatre B, Academic Building)

Architectured Metamaterials: Harvesting Light, Tunable Sound Switches and Beyond

Metamaterials are made of precisely fabricated constituents that are analogous to ‘atoms’ and ‘molecules’ in natural materials. These emerging class of metamaterials promise to fill the white space of material selection, giving enormous choice of unusual effective material parameters for different applications.

In the optical domain, we report our progress on enhancement of light harvesting and conversion in the micro/nanostructures, which promise for efficient light scattering and detection. As example, we will show our development of a thermochromic window which dynamically shields the solar-energy flux up to 76% at a low phase transition temperature. I will also introduce our ongoing efforts on broadband photo-absorbers, directional emitters for solid state lighting, as well as compact and power-efficient devices.

In the arena of micro/nanofabrication, I will also present our development of three-dimensional micro/nanofabrication technique, projection microstereolithography (PuSL), to enable design and exploration of digitally coded multifunctional and multimaterial lightweight metamaterials that display unusual properties such as enhanced stretchability negative thermal expansion. The microscale resolution and multi-material capabilities of the 3D printing system and the modeling tools developed can be used to design and fabricate architected materials for applications such as novel acoustic absorbers and micro-scale bioreactors for tissue engineering.

Biography:

Nicholas X. Fang received his BS and MS in physics from Nanjing University, and his PhD in mechanical engineering from University of California Los Angeles. He arrived at MIT in Jan 2011 as Associate Professor of Mechanical Engineering. Prior to MIT, he worked as an assistant professor at the University of Illinois Urbana-Champaign. Professor Fang's areas of research look at nanophotonics and nanofabrication. His research on nanoarchitectured metamaterials was highlighted among the top 10 Emerging breakthrough technologies of the year 2015. His recognitions also include the ASME Chao and Trigger Young Manufacturing Engineer Award (2013); the ICO prize from the International Commission of Optics (2011); the NSF CAREER Award (2009) and MIT Technology Review Magazine's 35 Young Innovators Award (2008).

9:40 - 10:20

Plenary Talk 2: Tarik Bourouina, ESIEE Paris, France (Lecture Theatre B, Academic Building)

Towards Ubiquitous Sensing and Analysis with MEMS: The Virtues of Light and Co-Integration of Functional Nanomaterials

MEMS devices already invaded large-scale consumer markets, namely automotive, display and smartphones, where significant added value was proven by providing numerous functionalities based on MEMS *physical* sensors. Then, what's next? In this talk, we will first present recent technological breakthroughs enabling MEMS to perform not only *chemical* sensing but also *chemical analysis* possibly in a contactless fashion. In particular, we will highlight how recent advances in MEMS optical spectroscopy on-chip will certainly lead to a paradigm shift in analytical chemistry thanks to integration into portable platforms such as smartphones, wearables in next generation IoT. On the other hand, we will focus on the topics of 'Sustainable Environment' and 'Smart Cities' as emerging new directions of research with considerable momentum towards miniaturized instrumentation and potentially with a global impact. Besides its multiscale nature, one systemic view of the City consists of a superposition of several networks: drinking water, energy, transportation, lighting, as well as citizen carrying smartphones. These are definitely new opportunities for novel MEMS sensors to be deployed over IoT platforms at reasonable cost and in a large scale, the city scale. In this context, illustrations will be given of co-integrating nanomaterials (Black Silicon, Zinc-oxide nanowires, Carbon Nanotubes) with MEMS and microfluidics, leading to novel functional devices applied to drinking water, air quality, and other fluidics natural resources.

Biography:

Prof. Tarik Bourouina holds M.Sc. in Physics, M.Eng. in Optoelectronics, Ph.D. in MEMS (1991), and HDR (2000) from Université Paris-Sud, Orsay. Since 1988, his entire career was devoted to the field of MEMS and Lab-On-Chip. He had several contributions in optical MEMS, among which the smallest MEMS-based FTIR Optical Spectrometer, Neospectra, jointly developed with Si-Ware-Systems, awarded the Prism award on photonics innovation in 2014.

Among his contributions to the scientific community, Dr. Bourouina served in the Technical Program Committee of IEEE MEMS from 2012 to 2013. He is now serving as an Editor in two journals of Nature Publishing Group, in partnership with the Chinese Academy of Sciences: "Light: Science and Applications" and "Microsystems and Nanoengineering".

Dr. Bourouina took several positions in France and in Japan, at the Université Paris-Sud Orsay, at the French National Center for Scientific Research (CNRS) and at The University of Tokyo. He is the representative of Université Paris-Est in the international research network on Nano and Micro Systems (NAMIS) (http://namis.iis.u-tokyo.ac.jp/). Since 2002 Dr. Bourouina is full Professor at ESIEE Paris, Université Paris-Est, appointed as Dean for Research from 2012 to 2015. His current interests include optofluidics, analytical chemistry on-chip, seeking new opportunities for MEMS in the areas of Sustainable Environment and Smart-Cities. He is the Co-Laureate of the French Excellence Grant (EquipEx "Sense-City"). He is also actively involved in the development of several companies launched by his former students and colleagues, which include Si-Ware Systems, Fluidion, Memscap and MEMS-Schlumberger.

10:20 - 10:35

Coffee Break (Hallway outside Lecture Theatre B)

10:35 - 12:00

A1: Theory, Design, Analysis, and Simulation (Lecture Theatre B, Academic Building)

Keynote Speech: [155] MEMS Based Electric Field Microsensors

Shanhong Xia, State Key Laboratory of Transducer Technology, Institute of Electronics, Chinese Academy of Sciences, China

MEMS based electric field sensors have the advantages of small size, high spatial resolution, low power consumption, ease of batch fabrication, low cost, high reliability and etc. They can be used for the measurement of electrostatic field as well as alternating electric field, and can be widely applied in various areas.

This presentation briefly reviews the development of electric field sensors, and introduces the working principles of MEMS based electric field microsensors. Novel sensing structures have been invented to improve the sensing ability, which demonstrate excellent characteristics. The design, fabrication，package，signal detection and system integration technologies of the MEMS electric field microsensors are described. To meet various application requirements, a series of innovative MEMS based electric field sensor systems have been successfully developed. Their applications in various fields, such as power grid, petrochemical, meteorology, and for thunderstorm warning, electrostatic protection and weather modification are reported.

Biography:

Shanhong Xia received her B.Sc. degree from Tsinghua University, Beijing, China in 1983, her M.Sc. degree from the Institute of Electronics, Chinese Academy of Sciences (IECAS) in 1986, and her Ph.D. degree in Electrical Engineering from Cambridge University, UK, in 1994. She received a Royal Fellowship from the Royal Society, UK in 1990 and a Berkeley Scholarship from the University of California at Berkeley, USA in 2002. She is now a professor at IECAS, as well as a fellow and council member of the Chinese Institute of Electronics, fellow and Standing Committee member of the China Micro-Nano Technology Society, vice-president of the Sensor Society and council member of the China Instrument and Control Society. She served as the General Chair and the International Steering Committee Chair at the 16th International Conference on Solid-State Sensors, Actuators and Microsystems (Transducers'2011). She is a member of editorial board of several journals such as the *IEEE Sensors Journal*, *Sensors & Actuators: A. Physical*, *Microsystems & Nanoengineering*, *Nanotechnology and Precision Engineering*, etc. Her research interests include sensors and microsystems, system-on-chip, wireless sensor network and micro/nano fabrications. Her current research mainly focuses on electric field microsensors, and integrated microsensor systems for water quality monitoring.

[137] A Study for Bending-Insensitive Capacitive-Type Touch Sensor with Stretchable Top Electrode and Structured Rubber Dielectric Layer

Dong-Joon Won, Myoung Huh and Joonwon Kim, POSTECH, South Korea

In this paper, studies were conducted to develop a bending-insensitive capacitive-type touch sensor capable of measuring a relatively wide range of forces (up to tens of kPa). The sensor consists of top and bottom electrodes, and there is a structured dielectric layer in between. The bottom electrode is made of patterned FPCB and the top electrode is made of stretchable electrode, so it can be easily extended to bending. The study contents are as follows: 1) We fabricated stretchable top electrodes (~0.8 Ω/sq in initial state, and gauge factor of about 3) applicable to our devices by using AgNW material. 2) Depending on the geometry of the structures forming the dielectric layer (e.g., height and shape of the structures, and distance between structures), the distance between the top and the bottom electrodes is determined during bending, which causes a change in the capacitance of the sensor. Through the mathematical modeling and study, we propose a dielectric layer structure that has the smallest change. 3) Finally, to validate the mathematical model, we conduct the bending test.

[42] A Modified Stochastic Collocation Algorithm for Uncertainty Quantification in the Thin Film Material

Yi-Qun Song, Zai-Fa Zhou, Jia-Rui Zhu, Mu-Zi Meng and Qing-An Huang, Southeast University, China

This paper presents a numerical method for performing uncertainty quantification (UQ) of process deviations that are difficult to measure experimentally. Thin films are widely used in MEMS devices, and its material properties often exhibit differences due to the inevitable process deviations under different conditions. In this work, the property prediction of young's modulus and residual stress for devices based on GaAs Monolithic Microwave Integrated Circuit (MMIC)

process has been implemented by achieving its statistics distributions using a modified stochastic collocation algorithm. The accuracy of this modified algorithm is also discussed.

[130] A Novel Electrode Design to Improve the Sensitivity of the MEMS Based Electrochemical Seismometer

Chao Xu, Junbo Wang and Deyong Chen, Institute of Electronics, Chinese Academy of Sciences, China

The electrochemical seismometer is a sensor used in resources exploration and seismic surveillance. Electrodes served as the sensing units of electrochemical seismometers have significant influences on performance. To improve the sensitivity, a new electrode design was proposed in this paper. The electrode area is larger and the distance between cathode and anode is shorter with ingenious changes to the electrode, which leads to the obvious increase of sensitivity (about 13000V/(m/s) @1.4Hz). Moreover, the bandwidth reached 120s-60Hz exactly after feedback circuit.

[51] Performance Analysis Considering Process Deviations for Piezoresistive Pressure Sensors Based on Stochastic Collocation Method

Jia-Ru Zhu, Zai-Fa Zhou, Mu-Zi Meng, Yi-Qun Song and Qing-An Huang, Southeast University, China

Process deviations which are difficult to accurately evaluate have great influence on the performance of MEMS sensors. This paper describes the analysis of the sensitivity of a MEMS piezoresistive pressure sensor, which is related to the length, thickness, piezoresistive coefficient and Poisson's ratio of the sensing elements. Sensitivity is considered as a key evaluation indicator of yield. Parametric sensitivity analysis has been conducted to find the critical design parameter, which is proved to be the thickness of diaphragm in this work. In order to simulate the actual process condition, material parameters of piezoresistive coefficient and Poisson's ratio are assumed to deviate from the nominal values by 6.25% and 25% respectively. Stochastic Collocation Method (SCM) is employed to analyze how to adjust the geometrical parameter in this case to maximize the yield of sensors. The results show that errors are within 0.7% for the results of 2-order SCM approximations compared with the Monte Carlo Simulation. The sensors with corresponding parameters are fabricated. Though average error between simulated and experimental results is about 23.55%, both of them reflect that yield of the sensor reaches maximum when the thickness of diaphragm is around 27μm, which verifies the analytical results.

B1: Material, Fabrication, and Packaging (Lecture Theatre D, Academic Building)

[83] Bending Durability of Organic Thin Film Transistor and Stress Sensing using Mechanoluminecence

Hayato Izumi, Yoko Haga, Yuichi Suemastu and Shoji Kamiya, Nagoya Institute of Technology, Japan
Nobuyuki Shishido, Kitakyushu Green Electronics Research Institute, Japan

This paper aims to evaluate the breaking point of organic thin film transistor (OTFT) for reliability and mechanical durability of flexible device, and also try to observe the bending stress distribution using mechanoluminecence. OTFT device on PEN film was used as bending test specimen. IV characteristic was measured during bending, and relationship between ON-current and tensile strain was evaluated. ON-current tended to decrease with increasing tensile strain. After bending test, several cracks of organic semiconductor layer and insulator layer were observed by SEM. For easily fracture detection of flexible device, continuously observation of luminance behavior on multi layered films during bending was successful using mechanoluminence materials.

[27] Physical Characteristics and Sensual Expressions on Fabrics

Ibuki Mishima and Yutaka Nonomura, Meijo University, Japan
Masanori Muroyama, Tohoku University, Japan

Assistant robots are expected to work with humans and live in human homes, and to assist humans by means of tactile sensing technologies. The relationships between sensual expressions as the feel of touch and physical characteristics are still not established. We examined sensual strengths related to touch, and measured physical characteristics with a friction sense tester for fabrics. And we expand the measuring field and materials of the friction sense tester with a general-purpose 3-axis force sensor. The MIUs (average friction coefficient) were measured with the friction sense tester and the 3-axis force sensor. They had good correlations. The measurement system of the force sensor enables to expand measuring field and materials. On the "soft feel" fabrics, the subductions of the z-axis head were increased as increase of the sensual strengths of "soft fell". The MIUs were also increased with the fabric fuzz length. They should be physical characteristics connected with sensual expressions.

[82] Plastic Deformation Enhanced Silicon Surface by Synergistic Effect between Defect and Hydrogen

Hayato Izumi, Masaru Nakamura and Shoji Kamiya, Nagoya Institute of Technology, Japan

This paper presents the mechanical properties of silicon surface was different from bulk materials in order to promote the plastic deformation by synergy effect between hydrogen and defects. Different four types of specimens were prepared to evaluate the relationship between defects, hydrogen and combination of defects and hydrogen by nanoindentation test. Either defect or hydrogen does not have effect on indentation depth under same load level. Surface defect and hydrogen had significantly deeper indents than the other cases. In case of shallow indentation depth, change rate of plastic deformation become relatively larger than deep indentation depth. These results showed that silicon surface in the presence of defect and hydrogen was softer than silicon bulk even at room, and suggested correlation with defect accumulation of silicon fatigue fracture.

[84] *In-situ* Growth of Platinum Nanowires on Polydopamine Film for Implantable Neural Electrodes

Bowen Fu, Kai Xia, Bin Sun, Tianzhun Wu and Qi Zeng, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, China

In this paper, we reported a low-cost and facile method to deposit metal layer for implantable neural electrode array, by growing platinum (Pt) nanowires (PtNW) in situ on patterned polydopamine (PDA) film. Compared with traditional metal patterning process like sputtering/evaporation and lift-off, our proposed method has the advantages of simple process, low cost and improved adhesion between metal layer and substrate using PDA as the buffer layer. The PDA/PtNW demonstrated good biocompatibility and low square impedance down to 6±1.5 Ω/ and remained almost unchanged after the mechanical stability testing.

[99] Acceleration of Wettability Switching on TiO_2 Thin Films by Combination of UV Irradiation and DC-Bias Voltages

Taizo Kobayashi and Satoshi Konishi, Ritsumeikan University, Japan

Since surface tension becomes more dominant physical factor in microfluidic phenomenon, capillary pumping has been utilized as a passive liquid manipulation mechanism for lab-on-a-chip applications. Recently, the liquid manipulation technologies with active-driven capillary using the wettability switching materials have been reported. Among those wettability switching technologies, photoresponsive wettability switchable surface has attracted much attention in microfluidic applications in terms of unnecessity of external electrical wire connections. We have previously reported microchannels integrated with TiO_2 thin films as optically driven capillary. Widening of switching range and acceleration of switching response of photoresponsive wettability are important issues for active capillary in lab-on-a-chip applications. In our previous works, switching range of photoresponsive wettability on TiO_2 photocatalyst has been successfully widened by applying topological micro-structure to its surface. This paper reports impacts of applying DC-bias voltages on TiO_2 thin films with different crystallographic structure on the photoresponsive wettability.

[122] Preparation of Metal-Organic Frameworks and its Crystallization Mechanisms Based on Microfluidics

Xiaohong Wang, Xiuqing Gong and Jinfeng Liu, Shanghai University, China

In this report, we use the “crystal hotel” to fabricate crystal film of HKUST-1 metal organic frameworks, also known as CuBTC (Cu_3(BTC)2·nH_2O) (BTC=1,3,5-benzenetricarboxylate), and study the mechanism of its crystallization in microenvironment. As we know the driving force of crystallization of HKUST-1 is evaporation which leads the self-assemble of metal ions and organic likers. In order to fabricate the bigger crystal with uniform properties, we introduced compressed air to limits the evaporation speed in rooms which could limit the nuclear number in each room. Finally, the experiment is pretty consistent with our assumption. In addition, we observed that almost transparent needle-shaped crystals were usually formed firstly in HKUST-1 crystal growth initial process, and then the blue flake crystal was formed based on these needle-shaped crystals. Finally, these needle-shaped crystals were absolutely disappeared while the flake crystal growed with dimeter of 86μm. But this phenomenon rarely appears in bulk solution which may result from the confined environment provided by “crystal hotel”. The Raman test was consistent with the result of Prestipino et al.

C1: Physical Sensors, Micro/Nano Fluidics (Lecture Theatre E, Academic Building)

Keynote Speech: [167] On-Chip Energy Storage Based-on Advanced Micro /Nanotechnologies

Xiaohong Wang, Department of Microelectronics and Nanoelectronics, Institute of Microelectronics, Tsinghua National Laboratory for Information Science and Technology, Tsinghua University, Beijing, China

The rapid development of portable and wearable electronics has greatly increased the demand for energy storage devices with similar physical properties and integration capability. Nowadays. Li-ion batteries have been being still mainstream as their high power and voltage output. With the advantages of high charge/discharge rate, long cycle life and high energy efficiency, supercapacitors can bridge the gap between traditional capacitors and batteries, and are of the same importance as rechargeable batteries to energy storage systems. This speech will introduce the design of high-aspect-ratio 3D micro supercapacitors and Si-based batteries. Also a novel polydimethylsiloxane substrate for stretchable microsupercapacitor (MSC) arrays, which enables facile integration with other electronics will be introduced.

Biography:

Prof. Xiaohong Wang received her Ph.D. degree in Department of Precision Instruments, Tsinghua University in 1998 and received her B.S. and M.S. degrees from Southeast University in 1985 and 1991 respectively. As a visiting scholar, she did the research on the electrode materials of micro SOFC in Professor Prinz Fritz's group,Stanford University from Nov. 2005 to Oct. 2006. She also had a short visiting research experience in Hong Kong University of Science and Technology and UCLA, on micro fuel cells and nano- photodetector devices in 2001 and 2007, respectively.

She filed two international patents (1 US authorized), 26 Chinese patents (17 authorized). She was the recipient of the National Award on Technology and Invention of China, the National Patent Excellent Award of China and the Beijing Municipal Government Award on Science and Technology Advancement. She has carried out 1 Key Project of Natural Science Foundation of China, 2 General Program of the State Natural Science Foundation projects, 1 International Exchange Key Program, 2 National Basic Research Program of China (973 program), 2 National 863 Program, Tsinghua National Laboratory for Information Science and Technology Cross-discipline Foundation project, Tsinghua University Independent Scientific Research Program，State Key Laboratory of Transducer Technology Open Fund project and many other projects. She has authored or co-authored more than 80 papers.

She is a senior member of IEEE society, and served as Associate Editor of IEEE/ASME Journal of Microelectromechanical Systems and NPG Microsystems & Nanoengineering. She has served as TPC members in several international conferences, like IEEE-MEMS2009/2012~2017, Transducers2011/2013/2015/2017(the Secretary-General ofTransducers2011), IEEE-NEMS2011/2012, APCOT2012/2014, and PowerMEMS2012~2017. She was General Co-Chair of IEEE-MEMS2016, Co-Chair of International Steering Committee (ISC) for IEEE-MEMS2017, and now she is an ISC member of IEEE-MEMS conference.

[49] Oven Controlled Low Consumption Pressure Sensor

Zhenyu Liu, Lidong Du and Zhan Zhao, State Key laboratory of Transducer Technology, Institute of Electronics, Chinese Academy of Sciences, Beijing, China
Xianghua Niu, Beijing Institute of Applied Meteorology, China

In this paper, in order to reduce the heating power and the size of the system, a chip level temperature control structure is designed. The heating resistance makes the MEMS chip working at a constant temperature. The thermal control accuracy is up to 0.05℃. Under the condition of environmental temperature from -50℃ to 50℃, system achieved a maximum absolute error within ±0.5 hPa after pressure calibration. Based on the simulation results of COMSOL software, achieving a low consumption and cost-effective pressure sensor.

[124] Reduction in the Effect of the Timing Jitter in Piezoelectric Accelerometer System by Oversampling Technique

Ranjith HG, Jhe-Ru Guo, Mingyi Lin and Sheng-Shian Li, National Tsing Hua University, Taiwan
Joseph Tseng and Eric Wu, GlobalMEMS.co.Ltd, Taiwan

The performance of high data rate accelerometer systems are often limited by system timing jitter. Jitter causes mismatch in the measurement of an actual value by an inaccurate sampling timing. Oversampling technique results in perfect reconstruction of bandwidth-limited signals by improving Signal-to-Noise Ratio (SNR) while avoiding aliasing as well

as phase distortion by relaxing the performance of anti-aliasing filters. In this paper we demonstrate that oversampling technique can be used to reduce the side-band noise caused by timing jitter which leads to 3 dB reduction in jitter noise power for every 2x analog-to-digital converters (ADCs) sampling rate in a piezoelectric accelerometer system.

[117] Tri-axis Fully-differential MEMS Accelerometer with Segmented Capacitance Detection

Shota Otobe, Daiseke Yamane, Hioroyuki Ito, Shiro Dosho, Noboru Ishihara, Katsuyuki Machida and Kazuya Masu, Tokyo Institute of Technology, Japan
Toshifumi Konishi, Tokyo Institute of Technology, NTT Advanced Technology Corporation, Japan
Teruaki Safu, NTT Advanced Technology Corporation, Japan

In this work, we propose a tri-axis fully-differential electrodes structure MEMS accelerometer with SCD for sub-1mG resolution. The MEMS device is fabricated by the multi-layer metal technology. The C-G measurement results show 3-axis operation of the device in the design sensing range. Evaluation results indicate the actual BN could be below 300 nG/√Hz. Those results confirm that the proposed device structure would be useful for high-resolution MEMS accelerometers.

[46] Breathing Monitoring by Energy-Less Respiration Sensor Based on Thermo-Sensitive Film

Yoshihumi Maeda, Yoshihiro Hasegawa, Kazuhiro Taniguchi and Mitsuhiro Shikida, Hiroshima City University, Japan
Miyoko Matsushima, Tsutomu Kawabe, Nagoya University, Japan

To realize the easy-to-use approach in the breathing flow monitoring, the energy-less respiration sensor based on thermo-sensitive film was proposed. Thermo-sensitive film composed of a thermo-sensitive ink and a base film was wrapped over the hole partially formed on the tube for monitoring the breathing. The response time reduced with the decrease of the base film thickness because of the thermal capacity reduction, and it became a constant below the thickness of 5.0 μm. The obtained minimum response time was 373 ms in the case of the ink thickness of 6.8 μm. The color at the hole area was successfully changed to be transparent according to the temperature change at the airflow.

12:00 - 14:00

Lunch (G/F Chinese Restaurant, HKUST)

14:00 - 15:00

Poster Session I (Outside Lecture Theatre J)

[13] A Reactor Scale Model Linked to 3-D Profile Simulator for the Simulation of DRIE Process

Zong-Ze Wu, Xiao-He Tang, Zai-Fa Zhou, Jia-Cheng Yu, Ze-Yu Tang and Qing-An Huang, Southeast University, China

This paper presents three-dimensional simulations of deep reactive ion etching process. In conventional method, the arrival angle distributions of ions and neutral particles are assumed to be Gaussian-like and Cosine-like for the simulation. To improve the application value and simulation accuracy, a plasma reactor scale model based on Particle-In-Cell method with Monte Carlo collisions is designed to obtain the particle energy and arrival angle distributions correspond to the actual situation. Finally, the topography simulation is described by narrow band level set method. The simulation profiles and corresponding experiments are found to be agreement, which verifies the effectiveness of our approaches.

[24] Mechanical Design of a Spin-MEMS Microphone with a Series of Spintronic Strain-Gauge Sensors

Kei Masunishi, Michiko Hara, Yoshihiko Fuji, Yoshihiro Higashi, Akiko Yuzawa, Kazuaki Okamoto, Shotaro Baba, Shiori Kaji, Tomohiko Nagata and Tomio Ono, Toshiba Corporation, Japan

This paper presents the mechanical design of a novel Spintronic MEMS (Spin-MEMS) microphone that has a series of spintronic strain-gauge sensors (Spin-SGSs) with a high gauge factor. The series of Spin-SGSs is integrated onto a bulk micromachined diaphragm. We compare a circular diaphragm with a rectangular diaphragm of the same area by ANSYS simulation. As a result of applying sound pressure, the rectangular diaphragm generated a larger uniaxial strain at a constant angle in the diaphragm over a wider range. By employing a design that integrates Spin-SGSs arrays along the long edge of the rectangular diaphragm, we obtained a Spin-MEMS microphone with a signal-to-noise ratio (SNR) of 49 dBA and a mechanical resonance frequency of 72 kHz.

[89] CMOS-MEMS Multispectral Infrared Emitter Arrays with Metamaterial Absorbers for Gas Sensors

Zhengxi Cheng and Bin Ma, Shanghai Institute of Technical Physics, Chinese Academy of Sciences, China
Hiroshi Toshiyoshi, Research Center for Advanced Science and Technology, The University of Tokyo, Japan

Following our previous work, multispectral infrared (IR) emitter arrays are integrated with polysilicon metamaterial absorbers for gas sensors by using CSMC (Central Semiconductor Manufacturing Corporation) 0.35 μm 2P3M CMOS process to develop frequency selective emissivity of CMOS-MEMS infrared emitters to match the absorption spectra of certain gases. Four types of micro hot plates were integrated with tri-layer polysilicon1 / BPSG / polysilicon2 metamaterial absorbers. The thermal simulation results showed that the hot plates could be modulated at as fast as 150 Hz. The absorption simulation results also showed that frequency selective emission was achieved as several absorption peaks appeared in 2~8 μm waveband and shifted according to the width of periodic polysilicon2 squares.

[28] Development of PSPICE Modeling for MEMS Thermal Wind Sensors

Shang Wang, MIng Qin and Qing-an Huang, Key Laboratory of MEMS of Ministry of Education, Southeast University, China

An approach to modeling wind sensors based on the lumped parameter circuit cell in PSPICE is presented in this paper. Three different models of thermal wind sensors designed on the silicon substrate are simulated and compared using PSPICE model for optimizing. The simulations of wind sensors working in CP (Constant Power) mode are achieved and both the steady-state and the dynamic characteristics of the wind sensor can be obtained through PSPICE simulation. This method provides an efficient simulation for complex MEMS devices such as wind sensors, and is suitable for the optimization of the sensor structures.

[37] Micro Column Design and Simulation of Columnar Preconcentrator for Gas Enrichment

Cheng Jie, Li Mingxiao and Huang Chengjun, Institute of Microelectronics of Chinese Academy of Sciences, China

Microfabricated columnar preconcentrator (μCPC) with circular and triangular silicon-based micro-column arrays were designed. FEM (Finite Element Modeling) analysis method was used to simulate two kinds of clumnar preconcentrators from the factors of arrangement and spacing of micro-column arrays. Based on the obtained coefficient of preconcentration effect, an optimal structure and dimension of clumnar peconcentrator for gas enrichment is suggested.

[77] Investigation of Air Damping Effect in a Silicon Sandwich Capacitive Accelerometer

Bin Tang and Yuming Mo, Institute of Electronic Engineering, China Academy of Engineering Physics, China

In this study, the air damping ratios of an unsealed chip of a capacitive accelerometer subjected to different pressures were measured by a special designed circuit in a static state test. Then, finite element method based on energy balance method and transient blade row model is used to simulate in ANSYS/CFX with a new formula of effective viscosity of the air derived from simulation and validated by experimental results. The numerical results are in good agreement with the experimental results. With the same method and the new formula of effective viscosity, the air damping ratio of a new chip without trapezoid grooves is simulated as well. The comparison of the two kind of chips shows that the air damping ratio decreases 63.4% after four trapezoid grooves were engrooved on the top and bottom electrode wafers. As a result, engrooving on the top and bottom electrode wafers provides a new way to reduce air damping effect.

[138] Tensile Testing Silicon Device in Transmission Electron Microscope for High-Magnification *in situ* Observation

Kohei Okada and Taeko Ando, Ritsumeikan University, Japan
Masahiro Nakajima, Nagoya University, Japan

Scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM) are powerful tools to observe deformed or fractured specimen. In this study, we have developed a tensile testing system conducting in TEM. The tensile testing system consists of testing device fabricated by micromachining technologies and actuator system in TEM holder.

[87] Parametric Analysis of Comb-Drive Resonators with Considering Process Deviations

Lili Gao, Zai-Fa Zhou and Qing-An Huang, Southeast University, China

Manufacturing process variations are always involved in the fabrication of micro-electro-mechanical systems (MEMS) devices. There exist mismatches between original designs and final products. This paper intends to explore the effect of process deviations on the resonance frequency of comb-drive resonators. Revised models are built based on topographical changes, which are constituted by process deviations in the Bosch process. The revised version of resonant frequency for the comb-drive resonator can be formulated. Comparisons have been made between modified models and ANSYS when considering process deviations. The errors behave smoothly around 2.03% if fix the trapezoid angle and 4.63% if fix the

number of ripples. Therefore, based on these revised models, an ideal SPICE equivalent circuit model of the comb-drive resonator can be conducted. It has succeeded in modified SPICE equivalent circuit models and it turns out to be good agreement between the results of model calculation and SPICE simulations. The error distributes nearly uniformly with the mean value about 11.7%. A self-analysis tool for MEMS devices has been achieved, where the software can achieve automatic optimizations when the process deviations are inclusively considered.

[64] Immobilization of Pt Nanoparticles on Hydrolyzed Polyacrylonitrile-Based Nanofiber Paper

Soon Yeol Kwon, Dong Gun Jung, Young Chan Choi, Jun Yeop Lee, Jae Yong Lee and Seong Ho Kong, Kyungpook National University, South Korea

The electrochemical activity of catalysts strongly relies on the uniform distribution of monodispersed Pt nanoparticles without being aggregated. Here, we propose a new hydrolysis-assisted smearing method for Pt loading on a free-standing paper-type electrode, polyacrylonitrile (PAN)-based nanofiber paper that acts as a Pt support. The hydrolysis increased the number of active nucleation sites for Pt adsorption on the PAN nanofibers by three times and as a consequence, their wettability was significantly enhanced.

[50] Investigation of the Relationship between the Microscopic Structure of La_2O_3 and CO_2 Response in La_2O_3/SnO_2 Stacked Devices

Ken Ono, Kyosuke Matsuda, Toyohashi University of Technology, Japan
Tatsuya Iwata, Kazuhiro Takahashi and Kazuaki Sawada, Toyohashi University of Technology, Electronics-Inspired Interdisciplinary Research Institute (EIIRIS), Japan

In this study, the CO_2 sensors based on La_2O_3/SnO_2 stacked structures were fabricated with controlling the of deposition condition of the La_2O_3-sensitization layer. CO_2 response of the devices changed with the rotational speed for spin-coating of the La_2O_3. From SEM and AES analyses, it was revealed that the La_2O_3 has porous structure and it was found that CO_2 response is linked to the La_2O_3 structure. Furthermore, it was suggested that the La_2O_3 structure is controllable by the spin-coating velocity.

[56] Thermally Assisted Reactive-Ion Etching Technique Using Detachable Self-Heated Stage

Gang Han, Yuka Kiryu, Daiki Ohkawa, Junichi Imai, Masayuki Sohgawa and Takashi Abe, Niigata University, Japan

In this study, a thermally assisted reactive-ion etching (TRIE) technique using a detachable self-heated stage as the etching stage in a desktop type TRIE etcher. The detachable stage was designed based on simulation results and its heating characteristics on application of RF power were evaluated. Results indicated that the temperature of the etching stage increased rapidly to 289 °C, but maintained a distribution of ≤3 °C. Its applications to minor metals of Ti, Ti-6Al-4V and Ti-3Al-2.5V were investigated. The resultant etches rates of Ti, Ti-6Al-4V and Ti-3Al-2.5V substantially increased with the use of the detachable self-heated stage. The detachable stage is suitable for wafer holding.

[92] Superhydrophobic Polymer with Hierarchical Porous Structure as QCM Sensing Material for Toluene/Water Selectively Detection

Jiaqiang Xu and Luyu Wang, Shanghai University, China

In this work, a superhydrophobic polymer with hierarchical porous structure is firstly used as novel Quartz crystal microbalance (QCM) sensing material for toluene detection. Superhydrophobic property, porous structure, and rich aromatic ring composition of the polymer make its stable toluene/water selectively detection performance. The sensor exhibits good sensitivity for toluene detection. The response remains stable at different ambient humidity. The detection limit reaches down to 1 ppm, and the selectivity is satisfactory to twelve kinds of common interfering gases. This superhydrophobic porous polymer functionalized QCM sensor may be a potential candidate for the future application of toluene detection.

[22] Comparison of Thermally and E-beam Evaporated Cr Spindt Tips

Peng Wang, Aron Michael and Chee Yee Kwok, University of New South Wales, Australia

In this paper, we report that thermal evaporation method is better suited to form sharper and denser Cr Spindt nano-tips than e-beam evaporation. Ultra-sharp Cr Spindt tips with 2.5nm tip radius are demonstrated by thermal evaporation with significantly better uniformity and yield than e-beam evaporation.

[32] Precise Identification of Crystallographic Directions on Si{111} Surface Using Self-Aligned Pre-Etched Patterns

Avvaru Venkata Narasimha Rao, Veerla Swarnalatha, Ashok Kumar Pandey and Prem Pal, Indian Institute of Technology Hyderabad, India

First time a simple and measurement free technique has been investigated for the precise identification of <110> crystallographic directions on Si{111} wafer surface. In this method, a set of circular shape mask patterns close to wafer edge are etched for the identification of <110> directions. On wet anisotropic etching these patterns transform to hexagonal shapes. The notches of hexagonal patterns align precisely along a straight line only when they lie on exact <110> direction. The self-aligned notches can easily be identified by visual inspection using an optical microscope. The major advantages of this technique are simple, precise, self-aligning, and pre-etched pattern occupies very less place near wafer edge.

[148] ZnO Nanostructures in Microsystem for Volatile Organic Compounds (VOCs) Sensing

Martine Capochichi-Gnambodoe, Marie Le Pivert, Mazen Erfan, Yamina G. Habba and Yamin Leprince-Wang, Université Paris-Est, ESYCOM, UPEM – 77420 Champs sur Marne, France
Alaa Fathy, Imadeddine Azzouz, Frédéric Marty, Tarik Bourouina, Université Paris-Est, ESYCOM, ESIEE Paris – 93162 Noisy-le-Grand, France
Yasser M. Sabry, Faculty of Engineering, Ain Shams University, 1 El-Sarayat St., Abbassia, Cairo, Egypt

In this work, firstly, we will show the gas sensing performance for Acetone (one of toxic gas in smoking) from different nanostructures of ZnO nanowires (NWs) in order to prove the important role of the surface /volume ratio. In the second part, we will show a microfluidic system for VOCs depollution by integrated ZnO nanostructure under photocatalysis effect.

[4] New Microfluidic Reactors for Photocatalytic Water Purification

Pui Hong Yeung and Xuming Zhang, The Hong Kong Polytechnic University, Hong Kong

Some industrial cities are facing water contamination because of improper handling of organic sewage. This would produce a huge amount of polluted water, threatening the marine environment seriously. Fortunately, semiconductor has been extensively utilized in the field of organic waste water purification. This work aims to investigate the properties of nanomaterials with the aid of solar reactor, finding the degradation efficiency of organic sewage. For simplicity, we use TiO_2 and TiO_2 doped with Au as the photocatalyst to degrade methylene blue (MB).

[23] Integration of Temperature Sensor onto MEMS Flow Sensor for Detecting Both Breathing and Body Temperature Information

Tomohiro Fujinori, Yoshihiro Hasegawa and Mitsuhiro Shikida, Hiroshima City University, Japan
Miyoko Matsushima and Tsutomu Kawabe, Nagoya University, Japan

Temperature sensor was integrated onto the MEMS flow sensor for detecting both breathing and body temperature signals from the airflow at the mouth. Both sensors were designed and fabricated by MEMS technologies for applying it to an animal experiment. The temperature sensor properties were investigated. The temperature at the sensor element increased with the increase of the applied electrical power. Conversely, it became almost a constant showing the environmental temperature in the case of less than 0.5 mW. Thus, we concluded the sensor should be operated by the value of less than 0.5-mW-power to detect air temperature accuracy. Finally, we confirmed it can detect the air temperature with the accuracy of less than 1.0 deg-C under different temperature's airflow conditions.

[40] Thermal Wind Sensor Based on Self-Heated Thermistors in Wheatstone Bridge Read-Out

Shi-Xuan Gao, Qing-An Huang and Ming Qin, Southeast University, China

In this paper, a two-dimension (2-D) self-heated MEMS wind sensor is proposed. Without central heating elements, eight thermistors are arranged in four directions symmetrically and each four thermistors in a line make up a Wheatstone bridges. With the constant current supply, two voltages including terminal voltage and the bridge-unbalanced voltage are measured. Therefore, the wind speed is extracted based on thermal loss principle, while the direction is obtained by calorimetric principle. Experiments results demonstrate that the sensor can detect the wind speed from 0.8m/s to 41.1m/s and the wind direction from 0° to 360°. Moreover, after calibration, the speed deviation is less than 2m/s and the direction error is no more than 6°.

[131] A Reconfigurable Screw-Connected Modular Microfluidic System Using 3D Printing

Xiaojun Chen and Daoheng Sun, Xiamen University, China

In this work, we propose an advanced reconfigurable modular microfluidic system employing 3D printed modules with assorted channel geometries that can be easily assembled to create complex, modular, and reversible in three dimensions.

The microfluidic system consists of two basic functional components: a screw fastener and an assembly module. Each assembly module has an own unique function that are connected together and bonded to form a multi-function microfluidic system using screw interconnects. Furthermore, we demonstrate screw interconnects are inserted into each microfluidic module's threaded ports to eliminate fluid leakage within the system and enable high pressure actuation, which offer a promising means to realize a larger integrated microfluidic system capable of sophisticated functionalities.

[139] Improvement of QTED by Double Spoke Structure in Disk Resonator Gyroscope

Wenyan Hu, Bo Fan, Fen Zheng, Dacheng Xu and Shuwen Guo, Soochow University, China

The purpose of this work is to present a new method to optimize the structure of Disk Resonator Gyroscope (DRG) limited by thermo-elastic damping (TED). DRG has been extensively investigated for its advantages of high precision, small volume, light weight, low power consumption, and ability to be mass fabricated. While previous publications have been reported to reduce TED by modifying ring geometry and changing length of spoke. In this work, we propose a double spoke structure to achieve higher quality of TED.

[111] A Wireless Flexible Pressure Sensor Based on Graphene/PDMS Sponge

Hairong Kou and Qiulin Tan, North University of China, China

A wireless flexible pressure sensor based on graphene/PDMS sponge has been reported for remote tactile-sensing applications, which is fabricated by folding the PDMS substrate with the cavity and using the highly sensitive graphene/PDMS sponge as dielectric layer and the wrinkled continuous Ag pattern as the antenna and electrode. Graphene/PDMS sponge performs high sensitivity as a capacitance sensor, which exhibits outstanding stability and durability, low detection limit, rapid response time, and can be utilized to detect subtle pressure. The capacitance sensor and a reading antenna formed a LC test circuit, which can transform the capacitance variation of graphene/PDMS sponge under external applied pressure into the corresponding variations of its resonance frequency. The sensor can be sensitive to monitor personal health and map human-skin signals, which was potential to be used for highly sensitive wireless detection in the wide range of wearable electronic, bionic-electronic skins and intelligent robot.

15:00 - 16:30

A2: Theory, Design, Analysis, and Simulation (Lecture Theatre B, Academic Building)

Keynote Speech: [165] Tailoring Electromagnetic Waves with MEMS and Metamaterials

Xin Zhang, Boston University, United States

In a quickly advancing world, scientific concepts and research ideas that once only existed in laboratories are being transformed into functional materials and devices. From an engineering perspective, Zhang's laboratory has concentrated on the design, fabrication, characterization, and testing of microelectromechanical systems (MEMS or microsystems) for the past decade and, more importantly, has been dedicated to tailoring and transforming these systems for use in fundamental research and to fulfill societal needs. In the area of advanced materials, Zhang has applied MEMS techniques to develop metamaterials--arrays of engineered structures that act like artificial atoms and exhibit unusual properties such as negative refractive indices. She has focused on creating metamaterials in the terahertz range (wavelengths between optical and microwave frequencies) that may ultimately be used for imaging and chemical detection. In this talk, Zhang will present her current basic research on MEMS and metamaterials, from the fundamental physics to their potential applications.

Biography:

Xin Zhang received her Ph.D. in Mechanical Engineering from the Hong Kong University of Science and Technology (HKUST). She was a Postdoctoral Researcher and then a Research Scientist with the Massachusetts Institute of Technology (MIT). She then joined Boston University as a Faculty Member, where she is currently a Professor of Mechanical Engineering, Electrical & Computer Engineering, Biomedical Engineering, Materials Science & Engineering, and the Photonics Center. Dr. Zhang is an Elected Fellow of AAAS, ASME, IEEE and OSA, and became both a US and EU-US National Academy of Engineering Invitee (ages: 30-45). In 2009, she was named the inaugural Distinguished Faculty Fellow, an appointment given to tenured engineering faculty at Boston University who is on a clear trajectory toward an exemplary career in all dimensions of science and engineering. In 2016, she was selected as the recipient of the IEEE Sensors Council Technical Achievement Award (advanced career) for distinguished contributions to

micro/nanoelectromechanical systems. In 2018, she was selected as the recipient of the Charles DeLisi Award and Lecture, an honor recognizing College of Engineering faculty at Boston University who has made outstanding contributions to engineering and society.

[100] Oven-Controlled N++ [100] Length-Extensional Mode Silicon Resonator with Electrical Isolation Anchors for Sub-Ppm Temperature Stability

Binbin Pei, Peng Zhong, Ke Sun, Heng Yang and Xinxin Li, State Key Laboratory of Transducer Technology, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China

This paper reports a frequency stability of ±300 ppb over the temperature range of -35 ºC to 85 ºC with the uniformly-heated oven-controlled N++ [100] length extensional (LE) mode silicon resonator suspended by two heating beams. In order to achieve uniformly-heated micro-oven and keep the sensitivity stable, electrical isolation anchors are designed to separate the heating voltage and the excitation voltage of the Wheatstone half-bridge. In addition, it is demonstrated that the control algorithm based on the thermoresistor on substrate and two-points linear fitting method for heating power versus chip temperature is sufficiently accurate to achieve high frequency stability over the industrial temperature range.

[118] Theoretical and Experimental Study of Peclet Number Effect on the Linearity of Thermoresistive Micro Calorimetric Flow Sensors

Beiqi Lijin, Ruijin Wang, Hangzhou Dianzi University, China
Wei Xu, Maria Paszkiewicz, Zhen Li and Yi-Kuen Lee, Hong Kong University of Science and Technology, Hong Kong

In this paper, we conduct an experimental and numerical study of the Peclet number effect on the linearity of Thermoresistive Micro calorimetric flow sensors (TMCF sensors) and reveal the effect of the thermal boundary layer on the output ΔT of TMCF through 2D CFD simulations. The results show that thinner thermal boundary layer suppresses the thermal diffusion and eventually causes a nonlinear response. In addition, a Peclet number Pe based criterion is proposed to determine the linear range of TMCF sensors. This criterion can be used for the design optimization of the new type of low-cost TMCF sensors for smart buildings and microfluidics.

[36] A Faster-Response Ruphen-Based Temperature Sensor for Nondestructive Testing of the Temperature of Cell

Miaomiao Cheng and Min Wang, Southern University of Science and Technology, China

The simulation results have proved the feasibility of using infrared radiation to realize the nondestructive testing of cell's temperature that accomplishes high accuracy at micro - nanometer level and eliminates the damage of UV light to cellular biology. In the next step, the accuracy of the simulation results will be verified by experiments so as to further modify the data to ensure the more precise of the sensor.

[129] Comprehensive Correction of Errors in Inertial Sensor Based Pedestrian Navigation System with One Kalman Filter

Yiming Ding, Jiajun Wang and Dacheng Xu, The School of Electronic and Information Engineering, Soochow University, China

This paper presents a pedestrian navigation system based on inertial sensors. This system utilizes the acceleration, angular rate and magnetic sensors. Different from most existing systems of this type which either only account for the zero state constraint or in very few cases consider sequentially such a constraint and the attitude error according to the magnetic sensor readings, we propose to integrate the observations of the velocity error, the attitude error and the position drift in the static phase in a single Kalman filter to compensate both the velocity and the orientation errors simultaneously. In order to improve the confidential level of the observed attitude error, one magnetic field disturbance detection/minimization and one straight line detection procedure are incorporated in the Kalman filtering process. Extensive experimental results in different environments show that this system outperforms existing inertial sensor based pedestrian navigation systems with reported precisions during whole period of experiment even under severe magnetic field disturbance.

[31] Frequency Response Characterization of Spin-MEMS Microphone

Akiko Yuzawa, Kenji Otsu, Tomio Ono, Shotaro Baba, Kei Masunishi, Yoshihiro Higashi, Shiori Kaji, Kazuaki Okamoto, Yoshihiko Fuji and Michiko Hara, Toshiba Corporation, Japan

The method for characterizing a frequency response of a diaphragm is reported. Circular and rectangular diaphragms were fabricated. The fabricated diaphragms were bonded to piezoelectric actuator and excited. The frequency resoponses of different residual stressed diaphragms were measured by using a LDV and compared with theoretical results.

B2: Material, Fabrication, and Packaging (Lecture Theatre D, Academic Building)

[94] Low-Temperature Alkali Metal Production Utilizing Scalloped Silicon Grooves for Microfabricated Alkali Vapor Cells

Yoshikazu Hirai, Katsuo Nakamura, Yuichi Kimoto, Toshiyuki Tsuchiya and Osamu Tabata, Kyoto University, Japan

We report a low-temperature process of microfabricated alkali vapor cells that is used for MEMS atomic clocks, utilizing Si groove with multiple re-entrant structures (i.e. scalloped patterns) to produce Cs. In order to enhance Cs production, process parameters of DRIE are adjusted to fabricating micro-size scalloped Si patterns. Sufficient amount of atomic Cs has been successfully observed in the MEMS cells by heating at about 315 °C, and we confirmed applicability in high quality of MEMS atomic clocks.

[74] Metal Plastic Forming by Mechanical Si Structure Indentation for Producing Metal Mold Master Applied for High Density Needle Fabrication

Yoshihiro Hasegawa, Yuka Yasuda, Kazuhiro Taniguchi and Mitsuhiro Shikida, Hiroshima City University, Japan

Metal plastic forming process by the micro-machined Si structures was newly proposed to produce the micro-sized metal mold mater, for the first time. A Si micro-needle structure produced by a photolithography and an anisotropic wet etching was applied as an indenter, and it was mechanically pressed into a metal substrate as a metal plastic forming process for producing the micro-sized holes in the metal mold master. The proposed process enables us to produce the various-sized concaved micro-structures onto the metal substrate in arbitrary-position by controlling the indentation process. It was finally applied to produce a high density micro-needle array composed of different needle height for the trans-dermal drug-delivery systems (DDS), as the example of its actual application.

[132] Self-Healing Coating for Glass to Stop Crack Propagation

Jongkyeong Lim, Dong-Joon Won and Joonwon Kim, Pohang University of Science and Technology (POSTECH), South Korea
Taedoo Choung, Samsung Electronics, South Korea

A transparent self-healing coating incorporating chambers and capsules capable of preventing the propagation of cracks in glass is presented. The main features of the self-healing coating include that (i) the refractive index of the healing-agent-containing chambers closely matches that of the matrix, and (ii) the minimum possible concentration of capsules is selected, while still being adequate to initiate the polymerization of the healing agent after its cracking-induced release. These unique features simultaneously satisfy the requirements of high transmittance (~90% in the visible region) and the ability to heal random and large-area cracks in glass-coating materials. The eco-friendly photopolymerizable hydrogel precursor used as the healing agent can easily seep into the crack sites by capillary action, given its low viscosity and excellent wetting of the glass. The hydrogel could be spatiotemporally polymerized by UV light (365 nm). Finally, the photopolymerized hydrogel could stop crack propagation because of its high mechanical strength and good adhesion to glass. Remarkably, the healed glass could withstand a force approximately four times greater than what can be withstood by the unhealed glass, after cracking.

[140] Fabrication of Hollow Nanoneedle Array by i-line Stepper: Toward Massively Parallel Intracellular Delivery

Moeto Nagai, Tokuma Miyamoto and Takayuki Shibata, Toyohashi University of Technology, Japan

Intracellular delivery with a nanoneedle is a versatile method of injecting various types of materials into a single cell. This study aims to enable the mass production of an array of hollow nanoneedles based on an i-line Stepper and silicon-on-insulator (SOI) wafer. We report the establishment of a process for controlling needle diameter, height, and pitch. They were achieved by separately fabricating needle tips on the front side and connecting channels on the back side. Electrokinetic ejection approach was applied to transport fluorescent DNA through a fabricated nanoneedle array.

[116] Control of In-Plane and Out-of-Plane Stress in MEMS Devices Built from Porous Silicon

Yaman Afandi, Xiao Sun, Gia Parish and Adrian Keating, The University of Western Australia, Australia

We propose and investigate the ability to control both the in-plane and out-of-plane stress in porous MEMS devices, offering the opportunity to optimize device performance and yield. Our studies show that a combination of current control during anodization and extended exposure to a moderate level of optical power can provide the uniquely capability to control the in-plane and lateral stress within porous silicon-based MEMS devices, providing a pathway to address the high sensitivity these films have to stress.

[47] Fabrication of Microchannel with Various Cross-Sectional Shapes

Joo Yong Kwon, Dong-Ki Lee and Young Hak Cho, Seoul Natl. Univ. of Sci. & Tech., South Korea
Jaewon Park, Southern Univ. of Sci. & Tech., China
Chiwan Koo, Hanbat National University, South Korea

In this study, we propose a novel and simple fabrication method of microchannel with various cross-sectional shapes such as parallelogram, rhombus, trapezoid, pentagon and hexagon. They were fabricated using anisotropic wet etching of Si wafer and self-alignment between Si structure and PDMS mold. (100) single crystal Si wafer was used to fabricate Si microchannel and the master for PDMS mold using photolithography and anisotropic KOH etching. The Si structure for microchannel and master were formed on same Si wafer by KOH etching, and PDMS mold was made from Si master. Finally, microchannels with various cross- sectional shapes could be easily formed through self-alignment between Si channel and PDMS mold. They were permanently bonded using O2 plasma treatment. It is expected that the fabricated microchannel with various cross-sectional shapes can be used in wide fields such as heat transfer, microscale transport of particle and fluid, particle separation based on inertial focusing and so on.

16:30 - 16:45

Coffee Break (Hallway outside Lecture Theatre B)

16:45 - 18:00

B3: Material, Fabrication, and Packaging (Lecture Theatre B, Academic Building)

[128] Isolation Characteristics of In-Plane Feedthrough across Au/SiOx Seal Ring for Wafer-Level RF MEMS Packaging

Masaaki Moriyama, Yukio Suzuki, Kentaro Totsu, Hideki Hirano and Shuji Tanaka, Micro System Integration Center (μSIC), Tohoku University, Japan

WLP (wafer-level packaging) with in-plane RF feedthrough based on Au-Au thermocompression bonding was developed. The impact of WLP on isolation is 0.6 dB at 10 GHz, and the best measured isolation is 29 dB at 10 GHz. Long-term hermetic test was done for 24 months, and no pressure change of sealed cavities was observed. This WLP technology is ready for RF MEMS switches.

[95] Micromachined Substrate Integrated Waveguide Using Glass Substrate with Metal-Coated Through Glass Silicon Vias

Ik-Jae Hyeon and Chang-Wook Baek, Chung-Ang University, South Korea

A substrate integrated waveguide (SIW) has been demonstrated using micromachined metal-coated through-glass silicon vias (TGSVs). Two-step deep reactive ion etching of silicon vias and selective tungsten coating onto them using a shadow mask are combined with glass reflow technique to realize a glass substrate with metal-coated TGSVs for millimeter-wave applications. The proposed metal-coated TGSV structures can effectively replace the metal vias in conventional through glass via (TGV) substrates, in which an additional individual glass machining process to form holes in the glass substrate as well as a time-consuming via metallization process are required. The glass substrate with metal-coated TGSVs is applied to fabricate the SIW with a cut-off frequency of 20 GHz as a test vehicle. The fabricated SIW shows an average insertion loss of 0.69 +/- 0.18 dB and a return loss better than 10 dB in the frequency range from 20 to 45 GHz.

[136] Development of Micromachined Pick-up Interface Chip for Micro Device Assembly

Yu-Chen Wu, Yen-Po Chen, Chih-Hsiang Yeh, Ping-Hsiu Hong and Weileun Fang, Dept. of Power Mech. Eng., National Tsing Hua University, Taiwan

This study designs and implements a micromachined pick-up interface chip in order to achieve array level vacuum pick and place process for micro-scale objects. As in Fig.1, the presented chip acts as an interface between the vacuum system and the micro objects. To prevent the damaged of the interface chip and the thin micro objects, the proposed design leverages the MEMS technology to provide the following merits: (1) supporting structure is available on the pick-up tip to prevent the damage of thin micro objects during vacuum, (2) pillar-supports are available at the backside of the interface

chip to prevent it from bending and damage. To prove the concept, the interface device is fabricated and the vacuum pick-up test on thin chip array is demonstrated.

[30] Tensile Test of Bonded Substrates Using Adhesive Resin for a Microfluidic Device Fabrication

Daisuke Nishikori, Masahiro Kondo and Sang-Seok Lee, Tottori University, Japan

Previously, we proposed a microfluidic device fabrication method using polyimide resin as a structure and adhesive material, which was considered as a new bonding method to replace anodic bonding. However, the bonding strength when the polyimide resin was used as an adhesive was not investigated. Here, to clarify the bonding strength, we performed uniaxial tensile test. As a result, we confirmed that the Si and glass substrate bonding case showed the strongest bonding strength of 1.63 kN/mm^2 when the bonding temperature was 240°C. We consider that the bonding strength is sufficient if the bonding temperature is higher than 180°C.

[93] Bonding of High Performance Cyclic Block Copolymer (CBC) for Microfluidic Applications

Chia-Wen Tsao, Chia-Yi Yen and Wan-Ci Syu, National Central University, Taiwan
Moh-Ching Chang and Zong-Fu Shih, USI Corporation, Taiwan

The cyclic block copolymer (CBC) is a new class of thermoplastic with excellent optical property, low water absorption, good chemical resistant and low density. It is also suitable for high throughput injection molding, injection blow molding, and embossing fabrication process. In polymer microfluidics fabrication, post-end bonding and sealing is a critical step in success polymer microfluidics fabrication. To verify the CBCs in the microchannel sealing/bonding, polymer microfluidics bonding techniques in two grades of cyclic block copolymers (CBC010 & CBC034) were evaluated in this conference presentation. Cyclic olefin copolymers (COC) and cyclic olefin polymers (COP) were used as microchannel bonding control/comparison groups since they have been commonly used as high-performance thermoplastics in polymer microfluidics applications. Thermal bonding, dry adhesive film bonding, and UV/ozone surface modification are investigated in this study.

Industry Session (Lecture Theatre D, Academic Building)

Keynote speech: Integration and Development of Disruptive Materials in a Manufacturing Fab

Wilbur Catabay, TSI Semiconductor, United States

Over the past few years, there has been declining capability of global domestic fabrication providing internal research and development for new materials and architectures. Most of the research and development is taking place at Universities or consortia's but have limitations to manufacturing and one of a kind process equipment.

This leaves a void for Integrated Device Manufacturers, small to mid-size companies, and more importantly incubation start-up companies with innovative technologies targeting today's "Smart Markets". IDM's and Entrepreneurs with new, smart architectures with novel disruptive materials are usually not accepted by the more mainstream foundry's, leaving them with precious few places to fabricate their technologies with secure IP protection and more importantly IP retention.

TSI Semiconductors will give an overview of how to close the gap to enable these disruptive technologies by way of novel materials and integration using CMOS platforms in a high-volume manufacturing fab.

Biography:

Wilbur Catabay is a veteran of the semiconductor industry with more than 25 years of experience. Recently, Mr. Catabay was VP of Technology at SVTC Technologies and President of Silicon Integrated Solutions, Inc., who provided Engineering Services for Device and Process Integration. He also was Senior Director for LSI Logic's Foundry Engineering & Integration organization and Director of the Advanced Process Module Development in the R&D organization. He was responsible for evaluating and developing advanced material research for CMOS transistors and advanced metal interconnect technology.

Mr. Catabay also worked with design and manufacturing organizations as the focal point for implementation of new process module technology from 130nm to 45nm CMOS technology nodes. In 1991, he was an assignee of the technical staff at SEMATECH. Mr. Catabay has submitted more than 100 invention disclosures and has been awarded more than 65 patents with patents pending during his tenure with LSI Logic and SVTC Technologies. He has published more than

50 technical articles in professional journals and presented at various technical conferences. In addition, he was the Patent Liaison and Inventor of the year at LSI Logic and currently serves as a board member/technical advisor for several technology firms. He attended San Jose State University in Industrial Technology with Business Management.

Challenges and Prospects of Phase Change Heat-Transfer Device

Andy Chi-Te Chin, Wuhan University of Technology, China

Today's electronic devices are becoming thinner, lighter, and shorter. Therefore, the internal design must be very compact, requiring higher power to improve performance, resulting in greater thermal load. When operating under high temperature environment, its efficiency and service life will decrease with the use of time. Electronic devices that operate at safe operating temperatures can save energy and cause less harm to the environment. However, using only metal-type heat sinks is not enough to satisfy the thermal management requirement for most modern compact electronics. Therefore, many phase-change heat-dissipating components have been taken into consideration, and they have gradually moved from the research laboratories to the market applications. For example, the heat pipe is applied to the IT industry and embedded in a standard aluminum extruded substrate, where the heat of the hot spot can be quickly removed, thereby reducing large amount of heat along the substrate to improve the overall thermal efficiency. Speaking of phase change heat-transfer devices, although there are many types in the research field such as “Pulsating Heat Pipe (PHP)”, “Loop Heat Pipe (LHP or CPL)”, “Vapor Chamber (VC)”, etc., the questions are which products are more likely to enter the market after the heat pipes? What are the challenges in the aspects of technology transfer and commercialization? Let’s illustrate these issues using a vapor chamber (VC) as an example. Compared to heat pipes, vapor chambers are more suitable to apply on a large cooling surface area when directly in contact with a heat source. They have the advantages to provide obvious heat spreading effect and eliminate hot spots, etc., to minimize the system thermal resistance and fit to space-limited electronics with high thermal density. It not only can withstand higher heat flux than traditional aluminum or copper heat spreading surfaces, but also improve the system packaging due to its smaller and thinner size. Because it requires less air flow from a fan to cool down a heat sink without high temperature incurred by hotspots, so it can provide a much quieter operating environment. It is believed that current applications such as electric vehicle batteries, high-power LED or high-performance servers, especially blade servers that require highly effective cooling effect with limited heat dissipation space can get promising results by using the VC solution. This technology will greatly reduce the size and weight of the entire heat dissipation module, and improve its performance and product life cycle when operating at lower temperature.

Industrialization of MEMS Electret Energy Harvester for Environmental Vibrations

Hiroyuki Mitsuya, R&D Center, Saginomiya Seisakusho, Inc., Japan

This project was designed to develop the technologies needed for the trillion-sensor era expected to arrive by 2030: a turning point when we begin consuming more than a trillion electronic sensors worldwide in a single year. The most vital elements of the tiny-sensor environment to come are the so-called energy harvesters: autonomous power sources that harness power from the environment without the aid of battery cells or power cables. In order to meet this upcoming demand, we have formed a collaborative enterprise including universities, research institutes, and industry. Among the various types of energy harvesters, we have realized and conceived, our group is currently developing a vibrational-type harvester with high conversion efficiency.

Specifically, our project focuses on an electret type energy harvester that produces electrical power from mechanical vibration through electrostatic induction. The power conversion efficiency can be further improved by using a) a high-density electret based on solid ions and b) the large electrical capacitance of an ionic liquid inserted between the electrodes. The most representative outcome of this project is the successful development of a 1-mW-class energy harvester based on solid-ion electrets. This and our other energy-harvesting technologies are currently being developed practically as energy sources for autonomous wireless sensors for an industrial factory, plant and infrastructure monitoring.

Panel Discussion

Alice Haixia Zhang, Peking University, China

Wilbur Catabay, TSI Semiconductor, United States

Andy Chi-Te Chin, Wuhan University of Technology, China

Tuesday, 26 June 2018

9:00am-9:40am	**Plenary Talk 3**: Zexiang Li, HKUST and DJI / James Wu, DJI, China (Lecture Theatre B, Academic Building)		
9:40am-10:20am	**Plenary Talk 4**: C.P. Hung, ASE Group, Taiwan (Lecture Theatre B, Academic Building)		
10:20am-10:35am	**Coffee Break** (Hallway outside Lecture Theatre B)		
10:35am-12:00pm	**C2: Physical Sensors, Micro/Nano Fluidics** (Lecture Theatre B, Academic Building)	**D1: Biological, Medical, Chemical Sensors** (Lecture Theatre D, Academic Building)	
12:15pm-2:00pm	**Lunch** (G/F Chinese Restaurant, HKUST)		
2:00pm-3:00pm	**Poster Session II** (Outside Lecture Theatre J)		
3:00pm-4:30pm	**C3: Physical Sensors, Micro/Nano Fluidics** (Lecture Theatre B, Academic Building)	**D2a: Biological, Medical, Chemical Sensors** (Lecture Theatre D, Academic Building)	**D2b: Biological, Medical, Chemical Sensors** (Lecture Theatre E, Academic Building)
4:30pm-4:45pm	**Coffee Break** (Hallway outside Lecture Theatre B)		
4:45pm-6:00pm	**C4a: Physical Sensors, Micro/Nano Fluidics** (Lecture Theatre B, Academic Building)	**C4b: Physical Sensors, Micro/Nano Fluidics** (Lecture Theatre D, Academic Building)	**D3: Biological, Medical, Chemical Sensors** (Lecture Theatre E, Academic Building)
6:30pm-9:00pm	**Conference Banquet** (Crowne Plaza Hong Kong Kowloon East)		

9:00 - 9:40

Plenary Talk 3: Zexiang Li, HKUST and DJI / James Wu, DJI, China (Lecture Theatre B, Academic Building)

DJI: The Leader in Drone Industry

DJI Innovations was a startup company led by Frank Wang, a student graduated from HKUST in 2006. DJI manufactures a range of high-end products, including micro unmanned aerial vehicles, flying platforms, flight controllers for multi-rotors, etc. DJI is the world's leader in the civilian and commercial drone industry, accounting for over 70% of the drone market. DJI's products have been widely used in aerial photography, film-making, agriculture, etc. DJI is keen to develop an open platform on which professional engineers and micro/nanotechnology researchers can work together for different industries.

Biography:

Zexiang Li attended the South-Central University in 1978, received his BS (with honor) degrees in Electrical Engineering and Economics from Carnegie-Mellon University in 1983, his MS degree in EECS in 1985, MA in mathematics and PhD in EECS in 1989, all from the University of California at Berkeley. He worked at ALCOA, the Robotics Institute of CMU and the AI Lab of MIT (89-90). He was an assistant professor at the Courant Institute of New York University (90-92). In 1992, he joined the Department of Electronic and Computer Engineering of the Hong Kong University of Science and Technology and is currently a professor of the department. He founded the Automation Technology Center(ATC) and currently serves as its director. Zexiang Li received the ALCOA Foundation Fellowship in 1979, and the E. Anthony Fellowship in 1983. He was a recipient of the University Scholar award from CMU in 1983, the E.I. Jury award from UC Berkeley in 1989, the Research Initiation award from NSF (US) in 1990, the Outstanding Young Researcher award (Class B) from NSF China in 2000, the LEAD award from AMI, USA in 2001, and the Natural Science award (3rd class) from

China in 1997. He became an IEEE Fellow in 2008. Zexiang Li served as a panel member of the Hong Kong Research Grants Council (RGC), an overseas member of the Natural Science Foundation of China (NSFC), and an associate editor for the IEEE Trans. on Robotics and Automation. He was the general Chair for the 2011 IEEE International Conference on Robotics and Automation (ICRA). Zexiang Li's research areas of interests include multifingered robotic hand, parallel manipulators, workpiece localization and inspection, motion control, precision assembly, and unmanned aerial vehicles (UAVs). He is the author of more than 100 journal and conference papers, and the books A Mathematical Introduction to Robotic Manipulation) (CRC Press 1993) and Nonholonomic Motion Planning (Kluwer 1994). Zexiang Li cofounded several companies with his colleagues and students from the Automation Technology Center, including Googol Technology, the first motion control company in China, iFlight Technology (or DJI) a leading company in UAV and flycam products and Lie Group Automation.

James Wu currently holds the position of Chief Scientist in DJI. Based in Shenzhen, China, Dr. Wu leads teams responsible for key advanced technology development and has performed a variety of management roles inside DJI. Dr. Wu earned his PhD degree in Electrical Engineering from Linkoping University in 2009.

9:40 - 10:20

Plenary Talk 4: C.P. Hung, ASE Group, Taiwan (Lecture Theatre B, Academic Building)

Latest SiP Enabling New System Integration

System in Package (SiP) provides the user the great promise to optimize and differentiate their products to meet their device / system requirements. This talk will review innovations in SiP technologies – Flip-Chip, Fan-Out and beyond, describing how these promises are fulfilled in achieving higher bandwidth, small form factor, with increased functionality and mixed wafer nodes, so very important in the IoT, big data and mobile applications.

Biography:

Dr. CP Hung currently holds the position of Vice President, Corporate R&D, at ASE Group. Based in Kaohsiung, Taiwan, he leads teams responsible for next-generation product development featuring integrated technologies, as well as a broad range of advanced chip, package, and system integration solutions.

During his tenure, Dr. Hung has performed a variety of management roles at ASE, including VP of Corporate Design, VP of Central Engineering & Business Development and VP of Logistic Services Integration. He holds 72 patents encompassing IC packaging structure, process, substrate and characterization technology. He has also published over 49 conference and journal papers.

Dr. Hung has been the SEMICON Taiwan PKG & TEST Committee Chair since 2013.

10:20 - 10:35

Coffee Break (Hallway outside Lecture Theatre B)

10:35 - 12:00

C2: Physical Sensors, Micro/Nano Fluidics (Lecture Theatre B, Academic Building)

Keynote Speech: [159] Self Powered Smart Sensing System

Alice H.X. Zhang, Peking University, China

This talk will introduce the self-powered smart system based on triboelectric nanogenerator (TENG), which not only can sustainably convert many mechanical energy forms into remarkable electricity with high efficiency, but also can be active

sensors. The talk will include flexible and stretchable touch/untouchable multi-functional E-Skin, healthcare monitoring system and other latest research achievements.

Biography:

Haixia (Alice) Zhang, received her Ph.D. degree from the Huazhong University of Science and Technology at 1998, joined Peking University at 2001 after her Post-Doc in Tsinghua. Her research fields include MEMS, Energy harvesting technologies and applications. She is Senior Editor of IEEE TNANO, IEEE-JMEMS, Microsystems & Nanoengineering, IET MNL, etc. She published 250+ peer-reviewed publications, invented 40 patents (include 5 US patents). She was the founder of IEEE NEMS at 2006 and served as General Chair at 2013 in Suzhou, hosted Transducers2011 in Beijing, and initiated the MINE conferences at 2017. She is chairing of Chinese International NEMS Society and IEEE NTC Beijing Chapter. She won National Invention Award of Science & Technology at 2006, Geneva Invention Gold Medal at 2014.

[67] Hermetically Packaged Resonant Microsensor for Photoacoustic Detection

Imran Latif, Zhonglie An, Masaya Toda and Takahito Ono, Tohoku University, Japan

Pulsed photoacoustics employs short laser pulses to generate acoustic pressure waves in the samples of interest. The photoacoustic signal is proportional to the absorbed optical energy which in turn depends on the absorption characteristics of the particular material. This process can be used for the identification of solids, liquids and gases. This paper describes the design, fabrication, and evaluation of a resonant type microsensor for the photoacoustic characterization of different optical materials. The microsensor is based on hermetically packaged Si micro-cantilevers, thereby avoiding the problems of viscous damping which normally degrade the performance of resonant type microsensors. Preliminary experiments have been conducted using different sample materials. The experimental results show that the microsensor is sensitive to the photoacoustic response of the sample materials.

[14] Capacitive Silicon Nanomechanical Resonator Capable of Selective Vibration of High-Order Mode

Nguyen Van Toan, Tsuyoshi Shimazaki, Naoki Inomata, Masaya Toda and Takahito Ono, Tohoku University, Japan

This work reports the design and fabrication of capacitive silicon nanomechanical resonators with the selective vibration of a high-order mode. The fixed-fixed beam capacitive silicon resonators have been successfully produced by uses of an electron beam lithography, photolithography, a deep reactive ion etching, and an anodic bonding method. All resonators with different vibration modes are designed to have the same resonant frequency for the performance comparison. Measurement results show that the higher-order mode capacitive silicon resonators can achieve lower the insertion loss than that of the lower-order mode capacitive silicon resonators. The motional resistance of the 4th mode vibration resonator is improved by 83%, 90%, and 93% over the 3rd, 2nd, and 1st mode vibration resonators, respectively.

[26] Vibration Mode and Piezoelectric Responses of MEMS Ultrasonic Sensors on Buckled Diaphragms

Kaoru Yamashita, Tomoki Nishioka, and Minoru Noda, Kyoto Institute of Technology, Japan
Paul Muralt, Swiss Federal Institute of Technology in Lausanne, Switzerland

Vibration modes and piezoelectric responses of ultrasonic microsensors on buckled diaphragms were investigated from the viewpoint of influence of the buckling deflection to the responses. The vibration modes were integrated into a fewer modes with increasing the buckling deflection, and the output voltage waveform as the piezoelectric responses showed less distorted damping oscillation. This means that the buckling deflection is suitable not only for the high sensitivity but also for the phased array applications.

[127] A Novel Method of Acceleration Measurement Based on Tunneling Magnetoresistance

Yingfei Yao, Cong Xue, Pei Wang and Dacheng Xu, Soochow University, China
Darrin Young, University of Utah, United States

As the fourth-generation magnetic field sensing technology, tunneling magnetoresistance (TMR) sensors have very high sensitivity (300mV/Oe) which provide a new way for developing the high-resolution micro-accelerometer. This paper reports a novel high-resolution accelerometer based on tunneling magnetoresistance. The proof mass of the sensor is a permanent magnet fixed on a micro-cantilever beam, whose minute movement under axial acceleration leads to the magnetic field variation which is precisely sensed by the TMR sensor. An experimental prototype has been successfully fabricated which showed a linear transfer curve with the sensitivity of 1.145V/g.

D1: Biological, Medical, Chemical Sensors (Lecture Theatre D, Academic Building)

[121] Multifunctional Thermal Biosensor for Urine Detection with Thermocouple Structure

Zhuqing Wang and Misuteru Kimura, Tohoku Gakuin University, Japan
Takahito Ono, Tohoku University, Japan

This research demonstrates multi-functional thermal biosensor with thermocouple structures that has integrated with freestanding microfluidic channels for urine detection. The free-standing SU-8 polymer-based microfluidic reactive chamber allows high sensitive measurement of small volumes of liquid samples. The fabricated biosensor shows a sensitivity of approximately 0.35 V/W. The results demonstrate that fabricated biosensor can be used to detect the concentration of glucose, albumen and creatinine solution which is capable of enzyme-catalyzed reaction detection for healthcare application.

[17] Fabrication of Large Area Nanowire Array on Flexible Substrate for Gas Sensing Application with Soft Lithography

Ning Tang, Cheng Zhou, Yang Jiang, Hemi Qu and Xuexin Duan, Key Laboratory of Precision Measuring Technology & Instruments, Tianjin Unviersity, China

This paper reported a high efficient and facile method to fabricate flexible poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate) (PEDOT:PSS) nanowire chemiresistive type of gas sensor by nanoscale soft lithography. Well-defined sub-100 nm nanowires are fabricated on polyethylene terephthalate (PET) substrate. The nanowire gas sensor shows a high flexibility and stability. The nanowire chemiresistive gas sensor is demonstrated for ammonia detection at room temperature and shows a limit detection at ppb level which is compatible with nanoscale gas sensors fabricated with conventional lithography techniques.

[80] Nanomechanical Piezoresistive Sensor with Polymer-Si Membrane for Gas Detection

Takumi Hokama, Md. Mahabub Hossain, Masaya Toda and Takahito Ono, Graduate School of Engineering, Tohoku University, Japan
Krzysztof Moorthi and Mai Yamazaki, Mitsui Chemicals Inc, Japan

This paper presents the design and fabrication process of a piezo resistive nanomechanical sensor with a Si-polymer composite for gas detection. The sensor consists of a Si-polymer composite membrane supported by two piezoresistive Si beams. The composite membrane is made of Si slits with 1 μm separation gaps and a functional polymer which is embedded in the Si silts. This composite acts as gas molecules absorber and consequently generated stress generator. As a result of simulation, the response of sensor takes a peak value when the shape of the composite is close to a square. The fabricated sensor shows a linear response to humidity with a sensing resolution of 0.14%RH.

[96] Gas Sensing System Composed of Low-Cost Microcantilever, Advanced Sensing Material, and Intelligent Processing Circuit

Haitao Yu, Xin Peng, Pengcheng Xu and Xinxin Li, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China

Gas sensors based on resonant microcantilevers have drawn significant attention in the application of trace molecule detection. In order to realize the practical application of microcantilever-based sensors, three critical points still must be addressed: inexpensive and batch fabricated microcantilevers, high performance sensing material and easily operated signal processing circuit with intelligent software. Herein, a gas sensing system is proposed to fulfill these demands. A low-cost and IC-foundry-compatible fabrication technology of the resonant microcantilever is developed. For the example of trace aniline detection, a scalable metal-organic-framework (MOF) material of MOF-5 with ultrahigh surface area and abundant specific aniline-adsorption sites is prepared. For sensing signal processing, an interface circuit with intelligent data processing capability is designed. Composed of the low-cost microcantilever, the advanced MOF-5 sensing material, and the intelligent signal process, the new gas sensing system shows satisfactory performance for trace aniline vapor detection.

[109] A Micro Gas Chromatography System with Robust and Suspended μTCDs

Bo-Wen Tian, Fei Feng, Bin Zhao, Fan Luo, Xue-Lei Yang, Hai-Mei Zhou and Xin-Xin Li, State Key Laboratory of Transducer Technology, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China

This paper reports a monolithic integration of micro gas chromatography (μGC) system, which includes micro separation column (μSC) and micro thermal conductivity detectors (μTCDs). Compared to the state of the art, we fabricate robust and suspended μTCDs with twelve anchors in a monolithic μGC system, which contribute to improve thermal isolation and sensitivity of detectors. What's more, we coat mesoporous silica nanoparticles (MSN) as stationary phase in μSC's deep channels to increase surface area, by which, higher μSC's separation resolution can be obtained.

[110] Study for Multifunctional Micro Gas Chromatography Separation Column

Bo-Wen Tian, Fei Feng, Bin Zhao, Fan Luo, Xue-Lei Yang, Hai-Mei Zhou and Xin-Xin Li, State Key Laboratory of Transducer Technology, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China

This paper reports a newly micro gas chromatography separation column (μGC-SC) with two different kinds of stationary phases, which is realized by regional coating method. Compared to the μGC-SC with single stationary phase, the new μGC-SC chip has wider scope of separation ability and good separation resolution. More significantly, regional coating method has potential to realize multifunction and customization of μGC-SC.

12:15 - 14:00

Lunch (G/F Chinese Restaurant, HKUST)

14:00 - 15:00

Poster Session II (Outside Lecture Theatre J)

[98] Circuits Design and Integration Scheme for Silicon Nanowire Sensors

Zhida Zhao, Kun Zhou and Zheyao Wang, Insitute of Microelectronics, Tsinghua University, China

Silicon nanowire (SNW) field-effect transistors (FETs) have shown great potential for biosensor applications because of their high sensitivity, low cost, and label-free detection. However, biomolecules with low concentrations normally cause weak signals and low signal to noise ratio. To reduce the electrical noises and avoid the parasitic effect, it is desired to integrate SNW with readout circuits on a signal chip. To achieve this target, a readout circuit and integration scheme for SNW is presented in this paper.

[8] In-Minutes Polymerase Chain Reaction with Specific DNA Amplification on Digital Microfluidics with Sloppy Temperature Control

Liang Wan, Haoran Li, Tianlan Chen, Cheng Dong, Yanwei Jia, Pui-In Mak and Rui Martins, University of Macau, Macau

This digital microfluidics (DMF) platform with on-chip micro-thermal-cycler by sloppy temperature control has successfully run an ultra-fast PCR within 2 minutes. The LATE-PCR with Molecular Beacon DNA probe wipes out false-positive as well as providing possibility for mutation detection. The entire platform is open for further integration with sample preparation and fluorescence detection towards a total-micro-analysis system.

[52] Design and Evaluation of 2-Transistor Pixel Configuration for pH Image Sensor with Charge Cumulative Function

Yoshitaka Arimi and Yasuyuki Kimura, Toyohashi University of Technology, Japan
Hiroo Yamamoto and Seiichiro Mizuno, Hamamatsu Photonics, Japan
Tatsuya Iwata, Kazuhiro Takahashi and Kazuaki Sawada, Toyohashi University of Technology, Electronics-inspired Interdisciplinary Research Institute (EIIRIS), Japan

In our previous work, the pH image sensor with a 2-transistor (2-Tr) pixel structure composed of a sensor gate (SG) and transfer gate (TG) was developed. However, the pH resolution capability of this sensor was only about 0.1 pH, and a lower pH resolution sensor was required strongly. For this reason, we propose 2-Tr pixel configuration for pH image sensor with charge cumulative function. By the cumulative function, the SNR becomes √n times smaller, and improvement of pH resolution expected. Based on this idea, a pH sensor chip with a 2-Tr pixel configuration was designed and device characteristics were evaluated. According to the repeating accumulations from 1 time to 10 times, the pH solution was improved from 0.190 pH to 0.021 pH. Therefore, it was possible to improve the pH resolution by using a 2-Tr type pH sensor pixel with cumulative function.

[61] Development of Capacitive Biosensor Based on Vertically Paired Interdigitated Electrode (IDE)

Ga-Yeon Lee, Jun-Hee Park and Jae-Chul Pyun, Yonsei University, South Korea

A vertically paired interdigitated electrode (IDE) for capacitive biosensor was developed for the non-labeled immunoassay. This work focused on the fabrication of vertically paired IDE for capacitive biosensor with several pairs and a nano-gap level distance between electrodes. The non-labeled detection of antigen-antibody interaction was demonstrated by using model antigen and antibody.

[62] Development of a Label-Free Needle Type Ion Image Sensor for Real-Time Monitoring of Potassium Ion Distributions

Yusuke Nakamura, Toyohashi University of Technology, Japan
Tatsuya Iwata, Kazuhiro Takahashi and Kazuaki Sawada, Toyohashi University of Technology, Electronics-Inspired Interdisciplinary Research Institute, Japan

We have newly developed a needle type potassium ion image sensor for in-vivo conditions that can observe potassium ion concentration gradient distributions in real time. It was confirmed that the output signal voltage of the pixel inserted into the agarose gel was increased and monitored K+ concentration in a deep part of the agarose gel.

[63] ITO-Based ISE as pH Sensor Integrated with MCU for the Drifting Compensation

Bo Gao, Yifan Xu, Wei Xu, Xiaoyi Wang, Zhien Wang, Qing Chen and Yi-Kuen Lee, Hong Kong University of Science and Technology, Hong Kong

Indium tin oxide (ITO) is widely used in displays, polymer-based electronics and microfluidics, due to its electrical conductivity and optical transparency. ITO also shows almost Nernst-slope pH response as sensing material. However, ITO suffer from drifting issues. The impact of dissolved oxygen in the electrolyte on the sensor performance was studied. And MCU-based signal processing was developed for drift-compensation and linearization.

[69] Evaluation of Antigen-Antibody Reaction on Suspended Graphene by Optical Interferometry

Shin Kidane, Hayato Ishida and Kazuaki Sawada, Toyohashi University of Technology, Japan
Kazuhiro Takahashi, Toyohashi University of Technology, JST-PRESTO, Japan

We evaluated antigen-antibody reaction on the suspended graphene, which deformed upward by Coulomb repulsive force of adsorbed antigen. We also demonstrated real time and label-free molecular detection on the suspended graphene by using optical interferometry in liquid.

[81] Investigation of pH Response and Interfacial Product of Ta2O5 Film Deposited on Tungsten

Yusuke Yamauchi, Takeshi Hizawa and Kensuke Murakami, Toyohashi University of Technology, Japan
Tatsuya Iwata, Kazuhiro Takahashi and Kazuaki Sawada, Toyohashi University of Technology, EIIRIS, Japan

Miniaturization of pixels down to 1 μm square is required of pH image sensors for biological applications such as investigation of brain functions. Then, we aim for realization in standard CMOS process by employing an extended gate structure which expands gate electrodes vertically. As compared with the case in which Ta_2O_5 is deposited on a SiO_2, the properties of the Ta_2O_5/W interface including roughness and the formation of oxidized/reduced layer can affect the film properties, thus the pH sensitivity. In this report, the pH sensitivity was decreased by depositing Ta_2O_5 on W compared with that deposited on SiN. It is ascribed to the conditions for Ta_2O_5 film formation. On the other hand, products such as suboxides of W and Ta were not observed by the XPS.

[119] Calibration Methods for the Long-Term Drift of NDIR Gas Sensor with Dual Elliptical Optical Structure

SeungHwan Yi, JinHo Kim and HanGil Park, Korea National University of Transportation(KNUT), South Korea

One elliptical optical structure [1, 2] in nondispersive infrared (NDIR) gas sensor could increase the sensitivity, however, the calibration for long-term drift of sensor performance would be a challenging matter with it. Even though dual elliptical optical structure showed the compensation algorithm of temperature variations [3], however, the calibration method for long-term drift of sensor performance was not reported so far. So, in this article, the calibration methods for long-term drift of performance were proposed and experimentally proved with dual elliptical optical structure and two different combinations of IR detectors.

[133] Effects of Extensional and Shear Stresses on Cells– The Case Study of White Blood Cells in a Setup of Spiral Microchannels

Thammawit Suwannaphan, Alongkorn Pimpin and Achariya Sailasuta, Chulalongkorn University, Thailand

Over the past years, a spiral microchannel has been used as one of the most common techniques for cell separation in the field of microfluidics. However, the hydrodynamic forces also potentially physically affect cells. The possibility of cell death could be caused by either extensional or shear stresses, and they have been drawn a great attention as both of them play an important role in decreasing cell viability as publicly reported [1-5]. Therefore, the examination of the cell viability, which was rarely reported in the past, should be conducted alongside with the test of setup efficacy. In this study, the experiments in a setup of sorting devices including syringe, silicone tube and spiral microchannel as shown in Fig. 1 were investigated. In this work, white blood cells (WBCs) were used as a model. Several methods including Trypan Blue,

Scanning Electron Microscopy (SEM) and Wright's staining were employed to examine cell viability, cell morphology and cell structures. To approximate an order of magnitude of stresses such as an average axial and radial extensional stress and shear stress as well as critical areas where cells can potentially be damaged and exposure time when cells are experienced by stresses, a computational simulation was implemented. In the experiments, the results showed that in a feeding system, consisting of syringe and silicone tube, either increasing the volumes of syringe—1, 2.5 and 5 ml or flow rates from 1 to 8 ml/min, had no effect on cell viability under a light microscopy with Trypan Blue. Although most cells about 95% were viable, they were physically damaged severely after passing through the feeding system at the maximum stress conditions, i.e. 5 ml syringe at 8 ml/min. SEM images in Fig. 2 were the evident of hydraulic stresses causing the change in cell morphology, cell membrane damaged and nucleus stretched. In addition, it was found that cells were also damaged internally causing cell membrane breakup and the leak of cytoplasm as shown the results of Wright's stain in Fig.3. The data showed that normal cells, i.e. the cells without damage, were decreased about 12% and 16% under SEM and Wright's stain as shown in Fig. 4. Finally, the examination of cell viability in a complete setup of spiral microchannel, i.e. the feeding system connecting with the spiral microchannel, showed that about 25% of cell lost occurred when using 1 ml syringe at 1 ml/min. This implied that cell death would majorly occur in the spiral microchannel instead of in the feeding system. The computational simulation confirmed that axial and radial extensional stress tensors and shear stress tensor induced in a syringe had a similar magnitude of about 10-14 Pa as shown in Fig.5, but exposure time was only 0.02 ms at the corner between a barrel and needle— 2.5x2.5 µm2 (for Path 1) and about 0.03 ms— 3.5x3.5 µm2 (for Path 2). In another part of the feeding system, i.e. a silicone tube, only wall shear stress was induced, and its magnitude was about 1.2 Pa, but exposure time was longer to 1.58 s at 1 ml/min. This short exposure time of the high stresses in the syringe and moderate magnitude of stresses for long time in the silicone tube might cause only slight damage to the cell and resulted in a little cell death found in the experiments. In the spiral microchannel, it was found that cells were experienced moderate magnitude of stress tensors along the streamline depicted in Fig. 6, and long exposure time of about 0.4 s. Considering these stress tensors, the cells experienced shear stresses in an order of magnitude and exposure time similar to those occurred in the silicone tube, but they experienced additional extensional stresses in the order of 1 Pa. The results implied that the cell death that was experimentally found more in this part of the setup might be occurred due to the effects of extensional stresses rather than shear stresses. Although the feeding system in the syringe and silicone tube did not affect cell viability suddenly, we believe that the change in cell morphology and structures could lead to the cell death later.

[39] A Simple Method to Detect Mercury Ions By 4-mbA Using Surface Enhanced Raman Scattering

Guanzhou Lin and Peimin Lu, Fuzhou University, China
Jia Zhu, Yun Huang, Xiaoyu Chen, Zhuojie Chen, Shengxiao Jin and Wengang Wu, Peking University, China
Tian Kang, Shenzhen Graduate School of Peking University, China

In this paper, we suggest a fast, simple and low-cost mercury ion detection method, using surface enhanced Raman scattering (SERS) on silver nanoparticles substrates. We develop the SERS substrates and add 4-mbA (4-mercaptobenzoic acid) into the mercury ion solution. The mercapto group in 4-mbA binds to mercury ions, resulting in a decrease in the intensity of the peak of the 4-mbA Raman spectrum, and thereby enabling the detection of mercury ions. Under optimal conditions, the limit of detection of mercury ions can reach to 10 pmol.

[41] Ultramicroelectrode Array for Rapid Detection of Biochemical Oxygen Demand

Jizhou Sun and Shanhong Xia, State Key Laboratory of Transducer Technology, Institute of Electronics, Chinese Academy of Sciences, China
Yijin Li, University of Chinese Academy of Sciences, China

Superfluous organics in water often cause intensive metabolism of bacteria and large consumption of dissolved oxygen, which will finally deteriorate water quality. Biochemical oxygen demand (BOD) is an international regulatory index for assessing organic water pollution, which needs to be rapidly detected in water quality monitoring. Aerobic microorganisms utilize organics for respiration, during which dissolved oxygen is consumed and measured as the BOD response. The standardized method for BOD measurement (5-day method, BOD5) is time-consuming and requires complicated operations. In this paper, in order to get rapid and sensitive detection of BOD, a microbial sensor with the membrane containing immobilized microorganism as recognition element has been developed based on the fabrication of ultramicroelectrode array (UMEA) and the electrodeposition of carboxyl graphene (GN-COOH). Compared with the traditional BOD electrode including immobilized microbial film and oxygen permselective membrane, the designed B.subtilis/ rGN-COOH/ UMEA electrode simplifies the structure for more effective mass transfer.

[65] Proposition of an EIS Type Dissolved Oxygen Sensor with ZnO Sensitive Layer for Multimodal Imaging

Yuya Sugihara, Kohei Ono, Takeshi Ishiyama, Takeshi Hizawa and Kensuke Murakami, Toyohashi University of Technology, Japan

Tatsuya Iwata, Kazuhiro Takahashi and Kazuaki Sawada, Toyohashi University of Technology, Electronics-Inspired Interdisciplinary Research Institute (EIIRIS), Japan

We have been developing ion image sensors that visualize dynamic ion motion. Because a number of chemicals interact in chemical phenomena, useful information is obtained by visualizing various substances besides ions simultaneously. Based on the idea, a multimodal ion image sensor with simultaneous imaging function of ions and gas is proposed. We have successfully realized a dissolved oxygen sensor using Electrolyte-Insulator-Semiconductor (EIS) structure with the sensitive layer of ZnO.

[71] Noise Analysis of Solid-State Nanopore Sensor for Biomolecule Detection

Yongliang Tang, Xu Hou and Songyue Chen, Xiamen University, Xiamen, China

Solid-state nanopore sensors are applicable for detection and analysis of biomolecules and ionic information. The working mechanism for nanopore resistive sensor includes resistive pulse recording of molecule transport through a nanopore, e.g. DNA sequencing, steady-state conductance change measurement at the ambient stimuli or target biomolecule immobilization on the inner walls of the nanopore decorated with recognition sites[1]. The ionic current through the nanopore is related to the concentrations and species of the target molecule. Noise analysis is critically important for optimizing the fabrication and working conditions of the sensor. The noise power spectrum of SiN solid state nanopores follows 1/f type, and is affected by the pore size, salt concentrations, etc. In this work, we report a comprehensive study of polyethylene terephthalate (PET) nanopores with both ionic current and noise power spectrum, aiming to provide an effective method for improving the sensitivity of nanopore sensors for biomolecule detection.

[86] Fabrication of TiO_2/GOD Composite-Based Glucose Biosensor with Surface Treatment

Junyeop Lee, Dong Geon Jung, Jae Yong Lee and Seong Ho Kong, Kyungpook National University, South Korea

Since Clark and Lyons first proposed enzyme-based glucose biosensor, numerous improvement has been achieved in this field. The first-generation biosensor, however, had several drawbacks of large interference from electrochemically oxidizable materials in samples and satisfactory detection limits. Since most electrochemical mediators have low selectivity for glucose, researchers have continued to investigate for increasing the electronic coupling between redox proteins (enzymes) and electrodes [5]. To solve these problems, there have been many reports to immobilize GOD using metal oxides and compounds. This is due to the biological compatibility of the biomolecules of TiO_2. Significant research of changes in signal intensity with changes in TiO_2 surface area have been reported. But, the effects on glucose biosensor by changes of surface shape were not reported. There is signal improvement for the effective surface area change depending on the synthesis method of TiO_2, morphology of TiO_2 and immobilization of GOD on TiO_2 film. If so, there also will be improvements in signal sensitivity due to the changes of surface shape of the substrate. Here we tested the effects of the glucose biosensor according to the changes of surface shape.

[76] A Monolithic Triaxial MEMS Accelerometer Based on Slanted Supporting Beams

Wei Xu and Jie Yang, Institute of Electronic Engineering, China Academy of Engineering Physics, China

This paper presents a novel triaxial capacitive MEMS accelerometer with slanted supporting beams and all-silicon sandwich structure. Its high symmetry is ensured by a specifically developed wet etch technique, and its all-silicon sandwich structure could bring in chip-scale hermetic sealing. Another large improvement of accelerometers' thermal stability is given by the implementation of double differential configuration, which could help to mitigate the thermal mismatch between MEMS die and ceramic package. By using anisotropic silicon wet etch and high temperature fusion bonding, this accelerometer was successfully fabricated. Measured results show that this accelerometer has a good centrifugal performance, and have a great opportunity for future high-precision three-axis inertial measurement.

[106] A Novel Flexible RFID Tag Besed on Nested Split-Ring-Resonator Matematerials for Ammonia Detection

Fengxiang Lu, Qianqian Guo, Hairong Kou and Qiulin Tan, Key Laboratory of Instrumentation Science & Dynamic Measurement, North University of China, China

A wireless and passive flexible sensor for high sensitivity of ammonia (NH3) detection is proposed. The sensor is based on microwave backscatter chip free label radio frequency identification (RFID) technology. Novel structures of nested split ring resonator (nested-SRR) are spurted on the substrate and act as chip free label tags. The tags can be easily coated by changing the size of nested-SRR, they have their own radar signature that can be used not only for identification but also for sensing. Moreover, the proposed nested-SRR chipless RFID tags provide more design flexibility. It can be extended to the ultrahigh (UFH) frequency range and the structure can be minimized to nanometer size with high sensitivity.

Here we used Ag-loaded molybdenum disulfide (MoS2) hierarchical nanostructures as sensitive material for NH3

detecting. Detection at low concentration of NH3 is of great scientific importance in environmental monitoring and various chemical/agricultural industries. The measured resonant frequency of the sensor is in S band, which is a typical frequency channel for application of RFID.

[44] A Paper-Based Single-Spiral LC Humidity Sensor for Dry Food Monitoring

Ming-Zhu Xie, Li-Feng Wang, Lei Dong and Qing-An Huang, Key Laboratory of MEMS of the Ministry of Education, Southeast University, China

In this paper, we proposed a simple and low-cost inductor-capacitance (LC) passive wireless humidity sensor for dry food monitoring. A single spiral inductor was inkjet-printed on the common paper substrate, the inductance and parasitic capacitance of the inductor form the LC resonant circuit, and the resonant frequency can be predicted by an easy theory analysis with a relative error around 6%. The sensor with 8 turns coil has a sensitivity of 144 kHz/%RH over the range from 15% to 90% relativity humidity, along with a good stability and repeatability performance during the humidity detection.

[21] Development of Optically-Induced Dielectrophoretic (ODEP) Force-Based Biochip System for High-Purity Isolation and Purification CD45neg/Epcamneg Cells

Yu-Xian Zhu, Tzu-Keng Chiu, Chia-Jung Liao, Wen-Pin Chou and Min-Hsien Wu, Chang Gung University, Taiwan

Cancer metastasis is a leading cause of cancer-derived death. Although the studies relevant to this issue have been carried out for more than a century the mechanism of cancer metastasis is still not fully clear. With the recent studies on circulating tumor cells (CTCs) they hold immense potential to provide more valuable information on the mechanism of cancer metastasis. In current CTC studies, however, CTCs are normally defined as the cancer cells in blood circulation that express specific surface antigens-EpCAM(CD45neg/ EpCAMpos). The studies based on this could miss the other metastatically more meaningful cancer cells due to high heterogeneity of CTCs (CD45neg/ EpCAMneg). To address these issues, we aim to develop an optically-induced dielectrophoretic force-based microfluidic biochip system for high purity (ideally 100%) cell isolation. We will use it to isolate target cells in a blood sample that includes leukocytes (CD45pos), conventionally defined CTCs (CD45neg/ EpCAMpos), and an unknown cell group (CD45neg/ EpCAMneg) in this study. In the future works, the technique of real-time PCR will be utilized to analyze the expression of cancer-related genes [e.g. genes relevant to stem cells, cancer stem cells (CSCs), or Epithelial- Mesenchymal Transition (EMT)] of the cell species abovementioned. Through these investigations, we will examine if there are “atypical CTCs” (e.g. the cancer cells that express CSCs or EMT-related genes) in the unknown cell group.

[6] Wide Dynamic Range CMOS Image Sensor with Adjustable Sensitivity Using In-Pixel Inverter Technique

Donghyun Seong, Byoung-Soo Choi, Sang-Hwan Kim, Jimin Lee and Jang-Kyoo Shin, School of Electronics Engineering, Kyungpook National University, South Korea

The proposed WDR CIS shows the operation of WDR mode by using in-pixel inverter technique. When the output of the inverter switches from 0 V to 3.3 V, the sensitivity of the proposed pixel changes lower than the sensitivity of the conventional pixel. The in-pixel inverter can be turned on if the sensitivity of pixel is needed to be lowered for the WDR mode. Therefore, the proposed APS might be applied to the wide dynamic range CMOS image sensor to acquire the images under various light conditions.

[73] In-house Polydimethylsiloxane Microfluidic Device on Single-Cell Trapping and Culturing of Leukemia Cell Line: Cellular Study and Analysis

Sudchaya Bhanpattanakul, Faculty of Veterinary Science, Chulalongkorn University, Thailand
Theerayuth Kaewamatawong, Achariya Sailasuta, Prapruddee Piyaviriyakul, Patarakrit Theewasutrakul, Dettachai Ketpun, Alongkorn Pinpim, Werayut Srituravanich, Tewan Tongmanee and Thammawit Suwannaphan, Chulalongkorn University, Thailand
Wutthinan Jeamsaksiri, Witsaroot Sripumkhai and Pattaraluck Pattamang, Thai Microelectronics Center (TMEC), Thailand
Mayuree Chanasakulniyom, Mahidol University, Thailand

Cell culture on microfluidic device has more benefits than conventional culture method especially in cellular microenvironmental control and real-time analysis. This study aims to develop the microfluidic device and modify suitable protocol for cell trapping and culturing with cell viability verification. The Polydimethylsiloxane (PDMS) microfluidic device with triangular microwell was fabricated by soft-lithography technique with oxygen plasma treatment. The varied concentrations of Jurkat Leukemia cell line were trapped with the 0.2 mL/h drawback continuous flow for 30 minutes and cultured for 72 hours. Cell viability was examined with Trypan Blue dye exclusion assay and Live/Dead

fluorescent dye staining inside the device. The simulation result indicated that the fluid flow through the main channel was laminar flow pattern with cell in each fluid layer. The trapping rates at cell concentration of 1×106, 1.5×106, and 2×106 cells/mL were accounted for approximately 20%, 45%, and 64% of all microwell, respectively. The viable cells at 72 hours after culturing were accounted for 69%. Our study results showed potential of our microfluidic device for trapping and culturing of living cells in short term period.

15:00 - 16:30

C3: Physical Sensors, Micro/Nano Fluidics (Lecture Theatre B, Academic Building)

Keynote Speech: [167] Development of Silicon Smart Sensors

Paddy French, Delft University of Technology, The Netherlands

The idea of smart sensors in Delft began with Simon Middelhoek in the 1970s. At the time this was seen as a pipe dream. Although there are many examples where smart-integrated sensors is not the best option, there are many cases where it is. Many aspects have to be considered before the decision is made whether to integrate or not. This presentation takes a look at those early days of sensors and the move to integration. This will continue with the development of new technologies and new IC processes. In some cases, the new IC processes present new challenges in terms of integrating sensors with electronics. The decision of integration or not will be discussed in terms of practicality, costs and the application. From this we will see examples of successful integrated devices, but also examples where the decision was made not to integrate.

Biography:

Paddy French received his B.Sc. in mathematics and M.Sc. in electronics from Southampton University, UK, in 1981 and 1982, respectively. In 1986 he obtained his Ph.D., also from Southampton University, which was a study of the piezoresistive effect in polysilicon. After 18 months as a post doc at Delft University, The Netherlands, he moved to Japan in 1988. For 3 years he worked on sensors for automotives at the Central Engineering Laboratories of Nissan Motor Company. He returned to Delft University in May 1991 and is now a staff member of the Laboratory for Electronic Instrumentation In 1999 he was awarded the Antoni van Leeuwenhoek chair and in June 2002 he became head of the Electronic Instrumentation Laboratory. He is Editor-in-chief of Sensors and Actuators A and General Editor of Sensors and Actuators A&B. His research interests are integrated sensor systems, micromachining, in particular for medical applications.

[75] Integration of Temperature Compensation Sensor with Flexible Flow Sensor Based on Cu on Polyimide Substrate

Ayami Kato, Yoshihiro Hasegawa, Kazuhiro Taniguchi and Mitsuhiro Shikida, Hiroshima City University, Japan

A temperature sensor was newly integrated to the flow sensor to compensate fluid temperature change during respiration. They were fabricated on a thin polyimide diaphragm formed on Cu on Polyimide (COP) substrate to shorten the response time. Both mechanical diaphragm and electrical feedthrough components were produced all at once in sacrificial layer etching of copper in COP substrate. The relationship between the applied flow rate and sensor output was obeyed the King's law, and we confirmed that the sensor output values coincided with each other irrespective of the fluid temperature flowing to the sensor.

[66] Design and Optimization of Micromachined Thermal Wind Sensor Based on LTCC Packaging Technology

YiZhou Ye, Shi-Xuan Gao, Ming Qin and Qing-An Huang, Southeast University, China

In this paper, a micromachined thermal wind sensor based on LTCC (low temperature co-fire ceramic) packaging technology is presented for the first time. Instead of a ceramic carrier, a variable-thickness LTCC film is utilized to package the wind sensor. Moreover, based on this new packaging method, insulation trenches can be designed between the heater and thermistors to suppress the unwanted lateral heat conduction in the chip. The feasibility of this design has been demonstrated by finite element method (FEM) simulation, and the results show that the proposed wind sensor achieves almost three-fold sensitivity improvement compared with the traditional wind sensor employing the ceramic carrier to protect the chip.

[123] Suppression of Deformation for Gripping Soft Objects Using Miniature Tactile Sensor with Hemisphere PDMS

Fumitoshi Suga, Ryoma Araki, Takashi Abe and Masayuki Sohgawa, Niigata University, Japan
Haruo Noma, Ritsumeikan University, Japan

In this study, the proximity and tactile composite MEMS sensor with PDMS as a contact part was attached to an electromotive manipulator, and gripping of soft objects was controlled using sensor output. It is demonstrated that soft object can be gripped without large deformation by the manipulator controlled using output from the sensor with hemisphere PDMS and gripping force can be adjusted automatically when the object is lifted up.

[141] Fabrication of Pneumatically-Driven Micro Particle Concentrator

Ho Won Lee, Hyuck Gi Kwon and Ok Chan Jeong, Inje university, South Korea
Ji-Young Ahn, Chungbuk National University, South Korea

In this paper, the pneumatically-driven micro platform was fabricated for the concentration of a large number of particles for the practical application. Unlike the typical microdevice for single particle trap, there was no passive structure for its trap and any kinds of unwanted stresses generated by the operational methods. The proposed platform consisted of three pneumatic rubber-seal valves for the concentration of the particles from the mixture of particle and 3-dimensional fluidic network. The fabricated platform was evaluated from the test of the concentration of the particles with various diameters. The percent concentration of the 24-um-diameter particle was about 3.82 % for 20 minutes.

D2a: Biological, Medical, Chemical Sensors (Lecture Theatre D, Academic Building)

[43] Silicon Nanowire Biosensor Integrated with Microfluidic Chip for Multiplexed Biomolecules Detection

Anran Gao, Yuelin Wang and Tie Li, Shanghai Institute of Microsystem and Information Technology, China

The integration of microfluidic delivery system with silicon nanowire (SiNW) biosensor for multiplexed biomolecules detection was reported. The SiNWs and polydimethylsiloxane (PDMS) chips were fabricated with complementary metal oxide semiconductor (CMOS)compatibility and low-cost methods. They were integrated together by using optimal O2 plasma parameters that enabled rapid and leakage-free bond formation. Capillary action enabled by the hydrophilicity of the channels using polyvinylpyrrolidone (PVP) was demonstrated to allow analyte solution delivery onto the sensor array directly. The multiplexed, real-time and label-free electrical biomolecules detection was demonstrated with high sensitivity.

[72] Monocyte Impedance as a Novel Label-free Biomarker for Rapid Phenotyping and Inflammatory Profiling Using Microfluidics

Chayakorn Petchakup, Hui Min Tay, Han Wei Hou and King Ho Holden Li, Nanyang Technological University, Singapore

We report a novel microfluidic strategy for high throughput monocyte isolation and phenotyping based on single-cell impedance profiling. We demonstrated a novel microfluidics approach for continuous label-free monocyte isolation and electrical profiling based on impedance profiling We envision this technology can be further developed for immunology research and point-of-care inflammatory risk stratification in major metabolic diseases such as diabetes mellitus.

[16] Microfluidic Environmental Sensors Using Liquid Metals

Hiroki Ota, Yokohama National University, Japan
Yuji Gao, National University of Singapore, Singapore
Ali Javey, University of California, Berkeley, United States

Electronic devices and sensors which exhibit large amounts of mechanical deformability have many applications such as in smart wallpapers and human-machine interfaces for prosthetics. In this regard, tremendous advancements have been made in engineering solid-state electronic materials and devices on elastic substrates. Recently, sensors based on using liquid active components embedded within soft elastomeric substrates have shown much promise for such applications as liquids present the ultimate limit in deformability. In this presentation, we report four microfluidic environmental sensors using liquid metals, highly sensitive pressure sensor based on the Wheatstone bridge, and temperature, humidity, oxygen sensors with liquid-liquid “heterojunction”. The work presents an important step towards the potential realization of liquid-state electronic systems that offer new form factors and functionality.

[115] A Disposable Microsensor with RhIr/MoS_2 Composite as Sensing Material for Trace NADH Determination

Xinyue Xu and Yuan Zhang, Materials Genome Institute, Shanghai University, China
Pengcheng Xu and Xinxin Li, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China

Herein, we report a RhIr/MoS_2 composite nanostructures based microsensor with ultrasensitive and highly specific response for the detection of NADH. The RhIr/MoS_2 nanostructures could be facilely synthesized through in-situ growth of RhIr nanocrystals on the surface of MoS_2 nanosheets. Electrochemical sensing performance measurements indicate that the fabricated microsensor exhibits a selective response to NADH, and a good linear relationship in the range of 5 to 100 nM. The oxidation potential of RhIr/MoS_2 modified microsenor is observed as 0.05 V. The specific response towards NADH as well as low oxidation potential and detection limit of 5 nM may be suitable for constructing a high efficient NADH sensor prototype.

D2b: Biological, Medical, Chemical Sensors (Lecture Theatre E, Academic Building)

Keynote Speech: [3] Intelligent Digital Microfluidics

Yanwei Jia, University of Macau, Macau

Digital microfluidics has attracted much attention due to its nature of using electronic actuation force to manipulate individual droplets, which removes the burden of using pumps and valves for channel microfluidic systems. The intelligent electronic control associated with the automatic analysis makes it an ideal platform for various biochemical applications and industrialization. In this talk, Jia will briefly introduce the development of digital microfluidics and its applications. She will focus on their most updated intelligent systems developed for different biomedical applications, especially for precision medicine. They have concentrated on the design, fabrication, electronic intelligent system construction, automatic image processing, and the application of the system in biomedical science. Novel 3D microstructures have been developed to increase the throughput of on-chip DNA analysis and single cell analysis. Innovative chip design and fabrication have speed up the DNA amplification from hours to minutes and the DNA analysis from minutes to seconds. Their attempt in industrializing their systems for precision medicine will also be reported.

Biography:

Dr. Yanwei Jia received her PhD, MSc and BSc degrees in Physics from the National University of Singapore (2006) and Hunan University in China (2002 and 1996) respectively. After PhD graduation, Jia had worked as a Research Fellow in the National University of Singapore in 2006 before she moved to Brandeis Univesity in the USA, working as a Postdoctoral Fellow, Research Associate and Research Scientist chronically (2006-2012). Dr Jia joined the State Key Laboratory of Analog and Mixed-Signal VLSI (AMSV) in University of Macau in 2013, working on digital microfluidics. She is currently an assistant professor in AMSV, leading a goup working on multidisciplinary research based on microfluidcis for biological/chemical applications, especially in the field of biomedical science. She has been awarded the Innovation Prize in 2008 by the International Organization for Biological Crystallization.

[29] A Microfluidic Device Based Chlorophyll a Concentration and Turbidity Sensor for Water Quality Monitoring

Ryota Isoyama, Tomoaki Kageyama, Masashi Miura and Sang-Seok Lee, Tottori University, Japan

Akihiro Maeda and Akihiro Mori, Environment Sanitation Research Center, Tottori, Japan

We designed and fabricated a microfluidic device based a sensor detecting chlorophyll a concentration and turbidity at the same time to monitor water quality. Sensor was fabricated using transfer technique of PDMS resin. We also performed a measurement of turbidity with standard sample solutions to clarify the correlation between photovoltage and turbidity. As a result, we could successfully confirm the relationship between photovoltage and turbidity.

[145] A Preparation of 2D and 3D Gelatin Scaffolds for Cell Culture in a Microfluidic Platform

Tepparit Wongpakham, Theerawat Tharasanit, Werayut Srituravanich and Alongkorn Pimpin, Chulalongkorn University, Thailand
Witsaroot Sripumkhai and Wutthinan Jeamsaksiri, Thailand Microelectronics Center (TMEC), Thailand

In recent years, a wide variety of microfluidic cell culture platforms has been developed to mimic and control the in vivo cellular microenvironment. This is due to the microfluidic device provides the possibility to culture tiny cell clusters or single cells in either two dimensional (2D) or three dimensional (3D) models. In addition, this cell culture technique can drive in vitro models toward the physiologic complexity of an in vivo animal model system with incorporate mechanical and chemical cues including fluid shear stress, surface topography, stiffness, tension, compression or chemical to mimic physiological microenvironments such as small structure in the extracellular matrix (ECM) and chemical signaling. Among various materials, gelatin, a biodegradable biomaterial, which has been extensively used for medical, pharmaceutical, and cosmetic applications, was often selected as the scaffolding materials of cell seeding. In this study, we aim to systematically investigate the role of topographical and mechanical stimulus on cells. Cells are harvested and cultured on 2D and 3D scaffolds made of gelatin thin film and gelatin microparticles within flat and array of wells microfluidic devices under the influence of fluid shear stress on cells.

[18] Target Recycling Signal Amplification Based Microarray Platform for High-Efficiency DNA Detection

Shixing Chen, Yuelin Wang and Tie Li, Shanghai Institute of Microsystem and Information Technology（SIMIT）, Chinese Academy of Science, China

Ultrasensitive DNA detection technologies without enzyme-based amplification held great promise. Herein we report a novel target recycling signal amplification method based on microarray platform system. Especially, the target recycling was achieved by a strand displacement process, no needing the help of any enzymes. In the presence of target DNA, the recycling system could be activated to generate a cascade of assembly steps with three hairpin DNA segments. Each recycling process were accompanied by a disassembly step that the last hairpin DNA segment displaces target DNA from the complex at the end of each circulation, freeing targets to activate the self-assembly of more Y shape DNA structures. This target recycling signal amplification method could detect target DNA at fM level, demonstrating its high sensitivity.

[134] Temperature Control System for Resonant Micro-Gravimetric Analyzer Based on ARM

Peng Xu, Mengmeng Cheng, Tianhai Lu and Dacheng Xu, Soochow University, China
Haitao Yu, State Key Lab of Transducer Technology, China

Advanced materials are becoming increasingly important in sensors, new energy and healthcare fields recently. The Resonant Micro-Gravimetric Analyzer (RGA) can quantitatively analyze the adsorption capacity and desorption capacity of advanced materials in shorter time than traditional material analysis method. The chemical MEMS sensor of RGA designed by resonant microcantilever structure can detect the mass change of materials at pg level through resonant frequency change of microcantilever. Microcantilever is loaded with the materials to be evaluated for a gravimetric sensing experiment. Temperature-varying experiment based on gravimetric sensing in RGA achieves the thermodynamic and kinetic parameters, which can characterize the performance of the materials in essence. The precision and stability of temperature environment deserves attention in this experiment. Therefore, an accurate and stable temperature control system designed for chemical experiment is proposed in this paper. The experiment results show that, this system achieves the temperature range of 0~100℃ and accuracy within ±0.1℃, which satisfies the RGA temperature requirement.

16:30 - 16:45

Coffee Break (Hallway outside Lecture Theatre B)

16:45 - 18:00

C4a: Physical Sensors, Micro/Nano Fluidics (Lecture Theatre B, Academic Building)

Keynote Speech: [156] Identification of Surface Nanobubbles and Resolving the Mechanical Properties of Liquid-Vapor Interface at Nanoscales

Longquan Chen, University of Electronic Science and Technology of China, China

Surface nanobubbles are nanoscopic gaseous domains populating on immersed substrates. They are difficult to be distinguished from hydrophobic droplets and particles due to their small sizes. In this talk, we introduce two approaches to differentiate nanoscopic gaseous, liquid, and solid structures: one is based on hydrodynamics and the other is based on force-distance curve by atomic force microscopy. We further show that the force-distance curve also allows us to characterize the mechanical properties of liquid-vapor interface at nanoscales.

Biography:

Dr. Chen received his Dr.-Ing. from the Technische Universität Darmstadt in 2013, and currently is a professor in the Department of Physics at the University of Electronic Science and Technology of China. His research focuses on interfacial fluids, nanomechanical measurements and microfabrication.

[112] 3D Printed Micromixer with Dual Helical Structures Characterized Asymmetric Split-and-Recombine Microchannel

Kunpeng Zhang, Zhou Zhou, Xiaojun Chen, Dezhi Wu and Daoheng Sun, Xiamen University, China

A 3D printed effective micromixer is proposed with dual helical structures characterized asymmetric split-and-recombine microchannel (DHASAR). The optimal diameter ratio n=2 was determined through simulations. Mixing performance and pressure drop analysis were conducted to characterize the proposed DHASAR micromixer.

[55] Droplet Array Generated by Biomimetic Structure of Nepenthes Peristome Surfaces

Zhiting Peng, Tianzhun Wu and Hui Yang, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, China

Here we exploited a novel pump-free and high-throughput droplet generation method using planar microfluidics, which is consisted of a micro-patterned polydimethylsiloxane (PDMS) substrate and a polyethylene terephthalate (PET) substrate. We demonstrated the high-throughput droplet generation in Figure 6, all of which were performed by using the above mentioned devices. We showed that the microfabricated structure mimicking nepenthes peristome surface produced droplet array with good uniformity.

[91] Microfluidic Reactors for Conversion of CO_2 into Glucose Precursor

Yujiao Zhu, Department of Applied Physics, Hong Kong Polytechnic University, Hong Kong
Jinlin Long, School of Chemistry and Chemical Engineering, Fuzhou University, China
Xuming Zhang, Department of Applied Physics, Hong Kong Polytechnic University, Hong Kong; Hong Kong Polytechnic University Shenzhen Research Institute, Shenzhen, China

This paper reports the use of enzyme-immobilized microfluidic reactor to convert CO_2 into glucose precursor with great feasibility, stability and reusability.

[135] Improved Nanoparticle Concentrator Chip Using AC Electroosmosis

Kensuke Fujita, Ken Yamamoto and Masahiro Motosuke, Tokyo University of Science, Japan

In this study, we developed a nanoparticle concentrator chip which can extract concentrated nanoparticle solution from the outlet relying alternating-current electroosmosis (ACEO). In this paper, we investigated the particle accumulation characteristics with different flow velocity to achieve a highly concentration level and confirmed that nanoparticle solution was successfully extracted with the increased concentration of more than four-fold concentration. The developed chip would lead to highly advanced nanoparticle analysis or sensing for virus or pathogen.

C4b: Physical Sensors, Micro/Nano Fluidics (Lecture Theatre D, Academic Building)

Keynote Speech: [164] Droplet Manipulation for Biomedical Applications Based on Bionic Surface Engineering

Tianzhun Wu, Shenzhen Institutes of Advanced Technology, Chinese Academy of Science, China

Droplet manipulation including droplet generation, mixing, splitting, capturing, storage and transport are fundamental and crucial for various biochemical reactions on chip and other medical applications, and they are strongly affected by the basic phenomena such as surface tension, wetting, diffusion and flow dynamics, which can be well controlled and tuned using various bionic MEMS surface engineering, such as construction of micro/nano structures, chemical treatments and material modifications. In this talk I will briefly introduce recent works of our group on this topic, including the droplet manipulation using patternable ultra-slippery surfaces, facile “droplet tweezer” based on stretchable superlyophobic surfaces (SLSs) and digital counting of droplet trains/arrays for high-throughput, high-sensitivity detection of DNA and protein for in vitro diagnostics.

Biography:

Tianzhun Wu received his bachelor and master degree of engineering in 2002 and 2004 respectively from Tsinghua University, China， and pursued his doctoral degree from 2006 to 2009 in the University of Tokyo, Japan. He worked as the postdoctor fellow in the University of Tokyo and Osaka University, then the assistant professor in Sun Yat-sen University. Since 2013 he became the associate professor and the founding director of the Research Center of Micro/nano Systems and Bionic Medicine with Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences (SIAT-CAS), and was promoted as the full professor in 2016. He has research experiences of more than 15 years on multi-disciplinary micro/nano materials, fabrication and devices, and his research interests including BioMEMS, MicroTAS and micro/nano surface engineering. He has published more than 30 SCI papers on famous international journals such as *Adv. Mater., J.Mater. Chem., Lab Chip* and so on. He has more than 18 granted patents of invention and more than 30 patents of invention pending including 8 PCT. He was awarded the honor of excellent youth of Guangdong Natural Science Foundation and Shenzhen Peacock Personnel (Calibri B Level), and served as the youth councilman of the Chinese Society of Micro/Nano Technology.

[142] Extraction of "Real Friction Coefficient" Depending on Micro Surface Roughness Using High Resolution MEMS Tactile Sensor

Kazuki Watatani, Kyohei Terao, Fusao Shimokawa and Hidekuni Takao, Kagawa University, JST-CREST, Japan

In this paper, interaction between micro area friction and its surface roughness is analyzed dynamically based on the measurement results using high resolution tactile sensor for the first time. Two components of frictional forces caused by "normal force" and "fine surface shape" are analytically expressed as a clear dynamic model. Using the high resolution tactile sensor with sharp contact tip, we can know "the real friction coefficient" which is considering the effect of surface roughness by applying the model and measurement results. It is clearly shown that frictional force has strong dependency on the surface micro roughness. Considering the surface micro shape of roughness, real friction coefficient is calculated and extracted even in a uniform material.

[143] Measurement of Touch Feeling on Hair Surface Using High Resolution Two-Axis MEMS Tactile Sensor

Kota Nakamitsu, Kazuki Watatani, Kyohei Terao, Fusao Shimokawa and Hidekuni Takao, Kagawa University, Japan

In recent years, as tactile measurement technology has improved, and there is an increasing demand for the sense of touch of various objects. Especially, the tactile information on the surface of human body is interesting because it is beneficial in terms of medical care, nursing and beauty. In this study, we focused on the sense of touch on hair. So far, we have developed the MEMS tactile sensor which can measure a micro surface shape and a frictional force at same position. In this paper, human's hair was measured using the MEMS tactile sensor. The results of measurement derived from directionality of hair surface structure using the MEMS tactile sensor is reported for the first time.

[120] Adhesion-free Separation of Particles/Cells Using Three Dimensional Negative Dielectrophoretic Force

Mio Mizoguchi, Ken Yamamoto, Babita Shashni, Shin Aoki and Masahiro Motosuke, Tokyo university of science, Japan

Single cell analysis would help extracorporeal diagnosis, drug development, and evaluation of treatment effect. Therefore, separation and recovery of specific cells from cell population have been actively researched. Although many methods have been suggested, we focused on dielectrophoretic (DEP) methods which can separate and recover similar-sized viable cells without labeling. Many researchers often use positive DEP in their methods, however, adhesion of target particles/cells to electrode edges frequently occurs due to the concentrated electric field. In this study, we developed a device that can prevent the adhesion of target particles/cells by using negative DEP and demonstrated 98.2% separation efficiency of two similar-sized polystyrene particles with different labeling.

[48] Design of a 3-axis MEMS Gyroscope Based on a Fully Differential Operation

Kuan-Ju Tseng and Sheng-Shian Li, Department of Power Mechanical Engineering, National Tsing Hua University, Hsinchu, Taiwan, Taiwan
You-Hong Huang, Inst. of NanoEngineering and MicroSystems National Tsing Hua University, Hsinchu, Taiwan, Taiwan
Ming-Huang Li, Micro and Nanotechnology Lab, University of Illinois Urbana-Champaign, IL, USA, Taiwan

A 3-axis MEMS gyroscope is designed and fabricated using an SOI-MEMS foundry technology. For the consideration of area and power, single driving loop is utilized for the coupling of Coriolis force. As the device is capacitively actuated and sensed, a fully differential operation is implemented to lower down the feedthrough level, meanwhile, also reducing the unwanted signals stemming from rotations of different axis. The quality factor is measured to be 33,450 for the driving

mode while exceeding 10,000 for all the sensing modes in vacuum. The pick-up signal in the driving loop is amplified with customized PCB. Then, with the aid of a Lock-in amplifier, oscillation is formed. The rate signal is observed in a spectrum analyzer, and the resolution is measured to be 5.4 deg/s in air for the rate signal from z axis.

D3: Biological, Medical, Chemical Sensors (Lecture Theatre E, Academic Building)

[25] MEMS Flow Sensor Integration into Tracheal Tube Device and Its Application to Respiration and Heartbeat Signal Detection in Infant

Yuki Mitsunari, Yoshihiro Hasegawa and Mitsuhiro Shikida, Hiroshima City University, Japan
Miyoko Matsushima and Tsutomu Kawabe, Nagoya University, Japan

MEMS flow sensor was integrated to a part of the infant type of tracheal tube. Three elements, a heater, flow direction sensors, and temperature compensation sensor were fabricated on the polyimide film, and they were assembled to the inside surface of the tube. Produced MEMS tube sensor was inserted into the PDMS adaptor, and they were mounted to the inside space of the slip joint. A developed the tracheal tube with MEMS flow sensor was applied to the airway of rat to measure the airflow. Both respiration and heartbeat values were successfully obtained from the airflow at the airway by applying FFT analysis.

[45] A Versatile Cell Poration Method for the Enhancement of Intracellular Uptake Using a Piezoelectric Hypersonic Resonator

Xinyi Guo, Zhixin Zhang, Hongxiang Zhang, Yanyan Wang, Wei Pang and Xuexin Duan, State Key Laboratory of Precision Measuring Technology & Instruments, Tianjin University, China

Efficient delivery of exogenous materials such as therapeutic agents, genes and probes into cells is of great importance. In this work, we developed a novel chemical-free intracellular delivery method based on hypersonic electromechanical resonators (with a frequency over GHz), which can directly induce stress on cell membranes, create reversible pores and successfully deliver anti-cancer drugs and genes into nucleus. The delivered amount can be well-controlled by tuning simple parameters, and localized drug delivery can be easily achieved owing to the miniature of the resonator. Both theoretical analysis and cell experiment have proved the high delivery efficiency of hypersonic poration, demonstrating it to be a promising method in biological researches and clinical applications.

[58] In-situ Synthesis of CdS Nanowire Photosensor for Chemiluminescent Immunoassays

Jae-Chul Pyun, Hong-Rae Kim, Byong-Gi An and Young-Wook Chang, Yonsei University, South Korea
Jae-Gwan Park, Korea Institute of Science and Technology (KIST), South Korea

A hypersensitive CdS nanowire (NW) photosensor was fabricated by an in-situ synthesis process that involved the direct synthesis of CdS NWs on an interdigitated electrode (IDE). Analysis of the photoresponse properties showed that the newly synthesized photosensor had enhanced sensitivity and a highly reproducible photoresponse compared to photosensors prepared from CdS NW suspensions. The NW photosensor was applied to measure the chemiluminescence of luminol, and the sensitivity was compared to a commercial photosensing system. Finally, the feasibility of the CdS NW photosensor for the application to the medical diagnosis of the human hepatitis B surface antigen (hHBsAg) was demonstrated using a lateral-flow immunoassay with a chemiluminescent signal band.

[70] An Evaluation Method for Electrochemical Imaging of High-density Ion-image Sensor

You-Na Lee, Takeshi Araki, Yasuyuki Kimura, Tatsuya Iwata, Kazuhiro Takahashi, Kazuaki Sawada and Toyohashi University of Technology, Japan

To achieve the detailed insights into cellular and sub-cellular biochemical functions, the ion-sensitive field effect transistor arrays of high-density pixels was introduced. While these arrays were able to monitor the dynamic behavior of chemical substance in 2-dimsional imaging, the spatial resolution of the images has to be improved for catching the biochemical signal transfer. In our previous work, a high-density (HD) 256×256-pixel array with the imaging performance of 2-μm was designed and simulated. The device characteristics are compared with the reported other HD ion-image sensors to confirm that our ion-image sensor has competitive pixel size. By using the proposed sensor, we evaluate the practical spatial resolution for ion detection in biological environments. The detection limit of the practical resolution is 4 μm. The relative difference under 10 % can be obtained for the spacing above 8 μm.

[35] Study on Deposition Condition of PIC Membrane for Enzyme-Type Label-Free ATP Image Sensors and Extracellular Imaging of Hippocampal Slice

Hideo Doi, Tomoko Horio, Tatsuya Iwata, Koichi Okumura, Kazuhiro Takahashi, Toshiaki Hattori and Kazuaki Sawada, Toyohashi university of technology, Japan
Parajuri Bijay and Schuichi Koizumi, Yamanashi university of technology, Japan

Effects of a deposition condition on the output response of 128×128-pixel enzyme type label free Adenosine Triphosphate (ATP) image sensors with a polyion complex (PIC) method was studied, and they were applied to extracellular imaging of hippocampal slice. The 3-4 μm-thick membrane sensor exhibited, a detection limit of 10 μM ATP. After a hippocampal slice, which was put on the sensor, was electrically stimulated, the sensor output increased by 5 mV. Consequently, a possibility of label free imaging of ATP released from hippocampal slices was demonstrated.

18:30 - 21:00

Conference Banquet (Crowne Plaza Hong Kong Kowloon East)

Wednesday, 27 June 2018

9:00am-9:40am	**Plenary Talk 5**: Xinxin Li, SIMIT, China (Lecture Theatre B, Academic Building)		
9:40am-10:20am	**Plenary Talk 6**: Sergej Fatikow, University of Oldenburg, Germany (Lecture Theatre B, Academic Building)		
10:20am-10:35am	**Coffee Break** (Hallway outside Lecture Theatre B)		
10:35am-12:05pm	**E1: Actuators, Force Sensors, Power MEMS** (Lecture Theatre B, Academic Building)	**E2: Actuators, Force Sensors, Power MEMS + RF MEMS/NEMS, Internet of Things (IoTs)** (Lecture Theatre D, Academic Building)	**G1: Optical MEMS and Nano-Photonics** (Lecture Theatre E, Academic Building)

9:00 - 9:40

Plenary Talk 5: Xinxin Li, Shanghai Institute of Microsystem and Information Technology, China (Lecture Theatre B, Academic Building)

Optimal Sensing-Nanomaterials Guided by Thermodynamic/Kinetic Material-'genome' Parameters

High-performance sensing nanomaterials are highly demanded in detection applications of trace-concentration biological and chemical molecules in gaseous or liquid-phase environment. The presentation addresses various types of functional sensing-nanomaterials such as CNT, graphene, mesoporous-silica, hyper-branch polymer, ZnO2-NW, MOF and multi-dimensional cooperative nanostructures. The sensing nanomaterials are loaded or even *in situ* self-assembled onto the main microsensor structures like resonant microcantilever, heating microplate or electrode-printed paper substrate for sensing signal readout. The detection targets include harmful VOCs, metal ions in water and biomolecules like DNA double-strand or dopamine. The developed sensing nanomaterials feature ultra-high sensitivity and have been used for trace-level detection. In order to comprehensively optimize the performance among sensitivity, sensing speed, stability and selectivity, the apparent performance of the sensing material is traced back to the nature of molecular interaction with the sensing-material, by quantitatively extracting the governing thermodynamic/kinetic parameters like enthalpy, entrapy, Gibbs free-energy and activation-energy. Guided with the obtained material-'genome' parameters, the sensing nanomaterials have been overall evaluated and synergistically optimized for improved sensing performance.

Biography:

Prof. Xinxin Li received B.S. degree from Tsinghua University and Ph.D. degree from Fudan University. Thereafter, he sequentially worked in Hong Kong University of Science and Technology as a Research Associate, in Nanyang Technological University, Singapore as a Research Fellow and, then, joined Tohoku University, Japan, as a Lecturer (COE fellowship). From 2001 to now, he has been a professor and now serves as the Director of the State Key Lab of Transducer Technology, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences. He has also served as Adjunct Professor in Fudan University, Shanghai Jiaotong University, Dalian University of Technology, ShanghaiTech University and Soochow University. From 2009-2013, he had served as Consultant Professor for World Class University Program of Korean in Chonnam National University, Korea. He was granted the National Science Fund for Distinguished Young Scholar in 2007. His Ph.D. student was awarded National Excellent 100 Ph.D. Dissertation in 2009. Prof. Li's research interest includes micro/nano sensors and MEMS/NEMS. He has invented about 100 patents and published about 400 papers in referred journals and conferences (including more than 200 SCI journal papers). He is now serving as TPC member for the conferences of IEEE MEMS and International Steering Committee member for Transducers. He is now the editor for NPG journal of Microsystems and Nanoengineering, the editorial member for Journal of Micromechanics and Microengineering and Scientific Reports.

9:40 - 10:20

Plenary Talk 6: Sergej Fatikow, Division for Microrobotics & Control Engineering (AMiR), University of Oldenburg, Germany (Lecture Theatre B, Academic Building)

High-Precision Robotics for Industry: Key Research Issues

Current research activities in AMiR focus on the industrial microrobotics and nanoscale automation. The areas of research include nanohandling robots and systems; automated nanohandling methods; robot control methods for nanopositioning; fast vision feedback at nanoscale, etc. Prof. Fatikow introduces this rapidly developing research field, the motivation, the key research problems and industrial applications. He addresses the current work on an automated microrobot cell inside a scanning electron microscope (SEM). The latter serves as a powerful vision sensor and the work space for nanohandling robots equipped with application-specific tools. Major components – the piezo-driven nanohandling robots, the robot control system, the fast vision feedback – are discussed. Finally, current research projects in AMiR and related industrial applications are outlined. They include automated assembly of nanophotonic structures, nano-robotic handling of graphene, automated characterization of nanomaterials, and others

Biography:

Professor Dr. Sergej Fatikow studied electrical engineering and computer science at the Ufa Aviation Technical University in Russia, where he received his doctoral degree in 1988 with work on fuzzy control of complex non-linear systems. During his work in Russia he published over 30 papers and received over 50 patents. In 1990 he moved to University of Karlsruhe in Germany, where he initiated the new research field of microrobotics. He became an assistant professor in 1996 and received his habilitation at University of Karlsruhe in 1999. In 2000 he accepted a professor position at the University of Kassel, Germany. A year later, he established a new Division for Microrobotics and Control Engineering (AMiR) at the University of Oldenburg, Germany. Since 2001 he is a full professor in the Department of Computing Science and Head of AMiR. His research interests include micro/nanorobotics, industrial robotics and automation at nanoscale, nanohandling inside SEM, AFM-based nanohandling, sensor feedback at nanoscale, and robot control. Professional activities include:

- Three books on MST, microrobotics and microassembly, robot-based nanohandling, and automation at nanoscale; over 120 book chapters and journal papers and over 250 conference papers.
- Founding Chair of Int. Conf. on Manipulation, Automation and Robotics at Small Scales (MARSS, 2016−), Founding Chair of Int. Conf. on Manipulation, Manufacturing & Measurement at Nanoscale (3M-NANO, 2011−), Chair of IEEE-RAS Technical Committee on Micro/Nano Robotics and Automation (2012−).
- Editorial Board of IEEE Robotics and Automation Letters (2015−), Int. J. of Adv. Robotic Systems (2015−), IEEE-ASME Trans. on Mechatronics (2010−2013, 2015−), Chinese J. of Mechanical Engineering (Springer, 2013−), J. of Micro-Bio Robotics (Springer, 2012−), IEEE Trans. on Automation Science & Engineering (2011−), Int. J. of Intelligent Mechatronics & Robotics (ICI-Global, 2010−), Int. J. of Optomechatronics (Taylor & Francis, 2009−).
- Acquisition and coordination of numerous projects. The research fund since 2001 is over 16 million Euro.
- Best Paper awards at 2014 IEEE-NEMS, 2011 IEEE Int. Conf. on Mechatr. & Automation, 2010 IEEE Int. Conf. on Automation Science and Engineering, 2010 IEEE ECTI-CON, 2006 SPIE Optics East, 2005 Int. Conf. on Automation, Robotics & Auton. Systems. Koh Young Best Paper award 2007 of Int. J. of Optomechatronics.
- 1000 Talent Plan chair professor at South China Univ. of Technology (2011−), Adjunct professor at Zhejiang Univ., China (2009−), Distinguished visiting fellow of Univ. Pierre and Marie Curie (Sorbonne), France, Distinguished visiting fellow of the Royal Academy of Engineering, UK); Elected fellow of the Int. Society for Nanomanufacturing, Advisory Board member of Robotics Engineering Dept., DGIST, South Korea, ...
- Reviewer/Evaluator for the EU, DFG, SNF, NSF, NRF, ANR, DNRF, RGC-HK, NSERC, IEEE-RAS, etc.
- Member of a professor search committee at several international universities.

10:20 - 10:35

Coffee Break (Hallway outside Lecture Theatre B)

10:35 - 12:05

E1: Actuators, Force Sensors, Power MEMS (Lecture Theatre B, Academic Building)

[53] Switching of a Micromachined Bistable Mechanism with Small Amplitude Vibration

Han Du, Fook Siong Chau and Guangya Zhou, National University of Singapore, Singapore

Curved beams have been widely used as micro bistable structures. However, the switching of a bistable mechanism that is based on a curved beam usually requires large actuation force and stroke. For some applications which may require a large distance between two states, switching statically using actuators with small stroke can be difficult. Thus, to achieve state switching of the curved-beam-based bistable mechanism with small actuation stroke, we propose a dynamic actuation method in a 2-degree-of-freedom (2-DOF) vibration system. By specially designing the mass ratio (m1/m2) and spring constant ratio (k1/k2), large oscillation amplitude ratio (A2/A1) can be achieved. Consequently, by driving on mass m1 with small actuation stroke, an amplified vibration amplitude can be achieved on mass m2, which subsequently switches the bistable mechanism designed for mass m2.

[85] PZT Based Bimorph Micro-Actuator with Low Thermal Budget Polysilicon as Passive Structure

Ssu-Han Chen, Aron Michael and Chee Yee Kwok, University of New South Wales, Australia

A bimorph thin film PZT micro-actuator with thick polysilicon as a passive structural layer is reported. A simple micro-cantilever actuator consisting of 1000 um long and 250 um wide with 4 um thick polysilicon structure flanked by a piezoelectric active layer on the top and bottom side has been fabricated to demonstrate the novel bimorph configuration. The actuator displays a flat profile with minimal tip deflection which indicates a balanced stress distribution in the structure. It is driven alternatively in both directions, demonstrating its unique suitability for micro-actuation mechanisms where a passive structural layer is required to enhance the mechanical performance and reliability of the system. The static and dynamic measurements show similar characteristics for the top and bottom actuation. The actuator has a measured resonance frequency of 6.3 kHz, and displacement voltage sensitivities of 17.9 nm/V and 25.6 nm/V in the upward and downward direction, respectively.

[33] Local Control of the Cross-Sectional Shape of the Artificial Biomimetic Tube by Pneumatic Balloon Actuator

Fumitaka Oya and Satoshi Konishi, Ritsumeikan University, Japan

This paper reports an artificial biomimetic tube which can form various shapes on demand. Previously, we developed the openable artificial biomimetic tube, which can be opened and closed appropriately [1]. The diameter and length of the tube was 1mm and 10mm. In this study, we design an openable tube composed of three sections of pneumatic balloon actuators (PBAs). Each section has parallelly arranged PBAs which can be driven in batch. We prepared novel artificial biomimetic tube composed of independent sections which can be deformed individually. We estimated the change of a cross-sectional shape as well as tensile strain. The strain affects cultured cells on the artificial biomimetic tube. Our proposed device will provide various conditions which can mimic the small intestine.

[105] Low-Frequency Wearable Energy Harvesters Generated from Human Joints Movement

Keli Li, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences; Shanghai Normal University, China
Qisheng He, Ruofeng Han, Jiachou Wang and Xinxin Li, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences; University of Chinese Academy of Sciences, China
Zhiguo Zhou, Shanghai Normal University, China

In this paper, a novel wearable energy harvester is developed to efficiently harvest energy from low-frequency human joints movement. An electroplated nickel-cantilever is integrated with a piezoelectric-film and bonded on a flexible substrate. Based on the magnetic interaction between the magnetized cantilever and the magnet, the harvester can frequency-up-conversion transfer kinetic energy of low-frequency human joints movement to high-frequency resonance of the cantilever. The harvester can generate stable and considerable electric-power for every movement cycle even when the frequency=0.5Hz. In addition, this proposed energy harvesting scheme can also realize a two-dimensional harvester generated from multi-direction excitation.

[68] Complementary Plasmonic Absorbers for Visible-Light Photcatalysis

Yat Lam Wong and Xuming Zhang, Department of Applied Physics, HK Polytechnic Univeristy, Hong Kong

Gold complementary plasmonic nanostructures (nanohole and nanoparticle array) integrating with TiO2 are studied on its ability to enhance the visible-light photocatalytic performance of TiO2.

E2: Actuators, Force Sensors, Power MEMS + RF MEMS/NEMS, Internet of Things (IoTs) (Lecture Theatre D, Academic Building)

[104] A High-Efficiency Threshold-Triggered Energy-Harvester for Sub-g Weak Vibration

Qisheng He, Ruofeng Han, Jiachou Wang, and Xinxin Li, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences; University of Chinese Academy of Sciences, China
Keli Li, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China

In this paper, a micro threshold-triggered energy-harvester, which employs two-stage ferromagnetic-coupling scheme, is proposed and developed to high-efficiently frequency-up convert sub-g weak-vibration energy into electricity. Once the vibration exceeds the threshold, the harvester can be triggered in to considerable generating state, otherwise, the harvester keeps in idle state with negligible generated power. Since small and fixed gap-distance between the two stages induces strong magnetic coupling, the sub-g harvester features high-efficient frequency-up-conversion electric-generation under sub-g weak vibration. In this scheme, the threshold is set by adjusting the attached seismic mass. The sub-g harvester generates 0.72μW power under 0.25 g vibration that is about 4 times higher than that of the previous harvester.

[9] Electrostatic Energy Harvester with Double Sided Electrodes for Force Reduction

Hiroki Uchida, Takayuki Fujita, Kensuke Kanda and Kazusuke Maenaka, University of Hyogo, Japan

This paper describes the double-sided electrodes electrostatic energy harvester for reducing attraction force and pull-in phenomenon. A horizontally symmetric structure and double-sided electrodes can reduce electrostatic attraction force that occurs opposite direction. From the preliminary design, we revealed the electrical power will be doubled by doubled effective harvesting area despite of no attraction force increasing.

[146] Low Resistance RF Micro Coil with Scroll-Shaped Structure for MRI

Chun-Hao Tseng and Tetsuji Dohi, Chuo University, Japan

This paper reports a low resistance RF micro coil with scroll-shaped structure for magnetic resonance imaging (MRI). The RF micro coil was fabricated by vacuum evaporation and electroplating copper (Cu) onto the three-dimensional (3D) printed scroll-shaped structure.The resistance of scroll-shaped coil at the frequency of 86 MHz was measured at 0.81 Ω. Compared to spring-shaped coil, the resistance of scroll-shaped coil decreased by 65%. The SNR of the scroll-shaped coil was 56, 40% higher compared to the spring-shaped coil experiment.

[20] Passive Wireless Pressure Sensitive Smart Bandage for Wound Management

Wenjun Deng, Lifeng Wang, Lei Dong and Qing-An Huang, Southeast University, China

Wound management relates to millions of patients' rehabilitation, it is important to monitor different factors that can affect wound healing, including pressure. In this work, we propose a novel low cost wireless pressure sensitive smart bandage for wound management. This smart bandage comprises of a flexible LC-type passive wireless pressure sensor enclosed by a commercial bandage acting as a cover package. The resonant frequency of the sensor changes in response of applied pressure, allowing a remotely monitoring with a readout coil. The passive wireless features of the LC-type pressure sensor make the wound management unlimited by wire connection and battery life. The resonant frequency of the sensor is observed to be a linear function of applied pressure in a range of 0-200 mmHg, with a sensitivity of -270.8 kHz/mmHg when the bandage is attached to the skin. All materials utilized to fabricate the smart bandage are completely flexible and wearable. This design can minimize the additional forces applied on the wound, and maximize the patient's comfort.

G1: Optical MEMS and Nano-Photonics (Lecture Theatre E, Academic Building)

Keynote Speech: [166] MEMS Based Multi-Spectral Dual-Axis Confocal Microendoscope

Wibool Piyawattanametha, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand

MEMS based microendoscopes have become important imaging tools for early cancer diagnosis and precise tumor resection. Due to various technical challenges, few microendoscopes have been translated to clinics or applied to human patients. Through synergistic collaborations, we have developed novel MEMS scanner enabled microendoscopic multispectral (640nm to 780nm) three- dimensional dual-axis confocal fluorescent imaging system for translational applications, including early cancer detection and staging on colorectal cancer, molecular imaging guided surgical navigation on head and neck cancer. Based on dual-axis confocal microscopic architecture, we have miniaturized the imaging system with compact form-factor by integrating micro-optics and a patterned gold coated MEMS scanner, which have been custom-made and mass-produced in the nanofabrication foundry. The metal coating of the scanning mirror provides over 80% high reflectivity over near infra-red range. Both axes of the MEMS scanner could perform large tilting angle (> 6 degrees mechanical scan angle) at DC and resonant mode. By advanced computational imaging approach, we have achieved real-time cross-sectional imaging in either raster or lissajous pattern scanning with fast frame rate (> 10 Hz) with large field-of-view (> 600 microns). Advanced real-time mosaicing algorithm has been developed to achieve broader view in millimeter scale. By utilizing molecular contrast probes conjugated with fluorescence dye, we have successfully demonstrated multi-spectral ex-vivo and in-vivo imaging on small animal tumor models and human tissue specimens, aimed for both early cancer detection and molecular imaging guided surgical navigation.

Biography:

Dr. Piyawattanametha received Ph.D. degree in Electrical Engineering from the University of California, Los Angeles, USA in 2004. Currently, he is with the King Mongkut's Institute of Technology Ladkrabang, Ladkrabang, Thailand as the Director of Advanced Imaging Research (AIR) Center. In 2013, he was selected by the World Economic Forum (WEF), Switzerland to be one of the 40 top young scientists under the age of 40. In 2014, he was one of the two recipients in the world to receive the prestigious Fraunhofer-Bessel Research Award from the Alexander von Humboldt Foundation, Germany for his pioneering work in light microendoscopy techniques. In 2015, he was awarded the Newton Fund Researcher Links from the British Council, United Kingdom for his novel optical imaging technique for early cancer detection. In 2017, he was selected to be a fellow in Leaders in Innovation Fellowships (LIF) from The Royal Academy of Engineering, United Kingdom.

[7] CMOS Image Sensor Using Two Photodiodes with Different Sensitivity and Switching Circuit for Extending Dynamic Range

Jimin Lee, Byoung-Soo Choi, Sang-Hwan Kim, Chang-Woo Oh, Donghyun Seong and Jang-Kyoo Shin, Kyungpook National University, South Korea

The proposed CIS has been fabricated using a 0.18-μm standard CMOS process, and the size of the proposed pixel is 13 μm × 13 μm. VREF is controlled appropriately to use a high-sensitivity photodiode at the low illumination condition and a relatively low-sensitivity photodiode at the high illumination condition. The signal of the selected photodiode by VCOMP becomes the output signal of the pixel. Therefore, the pixel output signal is possible to select between VHIGH and VLOW by two photodiodes and switching circuit depending on illumination condition. The experimental results show that the dynamic range of the proposed CIS is extended.

[78] Miniature Solid Tunable Lenses Using Free-Form Surfaces

Yongchao Zou, Fook Siong Chau and Guangya Zhou, National University of Singapore, Singapore

Compact tunable lenses (focal length adjustable) are on high demand in many modern optical systems such as mobile phone cameras, surveillance cameras, and biomedical endoscopes. These lenses, having small footprints, slim profiles, and fast response time, can provide optical imaging systems with dynamic optical zooming and autofocus functions. Most reported tunable lenses use liquid materials and they have limitations such as mechanical vibration and thermal instabilities. Here, we present a kind of tunable lenses that use paired free-form optical surfaces and do not involve any liquid materials in their setups. They are driven by microelectromechanical systems (MEMS) based actuators and their focal lengths are adjustable by displacing paired free-form surfaces relative to each other. We then highlight the applications of such miniature solid tunable lenses in endoscopes to achieve autofocusing and zooming while maintaining their ultra-thin configuration.

[114] Plasmonic Enhanced Upconversion Luminescence and Its Applications

Hyungduk Ko and Kisun Park, Korea Institute of Science and Technology, South Korea

In this paper, we introduce plasmonic nanostructures that can effectively enhance the upconversion luminescence (UCL) and present application devices that can be realized by the UCL process.

[144] Development of MEMS Tunable Plasomonic Color Filter Based on Metal/Insulator/Metal (MIM) Subwavelength Grating

Masato Mitsudome, Atsuya Hirata, Kazuaki Sawada and Kazuhiro Takahashi, Electrical & Electronic Information Engineering, Toyohashi University of Technology, Japan

We report on a tunable plasmonic color filter composed by a freestanding metal/insulator/metal(MIM) subwavelength grating integrated with a MEMS actuator. The MIM grating improves wavelength selectivity on the plasmonic color filter to suppress a light leakage at long wavelength side by 50-655 point. We also demonstrated the nanomechanical stretch of MIM subwavelength grating by the integrated MEMS actuator for transmission color tuning.