IEEE-NANO

Macau SAR, China July 22-26, 2019

PROGRAM

The 19th IEEE International Conference on Nanotechnology

The 19th IEEE International Conference on Nanotechnology

IEEE-NANO 2019

Conference Digest

Macau SAR, China

July 22 – 26, 2019

IEEE-NANO 2019 PROCEEDINGS

IEEE Catalog Number:	CFP19NAN-ART
ISBN:	978-1-7281-2892-4
IEEE Catalog Number (USB):	CFP19NAN-USB
ISBN (USB):	978-1-7281-2891-7

Copyright and Reprint Permission:

The Institute of Electrical and Electronics Engineers, Inc.

Welcome Message

Welcome to the 19th IEEE International Conference on Nanotechnology (IEEE-NANO 2019). This is the IEEE's flagship conference on nanotechnology, which is held and sponsored annually by the IEEE Nanotechnology Council (NTC) focusing on advanced research areas related to nanoscience and nanotechnology. This year's conference will be held from July 22th to July 26th at the Parisian Macao, Macau, China, and is intended to bring together researchers, scientists and engineers from around world to present their latest findings, accomplishments, innovations, and visions in the related fields of nanoscience and nanoengineering.

For IEEE-NANO 2019, we have received more than 310 abstract submissions. We have reviewed the submissions and organized the technical sessions into 7 plenary lectures, 7 keynote lectures, 15 invited sessions with special invited speakers, 18 regular oral sessions, 2 poster sessions. Overall, the entire technical program consists of 194 oral presentations (including plenary, keynote and invited lectures) and 39 posters displays. We are looking forward to learning about the latest nanotechnology and nanoscience advancements around the globe from our contributors of both oral and poster presentations. On the other hand, networking has always been a cornerstone of IEEE-NANO conferences. Several networking activities have been scheduled during IEEE-NANO 2019 including the Welcome Reception and the Conference Banquet. We hope IEEE-NANO 2019 will be a memorable and exciting platform for attendees to exchange information and ideas, identify new research interests, establish collaborations, make friends, and find new opportunities for their career. As a note, IEEE-NANO 2019 will again offer three conference awards – ***Best Conference Paper Award***, ***Best Student Paper Award***, and ***Best Poster Award*** – and we will announce the awards winners at the Conference Banquet. Moreover, we will also present certificates to the winners of the NTC's 2019 ***Pioneer Award in Nanotechnology***, ***Early Career Award in Nanotechnology***, and ***Distinguished Service Award***. We hope you will join us at the Conference Banquet to congratulate all the awards winners and celebrate their accolades with them.

We must stress that we greatly appreciate the support and the contributions from the Organizing Committee members, the Technical Program Committee members, local staff, and student volunteers for this conference. IEEE-NANO 2019 will not have been possible without their commitment and great efforts. We also wish to thank all the people who have helped and supported this conference in one way or another. Last but not least, our heartfelt thanks go to the authors, the reviewers, the conference participants, the sponsors, and the exhibitors. It is your participation and contribution that has continued to make IEEE-NANO successful for so many years.

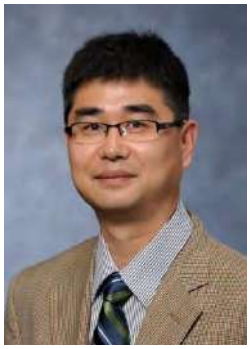
Besides enjoying the technical programs and networking activities during the conference, we highly suggest you to spend some time to enjoy the fascinating city of Macau, which is a special administrative region of China. According to Wikipedia, Macau was administered by the Portuguese Empire from the mid-16th century until 1999, when it was the last remaining European colony in Asia. In 1557, Macau was rented to Portugal from Ming Dynasty of China as a trading port. The Portuguese Empire administered the city under Chinese authority and sovereignty until 1887, when Macau, through a mutual agreement between the two countries, became a colony. Sovereignty over Macau was transferred to China on 20 December 1999. The Joint

Declaration on the Question of Macau and Macau Basic Law stipulate that Macau operate with a high degree of autonomy until at least 2049, fifty years after the transfer. Therefore, this city has a very rich collection of historical buildings reflecting the cultural heritages of both China and Portugal. We highly recommend you visit some of these sites recorded in the UNESCO World Heritage List: ***Ruins of St. Paul's***, ***Senado Square***, ***A-Ma Temple***, ***St. Lawrence Church***, ***Guia Fortress and Lighthouse***, ***Mandarin's House***, ***Dom Pedro V Theatre***, ***Na Tcha Temple***, etc.

Finally, we wish you a wonderful and enjoyable stay in Macau, China!

Lianqing Liu
General Chair

Wen Jung Li
General Co-Chair



Guangyong Li
Program Chair

IEEE-NANO 2019 Conference Committee

International Steering Committee

Toshi Fukuda (Nagoya University)
Stephen Goodnick (Arizona State University)
James Morris (Oregon State University)
Yufeng Jin (Peking University)
Wei Wang (Peking University)

General Committee

General Chair: Lianqing Liu (Shenyang Institute of Automation)
General Co-Chairs: Wen Jung Li (City University of Hong Kong)
Jin-Woo Kim (University of Arkansas, Fayetteville)
Yonhua (Tommy) Tzeng (National Cheng Kung University)
Program Chair: Guangyong Li (University of Pittsburgh)
Program Co-Chairs: Lombardi Fabrizio (Northeastern University)
Mingjun Zhang (Ohio State University)
Organizing Chair: Haibo Yu (Shenyang Institute of Automation)
Organizing Co-Chair: Zhenxing Wang (National Center for Nanoscience and Technology)
Finance Chair: Fanan Wei (Fuzhou University)
Publication Chair: Zhidong Wang (Chiba Institute of Technology)
Exhibition Chair: William Stanchina (University of Pittsburgh)
Exhibition Co-Chair: Li Zhang (The Chinese University of Hong Kong)
Sponsorship Chair: Walter Hu (University of Texas at Dallas)
Registration Chair: Lili Li (National Center for Nanoscience and Technology)
Publicity Chair: Zhan Yang (Soochow University)
Publicity Co-Chairs: Luca Pierantoni (Polytechnic University of Marche)
Masahiro Nakajima (Nagoya University)
Linlin Li (Beijing Institute of Nanoenergy and Nanosystems, CAS)
Local Arrangement Chairs: Qingsong Xu (University of Macau)
Lidai Wang (City University of Hong Kong)
Media Operations Chair: Shuai Yuan (Shenyang Jianzhu University)

Awards Committee

Best Paper Awards Chair: Xiaoning Jiang (North Carolina State University)

Program Committee

Program Chair: Guangyong Li (University of Pittsburgh)

Program Co-Chairs: Lombardi Fabrizio (Northeastern University)
Mingjun Zhang (Ohio State University)

Chairs of Tracks

Nano-acoustics

Chair: Xiaoning Jiang (North Carolina State University)
Co-Chair: James B. Spicer (Johns Hopkins University)

DNA Nanotechnology

Chair: Osamu Tabata (Kyoto University)
Co-Chair: Haitao Liu (University of Pittsburgh)

Nanobiology and Nano/bio-systems

Chair: Wenxue Wang (Chinese Academy of Sciences)
Co-Chair: Xuehai Yan, Chinese Academy of Sciences)
Yongliang Yang (Michigan stage University)

Nano-bio-imaging and Nanomedicine

Chair: Fang Yang (Southeastern University)
Co-Chair: Yu Zhang (Southeastern University)
Fan Zhen (Tongji University)

Nanoelectronics: Devices – SET, RTD, QD, Molecular

Chair: Dong-Kyun Ko (New Jersey Institute of Technology)
Co-Chair: Feng Xiong (University of Pittsburgh)

Nanoelectronics: Graphene and other 2D materials, CNTs and NWs

Chair: Jianshi Tang (Tsinghua University)
Co-Chair: Meng Li (Shenyang University of Technology)
Huanmin Li (University at Buffalo)

Nano/Molecular Heat Transfer & Energy Conversion

Chair: Zlatan Aksamija (University of Massachusetts-Amherst)
Co-Chair: Jinghua Hu (Wuhan University of Technology)

Nanomanufacturing and Nanoassembly

Chair: Yong He (Zhejiang University)
Co-Chair: D. Keith Roper (Utah State University)

Nanofabrication

Chair: Wei Wu (University of Southern California)
Co-Chair: Walter W. Hu (University of Texas at Dallas)

Nanomaterials: 2D Atomic Crystal Materials

Chair: Han Wang (University of Southern California)
Co-Chair: Jinshui Miao (Michigan State University)

Nanomaterials for Energy

Chair: Minlin Jiang (Nanchang University)
Co-Chair: Tzahi Cohen-Karni (Carnegie Mellon University)

Nanomaterials: Nanodielectrics

Chair: Michel Fréchette (Hydro-Québec)

Nano-Metrology and Characterization

Chair: Peng Li (National Center for Nanoscience and Technology)
Co-Chair: Hui Xie (Harbin Institute of Technology)

Nanomagnetics

Chair: Roy Chantrell (The University of York)

Nanopackaging

Chair: Pulugurtha Markondeya Raj (Georgia Tech)
Co-Chair: James E. Morris (Portland State University)
Katsuaki Suganuma (University of Osaka)
Chris Bailey(University of Greenwich)

Nano-Optoelectronics

Chair: Pao-Tai Lin (Texas A &M University)
Co-Chair: Kaikai Xu (University of Electronic Science and Technology of China)
Hong Koo Kim (University of Pittsburgh)

Nanophotonics

Chair: Liang Dong (Iowa State University)
Co-Chair: Qing Gu (The University of Texas at Dallas)

Plasmonics

Chair: Zhili Zhang, University of Tennessee, Knoxville
Co-Chair: Wei-Chuan Shih, University of Houston

Nanorobotics and Nanomanipulation

Chair: Lixin Dong (City University of Hong Kong)
Co-Chair: Yajin Shen (City University of Hong Kong)
Zhan Yang (Soochow University)

Nano Sensors and Actuators

Chair: Li Zhang (The Chinese University of Hong Kong)

Co-Chair: Xinyu Liu (McGill University)
Long Que (Iowa State University)

NEMS and Micro-to-nano-scale Bridging

Chair: Max Zenghui Wang (University of Electronic Science and Technology of China)

Co-Chair: Wen Li (Michigan State University)

Modeling and Simulation of Nanostructures and Nanodevices

Chair: Ki Wook Kim (North Carolina State University)

Co-Chair: Jean-Pierre Leburton (Beckman Institute for Advanced Science& Technology)

Spintronics

Chair: Supriyo Bandyopadhyay (Virginia Commonwealth University)

Quantum Computing

Chair: Nanrun Zhou (Nanchang University)

Late News Papers

Chair: HoYin Chan (City University of Hong Kong)

Associate Editors

Bandyopadhyay, Supriyo
Yu, Haibo
Dong, Liang
Dong, Lixin
Zhang, Li
Hu, Walter
Aksamija, Zlatan
Kim, Ki Wook
Tang, Jianshi
Kim, Hong Koo
Jiang, Minlin
Xie, Hui
Wang, Han
Yang, Yongliang
Jiang, Xiaoning
Li, Meng
Xiong, Feng
Fan, Zhen
Liu, Haitao
Lin, Pao
Miao, Jinshui
Spicer, James B.
Zhou, Nanrun
Li, Peng
Li, Huamin
Yang, Fang
He, Yong
Ko, Dong-Kyun
Zhang, Mingjun
Chan, Ho-yin
Wu, Wei

Reviewers

Aasmundtveit, Knut
Abbas, Yawar
Abburi, Aditya
Abdullah, Arif
Acharya, Manoranjan
AKITA, Seiji
Aksamija, Zlatan
Al-Dirini, Feras
Amer, Moh
Arai, Fumihito
Aravamudhan, Shyam
Asavakijthananont, Narawee
Atulasimha, Jayasimha
Baek, Chang-Ki
Balogun, Oluwaseyi
Banan Sadeghian, Ramin
Bandyopadhyay, Supriyo
Barangi, Mahmood
Barros, Michael
Barua, Radhika
Becherer, Markus
Bedewy, Mostafa
Bian, Ye
Bobinger, Marco Rudolf
Boctor, Emad
Bubanja, Vladimir
Burhanudin, Zainal
Cahay, Marc
Cai, Xinxia
Cao, Kun
Chen, Kuen-Lin
Chen, Mikai
Chen, Tao
Cheng, Jian-Yih
Chenying, Wang
Chien, Wei-Chih
Choi, Duk-Yong
Choi, Hongsoo
Choi, Won Mook

Cui, Yan
Dai, Liguo
Dai, Qing
Datta, Debopam
Deshmukh, Sanchit
Dhlamini, Mokhotjwa
Du, Xiaoqing
Du, Yanhao
Erickson, John
Fan, Xinjian
Fan, Zhen
Fan, Zheng
Forati, Ebrahim
Gao, Libo
Garg, Raghav
Gaulding, Ashley
Gong, Nanbo
Guo, Peijun
Han, Jin-Woo
He, Jin
Hsu, Chia-Ming
Hu, Benhui
Hu, Pan
Huang, Shengxi
Huang, Wenbin
Hui, Liwei
Huiyao, Shi
Isoshima, Takashi
Ito, Mitsuki
Ito, Takeshi
Jang, E-San
Janyasupab, Metini
Jia, Boliang
Jiang, Tao
Jin, Tiening
Jou, Jwo-Huei
Jung, Yeonwoong
Kahmei, Ralandinliu
Kailasam, Rathnakannan
Kang, Jeeun
Karahan, H. Enis
Ken Tye, Yong
Kim, Howuk
Kim, Jae Chul
Kim, Jaeyoun
Kim, Jinwook
Kim, Kihyun
Kim, Min A
Kong, Byoung Don
Krylyuk, Sergiy
La Torraca, Paolo
Lee, Chih-Ying
Li, Faqi
Li, Gongxin
Li, Minglin
Li, Pan
Li, Wei
Li, Yuanrui
Li, Zhou
Liao, Qinghong
Lin, Pao
Liu, He
Liu, Huicong
Liu, Jiankun
Liu, Leitao
Liu, Mei
Liu, Na
Liu, Peidang
Liu, Xiaochi
Lou, Xiaoping
Lourembam, Beloni
Luo, Jinping
Ma, Jessica
Maassen, Jesse
Maurano, Andrea
Meyyappan, M.
Muneer, Sadid
Murray, Todd
Oh, Soong Ju
Ok, Jong G.
Ouyang, Mengxing

Pawar, Vaishali
Pês, Beatriz
Potejana, Potejanasak
Prins, Ferry
Qin, Zhenpeng
Que, Long
Rama, Venkata Krishna Rao
Rao, Madhav
Rathore, Jitendra
Ren, Pinyun
Saudari, Sangameshwar
Shi, Hongyang
Shi, Jinjing
Song, Young Min
Spicer, James B.
Sun, Min
Sun, Yu
Sun, Zhiyong
Tan, Bin
Tang, Xin
Tao, Quan
Valsaraj, Amithraj
Veronis, Georgios
Vora, Patrick
Wang, Ben
Wang, Feifei
Wang, Honglei
Wang, Huaping
Wang, Jinke
Wang, Lefeng
Wang, Lidai
Wang, Peng
Wang, Shijie
Wang, Shue
Wang, Shue
Wang, Wenxue
Wang, Xi
Wang, Xiaoduo
Wang, Xudong
Wang, Yifei
Wang, Yunxiang
Wang, Zhuochen
Wei, Fanan
Wen, Yangdong
Wu, Chiu-Hsien
Xu, Anqin
Xu, Ke
XU, Shengqiang
Yan, Xiaodong
Yang, Cheng
Yang, Hao
Yang, Yongliang
Yumin, Dong
Yuxuan, Lin
Zeng, Fan
Zhang, Bohua
Zhang, Chuang
Zhang, Guangjie
Zhang, Kaili
Zhang, Mingjun
Zhang, Peng
Zhang, Qicheng
Zhang, Suoming
Zhang, Xiaoxian
Zhang, Xu
Zhang, Yuhao
Zhang, Yuzhao
Zhao, Huan
Zhao, Wenxiu
Zhao, Zhenxuan
Zhong, Ya
Zhou, Hang
Zhou, Xin
Zhou, Yufeng

IEEE-NANO 2019 Sponsors

We acknowledge the support of the following Sponsors to the 19th IEEE Conference on Nanotechnology

IEEE

Nanotechnology Council

Shenyang Institute of Automation, CAS

City University of Hong Kong

University of Macau

University of Pittsburgh

Chinese University of Hong Kong

National Key Laboratory of Science and Technology on Micro/Nano Fabrication

中国产学研投融资联盟
深圳产学研合作促进会

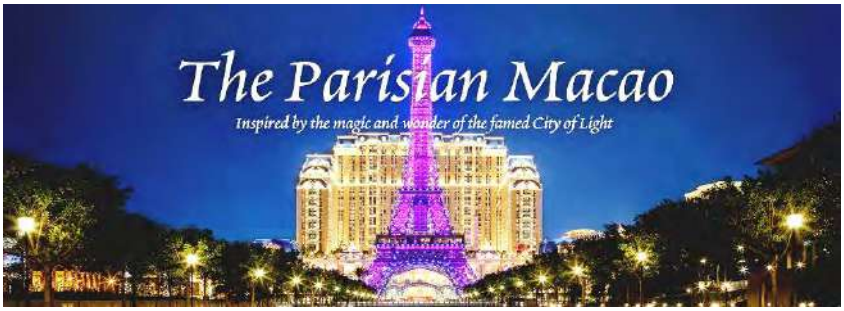
Shenzhen Industry-University-Research Institute Collaboration Association

General Information

The Parisian Macao

Address:

The Parisian Macao,
Estrada do Istmo, Lote 3,
Cotai Strip, Macao SAR,
P.R. China



Registration Desk at:

Date		Time	Venue
July 23	Tue	14:00-18:00	5/F, The Parisian Macao
July 24	Wed	08:30-18:00	5/F, The Parisian Macao
July 25	Thu	08:30-18:00	5/F, The Parisian Macao
July 26	Fri	08:30-17:30	5/F, The Parisian Macao

Social Events:

Welcome Reception on July 23

18:00-20:30 at Ballroom 7004, 5/F, The Parisian Macao

Banquet and Award Presentation on July 25

18:30-21:00 at Ballroom 7101, 5/F, The Parisian Macao

Lunch on July 24-26

12:45-14:00 at Ballroom 7101, 5/F, The Parisian Macao

For the social events, all registered participants are free.

Floor Map - The Parisian Macao, Level 5

(Registration Desk, Plenary and KeynoteTalks, Oral Sessions, Poster Sessions, Coffee Breaks and Conference Banquet, Reception, Lunches)

Official Language

The official language of the conference is English.

All presentation including discussion and submissions shall be made in English.

Instruction for Oral Presentations

In each oral presentation room, one LCD projector will be available. **The presenters have to bring their own laptop**. The presenters should prepare **Power Point Slides (4:3)** to facilitate their presentations. The slides and the presentations must be in **English**. Please test the slides before session start to avoid potential format problems caused by different software versions.

Duration for each category of oral presentation are listed below:

- **Plenary Talks** are scheduled for 40 minutes (including Q&A) each.
- **Keynote Speeches** are schedule for 30 minutes (including Q&A) each.
- **Invited Sessions** are schedule for 15 minutes (including 3 mins Q&A) each.
- **Regular Sessions** are schedule for 15 minutes (including 3 mins Q&A) each.

Instructions for Poster Sessions

Poster session represents an effective and valuable means for authors to present their research results. It offers an opportunity of meeting with interested attendees for in-depth scientific and technical discussions, and establishing new collaborations. Therefore, it is important that you display your results clearly to attract people who have an interest in your team's research work.

Your poster should cover the KEY POINTS of your paper, which include but not limited to background, methods, results and conclusion. Make your poster as self-explanatory as possible. This will save your time for discussions and questions with fellow researchers.

POSTER DIMENSIONS

- Your poster SHOULD have the following dimensions:
- **Poster Size: A1 Size 23.4 inches (59.4 cm) wide x 33.1 inches (84.1 cm) high.**
- Please note that printing out your submitted full paper in A4 size format is NOT acceptable as a poster.

POSTER CONTENT

- **Title:** The title of your poster should appear at the top with lettering of at least **42 pt** font size). Below the title, place the names of authors and their affiliations.

- **Text:** Text should be readable from five feet away. Use a minimum font size of **17 pt**. Keep the text brief. Try to use text to introduce the study, explain visuals and direct viewers' attention to significant data trends and relationships portrayed in the visuals, state and explain the interpretations that follow from the data. It is also a good idea to put future research plans or questions for discussion with viewers in your text.

- **Figures:** Each figure should have a brief title. Figures should be numbered consecutively according to the order in which they are first mentioned in the text. Try to use color figures rather than only black and white text to make your poster attractive and highlight the important technical content of your paper. Make sure that the text and the visuals are integrated.

POSTER CONTENT

Author should post up your poster on the poster panel in the morning of the day of your poster session. The detailed schedule of poster arrangement please refer to the Program Arrangement webpage. When you arrive for your session, please contact secretariat staff at the registration counter for:

1. Reporting presence,
2. Confirming the assigned board number,
3. Getting plastic tape.

Please note that your poster should be prepared well in advance. There will be no time or materials available for last minute preparations at the conference. Plastic tape will be provided to attach your posters to the boards.

Please remove your poster before end of the day, or it will be discarded.

Conference Attire

Appropriate attire is requested during the conference; e.g., casual attire at the Welcome Reception; smart causal for all technical sessions, and at the Banquet.

Getting to The Parisian Macao

BY AIR

From the Macao International Airport:

Only 5 minutes away via the complimentary Sands Cotai Central shuttle bus.

BY FERRY

COTAI WATER JET (CONNECTING HONG KONG AND MACAO COTAI STRIP)

Cotai Water Jet is the premium high-speed ferry service connecting Hong Kong and Macao, offering a journey that is comfortable, convenient and reliable.

Once in Macao, take the complimentary Sands Cotai Central shuttle bus to Sands Cotai Central.

For bookings, visit: www.cotaiwaterjet.com

BY LAND

From Zhuhai:
Lotus Bridge: Take a bus to Hengqin and proceed through Customs. Once in Macao, take the complimentary Sands Cotai Central shuttle bus to Sands Cotai Central.

From Gongbei Border Gate:
Proceed through Customs, and once in Macao, take the complimentary Sands Cotai Central shuttle bus to Sands Cotai Central.

Complimentary Shuttles Schedule

Schedules of The Sands® Cotai Central Shuttle Bus Services
(With Effective From 06 Jun 2016)

Border Gate	Taipa Ferry Terminal	Macau Ferry Terminal & Sands Macao
General Station ⇨ SCC 09:00 - 00:00 Every 15 - 20 minutes Dual Plate Station ⇨ SCC 09:00 - 00:00 Every 15 - 20 minutes SCC ⇨ Border Gate 09:30 - 23:30 Every 15 - 20 minutes	Taipa Ferry ⇨ SCC 07:30- 01:00 Overnight: 01:20 - 01:40 / 02:20 - 02:40 Every 5- 15 minutes SCC ⇨ Taipa Ferry 06:35 / 07:25 - 22:35 / 23:05 - 23:35 Every 10 - 15 minutes Overnight : 00:05 - 00:35 / 02:05 - 02:35 Every 15 minutes	Macau Ferry ⇨ Sands ⇨ SCC 09:00 - 00:00 Every 10 - 20 minutes SCC ⇨ Macau Ferry 09:30 - 00:00 Every 10 - 20 minutes SCC ⇨ Sands 09:00 - 00:00 Every 20 – 30 minutes
Lotus Port	**Cotai Connection**	**Macau International Airport**
Lotus Port ⇔ SCC ⇨ Venetian 09:00 – 22:00 Every 15 - 20 minutes SCC ⇨ Venetian ⇨ Lotus Port 09:30 – 22:00 Every 15 - 20 minutes	East Route 11:30 – 22:30 Every 15 – 20 minutes West Route 11:30 – 22:30 Every 15 – 20 minutes	MIA ⇔ SCC 10:00 – 14:00 Every 15 - 20 minutes MIA ⇔ SCC ⇨ Venetian 14:00 – 22:30 Every 15 - 20 minutes

About Macau

Macau also spelled Macao, officially the Macao Special Administrative Region of the People's Republic of China, is an autonomous territory on the western side of the Pearl River Delta, China.

Macau was administered by the Portuguese Empire and its inheritor states from the mid-16th century until late 1999, when it was the last remaining European colony in Asia. Portuguese traders first settled in Macau in the 1550s. In 1557, Macau was rented to Portugal from Ming China as a trading port. The Portuguese Empire administered the city under Chinese authority and sovereignty until 1887, when Macau, through a mutual agreement between the two countries, became a colony. Sovereignty over Macau was transferred to China on 20 December 1999. The Joint Declaration on the Question of Macau and Macau Basic Law stipulate that Macau operate with a high degree of autonomy until at least 2049, fifty years after the transfer.

Ruins of St. Paul's

The Ruins of St. Paul's refer to the facade of what was originally the Church of Mater Dei built in 1602-1640, destroyed by fire in 1835, and the ruins of St. Paul's College, which stood adjacent to the Church. As a whole, the old Church of Mater Dei, St. Paul's College and Mount Fortress were all Jesuit constructions and formed what can be perceived as the Macao's "acropolis". Close by, the archaeological remains of the old College of St. Paul stand witness to what was the first western-style university in the Far East, with an elaborate academic programme. Nowadays, the facade of the Ruins of St. Paul's functions symbolically as an altar to the city.

Address: Company of Jesus Square
Opening hours: Museum of Sacred Art and Crypt: 9 a.m. to 6 p.m. daily (except Tuesday afternoon), no admission after 5:30 p.m. (Tuesdays: closed after 2 p.m. Open as usual on public holidays.)
Bus routes nearby: 3, 3X, 4, 6A, 8A, 18A, 19, 26A, 33, N1A

Senado Square Senado Square

Senado Square has been Macao's urban centre for centuries, and is still the most popular venue for public events and celebrations today. Located close to the former Senate building, Sam Kai Vui Kun (Kuan Tai Temple) is also a reminder of the active participation of the local Chinese community in general civic affairs, providing a clear example of the multicultural dimension of the Macao community. The square is surrounded by pastel coloured neo-classical buildings, creating a consistent and harmonious Mediterranean atmosphere.

Address: Senado Square
Bus routes nearby: 3, 3X, 4, 6A, 8A, 18A, 19, 26A, 33, N1A

Macau Tower Convention & Entertainment Centre

Opened on 19th December, 2001, Macau Tower is 338 metres in height. It is an elegant construction offering magnificent panoramic views all over Macao and much of the Pearl River Delta from its observation deck and revolving restaurant, at the 223-metre level. There is the opportunity to walk around the outside of the tower, for instance “Skywalk X”.

Besides the tower, there are a 4-floor Convention and Entertainment Centre, restaurants, cinema, a 2-level basement and an outdoor plaza.

Address: Largo da Torre de Macau
Free entrance
Tel: +853 2893 3339
Fax: +853 2896 0103
E-mail: info@macautower.com.mo
Website: http://www.macautower.com.mo
Bus routes nearby: 9A, 18, 23, 26, 32

Local Time:

GMT/UTC + 08:00 hour

Currency

The pataca (composed of 100 avos) is the ficial unit of currency in Macau. It is available in coins and banknotes in denominations of:

Coins: 10, 20, 50, avos; 1 & 5 patacas.

Banknotes: 10, 20, 50, 100, 500, & 1000 patacas.

The Macau pataca can be freely converted into Portuguese escudos or Chinese yuan. It is pegged to the Hong Kong dollar – which is circulated freely in Macau at the rate of 103.20 patacas = HK$100.00, with a permissible variation of up to 10%.

Electricity

The electric system is 220 Volt AX (50 HZ). There are many plugs and sockets available for use in the hotel. Travelers with shavers, computers, and other personal electronics should carry a plug-adapter kit.

Emergency Number in Macau

999 / 110 / 112

Climate

The climate is fairly warm and tropical in Macau. Annual average temperature is about 20ºC (68ºF) and ranges from 16ºC (50ºF) to 25ºC (77ºF). Humidity levels are high and average values vary between 73% and 90%.

Autumn (October - December) is the most pleasant season. Days are sunny and warm and humidity levels are low.

For more information please visit website of the Macau Meteorological and Geophysical Bureau

Plenary Talk I.1
Wednesday July 24, 2019, 09:00-09:40
Room 7201, 5/F
Chair: Wen Jung LI, City University of Hong Kong
Co-Chair: Haixia ZHANG, Peking University

From Molecular Photovoltaics to the Harness of Sun Power

Alex K.-Y. JEN

Provost
Department of Materials Science & Engineering and Department of Chemistry
City University of Hong Kong, Hong Kong

ABSTRACT

In this talk, work related to molecular engineering the shape, size, interactive forces, interfaces, energy levels and controlled self-assembly of organic and inorganic hybrid functional materials to result in single molecular level photochemical reactions and unprecedented device performance in efficient energy generation will be discussed.

Among different printable solar cell technologies, organic solar cells (OSCs) and perovskite solar cells (PVKSCs) are two candidates that have immense potential. They have inherently easier manufacturability, where low-temperature solution processing via high-throughput printing techniques like spray coating, inkjet printing, screen printing, blade coating, and slot die roll-to-roll (R2R) coating) can be used for manufacturing at scale. OSCs and PVKSCs also offer versatility in form factor for realizing flexible, semi-transparent, and color-tunable solar cells. These variants are pivotal for the success of building integrated photovoltaics (BIPVs) and niche market products. Advancements in terms of non-fullerene acceptors (for OSCs) and multi-junction device architectures (for PVKSCs) have recently escalated the progression in power conversion efficiency (PCE). Record PCEs in lab scale devices are approaching 17% and 25% for OSCs and PVKSCs, respectively, and efforts for scaling up and demonstrating large scale modules have begun through close cooperation between academia and industry.

BIOGRAPHY

Alex Jen is currently serving as the Provost of the City University of Hong Kong. Before his current post, he was the Boeing-Johnson Chair Professor and Chair of the Department of Materials Science & Engineering at the University of Washington. He was also the Chief Scientist for the Clean Energy Institute endowed by the Washington State Governor. His research interest is focused on utilizing molecular, polymeric and biomacromolecular self-assembly to create ordered arrangement of organic and inorganic functional materials for photonics, opto-electronics, nanomedicine, and nanotechnology. He has co-authored more than 850 publications, given over 550 invited lectures. His work is well cited with more than 55,000 citations and a h-index of 113. He is also a co-inventor of more than 60 patents and

invention disclosures.

For his pioneering contributions in organic photonics and electronics, he was elected as an Academician by the European Academy of Sciences and the Washington State Academy of Sciences. He was also elected as Fellow for AAAS, MRS, ACS, PMSE, OSA, and SPIE professional societies. He has also been appointed as the Changjiang Chair and 1000 Talent Professors in China, as the World Class University Professor by the Korean National Research Foundation, and as the Distinguished Chair Professor by the National Taiwan University.

Plenary Talk I.2
Wednesday July 24, 2019, 09:40-10:20
Room 7201, 5/F
Chair: Wen Jung LI, City University of Hong Kong
Co-Chair: Haixia ZHANG, Peking University

Nano Electronics in "Beyond Moore's Law " Era

Meyya MEYYAPPAN

Chief Scientist for Exploration Technology
NASA Ames Research Center, USA

ABSTRACT

With the end of Moore's law in sight, the ITRS Roadmap ceased to issue a new edition. Instead, there are currently efforts by the industry along with IEEE and other professional societies to create new roadmaps, for example, *The International Roadmap for Devices and Systems (IRDS); The Heterogeneous Integration Roadmap (HIR).* Among other things, these roadmaps focus on Emerging Research Devices covering ~15 different candidate technologies including neuromorphic devices, quantum devices, nano carbon (graphene, CNT) based electronics, 2D material based electronics and many others. I will discuss two of the emerging areas, (nanoscale vacuum electronics, printed electronics), from our own work at NASA Ames Research Center.

We have been fabricating nanoscale vacuum tubes using entirely and exclusively silicon technology. Vacuum is superior to any semiconductor in terms of electron transport, in addition to being immune to the impact of all radiations. We have combined the best of vacuum transport and silicon technology to fabricate surround gate nanoscale vacuum transistors on 200 mm wafers with a channel dimension of 50 nm. These vacuum transistors, operating at a drive voltage of only 2 V, which is remarkable for vacuum devices, have the potential for THz electronics and several other applications. The surround gate provides excellent gate control over the transport across the vacuum channel. The drive current can be increased at the design stage by increasing the number of emitters fabricated on the source pad with a common collector (drain). This talk will provide an overview, physics, fabrication, radiation exposure and characterization results for these devices.

This talk will also provide an overview of the emerging printable electronics including material issues, tools and application development in the areas of memory devices, sensors and energy storage devices. The author thanks Jin-Woo Han, Ram Prasad Gandhiraman, Jessica Kohene, Dongil Moon, Myeonglok Seol, Sunjin Kim and Beomseok Kim.

BIOGRAPHY

Meyya Meyyappan is Chief Scientist for Exploration Technology at NASA Ames Research Center in Moffett Field, CA. Until June 2006, he served as the Director of the Center for Nanotechnology. He is a founding member of the Interagency Working Group on Nanotechnology (IWGN) established by the Office of Science and Technology Policy (OSTP). The IWGN is responsible for putting together the National Nanotechnology Initiative.

Dr. Meyyappan has authored or co-authored over 380 articles in peer-reviewed journals and made over 250 Invited/Keynote/Plenary Talks in nanotechnology subjects across the world and over 250 seminars at universities. He is a Fellow of IEEE, ECS, AVS, MRS, IOP, AIChE, ASME and National Academy of Inventors. He is currently the IEEE Electron Devices Society (EDS) Distinguished Lecturer, and he was the Distinguished Lecturer on Nanotechnology for both the IEEE Nanotechnology Council and ASME. He is currently the President-Elect of IEEE-EDS.

For his contributions and leadership in nanotechnology, he has received numerous awards including: a Presidential Meritorious Award; NASA's Outstanding Leadership Medal; IEEE Judith Resnick Award; IEEE-USA Harry Diamond Award; AIChE Nanoscale Science and Engineering Forum Award; Pioneer Award in Nanotechnology by the IEEE-NTC; Sir Monty Finniston Award by the Institution of Engineering and Technology (UK); IEEE-USA Professional Achievement Award; AVS Nanotechnology Recognition Award; IEEE Nuclear and Plasma Sciences Society Merit Award; AVS Plasma Prize; MRS Impact Award. For his sustained contributions to nanotechnology, he was inducted into the Silicon Valley Engineering Council Hall of Fame in 2009. He has received Honorary Doctorate from the University of Witwatersrand, Johannesburg, South Africa and Concordia University, Montreal, Canada.

For his educational contributions, he has received: Outstanding Recognition Award from the NASA Office of Education; the Engineer of the Year Award (2004) by the San Francisco Section of the American Institute of Aeronautics and Astronautics; IEEE-EDS Education Award; IEEE-EAB (Educational Activities Board) Meritorious Achievement Award in Continuing Education.

Plenary Talk I.3
Wednesday July 24, 2019, 10:20-11:00
Room 7201, 5/F
Chair: Wen Jung LI, City University of Hong Kong
Co-Chair: Haixia ZHANG, Peking University

Maxwell's Displacement Current Governed Triboelectric Nanogenerator for Self-Powered Systems and Blue Energy

Zhong lin WANG

Beijing Institute of Nanoenergy and Nanosystems,
Chinese Academy of Sciences, Beijing, China.

School of Materials Science and Engineering,
Georgia Institute of Technology, Atlanta, Georgia USA

ABSTRACT

Contact electrification (triboelectrification) effect, the most fundamental effect for electricity, has been known for over 2600 years since ancient Greek time, but its scientific mechanism remains unclear. The study of triboelectrification is recently revived due to the invention of the triboelectric nanogenerators (TENGs) by using the coupling of triboelectrification and electrostatic induction effects, which is the most effective approach for converting tiny mechanical energy into electricity for powering small sensors. TENG is playing a vitally important role in the distributed energy and self-powered systems, with applications in internet of things, environmental/infrastructural monitoring, medical science, environmental science and security. In this talk, we first present the physics mechanism of triboelectrification for general materials. Secondly, the fundamental theory of the TENGs is explored based on the Maxwell equations. In the Maxwell's displacement current proposed in 1861, the term □□E/□t gives the birth of electromagnetic wave, which is the foundation of wireless communication, radar and later the information technology. Our study indicates that, owing to the presence of surface polarization charges present on the surfaces of the dielectric media in TENG, an additional term □Ps/□t should be added in the Maxwell's displacement current, which is the output electric current of the TENG. Therefore, our TENGs are the applications of Maxwell's displacement current in energy and sensors. TENGs have three major application fields: micro/nano-power source, self-powered sensors and blue energy. We will present the applications of the TENGs for harvesting all kind mechanical energy that is available but wasted in our daily life, such as human motion, walking, vibration, mechanical triggering, rotating tire, wind, flowing water and more. Then, we will illustrate the networks based on triboelectric TENGs for harvesting ocean water wave energy, for exploring its possibility as a sustainable large-scale blue energy. Lastly, we will show that TENGs as self-powered sensors for actively detecting the static and dynamic processes arising from mechanical agitation using the voltage and

current output signals.

[1] C.Xu†, Y. Zi†, A.C. Wang†, H. Zou, Y. Dai, Xu He, P. Wang, .C. Wang, P. Feng, D. Li, Z.L. Wang* "On Electron Transfer Mechanism in Contact-Electrification Effect", Adv. Mater. 30 (2018) 1706790.

[2] Z.L. Wang, "On Maxwell's displacement current for energy and sensors: the origin of nanogenerators", Materials Today, 20 (2017) 74-82.

[3] Z.L. Wang, L. Lin, J. Chen. S.M. Niu, Y.L. Zi "Triboelectric Nanogenerators", Springer, 2016. http://www.springer.com/us/book/9783319400389

[4] Z.L. Wang "Triboelectric Nanogenerators as New Energy Technology for Self-Powered Systems and as Active Mechanical and Chemical Sensors", ACS Nano 7 (2013) 9533-9557.

[5] Z.L. Wang, J. Chen, L. Lin "Progress in triboelectric nanogenertors as new energy technology and self-powered sensors", Energy & Environmental Sci, 8 (2015) 2250-2282.

BIOGRAPHY

Dr. Zhong Lin (ZL) Wang is the Hightower Chair in Materials Science and Engineering and Regents' Professor at Georgia Tech, and Founding Director and Chief Scientist at Beijing Institute of Nanoenergy and Nanosystems. Dr. Wang pioneered the nanogenerators from fundamental principle to technological applications. His research on self-powered nanosystems has inspired the worldwide effort in academia and industry for studying energy for micro-nano-systems. He coined and pioneered the fields of piezotronics and piezo-phototronics for the third generation semiconductors. Wang is ranked No. 1 in Google Scholar public profiles in Nanotechnology & Nanoscience both in total citations and h-index impacts: http://www.webometrics.info/en/node/198.

Dr. Wang has received 2018 ENI award in Energy Frontiers; Global Nanoenergy Prize, The NANOSMAT Society, UK (2017); Distinguished Research Award, Pan Wen Yuan foundation (2017); Distinguished Scientist Award from (US) Southeastern Universities Research Association (2016); Thomas Router Citation Laureate in Physics (2015); World Technology Award (Materials) (2014); Distinguished Professor Award (Highest faculty honor at Georgia Tech) (2014); NANOSMAT prize (United Kingdom) (2014); The James C. McGroddy Prize in New Materials from American Physical Society (2014); MRS Medal from Materials Research Soci. (2011).

Dr. Wang was elected as a foreign member of the Chinese Academy of Sciences in 2009, member of European Academy of Sciences in 2002, academician of Academia of Sinica (Taiwan) 2018; fellow of American Physical Society in 2005, fellow of AAAS in 2006, fellow of Materials Research Society in 2008, fellow of Microscopy Society of America in 2010, fellow of the World Innovation Foundation in 2002, fellow of Royal Society of Chemistry, and fellow of World Technology Network 2014. Dr. Wang is the founding editor and chief editor of an international journal Nano Energy, which now has an impact factor of 15. Details can be found at: http://www.nanoscience.gatech.edu

Plenary Talk II.1
Thursday July 25, 2019, 09:00-09:40
Room 7201, 5/F
Chair: Walter HU, University of Texas at Dallas
Co-Chair: Xiuling LI, University of Illinois

Precise Chemical, Physical, and Electronic Nanoscale Contacts

Paul S. WEISS

California NanoSystems Institute and Departments of Chemistry & Biochemistry and Materials Science & Engineering,
UCLA, Los Angeles, USA

ABSTRACT

The physical, electronic, mechanical, and chemical connections that materials make to one another and to the outside world are critical. Just as the properties and applications of conventional semiconductor devices depend on these contacts, so do nanomaterials, many nanoscale measurements, and devices of the future. We discuss the important roles that these contacts can play in preserving key transport and other properties. Initial nanoscale connections and measurements guide the path to future opportunities and challenges ahead. Band alignment and minimally disruptive connections are both targets and can be characterized in both experiment and theory. I discuss our initial forays into this area in a number of materials systems.

BIOGRAPHY

Paul S. Weiss graduated from MIT with S.B. and S.M. degrees in chemistry in 1980 and from the University of California at Berkeley with a Ph.D. in chemistry in 1986. He is a nanoscientist and holds a UC Presidential Chair and a distinguished professor of chemistry & biochemistry and materials science & engineering at UCLA, where he was previously director of the California NanoSystems Institute. He also currently holds visiting appointments at Harvard's Wyss Institute and several universities in Australia, China and South Korea. He studies the ultimate limits of miniaturization, developing and applying new tools and methods for atomic-resolution and spectroscopic imaging and patterning of chemical functionality. He and his group apply these advances in other areas including neuroscience, and microbiome studies, and high-throughput stem cell transfection. He led, coauthored, and published the technology roadmaps for the BRAIN Initiative and the U. S. Microbiome Initiative. He has won a number of awards, in science, engineering, teaching, publishing, and communications. He is a fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, the American Chemical Society, the American Institute for Medical and Biological Engineering, the American Physical Society, the American Vacuum Society, the Canadian Academy of Engineering, and an honorary fellow of the Chinese Chemical Society. He is the founding and current editor-in-chief of ACS Nano.

Plenary Talk II.2
Thursday July 25, 2019, 09:40-10:20
Room 7201, 5/F
Chair: Walter HU, University of Texas at Dallas
Co-Chair: Xiuling LI, University of Illinois

Shrink Polymer Biosensors: Manufacturing from Micro to Nano

Tianhong CUI

Distinguished McKnight University Professor
University of Minnesota, USA

ABSTRACT

Polymer shrinkage becomes a new approach to do lithography and generate smaller structures by reforming larger pre-patterned structures. The facile polymer fabrication approach by embossing and thermoplastic shrinkage aims to do lithography in a nanoscale or reduce the feature size and dramatically increase the aspect ratio of imprinted microstructures. The shrinkage capability of embossed microstructures is obtained by molding at low temperatures for less cycle time. Embossed patterns are activated for shrinkage by removing projected structures and heating at higher temperatures. The final structures are defined with the shape of removed materials before shrinking polymer materials. Both two- and three-dimensional embossed structures were successfully shrunk into much smaller scale. This polymer-shrinking process brings a new way to extend the fabrication capability of polymer embossing process towards MEMS-based biosensors. This talk will present shrink polymer for nanolithography, high-aspect-ratio microstructures, and biosensors for medical applications.

BIOGRAPHY

Tianhong Cui is a Distinguished McKnight University Professor at the University of Minnesota. He is a Professor in Mechanical Engineering, and an Affiliate Senior Member in Department of Electrical Engineering and Department of Biomedical Engineering at the University of Minnesota. He is an Adjunct Professor at Mayo Clinic, a Visiting Fellow at the University of Cambridge, and a Distinguished Visiting Professor at University of Paris East. He is a Fellow of American Society of Mechanical Engineering (ASME). He is the founding Executive Editor-in-Chief for two Nature journals, Light: Science & Applications and Microsystems & Nanoengineering. He is also serving as the founding Editor-in-Chief for the first AAAS/Science Partner Journal titled Research. His research area is MEMS. He has more than 310 archived publications in scientific journals and conferences.

Plenary Talk II.3
Thursday July 25, 2019, 10:20-11:00
Room 7201, 5/F
Chair: Walter HU, University of Texas at Dallas
Co-Chair: Xiuling LI, University of Illinois

Materials Science with Two-Dimensional Atomic Layers

Pulickel M. AJAYAN

Benjamin M. and Mary Greenwood Anderson Professor in Eng
ineering
Department of Materials Science and NanoEngineering
Rice University, USA

ABSTRACT

There has been tremendous interest in recent years to discover, explore and demonstrate unique properties and applications of two-dimensional (2D) materials. This got started with the spectacular discovery of graphene and the outstanding properties that graphene presented. This talk will focus on the status of this field, with emphasis on the materials science of 2D atomic layers and their hybrid structures. Several aspects that include synthesis, characterization and manipulation will be discussed with the objective of achieving functional structures and applications based on 2D atomic layers. The concept of artificially stacked van der Waals solids, atomically thin planar heterojunctions, 2D alloys, and 2D layers based 3D constructs will be described using a number of examples consisting of graphene and other 2D layer compositions. The talk will explore the emerging landscape of 2D materials systems that include graphene, boron-nitrogen-carbon systems, and a large number of transition metal dichalcogenide compositions.

BIOGRAPHY

Pulickel M. Ajayan is a pioneer in the area of nanotechnology. He has published more than 1100 journal papers earning more than 90,000 citations and h-index of 148 (based on ISI web of science citation data). His work covers diverse areas of nanomaterials including nanoparticles, nanotubes, 2D materials, nanocomposite and energy storage materials. He holds 28 U.S. patents and some of his work has been commercialized through licensing and start-ups. He is the Benjamin M. and Mary Greenwood Anderson professor of Engineering at Rice University and the founding chair of the department of Materials Science and NanoEngineering. He is the recipient of awards such as the Spiers memorial award, MRS medal, Alexander von Humboldt-Helmoltz senior award, and lifetime nanotechnology award from the Houston Technology Center. He received Docteur Honoris Causa from the Universite Catholique de of Louvain and distinguished alumni recognition from his Alma Mater Banaras Hindu University and the Materials Science department at Northwestern University.

Plenary Talk III.1
Friday July 26, 2019, 09:00-09:40
Room 7201, 5/F
Chair: Han WANG, University of Southern California

DNA as an Engineering Material to Bridge between MEMS and Nanotechnology

Osamu TABATA

Professor
Department of Micro Engineering
Kyoto University, Japan

ABSTRACT

How can we improve functionality of MEMS by incorporate nanoscale structure made of various nanomaterials such as nanoparticles, nanotubes, proteins and other molecules? One promising way is to utilize self-assembly technique of multiple functional nanocomponents as Nature does. Although a complexity of the structure is essential factor to generate functionality, so far, no engineering methodology has been established to assemble multiple functional nanocomponents to specific positions on MEMS in a specific sequence. This is a challenging goal to be addressed, namely controlling assembly position and sequence of multiple nanoscale functional components made of a variety of nanomaterials to realize high functional Nanosystem.

To address this goal, a concept of an Oriented Self-Assembly on MEMS approach in which DNA is utilized to bridge MEMS and Nanotechnology has been proposed. In this approach, DNA origami (DO) proposed by Rothemund in 2006 is self-assembled on MEMS according to a given system design. The advantages of DO as a nanocomponent can be summarized as; (1) the surface is precisely addressable with sub-nanometer resolution, (2) various nanomaterials can conjugate with DO, (3) higher order structure (multimer structure) can be formed by binding them each other, (4) various 2D or 3D shape can be constructed, (5) mechanical rigidity is controllable, (6) DNA based sensing and actuation mechanism can be incorporated. Owing to these advantages, many applications including sensors will be expected. However, there are still many issues are remained to be solved such as mechanical properties, dynamics of the self-assembly process, etc. In this talk, the current status of DNA nanotechnology, newly proposed DNA origami sacrificial process and its application will be presented.

BIOGRAPHY

Osamu Tabata received his M.S. and Ph.D. degrees from Nagoya Institute of Technology, Japan, in 1981 and 1993, respectively. In 1981, he joined the Toyota Central Research and Development Laboratories, Inc., Japan. In 1996, he joined the Department of Mechanical Engineering, Ritsumeikan University, Japan. In 2003, he moved to the Department of Mechanical Engineering, Kyoto University, Japan. Since April 2005, he has been a

Professor at the Department of Micro Engineering, Kyoto University. From October 2019, he will move to Kyoto University of Advanced Science as a founding Dean of Engineering School. He is currently engaged in research on micro/nano processes, MEMS, DNA nanotechnology and micro/nano system synthetic engineering.

Prof. Tabata was a guest professor at the Department of Microsystem Engineering, University of Freiburg, Germany from September to December 2000, a guest Professor of ETH Zurich, Switzerland from January to March 2001, a visiting senior international scientist of the Chinese Academy of Science in 2010, a guest Professor of Huazong University of Science and Technology, China from July 2011 to July 2014, a senior research fellow at the Freiburg Institute for Advanced Studies (FRIAS) from May 2010 to September 2012, a distinguished visiting researcher of American University in Cairo in 2016 and a visiting Professor of Tsinghua University China from November 2018. He is a senior editor of the IEEE Transactions on Nanotechnology (TNANO), an associate editor of the ASME/IEEE Journal of Micro Electro Mechanical Systems (JMEMS), and an editorial board member of the Elsevier Journal Sensors and Actuators. He is also a program committee member of many important International Conferences in his area of expertise. He is a Fellow of Institute of Electrical Engineer Japan.

Keynote Talk I.1
Wednesday July 24, 2019, 11:15-11:45
Room 7201, 5/F
Chair: Ting ZHANG, Suzhou Institute of Nanotech and Nanobionics, CAS
Co-Chair: Haibo YU, Shenyang Institute of Automation, CAS

Nanomechanics of 1-D Semiconductors and Elastic Strain Engineering

Yang LU

Associate Professor
Department of Mechanical Engineering
City University of Hong Kong, Hong Kong

ABSTRACT

Due to their importance in nanoelectronics and nanoelectromechanical systems (NEMS), one-dimensional (1-D) semiconductor nanostructures have stimulated great interests in the past decades, however, to achieve the full potential of these nanoscale building blocks in their functional devices will highly depend on their mechanical performance and reliability. In this talk, we show our recent nanomechanical study of semiconductor materials including silicon (Si) nanowires and diamond nanoneedles. Based on our in situ characterization techniques, we showed that VLS-grown single crystalline silicon nanowires with diameters ~100nm can be repeatedly stretched above 10% elastic strain at room temperature (*Science Advances* 2016), with a few cases up to 16% tensile strain, approaching the theoretical elastic limit of silicon. Then we further characterized the bending flexural behavior of single and poly-crystalline diamond nanoneedles and found that single-crystalline diamond needles are capable of undergoing ultralarge elastic bending deformation, up to ~9% local tensile strain (*Science* 2018), with the corresponding local stress (about 90GPa) approaching the ideal strength of diamond. In addition to the promising flexible electronics and MEMS/NEMS applications, our discoveries have opened up new avenues to explore how nanoelectronics and optoelectronics devices can be designed and modulated through the emerging “elastic strain engineering” of 1-D semiconductor nanostructures (*JPCC* 2018, *JAP* 2019).

BIOGRAPHY

Prof. Yang Lu is an Associate Professor in the Department of Mechanical Engineering (also affiliated with Department of Materials Science and Engineering) at City University of Hong Kong. Before joining CityU in 2012, he did postdoctoral research in the Nanomechanics Lab at Massachusetts Institute of Technology (MIT) for about two years. He obtained his B.S. degree in Physics/Microelectronics from Nanjing University and Ph.D. degree in Mechanical Engineering and Materials Science from Rice University, respectively. Prof. Lu has extensive experiences in nanomechanics and nanomanufacturing, and contributed to the discoveries of “cold welding” of ultrathin metallic nanowires and

“ultralarge elasticity” in nanoscale covalent crystals, respectively. As the first or corresponding author, Prof. Lu has published more than 60 research papers in leading academic journals including Science, Nature Nanotechnology, Science Advances, etc. He serves as Managing Editor/Associate Editor for Materials Today and Editorial Board Member for SCIENCE CHINA Technological Sciences and Scientific Reports. Prof. Lu is a recipient of “Early Career Award 2013/2014” awarded by Hong Kong University Grants Committee (UGC) and The President’s Award 2017 of City University of Hong Kong.

Keynote Talk I.2
Wednesday July 24, 2019, 11:45-12:15
Room 7201, 5/F
Chair: Ting ZHANG, Suzhou Institute of Nanotech and Nanobionics, CAS
Co-Chair: Haibo YU, Shenyang Institute of Automation, CAS

Reconfigurable Magnetic Microrobot Swarm: Multi-Mode Transformation, Locomotion and Manipulation

Hui XIE

Professor
State Key Laboratory of Robotics and Systems
Harbin Institute of Technology, China

ABSTRACT

Nature provides a repertoire of examples that living systems organized in a coordination manner can solve complex problems and complete a task that goes beyond individual's capabilities. For example, a colony of ants can collectively achieve complex tasks such as constructing nests and gathering a large prey. This talk presents a strategy that uses alternating magnetic fields to program hematite colloidal particles into liquid, chain, vortex, and ribbon-like microrobotic swarms and enable fast and reversible transformations between them. What makes more sense is that the chain is characterized by passing through confined narrow channels and the herring school-like ribbon procession is capable of large-area synchronized manipulation, while the colony-like vortex can aggregate at a high density towards coordinately handling heavy loads. This reconfigurable microrobot swarm has a significant potential to investigate fundamentals in living systems and serve as a functional bio-microrobot system for biomedicine.

BIOGRAPHY

Hui Xie is a full professor in the State Key Laboratory of Robotics and Systems, School of Mechatronics Engineering at Harbin Institute of Technology (HIT), Harbin, China. In 2006, Xie received Ph.D. degree in Mechatronics Engineering from Harbin Institute of Technology, Harbin. His current research interests include microrobotics/nanorobotics, nanomanipulation/characterization, AFM three-dimensional micro/nano CD metrology, AFM multiparametric imaging and characterization of complex cellular and biomolecular systems under physiological conditions, and micro/nano swimming robots (swarms).

Xie’s work was partly supported by the China National Science Fund for Excellent Young Scholars (2012) and the Program for New Century Excellent Talents by the Ministry of Education of China (2012). He won two Technological Invention Awards (1st Prize, 2005/2007) and one Natural Science Award (2nd Prize, 2017) of Heilongjiang Province. He has served as an Associate Editor of IEEE Access and IEEE/ASME Transactions on Mechatronics.

Keynote Talk I.3
Wednesday July 24, 2019, 12:15-12:45
Room 7201, 5/F
Chair: Ting ZHANG, Suzhou Institute of Nanotech and Nanobionics, CAS
Co-Chair: Haibo YU, Shenyang Institute of Automation, CAS

All-In-One Self-Powered Smart System

Haixia ZHANG

Professor
Department of Microelectronics,
Peking University, China

ABSTRACT

In the past decades, the development of new material and fabrication process make the electronics engineering bloom again from the traditional silicon-based electronics to the polymer based stretchable electronics. This talk will focus on the TENG based self-powered smart devices first, which is beneficial for solving the energy supply problem of sensor networks in the stretchable electronic system. We will summarize the choice of the working mode and the detection mode, which is the fundamental point for designing a proper e-skin with the expected function. Then, the method to mimic the properties of human skin, which must meet the demands of mechanical stretchability and electrical conductance at the same time, is reviewed from the electrode aspect and dielectric aspect, respectively. The material development and structure construction are two main approaches for making the conductor into stretchability. For the dielectric, the methods to improve the performance and endow more human skin functions like biocompatibility, self-healing and humidity-resistance are also stated. Furthermore, all-in-one self-powered smart system will be introduced with demonstration around the following major categories: working principles, advanced materials, active sensors, actuators. Followed by discussion of their great potential in different application fields and the trend of integrated microsystems for AI, IOT and other hot topics.

BIOGRAPHY

Dr. Zhang is a pioneer and leading scientist in micro/nanotechnology, especially in high efficiency energy harvesting and self-powering devices & systems. Dr. Zhang has authored and co-authored 250+ peer reviewed scientific articles on the prestigious journals such as, Energy & Environmental Science, Nano Energy, Nano Letters, ACS Nano, Advanced Materials, Advanced Functional Materials, et al. She edited and co-edited 8 books and book chapters, and held 46 patents including 3 US patents. She has delivered 100+ plenaries, keynotes, invited and seminar talks at international and national academic conferences as well as universities and research institutions. She is the founder of iCAN (International Contest of Innovation), co-founder and general Chair of IEEE NEMS conference. She serves on editorial board of IEEE TNano, JMEMS, Microsystem and Nanoengineering, et

al.

Dr. Zhang is a pioneer and world leader for her outstanding research achievements and creativity in micro/nanotechnology, especially in high efficiency energy harvesting and self-powering devices & systems. Her research has impacted the field of MEMS field in a number of aspects, such as developing mass production technology of micro-nano structures with high surface charging density based on MEMS fabrication to enhance the performance of triboelectric nanogenerator, applying piezoelectric, magnetic and triboelectric principles for hybrid nanogenerator, and high efficiency energy management circuit to achieve long-term power supply for microsystems, her contributions of active sensing and smart skin also inspect the academic field worldwide.

Dr. Zhang has productive scientific output and won numbers of Awards/Honors. She authored and co-authored 250+ peer reviewed scientific articles on the prestigious journals such as, Energy & Environmental Science, Nano Energy, Nano Letters, ACS Nano, , Advanced Materials, Advanced Functional Materials, et al. She edited and co-edited 8 books and book chapters, and held 42 patents including 3 US patents. She has delivered 100+ plenaries, keynotes, invited and seminar talks at international and national academic conferences as well as universities and research institutions. She is very active in academic service, was the founder and general Chair of IEEE NEMS conference, NTC Beijing Chapter Chair. She serves on editorial board of IEEE Tnano, JMEMS, Microsystem and Nanoengineering, et al.

Keynote Talk II.1
Thursday July 25, 2019, 11:15-11:45
Room 7201, 5/F
Chair: Jianshi TANG, Tsinghua University
Co-Chair: Soong Ju OH, Korea University

Flexible and Stretchable Sensing Electronics

Ting ZHANG

Professor
i-Lab, Suzhou Institute of Nanotech and Nanobionics
Chinese Academy of Sciences, China

ABSTRACT

Flexible and stretchable electronics are an exciting frontier for the next generation of wearable and portable electronic devices. In recent five years, Our group have made the several research achievements: Established the methodology for developing novel flexible/stretchable microsensors based on high quality nanomaterials, and developed the novel flexible/stretchable bionic devices such as “electronic-skin”, “electronic-eardrum”, and “electronic-fingerprint” etc., which set up the technical basis for their applications in wearable smart systems, human-computer interaction, disease diagnoses and health assessments. In this talk, I will present the recent progresses of nanomaterials based high-performance flexible and stretchable sensing electronics. I’d like to discuss the important roles of the nanomaterials, device interface, and micro-structure design in achieving high flexibility and stretchability, and also the strategies to achieve high sensitivity, stability, and fast response time of the sensing devices. The facile and low-cost printing method for fabricating engineered flexible sensors and sensor arrays will be addressed, and the applications in several areas such as robotic sensory skins, wearable health monitoring systems, bio-integrated devices, and human-machine interfaces will be demonstrated.

BIOGRAPHY

Dr. Ting Zhang is a full professor at Suzhou Institute of Nanotech, Chinese Academy of Sciences. He received his B.S. (1999) and M.S. (2002) degree from Nankai University, and Ph.D. degree at University of California, Riverside in 2007. His research mainly focuses on the development of electronic micro/nanosensing devices and smart microsystems, including Flexible/Stretchable and MEMS devices. The devices are mainly developed for medical diagnostics, robotics, wearable smart systems and environmental monitoring applications. He has published more than 60 peer-review papers in journals like Advanced Materials, Science Advances, Nano Letters, etc. The papers have been cited for over 3000 times. He has also applied more than 30 patents (including 2 international patents). 4 patents have been licensed and successfully applied in Industry.

Prof. Zhang serves as the associate editor for Nature-Microsystems&Nanoengineering, the guest editor for journals such as Sensors, Nanomaterials. He also serves as senior

member of Chinese Society of Micro-Nano Technology, Senior Member of China Society of Mechanical Engineering, committee member in China Electronic Society, the National Technical Committee Member on MEMS Devices for Microelectromechanical Standardization(SACTC336WG1), etc. He got the Young Talented Scientist Award from China Instrument and Control Society (2016), the Science Fund for Distinguished Young Scholars of Jiangsu Province (2016), Six Talent Peaks Project in Jiangsu Province (2017), and was awarded as 7th Leading Talent Honor in Suzhou, China (2013), etc. He served as the executive chair of 7th China Wearable Computing Conference (2017), session chair and committee member for various conferences in the fields of flexible electronics, micro/nanotechnology, and MEMS technology such as IEEE-NEMS, Transducers, and ICFPE, etc.

Keynote Talk II.2
Thursday July 25, 2019, 11:45-12:15
Room 7201, 5/F
Chair: Jianshi TANG, Tsinghua University
Co-Chair: Soong Ju OH, Korea University

Not Your Ordinary Etching: MacEtch of Si, Ge, III-V, and Wide Bandgap Semiconductors

Xiuling LI

Professor
Department of Electrical and Computer Engineering
University of Illinois, Urbana-Champaign, USA

ABSTRACT

Metal assisted chemical etching (MacEtch, also known as MACE) is an unorthodox anisotropic etching method, that defies the isotropic nature of wet etch through local electrochemical effect. This etching method could have profound impact on semiconductor fabrication, because of its simplicity, versatility, and the absence of high energy ion-induced damage. In this talk, I will discuss the history [1], mechanism, and its applicability at the device level to Si, Ge [2], III-Vs [3, 4], wide bandgap semiconductors such as β-Ga_2O_3 [5]. In particular, forward MacEtch, where etching takes place directly underneath the metal catalyst patterns, produced site-controlled semiconductor nanostructures with unpresented aspect ratio (> 100:1). Inverse-MacEtch (*I-MacEtch*) [2,3], bypassing the metal edge roughness, allowed the formation of atomically smooth sidewalls. Magnetic-field guided MacEtch (*h-MacEtch*) enabled 3D control of the etching trajectory. Self-anchored catalyst *(SAC)-MacEtch* [6], using porous catalyst patterns, led to the fabrication of through-Si-vias by preventing the catalyst from detouring.

[1] "Metal-assisted chemical etching in HF/H_2O_2 produces porous silicon", X. Li and P.W. Bohn, Appl. Phys. Lett.77, 2572 (2000).

[2] “Enhanced performance of Ge photodiodes via monolithic antireflection texturing and α-Ge self-passivation by inverse metal-assisted chemical etching,” M. Kim, S. Yi, J. D. Kim, X. Yin, J. Li, J. Bong, D. Liu, S.-C. Liu, A. Kvit, W. Zhou, X. Wang, Z. Yu, Z. Ma, and X. Li, ACS Nano, 12 (7), pp 6748–6755 (2018).

[3] “Ultra-High Aspect Ratio InP Junctionless FinFETs by a Novel Wet Etching Method,” Y. Song, P. K. Mohseni, S. H. Kim, J. C. Shin, T. Ishihara, I. Adesida, and X. Li, IEEE Electron Dev. Lett. 37(8), 970-973 (2016).

[4] “Damage-Free Smooth-Sidewall InGaAs Nanopillar Array by Metal-Assisted Chemical Etching," L. Kong, Y. Song, J. D. Kim, L. Yu, D. Wasserman, W. K. Chim, S. Y. Chiam, and X. Li, ACS Nano, 11 (10), pp 10193-10205 (2017).

[5] M. Kim, H.-C. Huang, J. D. Kim, K. D. Chaback, A. R. Kumar, W. Zhou, and X. Li, "Nanoscale Groove Textured β-Ga_2O_3 by Room Temperature Inverse Metal-assisted

Chemical Etching and Photodiodes with Enhanced Responsivity," Appl. Phys. Lett. 113 (22), 222104 (2018).

[6] JD Kim, M Kim, L Kong, PK Mohseni, S Ranganathan, J Pachamuthu, WK Chim, SY Chiam, JJ Coleman, X. Li “Self-Anchored Catalyst Interface Enables Ordered Via Array Formation from Submicrometer to Millimeter Scale for Polycrystalline and Single-Crystalline Silicon,” ACS appl. Mater. interfaces 10 (10), 9116-9122 (2018).

BIOGRAPHY

Xiuling Li received her B.S. degree form Peking University and Ph.D. degree from the University of California at Los Angeles. Following post-doctoral positions at California Institute of Technology and University of Illinois, as well as industry experience at EpiWorks, Inc., she joined the faculty of the University of Illinois in 2007 in the Department of Electrical and Computer Engineering. She has published >140 journal papers and holds >20+ patents in the area of nanostructured materials and devices. She is a Fellow of the IEEE and the American Physics Society. Her other honors and awards include NSF CAREER award, DARPA Young Faculty Award, and ONR Young Investigator Award. She currently serves as a Deputy Editor of Applied Physics Letters and Vice President for Finance and Administration of the IEEE Photonics Society.

Keynote Talk II.3
Thursday July 25, 2019, 12:15-12:45
Room 7201, 5/F
Chair: Jianshi TANG, Tsinghua University
Co-Chair: Soong Ju OH, Korea University

Nanoimprinted Perovskite Devices towards Integrated Optoelectronics

Walter HU

Professor
Department of Electrical and Computer Engineering
The University of Texas at Dallas, USA

ABSTRACT

There have been tremendous interests in searching for cost-effective, massively scalable and wavelength tunable materials for on-chip light sources, photodetectors, and solar cells. Organic-inorganic hybrid perovskites are an emerging class of material that have led to great advances in the performance of solution-processed optoelectronic devices, in particular, solar cell to reach 23% power conversion efficiency and bright LED with 10% luminous efficiency, in the last few years.

As perovskite cannot be patterned using conventional lithography due to solvent/liquid incompatibility, one key issue is how to pattern perovskite into micro- nanostructures for active devices while at the same time to improve material properties for high performance. In this talk, our recent work of using NIL to precisely pattern perovskite nanostructures for various optoelectronic devices such as photodetectors, laser, and LED will be reviewed. Future direction of hybrid integration of perovskite on Si ICs and flexible substrates will be discussed.

BIOGRAPHY

Dr. Walter Hu is currently a full Professor of The Department of Electrical and Computer Engineering of the University of Texas at Dallas. His research has focused on developing nanolithographic techniques to fabricate useful nanostructures in functional materials such as Si, 2D semiconductor, organic polymer, and Perovskite. Using these nanostructures as a platform, his group explores practical applications in biosensing, optoelectronics, and nanomedicine. He has published 62 journal papers and 104 conference publications. Walter has received the NSF Career award (2010), Outstanding Oversea Researcher Award from Chinese National Science Foundation (2016), and Senior Faculty Research Award of UT Dallas (2013), etc. In 2016 and 2017, he served as IEEE NanoTechnology Counsel (NTC) Distinguished Lecturer. He also served as Chair for Nanofabrication TPC of IEEE Nano (2014~2016), guest editor of IEEE Access currently, and associate editor and committee member for various conferences.

Keynote Talk III.1
Friday July 26, 2019, 09:40-10:10
Room 7201, 5/F
Chair: Wei WU, University of Southern California
Co-Chair: Amit TRIVEDI, University of Illinois at Chicago

Flexible and Stretchable Sensing Electronics

Han WANG

Assistant Professor
Ming Hsieh Department of Electrical and Computer Engineering
University of Southern California, USA

ABSTRACT

In this talk, I will discuss our recent research in studying the electronic, optical and ferroelectric properties of emerging low-dimensional materials, and in developing them for electronic and photonic device applications. The first part of the talk will focus on discussing the basic properties of emerging 2D materials such as black phosphorus and its applications in mid-infrared optoelectronics. Our recent research on the ferroelectric monolayer materials will also be presented. In the second part of the talk, I will discuss our work on applying advanced 4-dimensional imaging including a newly developed scanning ultrafast electron microscopy (SUEM) technique to study the photo-carrier transport in low dimensional materials. I will conclude with remarks on promising future research directions of low-dimensional material properties and devices, and how the emerging materials may benefit future generations of electronics and photonics technology in sensing, imaging and communications.

BIOGRAPHY

Han Wang is an Assistant Professor of Electrical and Computer Engineering and holder of the Robert G. and Mary G. Lane Early Career Chair at University of Southern California (USC). He received the B.A. degree in electrical and information science from Cambridge University in 2007 and his PhD degree from Massachusetts Institute of Technology (MIT) in 2013. From 2013 to 2014, he was with the Nanoscale Science and Technology group at IBM T. J. Watson Research Center. His research interests include the fundamental study and device innovation in electronics and photonics technology based on emerging nanomaterials for computing, communication and sensing applications. His work has been recognized with numerous awards including the Army Research Office Young Invesitgator Award, National Science Foundation CAREER award, USC Viterbi Junior Faculty Research Award, USC Zumberge Faculty Research Individual Award, the Roger A. Haken Best Paper Award in IEEE International Electron Device Meeting (IEDM), the Best Paper Award in International Conference on Compound Semiconductor Manufacturing Technology (CS MANTECH) and the MIT Jin-Au Kong Best Doctoral Thesis Award. He is also the recipient of the Orange County Engineering Council (OCEC) Outstanding Educator Award in the Los Angeles area. Dr. Wang has authored or coauthored more than 100 publications in distinguished journals and conferences.

IEEE-NANO 2019 Conference Program

July 22-26, 2019

The Parisian Macao, Macau SAR, China

July 23 (Tuesday)	
	Foyer
14:00-18:00	**Registration**
	7004
18:00-20:00	**Welcome Reception** at 7004

July 24 (Wednesday)						
		7201				
08:50-09:00	**Registration**	**Opening Ceremony**				
09:00-09:40		Plenary I.1 *Alex K.-Y. JEN, City University of Hong Kong, China* **"From Molecular Photovoltaics to the Harness of Sun Power"**				
09:40-10:20		Plenary I.2 *Meyya MEYYAPPAN, NASA Ames Research Center, USA* **"Nano Electronics in " Beyond Moore's Law " Era"**				
10:20-11:00		Plenary I.3 *Zhong Lin WANG, Georgia Institute of Technology, USA* **"Maxwell's Displacement Current Governed Triboelectric Nanogenerator for Self-Powered Systems and Blue Energy"**				
11:00-11:15		**Coffee Break** at Foyer				
11:15-11:45		Keynote I.1 *Yang LU, City University of Hong Kong, China* **"Nanomechanics of 1-D Semiconductors and Elastic Strain Engineering"**				
11:45-12:15		Keynote I.2 *Hui XIE, Harbin Institute of Technology, China* **"Reconfigurable Magnetic Microrobot Swarm: Multi-Mode Transformation, Locomotion and Manipulation"**				
12:15-12:45		Keynote I.3 *Haixia ZHANG, Peking University, China* **"All-In-One Self-Powered Smart System"**				
12:45-14:00		**Lunch** at 7101				
		7201	**7204**	**7205**	**7304**	**7305**
14:00-15:30		WeOAO1- **Award Session I**	WeOAO2- **Invited Session: Flexible and Stretchable Electronics**	WeOAO3- **Invited Session: Quantom Information Processing**	WeOAO4- **Nanomaterials for Energy**	WeOAO5- **Invited Session: Micro/nano Energy Harvesting Technology for Soft Electronics**
15:30-16:30		**Coffee Break**		WePSPP- **Poster Session I**		
16:30-18:00		WeOBO1- **Award Session II**	WeOBO2- **Invited Session: Nanotechnology: Materials, Devices to Instrumentations**	WeOBO3- **Invited Session: Ultrahigh-Precision Mechatronics and Automation Systems**	WeOBO4- **Nanomaterials**	WeOBO5- **Nanofabrication**

July 25 (Thursday)						
		7201				
09:00-09:40	**Registration**	Plenary II.1	***Paul S. WEISS,*** *University of California, Los Angeles* **"Precise Chemical, Physical, and Electronic Nanoscale Contacts"**			
09:40-10:20		Plenary II.2	***Tianhong CUI,*** *University of Minnesota, USA* **"Shrink Polymer Biosensors: Manufacturing from Micro to Nano"**			
10:20-11:00		Plenary II.3	***Pulickel Madhavapanicker AJAYAN,*** *Rice University, USA* **"Materials Science with Two-Dimensional Atomic Layers"**			
11:00-11:15		**Coffee Break** at Foyer				
11:15-11:45		Keynote II.1	***Ting ZHANG,*** *Suzhou Institute of Nanotech and Nanobionics, Chinese Academy of Sciences, China* **"Flexible and Stretchable Sensing Electronics"**			
11:45-12:15		Keynote II.2	***Xiuling LI,*** *University of Illinois, USA* **"Not Your Ordinary Etching: MacEtch of Si, Ge, III-V, and Wide Bandgap Semiconductors"**			
12:15-12:45		Keynote II.3	***Walter HU,*** *University of Texas at Dallas, USA* **"Nanoimprinted Perovskite Devices towards Integrated Optoelectronics"**			
12:45-14:00		**Lunch** at 7101				
		7201	**7204**	**7205**	**7304**	**7305**
14:00-15:30		ThOAO1- **Nanoelectronics: Graphene and Other 2D Materials, CNTs and NWs I**	ThOAO2- **Invited Session: Advanced Micro/nano Robotics**	ThOAO3- **Nano-Acoustics**	ThOAO4- **Nano/bio-Systems**	ThOAO5- **Nano/Molecular Sensors, Actuators, and Systems**
15:30-16:30		**Coffee Break**		ThPSPP- **Poster Session II**		
16:30-18:00		ThOBO1- **Nanoelectronics: Graphene and Other 2D Materials, CNTs and NWs II**	ThOBO2- **Invited Session: Nano Energy and Smart Systems**	ThOBO3- **Invited Session: Nano-Acoustics**	ThOBO4- **Nano-Bio-Imaging**	ThOBO5- **Nanoscale Metrology and Characterization**
18:30-21:00		**Conference Banquet and Award Presentation** at 7101				

July 26 (Friday)						
		7201				
09:00-09:40	**Registration**	Plenary III.1 ***Osamu TABATA**, Kyoto University* **"DNA As an Engineering Material to Bridge between MEMS and Nanotechnology"**				
09:40-10:10		Keynote III.1 ***Han WANG,** University of Southern California, USA* **"Fundamental Properties and Device Prospect of Emerging Low-Dimensional Materials"**				
10:10-10:55		FrPIIT- **Invited Talks I: NanoManufacturing**				
10:55-11:15		**Coffee Break**				
		7201	**7204**	**7205**	**7304**	**7305**
11:15-12:45		FrOIIT- **Invited Talks II: NanoElectronics**	FrOIIS- **Invited Session: Materials Innovation for Next-Generation Spintronics**			
12:45-14:00		**Lunch** at 7101				
14:00-15:30		FrOAO1- **Nanorobotics and Nanomanipulation I**	FrOAO2- **Invited Session: Magnetic Skyrmions**	FrOAO3- **Invited Session: Computing with Nanotechnologies**	FrOAO4- **Nanobiology and Nanomedicine**	FrOAO5- **Nanoelectronics**
15:30-15:45		**Coffee Break**				
15:45-17:30		FrOBO1- **Nanorobotics and Nanomanipulation II**	FrOBO2- **Invited Session: Low-Dimensional Materials, Devices and Applications**	FrOBO3- **Invited Session: Dynamics on DNA Nanostructure**	FrOBO4- **Modeling and Simulation**	FrOBO5- **Nano-Optics, Nano-Optoelectronics, and Nanophotonics**

Wednesday, July 24th, 2019

Wednesday July 24, 2019

WePLPL Room 7201

Plenary Session I (Plenary Session)

Chair: Li, Wen Jung — City University of Hong Kong

Co-Chair: Zhang, Haixia — National Key Laboratory of Science and Technology on Micro/Nano Fabrication, Peking University and Shanghai Jiaotong University

09:00-09:40 WePLPL.1

*From Molecular Photovoltaics to the Harness of Sun Power (I)**

Jen, Alex K-Y. — City University of Hong Kong

09:40-10:20 WePLPL.2

*Nano Electronics in " Beyond Moore's Law " Era (I)**

Meyyappan, M. — NASA Ames Research Center

10:20-11:00 WePLPL.3

*Maxwell's Displacement Current Governed Triboelectric Nanogenerator for Self-Powered Systems and Blue Energy (I)**

Wang, Zhong lin — Georgia Institute of Technology

WeKNKN Room 7201

Keynote Session I (Plenary Session)

Chair: Zhang, Ting — Suzhou Institute of Nanotech and Nanobionics, Chinese Academy of Sciences,

Co-Chair: Yu, Haibo — Chinese Academy of Sciences

11:15-11:45 WeKNKN.1

*Nanomechanics of 1-D Semiconductors and Elastic Strain Engineering (I)**

Lu, Yang — City University of Hong Kong

11:45-12:15 WeKNKN.2

*Reconfigurable Magnetic Microrobot Swarm: Multi-Mode Transformation, Locomotion and Manipulation (I)**

Xie, Hui — Harbin Institute of Technology

12:15-12:45 WeKNKN.3

*All-In-One Self-Powered Smart System (I)**

Zhang, Haixia — National Key Laboratory of Science and Technology on Micro/Nano Fabrication, Peking University and Shanghai Jiaotong University

WeOAO1 Room 7201

Award Session I (Oral Session)

Chair: Jiang, Xiaoning — North Carolina State University

Co-Chair: Wu, Wei — University of Southern California

14:00-14:15 WeOAO1.1

Flexible Carbon Nanotube Sensors with Screen Printed and Interdigitated Electrodes, pp. 1-4

Loghin, Florin — Technical University of Munich

Bobinger, Marco Rudolf — Technical University of Munich

Rivadeneyra, Almudena — Technical University of Munich

Becherer, Markus — Technische Universität München

Lugli, Paolo — Free University of Bozen-Bolzano

Printed electronics is a rapidly emerging field due to the development of new types of functional materials and inks that can be deposited using well-known and widely established printing techniques. Commonly, sensor structures or interconnects on printed circuit boards (PCBs) are fabricated using wet etching and photolithography steps. To overcome the limitations of those techniques, in this contribution, we use a simple and scalable screen printing process to deposit silver-flake based interdigitated (IDE) structures onto sprayed carbon nanotube (CNT) films. The silver (Ag) structures show a low sheet resistance and resistivity of 0.14 Ω/sq. and 6.1·10-7 Ω·m, respectively, at a thickness of around 4.4 µm. Attributed to its flexibility and robustness, a polyimide foil (Kapton®HN) was selected as the substrate. The CNT films with printed IDE that are entirely fabricated in the ambient air are then characterized as resistive gas sensors to detect ammonia (NH3). A high response of around 20% is achieved for an NH3 concentration of 50 ppm.

14:15-14:30 WeOAO1.2

Acoustic Characterization of Laser-Induced Graphene Film Thermoacoustic Loudspeakers, pp. 5-8

La Torraca, Paolo — University of Modena and Reggio Emilia

Bobinger, Marco Rudolf — Technical University of Munich

Romero, Francisco — University of Granada

Rivadeneyra, Almudena — Technical University of Munich

Ricci, Yuri — University of Modena and Reggio Emilia

Cattani, Luca — ASK Industries S.p.A

Morales, Diego — University of Granada

Rodriguez, Noel — University of Granada

Salinas-Castillo, Alfonso — University of Granada

Larcher, Luca — Universityy of Modena and Reggio Emilia

Lugli, Paolo — Free University of Bozen-Bolzano

We report on the superior performance of laser-induced graphene (LIG) film thermoacoustic (TA) loudspeakers. LIG films are fabricated by laser-ablation of polyimide foil and contacted by screen-printing of silver paste, allowing for a facile, ambient condition fabrication process. The LIG film TA loudspeakers achieve up to 50 dB SPL at 1m distance, showing a 10 dB higher efficiency with respect to the nanostructured TA loudspeakers with polyimide substrate reported in literature.

14:30-14:45 WeOAO1.3

Exploiting Lithography Limits for Hardware Security Applications, pp. 9-12

Khan, Raihan Sayeed — University of Connecticut

Noor, Nafisa — University of Connecticut

Jin, Chenglu — University of Connecticut

Muneer, Sadid — University of Connecticut

Dirisaglik, Faruk — Eskisehir Osmangazi University

Cywar, Adam — Analog Devices

Nguyen, Phuong Ha — University of Connecticut

Dijk, Marten van — University of Connecticut

Gokirmak, Ali — University of Connecticut

Silva, Helena — University of Connecticut

Hardware security primitives such as physical obfuscated keys (POKs) allow tamper-resistant storage of random keys based on manufacturing or physical variability. The output bits of existing POK designs need to be first corrected due to measurement noise using error correction methods and then de-correlated by privacy

amplification processes. These additional requirements increase the hardware overhead and reduce the efficiency of the system. In this work, we propose an intrinsically reliable POK design capable of generating random bits by exploiting the limits of the lithographic process for a given technology. Our design does not require any error correction and requires only XOR circuits for privacy amplification which reduces the hardware overhead of the whole system.

14:45-15:00 WeOAO1.4

Investigation on Nickel-Based Nano-Scaffold Getter with Induction Heating and Rapid Activation, pp. 13-18

Lin, Siying	Xiamen University
Huang, Xiang	Xiamen University
Gu, Dandan	Xiamen University
Lv, Wenlong	Xiamen University
Wang, Lingyun	Xiamen University

Abstract—Getter is an important component of MEMS vacuum packaging, which can improve the performance, life and stability of the MEMS device. The existing 2D planar film getter has a low suction capacity and requires long-time activation, which restricts the high-quality batch production of MEMS devices. In this paper, the technology of nickel-based nano-scaffold getter combined with micro-area induction heating activation is adopted to meet the characteristic requirements of MEMS vacuum device packaging for large start-up inspiration rate, high inspiration capacity and quick activation of getter. Focusing on the structure and morphology, deposition of getter materials, getter performance test of nickel-based nano-scaffold based high-efficiency getter that can be induced and activated was preliminarily obtained.

15:00-15:15 WeOAO1.5

Effect of Thin SiO2 Layer on Silicon-On-Glass Anodic Bonding, pp. 19-22

Chen, Zikun	Fuzhou University
Gao, Chengwu	Institute of Microelectronics, Peking University
Guan, Taotao	Peking University
Yang, Fang	Peking University
Shi, Longzhao	Fuzhou University
Zhang, Dacheng	Peking University

this paper reported the effect of SiO2 on the silicon-on-glass anodic bonding theoretically and experimentally for the first time. Silicon glass bonding mechanism based on soft break-down of SiO2 is established and demonstrated. The electrical model of Si-SiO2-Glass anodic bonding stated clearly that anodic bonding voltage must be higher than the break-down voltage of SiO2 to start bonding. The break-down voltage of SiO2 is proportional to its thickness. Bonding strength is finally extracted by a customized on-chip testing device. It is found that the thin SiO2 layer on the silicon surface affects the bonding strength seriously. The bonding strength of anodic bonding with SiO2 layer is 25% stronger than that of typical Si-Glass anodic bonding near the periphery of the silicon wafer, and 8% stronger than that of typical Si-Glass anodic bonding in the central region of the silicon wafer.

15:15-15:30 WeOAO1.6

An Efficient Method to Reduce Crosstalk for Multi-Layered GNR Interconnects at 32 Nm Technology, pp. 23-27

Kumbhare, Vijay Rao	DSPM IIIT Naya Raipur
Paltani, Punya Prasanna	DSPM IIIT Naya Raipur
MAJUMDER, MANOJ KUMAR	IIIT Naya Raipur

In recent, the coupling capacitance becomes prominent in deep submicron and nanotechnology. It can significantly affect the performance of a digital circuit that causes digital logic fault and degrades the performance of Integrated Circuits (ICs). To address this problem, the research paper introduces two shielding methodologies (active and passive shielding) of a multi-layered graphene nanoribbon (MLGNR). An RLC based multi-conductor transmission (MTL) line model is simplified to an equivalent single conductor (ESC) to address the impact of the crosstalk-induced delay. The model parameters are used with reference to the ITRS 32 nm technology in order to demonstrate the performance for different interconnect spacing and lengths. For better understanding, shielded and unshielded methodologies are demonstrated to provide a comparative analysis and improvement with respect to unshielded interconnect lines. Irrespective of the shielding methodology, it is evident that an active shielding provides an improved crosstalk-induced delay compared to passive shielding for different interconnect spacing. At 32nm, the simulation results demonstrate that an active shielded interconnect outperforms passive and without shielding techniques by on an average 6.31% and 44.51% for the crosstalk-induced delay, respectively for different spacing at global lengths. In addition to that, active shielding provides an improved power delay product (PDP) of approximately 6.75% and 16.83% than passive shielded interconnects for 5nm and 20nm spacing, respectively at 1000µm length. Therefore, in order to accomplish the constraint of next-generation technology, an MLGNR can be adopted as a desirable shielding nanomaterial.

WeOAO2 Room 7204

Invited Session: Flexible and Stretchable Electronics (Invited Session)

Chair: Zhang, Ting	Suzhou Institute of Nanotech and Nanobionics, Chinese Academy of Sciences,
Co-Chair: Lee, Chengkuo	National University of Singapore

14:00-14:15 WeOAO2.1

Graphene E-Skin for Physiological Signal Detection (I), pp. 28-28

Ren, Tianling Tsinghua Univ

Physiological signals and motion activities monitoring has exhibited a huge market in the past few decades, reaching the number of $5 billion in 2015. Owning plenty of excellent properties, graphene has been an ideal material for flexible and wearable devices, which can be used to monitor life signals. Graphene, the strongest and thinnest material, is suitable to be wearable device. To obtain the large are and low cost graphene, the laser scribed graphene was proposed. After a few minutes of fabrication and preparation, the programmable graphene pattern can be transferred and attached to any object easily and stably, showing prosperous future potential in health care and intelligent systems. Many physiological signals such as pulse, respiration, joint movement can be detected by the graphene e-skin. Besides electronic e-skin mentioned above, graphene can also be applied to make strain sensors and artificial throat. All of this devices show excellent performance in sensitivity, range, durability and stability, which are essential to health monitoring. Beyond that, these devices possess flexible peculiarity and then make it possible for the fabrication of wearable electronics, with a prosperous future in detection of physiological activities.

14:15-14:30 WeOAO2.2

Flexible Wearable Triboelectric Patches Using Minimalist Design As Novel Human Machine Interfaces (HMIs) (I), pp. 29-29

Lee, Chengkuo National University of Singapore

In the past few years, we have witnessed the significant progress in the smart phones and mobile devices. Wide-range of new applications in healthcare, human-machine interfaces, gaming, virtual reality (VR) and augmented reality (AR) are becoming possible because of the new features provided by novel sensors, well-established smart phone industry infrastructure, and the sensor communication networks. Except to the MEMS based inertial sensors and microphones which are the well-known human-machine interfaces (HMIs), novel textile-based self-powered sensors and stretchable flexible polymer tactile sensors towards diversified applications including energy harvesting, internet of things (IoT), healthcare monitoring, and novel human-machine interfaces for VR and AR applications are introduced. By leveraging the minimalist design, simple flexible wearable triboelectric patches empower the next-generation wearable devices for robotics manipulation, VR and AR control

applications. We foresee the wide application of our new technologies in the future healthcare and amusement applications.

14:30-14:45 WeOAO2.3

Wearable Nanodevices for Single-Cell Sensing and Transfection (I), pp. 30-30

Chang, Lingqian Beihang University

Wearable healthcare devices are mainly used for biosensing and transdermal delivery. Recent advances in wearable biosensors allow for long-term and real-time monitoring of physiological conditions at a cellular resolution. Transdermal drug delivery systems have been further scaled down, enabling wide selections of cargo, from natural molecules (e.g., insulin and glucose) to bioengineered molecules (e.g., nanoparticles), to be delivered into local tissues or cells. Research in our lab (INSCA) are focused on emerging nanodevices for single cell analysis and transfection. In the scenario of in vivo gene transfection, a novel nanodevice implemented on a nano-channel array chip, named Nano-electroporation, show high precision for delivery of molecules into single cell with high delivery efficiency, safety, and dose control. In another scenario, we designed wearable electrochemical microsensors for non-invasive detection of glucose and lactic acid from interstitial fluids, aiming for daily bed-side monitoring of physiological parameters of patients.

14:45-15:00 WeOAO2.4

Micro/nano-Devices for Biomedical Applications (I), pp. 31-31

Xie, Xi Sun Yat-Sen University

Micro/nano system technology have greatly facilitate the development of bioinformatics research. In the field of bioelectronics and bioinformatics, researches have been greatly attracted by biological system modeling and disease predictions based on the understanding of intracellular protein dynamic expression. We have been focusing on the fundamental research on micro/nano-system for biomedical applications, trying to address the key issues on three levels, from the outside to the inside, in vitro – transdermal – and in vivo, aiming to overcome the key challenge of how to develop bio-safe technology to detect and regulate biological disease: 1) On the in vitro cellular level, we made breakthrough process on the development of nano-devices that could safely penetrate cell membrane, achieving regulation and sensing of the intracellular contents dynamically. 2) On the transdermal level, we systematically developed transdermal theranostic system, achieving precise and in situ detection and therapy of diseases. 3) On the in vivo level, we creatively develop bio-safe implantable theranostic system, achieving safe regulation and sensing of diseases in vivo. Our work holds great promise on facilitating the development of new tools for biomedical sensing detection and biomedical therapy, which would be critically important for the field of bioelectronics.

WeOAO3 Room 7205

Invited Session: Quantom Information Processing (Invited Session)

Chair: Zhou, Nanrun Nanchang University

Co-Chair: Xiao, Xiaoqi Shanghai Dianji University

14:00-14:15 WeOAO3.1

Joint Remote State Preparation of Single Qubit State Based on Cavity QED (I), pp. 32-32

Xiao, Xiaoqi Shanghai Dianji University

During the last three decades, the combination of the quantum mechanics theory and the computation and information science has sparked an upsurge of research interest in a new and novel discipline, quantum information and computation, which has been proved to be able to provide improved performances of computation and information processing by utilizing the quantum properties of the state of the physical system where information is encoded on such as superposition, entanglement, measurement-collapse and so on. Among these systems, the cavity QED system has gained more attention for it provides a perfect platform for the interaction between atoms and photons, where in quantum information the atoms are usually regarded as the steady qubits while photons working as the flying qubits to mediate the interaction between them. Taken into account of its advantage, we are concerned with quantum information processing (QIP) in cavity QED system, especially the remote state preparation (RSP). These schemes make fully use of the interaction between atoms and cavity fields to realize the manipulation of quantum states. In this presentation, I would like to display our works on joint remote state preparation of a sigle-qubit state via a three-atom entangled GHZ state and W state, respectively. From the view of the experimental feasibility, the identical two-level atoms and only single-qubit rotation operations are involved in our scheme, which can be realized through the interaction between the single two-level atom and the Ramsey field.

14:15-14:30 WeOAO3.2

Multi-Party Semi-QKD Protocol Based on Four-Particle Cluster States (I), pp. 33-33

Zhou, Nanrun Nanchang University

The application of semi-quantum conception can provide unconditional secure communication for communicators without quantum capabilities, however semi-quantum key distribution (SQKD) is only half as efficient as quantum key distribution (QKD), or even lower. In particular, the efficiency is more worrying when the quantum sender distributes the key to several classical receivers. A semi-quantum key distribution (SQKD) protocol based on four-particle cluster states is put forward, which can achieve key distribution among one quantum party and two classical parties simultaneously. Furthermore, this protocol can be expanded to the -party (> 3) communication scheme. Compared with the existing multi-party SQKD protocol, the proposed protocol and the extended one own more excellent time efficiency and qubit efficiency. The security of the proposed SQKD protocol under ideal circumstances is validated while the key rate under non-ideal conditions is calculated.

14:30-14:45 WeOAO3.3

Quantum Network Dialogue Protocol with Continuous Variable Single-Mode Squeezed States (I), pp. 34-34

Gong, Li-Hua Nanchang University

To maintain the advantages of quantum dialogue protocols based on continuous variables and to develop a more practical quantum network dialogue protocol, a continuous variable quantum network dialogue protocol covering multiple communicators based on single-mode squeezed states is investigated. The security of the channel could be determined by comparing the measured components and there is no information leakage in the communication process according to the Uncertainty Principle and the Quantum Non-Cloning Theorem. Specifically, Alice sends single-mode squeezed states respectively to Bob, Charlie, and etc. Then Bob, Charlie, et al. encode the secret information with a specific encoding rule, insert the Gaussian random data into the encoded message, and send them to Alice. They can deduce the secret information of their counterparts according to the measurement results. In addition, the quantum network dialogue protocol could enable multiple communication parties to transmit and/or receive information at the same time. The new proposed quantum network dialogue protocol based on single-mode squeezed states is much easier to implement compared with those based on the discrete-variable quantum states.

14:45-15:00 WeOAO3.4

A Generalized Information Theoretical Model for Quantum Secret Sharing (I), pp. 35-35

Li, Zhihui Shaanxi Normal University

An information theoretical model for quantum secret sharing scheme was introduced by H. Imai et al. (Quantum Information Computation 5(1), 69–80 2005), which was analyzed by quantum information theory. We analyze this information theoretical model using the properties of the quantum access structure. By the analysis, a generalized model definition for the quantum secret sharing schemes is proposed. In our model, there are more quantum access structures, which can be realized by our generalized quantum secret sharing schemes than those of the previous one. In addition, we also analyze two kinds of important

quantum access structures to illustrate the existence and rationality for the generalized quantum secret sharing schemes and consider the security of the scheme by simple examples.

15:00-15:15 WeOAO3.5

Entanglement Dynamics in an Atom-Cavity-Optomechanical System (I), pp. 36-36

Liao, Qinghong — Department of Electronic Information Engineering, Nanchang Unive

The tripartite entanglement plays an important role in many important applications such as teleportation, dense coding and quantum key distribution. We investigate the dynamics of entanglement in a tripartite cavity-optomechanical system consisting of a two-level atom in a high-finesse optical cavity with a vibrating mirror at one end. The influence of atomic coherence on the time evolution of entanglement is examined. It is shown that the maximally entangled state between the atom, the field and the oscillating mirror can be generated in the ideal case. Moreover, it is found that the entanglement of bipartite and tripartite entanglement can be controlled by atomic coherence and the parameters of optomechanical coupling coefficient and atom-field coupling strength.

WeOAO4 Room 7304

Nanomaterials for Energy (Oral Session)

Co-Chair: Du, Xiaoqing — Institute of Materials, China Academy of Engineering Physics

14:00-14:15 WeOAO4.1

Thermal Conductivity of Rough Silicon Nanowires with Silicide Layer, pp. 37-41

Lee, Seungho — Pohang University of Science and Technology (POSTECH)
Kim, Kihyun — Pohang University of Science and Technology
Meyyappan, M. — NASA Ames Research Center
Baek, Chang-Ki — POSTECH / CiTES

Rough silicon nanowires have considered as promising building block for high efficiency thermoelectric device. We demonstrate that the thermal conductivity of rough nanowires is further reduced by forming cobalt silicide layer on their both ends. This reduction is experimentally investigated using differential 3ω method. The rough nanowire exhibits 10% reduction of thermal conductivity by forming a 100 nm thick cobalt silicide layer at both nanowire ends. To investigate the effect of silicide layer on the reduction in thermal conductivity, the theoretical analysis was performed using the nanoinclusion scattering and interfacial thermal resistance model. It found that the cobalt silicide layer reduces thermal conductivity by disturbing thermal transport in the silicon/cobalt silicide interface.

14:15-14:30 WeOAO4.2

A Frequency Up-Converted Piezoelectric Energy Harvesting System with Broad Bandwidth Based on MEMS PZT Thick Film Technology, pp. 42-45

Huang, Manjuan — Soochow University
Liu, Huicong — Soochow University
Chen, Tao — Soochow University
Yang, Zhan — Soochow University
Sun, Lining — Soochow University

In this paper, an impact-based frequency up- converted piezoelectric energy harvesting system (PEHS) is proposed and fabricated using MEMS piezoelectric thick film technology. The PEHS mainly consists of a high-frequency piezoelectric cantilever (PC-H) with resonate frequency of 935 Hz and a low-frequency stainless-steel cantilever (SC-L) with resonate frequency of 23 Hz. Under the external low-frequency vibration excitation, the SC-L at the bottom impacts the PC-H during the movement, in this way the low-frequency external vibration is converted to high-frequency piezoelectric cantilever vibration. When the PC-H is triggered to vibrate at 935 Hz, the maximum voltage output is 74 mV at 1.0 g. Then incorporate the PC-H with SC-L and form the PEHS, at driving frequency of 20 Hz to 34 Hz, the maximum voltage output and 3dB bandwidth of the PEHS reach 1220 mV and 4.7 Hz, respectively. The maximum voltage output of the PEHS (1220 mV) is more than 16 times of that of the single PC-H (74 mV).

14:30-14:45 WeOAO4.3

Hydrogen Isotope Effects of Nanoporous Palladium, pp. 46-47

Du, Xiaoqing — Institute of Materials, China Academy of Engineering Physics

Separation of hydrogen isotopes with each other is important in hydrogen energy areas, such as the ITER project. Materials with excellent hydrogen isotope effects are needed. Porous palladium has become a worthwhile material in related areas, because of its porous structure, large specific surface area, as well as high absorption of hydrogen isotopes in palladium. Nanoporous palladium (np-Pd) with pore scale of about 5nm was fabricated by method of dealloying corrosion. This np-Pd has a huge specific surface area of 177.3 m2/g. In this work, hydrogen isotope effects of this material are studied in comparison with that of spongy palladium (s-Pd). The kinetic curves and pressure-composition isotherms (PCT) of hydrogen (deuterium) absorption at room temperature were obtained. PCT testing in the temperature range of 25℃ to 65℃ were also carried out. Results show that np-Pd has much faster reaction rates than s-Pd both in hydrogen and deuterium absorption, but shows less difference between hydrogen and deuterium. Np-Pd exhibits lower plateau pressures than s-Pd in both hydrogen and deuterium absorption in the PCT experiments. PCT curves have the same shape in np-Pd and s-Pd, and typical α-β phase transition and wide plateau region appear. Np-Pd shows positive isotope effects like the case in s-Pd. We use a formula, which goes as: αD-H=(PD/PH)1/2, to characterize D/H separation factors at different temperatures among 25℃ to 65℃. D/H separation factors increase with the decreasing of temperatures. This is similar between np-Pd and s-Pd, but the increasing rate is larger for np-Pd. Np-Pd has higher D/H separation factors at 35 ℃ and lower temperatures, showing obvious hydrogen isotope effects. This is an advantage in use of hydrogen isotopes separation at temperatures no higher than 35 ℃. Together with the much faster reaction rates, np-Pd is considered to be a promising material for tritium processing applications.

14:45-15:00 WeOAO4.4

*Activating Inert Basal Plane of MoS2 for H2O Dissociation and HER Via Formation of Vacancy Defects: A DFT Study**, pp. 48-53

Ye, Kongqiang — Fuzhou University
Li, Minglin — Fuzhou University
Luo, Jing — Xiamen Tungsten Co., Ltd
Bo, Wu — Fuzhou University
Lai, Lianfeng — Ningde Normal University

The molybdenum disulfide (MoS2), as a promising and nonprecious catalyst, has attracted growing interest towards the hydrogen production, especially the dissociation of water and the hydrogen evolution reaction (HER). However, the known active sites are limited to edges and one primitive cell missing vacancies. Herein, the potential catalytic activities of five types of vacancies in the inert basal plane of MoS2 are investigated by using first-principle density functional theory (DFT) calculations. two types of vacancies (VMo and VMoS2) are found to have the promising catalytic activities for the splitting of H2O and have the comparable or even better catalytic activities for the HER, in compared with the precious platinum. Our theoretical works suggest that formation of the specified vacancy defects on the inert basal plane will enhance the catalytic activities of MoS2 for the dissociation of H2O and the HER, which improves the efficiency of hydrogen production.

15:00-15:15 WeOAO4.5

Development of Heterocyclic-C61-Butyric Acid Methyl Ester/ Pyrazine (HCBM-Pyrazine) Acceptor Material for Organic Solar Cells Applications, pp. 54-58

Bani Salim, Muath — Texas A&M University–Kingsville

Nekovei, Reza — Texas A&M University-Kingsville
elwaie, Tamer A — Irma Lerma Rangel College of Pharmacy, Texas A&m University
Jeyakumar, R. — Materials and Devices Division, National Physical Laboratory, Ne

This paper presents a novel modification on the Phenyl-C61-butyric acid methyl ester (PCBM) for better performance as an acceptor material in the organic solar cells (OPV). Heterocyclic ring (Pyrazine) was used in the place of the Phenyl group of the PCBM to form a new acceptor material Heterocyclic-C61-butyric Acid Methyl Ester/ Pyrazine (HCBM-Pyrazine). The electronic properties for the new material are obtained theoretically by using Density Functional Theory (DFT) method with the help of the Gaussian 16 program. The results show that the HCBM-Pyrazine can create more voltage if used with any donor materials. Besides that, it has larger electrons affinity making it better acceptor than the original PCBM. Also, the results show that both molecules have closer absorption spectrum and reorganization energies.

15:15-15:30 — WeOAO4.6

In Situ Observations of Interfacial Evolutions in Solid-State Lithium Battery with Sulfide-Based Solid Electrolyte, pp. 59-62

Fan, Zheng — University of Houston

Solid electrolytes enable safe rechargeable lithium batteries and allow batteries with lithium metal anodes to possess higher energy density than that of conventional liquid electrolyte-based batteries. However, the structural evolution-induced interfacial failures during the electrochemical cycling were not fundamentally explored. In this report, a practical setup is developed for in situ detection of the electrochemical reaction-induced micro and nanoscale morphological changes along with the battery interface. We have focused on the anode interface between lithium metal electrode and sulfide solid electrolyte while monitoring an inflating phenomenon in the electrolyte during the lithium plating. This observation suggests that the lithium dendrite formation, as well as the lithium deposition in the porous structures, drives the volume expansion of the solid electrolyte layer. This rare finding offers a fresh perspective, indicating a new impact for the lithium plating in sulfide electrolyte, which does not accord with the conventional structural evolution model at the electrode-solid electrolyte interface. This study provides significant insights into the mechanism of the interfacial phenomena in sulfide solid-state battery and paves the way for advanced engineering of them.

WeOAO5 — Room 7305

Invited Session: Micro/nano Energy Harvesting Technology for Soft Electronics (Invited Session)

Chair: Zhang, Haixia — National Key Laboratory of Science and Technology on Micro/Nano Fabrication, Peking University and Shanghai Jiaotong University
Co-Chair: Wang, Fei — South University of Science and Technology of China

14:00-14:15 — WeOAO5.1

Vibration Energy Harvesters for Self-Powered Wireless Sensing (I), pp. 63-63

Wang, Fei — South University of Science and Technology of China

Recently, energy harvesting devices have been developed to extract energy directly from our ambient environment such as vibration sources. There are a few challenges for micro-scale vibration based energy harvesters such as the MEMS-compatible fabrication, normalized power density and bandwidth. Based on advanced MEMS technologies, we have developed the optimization methods to improve the normalized power density and the bandwidth of the electrostatic energy harvesters. In particular, the displacement limitation and low air damping effect with perforated electrode or packaging pressure control on the device performance will be discussed. Recently, we have developed a self-healing setup to sovle the charge decay problem of the electret, which would prolong the lifetime and improve the stability of the energy harvester. With optimized performance, the micro energy harvesting devices could be applied for more sustainable and scalable wireless sensor networks, and will help to provide environment friendly electronics, self-powered systems and the next generation of smart cities.

14:15-14:30 — WeOAO5.2

Self-Powered Sensing Based on Triboelectric Nanogenerator and Impedance Matching Effect (I), pp. 64-64

Sun, Xuhui — Soochow University

Triboelectric nanogenerators (TENGs) based on the coupling effect of triboelectrication and electrostatic induction have been developed to be a promising strategy to harvest mechanical energy and convert them to electricity. Traditional TENG based self-powered sensing systems have been demonstrated by measuring the triboelectric effect of the sensing materials altered by the external stimulus. However, the limitations of triboelectric sensing materials and instable outputs caused by ambient environment significantly restrict their practical applications. In this talk, I will illustrate the impedance matching effect based self-powered sensing process which can avoid the external impacts. Since a TENG is intrinsically a capacitor, while connecting with an external load, the output current from the TENG will decrease with the increment of the load resistance. By using a traditional sensor as the external load of TENGs, a self-powered sensing system can be achieved through monitoring the variation in the current or voltage signals. Several powered systems will be introduced in this talk, such as real-time ultraviolet photodetector, vehicle emission testing system, self-powered weighing/pressure system, on-line ion concentration monitor, etc. This novel self-powered sensing system is not affected by working frequency and requires no external power supply, which is favorable to improve the stability and reliability for practical application.

14:30-14:45 — WeOAO5.3

Tribotronics for Active Mechanosensation and Self-Powered Systems (I), pp. 65-65

Zhang, Chi — Beijing Institute of Nanoenergy and Nanosystems, CAS

Tribotronics has attracted great attentions as a new research field about the control and tuning of semiconductor transport by triboelectricity. Here, the tribotronics is firstly reviewed for active mechanosensation and human-machine interfacing. As the fundamental component, contact electrification field-effect transistor is analyzed, in which the triboelectric potential could be used to control the electrical transport in semiconductors. On the basis, several tribotronic functional devices have been developed including tribotronic smart skin, tactile sensing array and tuning diode, which has demonstrated triboelectricity-controlled electronics and established the active mechanosensation for external environment. In addition, the triboelectric power management strategy is also reviewed, in which the triboelectricity can be managed by electronics in reverse action. With the implantation of triboelectric power management module, the harvested triboelectricity by various kinds of human kinetic and environmental mechanical energy could be effectively managed as a power source for self-powered systems. By the research prospects for interactions between triboelectricity and semiconductor, tribotronics is expected for significant impacts and potential applications in MEMS/NEMS, flexible electronics, robotics, wireless sensor network, and Internet of Things.

14:45-15:00 — WeOAO5.4

Carbon Based Wearable Devices for Soft Electronics (I), pp. 66-66

Zhang, Min — Peking University

Soft electronic applications from human-machine interactions in artificial intelligence to wearable devices for the Internet of Things are changing the world. As core foundation devices of an all-soft system, input, output, power generator, and the processing devices are all expected to be soft. Among them, the soft transistors are expected to have high flexibility or stretchability, low

power, and high uniformity. Strain sensors with broad sensing range, high sensitivity and linearity are highly desirable in health monitoring systems to detect both large strains and subtle strains. High-efficiency soft nanogenerators are expected to provide stable power. To address these requirements, our group has designed and realized a carbon based soft device platform. In this platform, we have built up a series of carbon based thin film transistors (TFTs), including transparent all-carbon TFTs, flexible all-carbon TFTs, rollable all-carbon TFTs, and stretchable all-carbon TFTs. We have also explored and proposed some new integration solutions for soft electronics, especially for low-dimension material integration. Besides, we have realized highly linear and broad-range- detection strain sensors by designing a fin-like microstructure, combining the advantages of vertical carbon nanotubes (CNTs) and Ecoflex. For the soft power, we have realized high performance triboelectric nanogenerators by embedding the aligned CNTs on the PDMS surface as the effective dielectrics to donate electrons. This design introduces material modification and surface morphology at the same time. The stretchable aligned CNT–PDMS films can be universally utilized as a positive triboelectric layer for nanogenerators, pairing with different polymeric materials. With the novel carbon based wearable devices, the soft platform provides promising solutions to flexible or stretchable electronics.

15:00-15:15 WeOAO5.5

Triboelectrification Based Active Sensor and Its Hybrid Sensors for Multiple-Functional Tactile Sensing (I), pp. 67-67

Meng, Bo — Shenzhen University

The well-known phenomenon of triboelectrification (also called contact electrification) has been exploited for energy harvesting use, and it has shown to achieve high power density with considerable efficient and make it feasible the low-cost mass production of flexible generators. Meanwhile, this triboelectric nanogenerators were widely investigated for active sensing applications. In our work, triboelectrification based active sensor and its hybrid sensors have been developed for multiple-functional tactile sensing use as well. Well-designed single-electrode triboelectric nanogenerator shows ability in material distinguishing, surface roughness, deformation and motion detection et. al. With the combinations of piezoresistive and capacitive transducers, pressure and hardness can be measured at the meantime. Which helps to realize objects identification, showing potential applications in robotics and industrial use.

WePSPP Hallway

Poster Session I (Poster Session)

Chair: Li, Meng — Shenyang University of Technology

15:30-16:30 WePSPP.1

Molecular Dynamics Simulation of Self-Assembly and Electroporation of Lipid Bilayer Membrane in Martini Force Field, pp. 68-71

Liu, Min — Xidian University
Gan, Jinrui — Xidian University
Gao, Libo — Xidian University
Wang, Weidong — Xidian University

The lipid bilayer membrane is a major component of cells and intracellular membranes in vivo, and plays an indispensable role in organisms. Currently in the medical field, lipid bilayer membranes are used as devices for targeted delivery of proteins, nucleic acids and drugs in the treatment of a variety of diseases. Based on coarse-grained molecular dynamics (CGMD), this paper studies the modeling method of the lipid bilayer with water as solvent in the Martini force field. The coarse-grained lipid bilayer membrane model can expand the time scale and improves the computational efficiency of molecular dynamics (MD) simulation. The self-assembly process of DPPC bilayer lipid membrane is simulated in Martini force field and the radial distribution function (RDF) is also analyzed. In addition, this paper studies the molecular dynamics of 1,2-dipalmitoyl-sn-glycero-3-phosphocholine (DPPC) lipid bilayer membrane electroporation under Martini force field, which provides a theoretical reference for the application of coarse-grained molecular dynamics in biomedical and other related fields.

15:30-16:30 WePSPP.2

Simulations of Methane and Acetone Detector Based on Pristine Graphene Nano-Sheet Over Intrinsic 4H-SiC Substrate, pp. 72-75

Rashid, Muhammad Haroon — Tallinn University of Technology
koel, Ants — Tallinn University of Technology
Rang, Toomas — Tallinn University of Technology
Ziko, Mehadi Hasan — Tallinn University of Technology

Nowadays graphene and its derivatives have gained the interest of researchers due to their exceptional optical, electrical and chemical attributes. They have emerged as potential candidates for electronics and optoelectronics sensor applications. Graphene is highly sensitive to any physical change in its surrounding environment that makes it a suitable candidate for sensing a large variety of organic and inorganic molecules. Volatile and flammable organic compounds like acetone and methane can lead to fatal accidents in domestic and industrial environments. In this article, nanoscale simulations of graphene nano-sheet based methane and acetone detector have been done. Intrinsic 4H-SiC has been used as a substrate for graphene nano-sheet. These simulations have been carried out in QuantumWise Atomistix Toolkit (ATK) software that is an atomic scale semiconductor device simulator. A noticeable change in the density of states (DOS) and electrical conductivity through the device has been observed in the presence of target molecules. This change in electrical conductivity through this nano-scale device can be used as a detection signal for methane and acetone molecules to develop a physical sensor.

15:30-16:30 WePSPP.3

Scanning Electron Microscope Calibration with SE2 and Inlens Detectors, pp. 76-79

Bian, Weiguo — Jiangsu Provincial Key Laboratory of Advanced Robotics & Collabo
Wang, Mingyu — Jiangsu Provincial Key Laboratory of Advanced Robotics & Collabo
Yang, Zhan — Soochow University

Abstract—In this paper, we proposed an ideal that calibration in the scanning electron microscope (SEM) with SE2 detector and Inlens detector. The parameters (intrinsic and extrinsic) were both achieved. This approach required rotation and translation of the chessboard calibration to obtain multi-images. Experiments were realized by varying the orientation and the position of chessboard pattern from different work distance (WD). It can be seen from the calibration results that the SE2 detector and the Inlens detector have different overall average pixels at different work distances. By comparing the calibration results, it was found that the two detectors had close pixel errors when the work distance was between 6.4mm and 6.5mm. The results show that the calibration approach was accurate and efficient.

15:30-16:30 WePSPP.4

Rapid Quantitative Detection of Salmonella Spp. Via Magnetic Beads-Based Fluorescent Lateral Flow Immunoassay, pp. 80-85

Zhuang, Linlin — Southeast University
Gong, Jiansen — Poultry Institute, Chinese Academy of Agricultural Sciences, Jia
Ji, Yongxin — Nanjing Nanoeast Biotech Co., Ltd
Gu, Ning — Southeast University
Zhang, Yu — Southeast University

Polymerase chain reaction (PCR) plays an increasingly important role in microbial detection. However, the existing methods are difficult to be widely applied due to factors such as instruments, reagents, and experimental conditions. In this study, we developed

a robust and reliable fluorescent lateral flow immunoassay combined with polymerase chain reaction (PCR-LFIA) based on magnetic beads purification for rapid detection of Salmonella app. The PCR-LFIA assay can avoid false positives caused by primer dimers. The sensitivity of PCR-LFIA method was 6 CFU/mL of Salmonella pure culture or 600 CFU/mL of artificially spiked chicken faeces. The specificity of PCR-LFIA assay was verified by eighteen Salmonella and non-Salmonella reference strains. Six of the eighty-five (7.1%) samples collected were positive by PCR-LFIA assay and the results were further confirmed by biochemical characteristics. This assay allows quantitative detection of Salmonella with a cutoff value of 175 and can be completed in 80 minutes. In conclusion, the optimized PCR-LFIA method can potentially serve as an effective diagnostic tool for timely response to disease outbreaks.

15:30-16:30 WePSPP.5

Fabrication of Microlens Arrays on Flexible Films Using Electrohydrodynamic Jet Printing, pp. 86-89

Zhong, Ya	Chinese Academy of Sciences
Yu, Haibo	Chinese Academy of Sciences
Zhou, Peilin	Shenyang Institute of Automation, Chinese Academy of Sciences
Zou, Wuhao	University of Chinese Academy of Sciences, Shenyang Institute Of Automation
Wang, Yuechao	State Key Laboratory of Robotics, Shenyang Institute of Automation
Liu, Lianqing	Shenyang Institute of Automation, Chinese Academy of Sciences

Abstract—In recent years, flexible microlens arrays (MLAs) have attracted attention owing to their characteristics of easy deformation, stretchability, and attachability. This paper introduces a new method for fabricating MLAs via direct writing on a polydimethylsiloxane (PDMS) film substrate using electrohydrodynamic jet (e-jet) printing. This method involves forming neatly arranged 10 × 10 MLAs by directly printing the droplets of a high-viscosity photocurable gel at the target location. The manufactured MLAs demonstrate a uniform shape and smooth surface. The overall size of the MLAs is approximately 275 × 275 μm2–320 × 320 μm2. The diameter of a single microlens is flexible and can be adjusted from 5.5 μm to 15 μm. By applying the MLAs, we can obtain a clear and uniform image.

15:30-16:30 WePSPP.6

Pulsed Laser Deposited MoS2 for the Fabrication of MoS2/Graphene Photodetector, pp. 90-93

Zhang, Shuye	State Key Laboratory of Advanced Welding and Joining, Harbin Ins
Zhang, Yanxin	Harbin Institute of Technology
Lin, Tiesong	Harbin Institute of Technology
He, Peng	Harbin Institute of Technology

Since the 21st century, with the continuous development of technology, much tremendous progress has been made in the microelectronics industry. When the channel of the device is reduced to the nanometer scale, the silicon-based semiconductor has approached its physical limit, and the performance begins to decrease, so the traditional silicon-based semiconductor industry has entered the research bottleneck. Compared with traditional silicon-based semiconductors, two-dimensional materials are increasingly used in the semiconductor industry due to their ultra-thin atomicity and semiconductor characteristics. As a typical representative of two-dimensional materials, MoS2 is widely used for device preparation, including gas sensors, phototransistors, flexible thin film transistors, lithium-ion battery electrodes and heterojunction diodes. However, achieving high-quality, controllable large-area preparation of MoS2 is still a major problem, which seriously hinders the development of MoS2 in the application field. In this paper, pulsed laser deposition is used to prepare large-sized MoS2 by controlling different deposition time.

15:30-16:30 WePSPP.7

5-Bit Spiral Distributed RF MEMS Phase Shifter, pp. 94-98

Tian, Wenchao	Xidian University
Zhang, Yuting	Xidian University
Li, Mengjuan	Xidian University
Xie, Zhongliang	Xidian University
Li, Wenhua	Xidian University

A new spiral distributed radio frequency micro-electromechanical system (RF MEMS) phase shifter which uses 31 MEMS switches to achieve 5-bit phase shifts is designed in this paper. The area of the phase shifter is 2.6×2.6 mm2. The simulation results of phase shift are 11.43°, 23.04°, 44.53°, 91.73° and 182.65° when the central operating frequency is 40 GHz. The deviations of the design target are 0.18°, 0.54°, 0.47°, 1.73° and 2.65°, respectively. Insertion loss and return loss are -15.1092 dB/-8.9120 dB, -14.2271 dB/-9.9053 dB, -13.5592 dB/-9.3319 dB, -13.2439 dB/-11.6679 dB and -16.3046 dB/-10.2057dB, respectively. The simulation results and phase shift accuracy of the 31 phase shifts of RF MEMS phase shifter are given, and the deviation of the design target is within 3.72°. It realizes the requirements of RF MEMS phased array system. This phase shifter has the advantages of high frequency, small size, high precision, low loss and low cost.

15:30-16:30 WePSPP.8

Wide-Field Planar Magnetic Imaging Using Spins in Diamond, pp. 99-102

Chen, Yulei	North University of China
Tang, Jun	North University of China
Guo, Hao	North University of China
Li, Zhonghao	The North University of China
Gao, Yanjie	North University of China
Liu, Yusong	North University of China
Shi, zhenrong	The North University of China
Liu, Jun	North University of China

The nitrogen-vacancy color centers in diamond can be used as an excellent magnetic sensor. In this work, we present a wide-field planar magnetic imaging technique based on nitrogen-vacancy color centers. Through optically detected magnetic resonance (ODMR) which is readout from a scientific CMOS camera to extract resonance frequency, we experimentally reconstruct the magnetic field distribution of permanent magnets and particles of magnetite (Fe3O4). The imaging field of this technology can reach the sub-millimeter level and the spatial resolution can reach the optical diffraction limit. The presented wide-field NV imaging technique offers wide-field imaging, high spatial resolution, and high magnetic sensitivity.

15:30-16:30 WePSPP.9

Ultrasonic-Responsive Pluronic P105/F127 Micelles for Overcoming Multidrug Resistance in Cancer, pp. 103-105

Sun, Min	Tongji University
Sun, Yu	Tongji University
Zhang, Mingjun	The Ohio State University
Fan, Zhen	Tongji University

Herein, the Pluronic P105 and F127 mixed micelles (PM) was fabricated by self-assembly for combating multidrug resistance (MDR) in cancer. The approximate diameter of our prepared PM is 115.7 nm, which makes it possible as a drug carrier. In vitro drug release assay indicated that the ultrasound could accelerate the drug release rate in doxorubicin-loaded Pluronic micelles (PM/D). MDR human breast cancer cell line (MCF-7/ADR) was utilized to evaluate the therapeutic effects of PM/D. Our experiments demonstrated that, after 3 min of ultrasound, more amount of chemo-drug was released and took in MDR cell, resulting in a significant cytotoxicity. Such enhanced therapeutic efficiency could be attributed to the combined effects of Pluronic's capacity in overcoming MDR and ultrasound-controllable drug release.

15:30-16:30 WePSPP.10

Design of a Test Structure Based on Chevron-Shaped Thermal Actuator for In-Situ Measurement of the Fracture Strength of MEMS Thin Films, pp. 106-109

Li, Meng-Jie	Southeast University
Zhou, Zai-Fa	Southeast University
Yi, Li-Yan	Southeast University
Wang, Xi-Jie	Southeast University
Adnan, Saeed	Southeast University

A test structure to demonstrate the fracture strength of MEMS thin films is designed. The test structure consists of a chevron-shaped thermal actuator and the test specimen. A voltage is applied across the beams of the actuator, providing thermal expansion force to fracture the test specimen. The fracture strength can be calculated by reading the displacement of the beams when the specimen is just fractured. The calculation formula is derived by analyzing the force and displacement provided by the actuator. Chevron thermal actuator with 6 different design dimensions is designed and simulated in COMSOL Multiphysics, and a heat sink is added to the structure to limit the heat flow to the test specimen. The shape of the actuator remains the same. Only the length and the number of beams, length and width of the shuttle and the pre-bent angle are changed in each model. A model which can provide large force and displacement at low temperature is found after analyzing the results.

15:30-16:30 WePSPP.11

Development of Immunoassay Bio-Chip Based on Stacked Nanoparticles, pp. 110-112

Deng, Zu-Yin	National Chung Hsing University
Chen, Kuen-Lin	National Chung Hsing University
Wu, Chiu-Hsien	National Chung Hsing University

In this study, we built a biosensing chip based on magnetic induction change. The gold and iron oxide magnetic nanoparticles(npls) were deposited on a glass substrate Interlaced. The top layer of gold npls were functionalized for binding target antigen Bovine serum albumin (BSA). The viscosity of antigen molecules influence the magnetic susceptibility from Brownian relaxation. Therefore, the concentration of antigen could be measured the magnetic strength. The lowest concentration for detection was 15 μg/mL, and the immune response time was 10 - 15 seconds.

15:30-16:30 WePSPP.12

Copper Oxide Nanorods Pesticide Sensor for Methyl Parathion Detection, pp. 113-116

Sakdarat, Phichamon	International School of Engineering (ISE), Faculty of Engineering
Chongsuebsirikul, Jidapa	International School of Engineering (ISE), Faculty of Engineering
Phongphut, Angkana	Department of Chemical Engineering, Faculty of Engineering, Chul
Klinthingchai, Yoottapong	Department of Chemical Engineering, Faculty of Engineering, Chul
Prichanont, Seeroong	Department of Chemical Engineering, Faculty of Engineering, Chul
Thanachayanont, Chanchana	National Metal and Materials Technology Center (MTEC), National
Pungetmongkol, Porpin	International School of Engineering (ISE), Faculty of Engineering

Currently, most electrochemical based pesticide sensors use acetylcholinesterase enzyme modifying on working electrode surface to sense the concentration of the organophosphate pesticides. Since this method has high sensitivity and easy to prepare; however the cost of the enzyme is very expensive and the stability of the enzyme activity is poor which result in short lifetime. From those drawbacks of current pesticide sensor, non-enzymatic sensor is an alternative way to detect pesticide with lower cost, higher sensitivity and stability. In this work, copper oxide nanorods were used to overcome the difficulties of enzymatic pesticide sensor. To obtain cost effective and simple preparation pesticide sensor, direct anodization and annealing processes were used to synthesize copper oxide nanorods. We used our synthesized copper oxide nanorods in electrochemical analysis by performing cyclic voltammetry in organophosphate pesticide. Our copper oxide nanorods electrode exhibits sensitivity and detection limit of 1.234 μA/ng mL</i>$^{-1}$ and 0.0761 ng/mL, respectively. Our copper oxide nanorods electrode provides high sensitivity and desirable detection limit with higher stability and lower cost than the common enzyme- based pesticide sensor.

15:30-16:30 WePSPP.13

Highly Flexible and Stretchable Structure Based on Au/Graphene Film and Polyurethane Yarn, pp. 117-120

Li, Xiaoting	City University of Hong Kong
Lai, King Wai Chiu	City University of Hong Kong

Flexibility and stretchability are two key components to be considered in fabricating flexible and stretchable electronic devices. However, most of the current reported flexible and stretchable devices used for wearable electronic devices usually have limited flexibility and stretchability. In this work, a novel flexible structure, which employs Au/graphene film as sheath and polyurethane (PU) yarn as core, is fabricated by a layer-by-layer (LbL) self-assembly method, followed by magnetron sputtering technology. The as-prepared flexible structure demonstrates outstanding flexibility and stretchability which endowed by the core material PU yarn (can be stretched as long as 500%) and superior conductivity which endowed by sheath materials Au/graphene (the resistance reaches to around 5.0 kΩ/cm), showing enormous potential in the development of flexible electronics.

15:30-16:30 WePSPP.14

Computational Properties of Ising Spin Model on Spin Connection Parameters, pp. 121-124

Miki, Tsukasa	Tokyo University of Agriculture and Technology
Ito, Mitsuki	National Institute of Technology, Kushiro College
Hirata, Yosuke	Tokyo University of Agriculture and Technology
Kushitani, Yuki	Tokyo University of Agriculture and Technology
Shimada, Moe	Tokyo University of Agriculture and Technology
Shirakashi, Jun-ichi	Tokyo University of Agriculture and Technology

Recently, a new computing architecture using Ising spin model is gaining increasing attention. The Ising spin model is considered as an efficient computing method to solve combinatorial optimization problems. Depending on the problems, Ising spin model requires an arbitrary topology and wide range of interaction coefficient values on the spin connection. Hence, we focused on the number of spin connection. In this work, we investigated computational properties of Ising spin model with various numbers of spin connections through solving combinatorial optimization problems. Consequently, the architecture with fully connectable spins makes Ising spin model well suited for solving complex combinatorial optimization problems.

15:30-16:30 WePSPP.15

Investigation on Visible Emission of ZnO Films Deposited on Copper Nitride Substrates, pp. 125-128

Ding, Jijun	Xi'an Shiyou University
Chen, Haixia	Xi'an Shiyou University
Li, Huidong	Xi'an Shiyou University
Fu, Haiwei	Xi'an Shiyou University

ZnO films with different oxygen gas flow rate are deposited on copper nitride substrates by radio frequency magnetron sputtering. All samples are annealed in vacuum at 350 ℃ for 1h. Results indicates that Cu3N diffraction phase is observed in the XRD pattern of copper nitride substrates. As ZnO layer is deposited on copper nitride substrates, Cu3N diffraction peak disappears. PL spectra of all samples shows two blue emission peaks and a green emission. Under the unbalanced stoichiometric ratio, the blue peaks are enhanced. Especially, at a low oxygen gas flow rate of 5:25 sccm, two blue peak intensity reach maximum. In this case, there are overabundance Zn atoms due to a poor oxygen atmosphere. Both interstitial Zn and various substitution defects will appear in the deposited films, thus causing the intensity increment of visible emission peaks.

15:30-16:30 WePSPP.16

Development of Micro-Needle Array for Tumor Vaccine Patch Applications, pp. 129-132

Yu-Hsiang, Tang — Taiwan Instrument Research Institute, National Applied Research

Huang, Tsung-Tao — Taiwan Instrument Research Institute, National Applied Research

Abstract—Microneedles have been given sufficient potential as a patch for transdermal drug delivery. However, very few product on the application of MEMS for the vaccine delivery is reported. The aim of this paper is to develop the vaccine coated solid microneedle patch by the use of micro-electromechanical systems (MEMS) technology, The fabrication of a silicon microneedle arrays made by UV lithography, inductively coupled plasma reactive ion etching (ICP-RIE) and wet chemical etching process. To solve the limitation of low vaccine volume carried, groove and pocket structure will be introduced. Besides, through the control of formulation of surface tension, viscosity and hydrophilic/ hydrophobic properties by optimization of vaccine formulation composition, the vaccine carried volume can be achieved. Moreover, bioactive of vaccine will be investigated by parameter of the osmotic pressure and phase-transformation. Combination of vaccine formulation and microneedle to fabricate the delivery device, the release profile of the device will be evaluated in vitro, and will be further evaluated in the artificial human skin system to observe the immune response. The research will be included two parts: 1. vaccine coated solid microneedle patch device will be established; 2. design a microneedle patch having specific application, such as enterovirus 71 vaccines, and to realize a commercial available vaccine microneedle patch device. Consequently, a microneedle array with biodegradable porous tips was further developed based on the fabricated microneedles patch.

15:30-16:30 WePSPP.17

Plasmonic Sensing of Spherical Analytes Accumulated on a Double-Bent Gold Nanostrip Array, pp. 133-134

Wi, Jung-Sub — Korea Research Institute of Standards and Science

Lee, Jinhyung — Korea Research Institute of Standards and Science

For the effective placement of target analytes on nanoplasmonic sensing spots, we combined a one-dimensional Au nanostrip array with a dip-coating method. During the dip-coating step, target analytes were self-aligned at the valleys between neighboring Au strips, in which electromagnetic fields were locally enhanced by interactions between the adjacent strips. Using the proposed method, the accumulation of polystyrene beads and their removal were successfully measured by monitoring changes in the localized surface plasmon resonance wavelength.

15:30-16:30 WePSPP.18

*Modeling of CNTFET MVL Comparator Using 14nm Node Technology**

Farhana, Soheli — Universiti Kuala Lumpur

In this paper, modeling of a carbon nanotube field effect transistor (CNTFET) based multi-valued (MVL) comparator using current mode 14 nm node technology is presented. Existing MVL comparator circuits consume high power. The model presented in this paper demonstrated the low power required. It has been simulated with PSPICE using the transistor model parameter values of the for 14nm CNTFET process. With a 1.2-volt power supply, simulations show that the proposed MVL CNTFET comparator consumes 0.104 mW total average static power and a sampling rate 600MHz. Power and speed for CNTFET MVL comparators designed in these technologies are discussed. The comparator design is suitable for the needs of mixed-signal integrated circuit design and can be implemented as a conversion circuit for systems based on multiple-valued logic design.

WeOBO1 Room 7201

Award Session II (Oral Session)

Chair: Wu, Wei — University of Southern California

Co-Chair: Jiang, Xiaoning — North Carolina State University

16:30-16:45 WeOBO1.1

A Reconfigurable Interconnect Technology Based on Spoof Plasmon, pp. 135-140

Joy, Soumitra — University of Michigan

Bari, Md Faizul — Bangladesh University of Engineering and Technology

Baten, Zunaid — Bangladesh University of Engineering and Technology

Lan, Feng — University of Michigan

Mazumder, Pinaki — University of Michigan

The bottleneck of inter-chip communication speed, for instance, that between logic and memory units is a long-standing issue in acquiring ultrafast computing. While research from two extreme ends of technologies: electrical, and optical interconnect have their own pitfall in constructing an energy-economic route of communication with high bandwidth density, a radically different technology named as spoof plasmon based communication may bring new insight towards addressing the issue. The technology smoothly interweaves the advantages of electrical interconnect and that of optical ones. In the present work, we have given a proof-of-concept demonstration of the signal transfer capacity of spoof plasmon parallel data-bus. We demonstrated that spoof plasmon channel can accommodate two different kinds of mode: electro-SSPP mode and opto-SSPP mode. Depending on the data-traffic, SSPP channel can be dynamically reconfigured for supporting either of the two modes for information transfer in order to minimize energy consumption. In addition, we also endeavored to provide an answer to the question that whether the metasurface based information transfer system can be reliable in case of pattern distortion emanated from fabrication process variations or after-fabrication effect that introduces nonidealities to the designed structure.

16:45-17:00 WeOBO1.2

Enhancing Environmental Sensing Capability of AFM-Based Nanorobot Via Spiral Local Scan Strategy, pp. 141-146

Sun, Zhiyong — University of Hong Kong, Northeastern University (CN), Michigan

Xi, Ning — University of Hong Kong

Yu, Huiyang — University of Hong Kong

Xue, Yuxuan — University of Hong Kong

Bi, Sheng — University of Hong Kong

CHEN, Liangliang — Michigan State University

Atomic force microscopy (AFM) based nanorobotic technology has been widely implemented in light of the overwhelming advantages, such as nanometer spatial resolution, adaptability to various ambient, and numerous advanced measurement approaches. It is noted that even though the AFM possesses nanometer imaging resolution, it is hard to achieve nanometer tip locating precision due to complicated uncertainties, especially the nonlinearity of tip-environment interaction and the random drift influence. Since

an AFM image is typically utilized as a map for nanomanipulation, the uncertainty distorted image will definitely introduce location deviation between the real and the captured nano-world, which typically leads to low efficiency or even failure of tasks. Besides, complicated tip-environment interaction is generally hard to model and to make accurate prediction, which will also lead to task failure. Therefore, to achieve highly accurate operation at the nanoscale, environmental sensing capability of AFM-based nanorobot should be promoted. In this paper, we propose a local environment sensing approach to detect positioning uncertainty between nanorobot tip and its surroundings by developing a multi-functional spiral local scan (MSLS) strategy comprised of structured objects location detection function and local surroundings imaging function. Briefly, sphere/cylinder-like object location detection strategies were proposed; a tip motion predictor was developed to tackle the heavy noise issue of detection tasks at dozens of nanometers scale, based on which a local area imaging approach was established. Efficiency of the MSLS method was verified through experimental study.

17:00-17:15 WeOBO1.3

Optical Characterization of ZnO Nanoforest for Hardware Security Applications, pp. 147-152

Noor, Nafisa — University of Connecticut

Silva, Helena — University of Connecticut

Disordered systems or materials with intrinsic variability in some measurable quantity are recently being considered for hardware security applications like physical unclonable functions (or PUFs). An inexpensive optical PUF system based on a dense nanoforest of ZnO nanorods is presented here. A relatively concentrated seed solution used in the synthesis process results in these high density nanorods grown mostly in the upright direction with some vertical hollow spots in between neighboring nanorods. This nanorod arrangement grown on optically reflective substrates works as a nano-porous thin film and produces Fabry-Pérot fringes under perpendicularly incident focused white light. The local variations in density, height, diameter, orientation angle, and hexagonal perfection of the ZnO nanorods give rise to unique and reproducible scattering light spectra that vary significantly from one spot on the sample to another. Over 1500 optical measurements are performed to show the strongly variable optical characteristics. These distinct spectra show promise as the raw responses for ZnO-based optical PUFs.

17:15-17:30 WeOBO1.4

Implantable Microelectrode Arrays for Epileptiform Electrical Signals Detection in the Awake Epileptic Mice, pp. 153-156

Cai, Xinxia — Institute of Electronics, Chinese Academy of Sciences,

Xiao, Guihua — The State Key Laboratory of Transducer Technology, Inst. Of

Song, Yilin — The State Key Laboratory of Transducer Technology, Inst. Of

zhang, yu — The State Key Laboratory of Transducer Technology, Inst. Of

Xu, Shengwei — Institute of Electronics Chinese Academy of Sciences,

Gao, fei — The State Key Laboratory of Transducer Technology, Inst. Of

Xie, jingyu — The State Key Laboratory of Transducer Technology, Inst. Of

Wang, Mixia — The State Key Laboratory of Transducer Technology, Inst. Of

Yin, Huabing — Division of Biomedical Engineering, School of Engineering, Unive

Cui, Tianhong — Department of Mechanical Engineering, Univ. of Minnesota

Millions of people are affecting by epilepsy due to the unclear pathogenesis. In this paper, we fabricated an implantable microelectrode array for spike patterns and local field potential signals detection in the hippocampus of awake epileptic mice. The abnormal epileptiform electrical signals were recorded when the mice were occurring a seizure. During a seizure, pyramidal neurons with higher amplitude appeared together with interneurons which firing intensively. The abnormal local field potential (LFP) waveform changed from the slow oscillation with low frequency and high amplitude, to the sharp-wave and spike-wave. The oscillation frequency of LFP waveform is low while amplitude is high at the beginning and ending of seizure. On the contrary, in the middle of seizure, frequency is high while amplitude is low. This detection technology provides us an effective method to understand the neuron activities at neuron level.

17:30-17:45 WeOBO1.5

Wave-Based Spiking Neural Network with Nano-Structured Electronics (I), pp. 157-162

Katayama, Yasunao — IBM Research - Tokyo

The present paper is on neuromorphic computing with temporal spike signaling as elastic waves and building blocks using nano-structured electronic systems. Wave-based neuromorphic computing for energy-efficient brain-inspired computing can natively calculate weighted-sums with delay spreads as wave superposition and propagation for temporal spiking neural networks (SNN) processing. Single particle quantum effects of electron wave packets, traveling at the Fermi velocity in nano-structured systems, are exploited to constitute various building blocks. We will first describe passive elements whose delay can be widely controlled electrically as well as geometrically. Then, splitter and combiner building blocks are configured with coupled quantum systems and alignment gate. Finally, we explain self-resetting integrate-and-fire building blocks with tunneling in coupled nano systems. Independent changes of the static potential at subband edges and Fermi potential lead to rich dynamics of Coulomb and quantum interplay to accomplish critical temporal SNN building block functions.

17:45-18:00 WeOBO1.6

Effects of Interface Trap Charges on the Electrical Characteristics of Back-Gated 2D Negative Capacitance FET, pp. 163-166

Jiang, Chunsheng — Microsystem & Terahertz Research Center, China Academy of Engine

Zhong, Le — Microsystem & Terahertz Research Center, China Academy of Engine

Xie, Lei — Microsystem & Terahertz Research Center, China Academy of Engine

In this work, a fully analytical compact drain current model of back-gated two-dimensional (2D) negative capacitance (NC) FET including interface trap charges has been developed by solving Poisson's, drift-diffusion and 1-D Landau-Khalatnikov equations, and it is validated against the experimental data. In addition, the impact of interface trap charges on the electrical characteristics of the back-gated 2D NC-FET is investigated systematically based on the model. It is found that the subtresdhold swing (SS) and on-off current ration (Ion/Ioff) are seriously degraded because of the presence of interface traps at 2D channel/oxide interface and 2D NC-FET with a big tf is more immune to the degradation induced by the interface traps

WeOBO2 Room 7204

Invited Session: Nanotechnology: Materials, Devices to Instrumentations (Invited Session)

Chair: Yeow, John T.W. — University of Waterloo

Co-Chair: Kim, Jin-Woo — University of Arkansas

16:30-16:45 WeOBO2.1

Multifunctional Hybrid Soft Nanomaterials: Design and Assembly Jin-Woo (I), pp. 167-167

Kim, Jin-Woo — University of Arkansas

Recent advances in nanotechnology have yielded nanomaterials, both hard and soft nanomaterials, with a variety of shapes, sizes

and compositions, and their unique physicochemical properties, stemming from their size, shape and composition, have offered enormous promise to advance diverse fields, ranging from optics, electronics, and biomedicine to name a few. Recently, great interest has been focused on their promising attributes for manipulating into multifunctional hybrid nanostructured materials with tailored size, shape and function. These hybrid nanomaterials would yield advanced properties that have multifaceted applications in various fields. Despite recent progress, however, there still is plenty of room for improvement and many untapped possibilities for innovative strategies to be developed. This presentation will focus on the recent advances in the design and fabrication of multifunctional hybrid nanocomposites for advanced materials and devices particularly in bio/nano medicine. It will also discuss the fundamental challenges to as well as future directions of the controlled assembly of hybrid soft nanocomposites with specific shape and function, and present our strategies to realize the control and functionality necessary to overcome the challenges. This work was supported in part by the National Science Foundation (CMMI-1235100 and OIA-1457888) and the National Institute of Health (1R21HG010055).

16:45-17:00 WeOBO2.2

THz Spectroscopy for Molecular and Nanoscale Material Analyses (I), pp. 168-168

Han, Haewook Pohang University of Science and Technology

THz band (0.3-30 THz) has become important in diverse fields of science and engineering, including nanotechnology and biotechnology, offering immense opportunities to advance the fields. What distinguishes a spectral band from another at the most fundamental level is how the electromagnetic wave interacts with matter. THz photon energy (1-100 meV) is closely related not only with the intra-band dynamics of solid-state materials, such as semiconductors and quantum matters (e.g., graphene and topological insulators), but also with the intermolecular vibration dynamics of biomolecular systems, including water molecules. This presentation will discuss the recent advances in Nano-Bio THz Photonics Laboratory at POSTECH, including THz time-domain spectroscopy and THz spectroscopic near-field microscopy, which are powerful tools for probing fundamental low-energy dynamic processes in solid-state and biological materials at molecular and nanoscales that is crucial for developing next-generation electronic and optical devices.

17:00-17:15 WeOBO2.3

Micro/Nano Cracks-Based Flexible Pressure Sensor for Wearable Devices Application (I), pp. 169-169

YANG, Zhuoqing Shanghai Jiao Tong University (SJTU)

Inspired by the structure of skin, a flexible pressure sensor is proposed here, which consists of a flexible Kapton/polydimethylsiloxane (PDMS) substrate, a sensing structural layer of a fine-wire connected conductive network and a protective layer of PDMS. Notably, cracks, often referred to as defects, were utilized to fabricate the conductive network in this work. The ordered micro/nano cracks were induced by changing the temperature of the patterned photoresist film suddenly to form the regular hexagonal array micro/nano-channel network. Then the Ni/multilayer graphene oxide/Ni sandwich composites were introduced to obtain the conductive fine-wire connected network by electroplating and graphene oxide electrodeposition. When the sensor is under pressure, the strain effect of the bottom Ni network, the change of intermediate multilayer graphene oxide microstructure, and the breaks of electron transport paths owing to the top wrinkled Ni cracking, contribute to the resistance change together. Furthermore, the pressure sensor was demonstrated to have good potential in e-skin application, such as pulse detection, laughter and swallowing movement recognition. This work provides a new and convenient approach to fabricate a sensing conductive network with nanowires by induced cracks for potential wearable devices application.

17:15-17:30 WeOBO2.4

Ultrasonic-Assisted Sintering of Cu@Ag NPs Nanoparticles in Air for High-Temperature Power Device Packaging (I), pp. 170-170

Ji, Hongjun Harbin Institute of Technology at Shenzhen

The emerging of the third-generation wide bandgap semiconductors, such as SiC and GaN, require novel interconnection materials and packaging methods for die attachment, with high re-melting temperature and high thermal conductivity. Nanoparticle sintering becomes a new choice for high temperature packaging, such as Ag or Cu NPs sintering, because the sintering temperature is lower but the sintered structures have good performances with high remelting temperature. Though the Ag nanoparticle paste has been exhaustively investigated and practically applied, its wide application has been extremely limited because of severe migration and high cost. Cu nanoparticle paste may be a better alternative material due to its better performances than Ag nanoparticle paste but with lower cost. However, the storage and sintering process of Cu nanoparticle paste are more challenged because of the poor oxidation resistance of nano-sized Cu in air. To remedy these drawbacks, a Cu-Ag core-shell (Cu@Ag) NPs paste has been proposed for printing electronics because of its anti-oxidation, anti-migration and lower cost features. We successfully synthesized Cu@Ag NPs paste, and they were successfully applied for joining Cu/Cu@Ag NPs paste/Cu firstly in air by the ultrasonic-assisted sintering (UAS) at a temperature of as low as 160 ℃. Their sintered microstructures featuring with dense and crystallized phases are completely different with the traditional thermo-compression sintering. The shear strength of the joints reached to 54.27 MPa, exhibiting one order of magnitude higher than thermocompression sintering (TCS) at the same temperature (180℃). This ultra-low sintering temperature and high performance of the sintered joints were ascribed to ultrasonic effects and systematically investigated. The ultrasonic vibrations had distinct effects on the metallurgical reactions of the joints, resulting in the contact and growth of Cu core and the stripping and connection of Ag shell, which contributes to the high shear strength. Profile Invited talks Associate Editor None Status Final version received Date of latest decision July 6, 2019 Keywords Nanoelectronics Session Invited Session: Nanotechnology: Materials, Devices to Instrumentations (Invited Session) Schedule code WeOBO2.4 Notes

17:30-17:45 WeOBO2.5

Multi-Pixel Field Emission Based X-Ray Generators (I), pp. 171-171

Yeow, John T.W. University of Waterloo

The first concept of multi-source Computed Tomography (CT) systems originated in the 1980s, and opened the way to innovative system concepts in X-ray and computed tomography. Multi-source CT systems offer promising opportunities in system performance. In addition, multi-source X-ray radiographic systems are widely studied, namely for X-ray stereographic imaging, X-ray tomosynthesis imaging, and inverse-geometry imaging. One significant benefit of the multi-source X-ray technology is the ability to fabricate the source array in various two-dimensional configurations. The more complicated distributive source topologies are designed to improve the sampling of projection data, to further improve both in-plane and depth imaging resolution within the constraints of the limited-angle acquisition of projection data. In multi-source systems, the X-ray sources are arranged in an array format, and each source is launched individually. However, current X-ray generators are not suited for these systems because of their large size, huge power requirement, and slow response. This talk will focus on the field emission X-ray technology that enables to the realization of multi-source CT systems.

17:45-18:00 WeOBO2.6

Engineered Materials for Sensing Applications (I), pp. 172-172

Vellaisamy, A. L. Roy City University of Hong Kong

Growing industrialization and urbanization has put human beings and other living organisms at risk against new threats due to the contamination of food, water and air. These Contaminants

endanger all the living organisms in this world, especially for human beings genetic disorders and unknown diseases become common nowadays. The WHO statistics show that more than 422 million people worldwide are suffering from contamination related illness. The growing prevalence of such disorders has been linked to exposure to chemicals in plastic, food and water. Although regulatory steps have been taken to minimize risk, cases of overexposure (2011 Taiwan food crisis, Flint and Hong Kong lead contamination, etc.) still occur. Detection of these chemicals is done in testing labs using expensive and time consuming mass spectrometer systems that require specially trained users. In the regard, we demonstrate a real-time monitoring system for a rapid pre-screening test that could curtail cases of contamination. Over the years, we have developed an electronic sensor platform based on molecular level interaction between the target and analyte to detect these toxins[1] [2]. The advantage of our sensor platform is that it can be used for on-site detection; it is easy to operate and provides results on real-time basis. In addition, we have demonstrated a sensor system to monitor pulse waveform in real-time[3]. This would allow the user to quickly self-diagnose for problems such as myocardial ischemia and seek medical attention immediately. In this talk, I discuss the latest advancements of our sensor platform in terms of basic science to successful launch in the market

WeOBO3 Room 7205

Invited Session: Ultrahigh-Precision Mechatronics and Automation Systems (Invited Session)

Chair: Xu, Qingsong University of Macau

Co-Chair: Li, Shihua Southeast University

16:30-16:45 WeOBO3.1

A Novel 5-DOF Flexure-Based Passive Alignment Stage for Microassembly System, pp. 173-178

Chen, Shasha Beihang University

Chen, Weihai Beihang University

Liu, Jingmeng Beihang University

Chen, Wenjie Singapore Institute of Manufacturing Technology

In order to avoid the damage of collision between the assembly targets during microassembly, a new 5-degreeof-freedom (2-DOF) fleuxre-based passive alignment stage for microassembly system is presented. With fiber assembly as the application field, the design, modeling and simulation of the proposed stage are proposed. The proposed stage mainly consists of a 3-DOF in-plane mechanism and a 2-DOF off-plane mechanism. The alignment motion of the stage is achieved by adopting a variety of flexure hinges. Due to the remote center of compliance (RCC) characteristic, the proposed stage can compensate position error in different directions decoupleably. In order to guarantee successful fiber assembly process, the stiffness of the proposed stage is strictly controlled. The pseudorigid-body-model (PRBM) method is utilized to calculate the stiffness of the stage along its working directions. Then the finite element analysis (FEA) is conducted to verify the stiffness theoretical model and test the dynamic performance of the stage. Both the theoretical and FEA results demonstrate the superior property of the design, which indicates that the proposed stage can meet the requirements for compensating the relative position error between the fiber and the optical switch.

16:45-17:00 WeOBO3.2

Design, Modeling and Analysis of a Novel Backdrivable Cable-Driven Series Elastic Actuator, pp. 179-183

Wang, Zhengyu Hefei University of Technology

Zi, Bin Hefei University of Technology

Wang, Daoming Hefei University of Technology

Qian, Jun Hefei University of Technology

This paper presents a study on the design, modeling and preliminary analysis of a novel Backdrivable Cable-Driven Series Elastic Actuator (BCDSEA) on a long-distance cable-driven revolute joint. The BCDSEA includes of a motor and cable-driven module, cable-pulley systems, a simplified revolute joint, a backspring and cable-driven module. The driving cable is actuated by a servo motor and a miniature ballscrew with an auxiliary spring. The steel cables are simplified as mass-spring-damper system models. The returning cable is back actuated by a linear backspring. The detailed modeling processes are presented considering the different inputting sensors data and the local dynamical features. Two types of the driving cable model and two types of the returning cable model are proposed for the driving and returning cable dynamics. Thus, four types of dynamic models are derived for the simplified cable-driven revolute joint in this study. The preliminary analyses of the proposed dynamic models are discussed with the potential applications of this actuator.

17:00-17:15 WeOBO3.3

A Nonlinear State-Constrained Controller for Permanent Manget Synchronous Motor Systems with Mismatched Disturbances, pp. 184-185

Dai, Chen Southeast University

Li, Shihua Southeast University

Yang, Jun Southeast University

The permanent magnet synchronous motor regulates the speed and current in one loop under the non-cascade control structure. Since the q-axis current is no longer governed by a reference signal, excessive transient current may threaten the circuit safety. Meanwhile, mismatched disturbances caused by the load torque can bring about severe interference and even violate the current constraint. In this paper, a nonlinear state-constrained control scheme is proposed. Simulation results have verified its effectiveness. More on going experimental tests will be presented in the final paper.

17:15-17:30 WeOBO3.4

A Novel Piezoelectric Transducer for Driving Underwater Robotic Finger (I), pp. 186-186

Wang, Liang Nanjing University of Aerounautics and Astrounautics

To eliminate the problem of the structural damage of traditional manipulators caused by depth water pressure, a novel piezoelectric actuated underwater robotic finger is proposed in this study. The robotic finger adopting an open configuration is composed of three phalanges and two joints. A novel bonded-type piezoelectric transducer employed as the actuator in each phalanx pushes the joints by friction. The geometrical parameters of the bonded-type piezoelectric transducer are determined by the finite element method, and a prototype of the proposed robotic finger is manufactured and tested. Experiment investigation is conducted to confirm the calculation results and evaluate output performances of the robotic finger prototype. Experimental results indicate that water has little effect on the driving frequency of the piezoelectric transducer. The proposed robotic finger exhibits potential to be employed as the underwater manipulators.

17:30-17:45 WeOBO3.5

Design of a Novel Macro/Micro Nanopositioner for MicroLED Chip Mass-Transfer Operations (I), pp. 187-187

Tang, Hui Guangdong University of Technology

Recently, MicroLED chip has attracted much attention in both academia and industry since its perfect performances, such as high power efficiency, high brightness, and satisfactory color gamut. To a certain extent, MicroLED chip is quite tiny up to tens of microns. To assemble a high definition display screen, there are tens of millions of MicroLED chips should be transferred. Nowadays, due to different density of chips on donor wafer vs display substrate, there is no reliable method of mass-transfer yet, because the existing methods cannot meet the requirement of precision position adjustment in the scale of nanometer. This study aims to develop a high precision transfer mechanism, which can achieve the mass-transfer of microchips from donor wafer to display substrate in an large array and high precision manner. Thus, a novel flexure-based macro/micro nanopositioner with relatively large adjustment distance and nanometer scale motion accuracy is proposed in this paper, which is driven by electro

magnetic and piezoelectric forces. Finally, a series of mechanism optimal designs, analytic modeling and hydrodynamic simulation analysis are carried out. The theoretic and FEA analysis results uniformly indicate that the proposed nanopositioner can achieve chip pitch adjustment, 2-DOF deviation correction, as well as chip interconnection in the scale of nanometer.

17:45-18:00 WeOBO3.6

Design of a New Rotary Micropositioning Stage Driven by Piezoelectric Actuator, pp. 188-192

Zhang, Hanlun University of Macau

Xu, Qingsong University of Macau

This paper presents the design of a new rotary micropositioning stage, which is actuated by a linear-type piezoelectric stack actuator. This structure realizes a large enough output angle by introducing lever displacement amplifiers. This work also includes innovative designs for accepting the force and displacement of PZT. Moreover, it avoids undesired displacement by adopting symmetrical structure design. The proposed design also exhibits a compact structure, which provides convenience in practical application. Finite-element analysis is conducted with simulation study to verify the performance of the presented rotary micropositioning stage.

WeOBO4 Room 7304

Nanomaterials (Oral Session)

Chair: Tzeng, Yonhua National Cheng Kung University

Co-Chair: Zhang, Li The Chinese University of Hong Kong

16:30-16:45 WeOBO4.1

Prediction of Strain Effect on Hydrogen Evolution Reaction on VMo-SLMoS2, pp. 193-196

Lai, Lianfeng Ningde Normal University

Ye, Kongqiang Fuzhou University

Li, Minglin Fuzhou University

Luo, Jing Xiamen Tungsten Co., Ltd

Bo, Wu Fuzhou University

Ren, Zhiying Fuzhou University

The catalytic activity for the hydrogen evolution reaction (HER), as well as the structural and electronic properties, of monolayer MoS2 with single Mo vacancies (VMo-SLMoS2) under different strains were investigated by first-principles density functional theory (DFT) for the first time. We found that the HER catalytic activity of VMo-SLMoS2 can be optimized using biaxial compressive strain. A 4.5% biaxial compressive strain can be used to reduce ΔGH to be only -0.03 eV and -0.04 eV at the active sites. Our results suggest a new way for the applications of SLMoS2 in the optimization of hydrogen evolution performance with point defects.

16:45-17:00 WeOBO4.2

Photo Aligned Quantum Rod Films by Inkjet Printing for Modern LCDs with Extended Color Gamut, pp. 197-200

GUPTA, Swadesh Kumar Hong Kong University of Science and Technology, Hong Kong

Prodanov, Maksym Hong Kong University of Science and Technology

Diakov, Maksym HKUST

Vashchenko, Valerii Hong Kong University of Science and Technology

Kang, Chenbin Hong Kong University of Science and Technology

Srivastava, Abhishek Kumar Hong Kong University of Science and Technology

Polarized emissive quantum rod films have been prepared using inkjet printing on photoaligned substrate. Quantum rod backlight unit show wide color gamut of 96.9% of BT2020 with high polarization ratio providing an optical efficiency of 7.8% for LCD.

17:00-17:15 WeOBO4.3

ZIF-67-Based Nanofiber Filters As Highly Promising Candidates for Air Pollution Control, pp. 201-202

Bian, Ye The Chinese University of Hong Kong

Wang, Shijie The Chinese University of Hong Kong

Chen, Chun The Chinese University of Hong Kong

Zhang, Li The Chinese University of Hong Kong

Particulate matter and formaldehyde are serious issues to pose great threat to human health. In this work, we proposed an immersion method to integrate ZIF-67 nanocrystals into an organic polymer matrix homogenously. The prepared MOF-based filters achieved high filtration efficiency for both particulate matter and formaldehyde. With the superior filtration performance for PM2.5 and formaldehyde, the ZIF-67-based nanofiber filters hold great promise for indoor air purification.

17:15-17:30 WeOBO4.4

*Sub-Surface Localization of Graphene by Near-Field Ultrasound Vibration**

Li, Meng Shenyang University of Technology

With the advent of the atomically two-dimensional materials, the unavoidable short channel effects for the traditional nanodevice can be almost eliminated. While the two-dimensional materials are believed to hold significant promise in the next-generation electronics, challenge remains. To fabricate nano-devices by lithography, accurate positioning of the two-dimensional materials below the sacrificial layers is necessary. However, when the plane dimension of the materials downsized to a few nanometers, the normal positioning will become extremely difficult due to the limitation of the optical resolution. Here, we theoretically propose a novel method for sub-surface localization via near-field ultrasound. Graphene was chosen as a representative and the sub-surface localization of graphene can be realized through the detection of the Young modulus discrepancy variation via near-field ultrasound vibration. The elaborated theory paves the way for the realization of the precise sub-surface localization and nanoscale device fabrication in the future.

17:30-17:45 WeOBO4.5

Synthesis of High Throughput Ibuprofen Nanoparticles Via Supercritical CO2 Processing, pp. 203-206

Sharma, Sudhir New York University Abu Dhabi

Jagannathan, Ramesh New York University Abu Dhabi

we report synthesis of high throughput ibuprofen molecular clusters via supersonic jet expansion of the supercritical CO2 processing. In our process, we used a custom designed double stage collection vessel cooled to liquid N2 temperatures, resulted in the collection of ibuprofen molecular clusters embedded in “dry ice” with a yield up to 80% (w/w). The effect of four surfactants on the size of ibuprofen nano-particles were investigated. Drop casting of these aqueous solutions on a silicon substrate and ambient drying resulted in stable, viscous liquid films observed by atomic force microscopy (AFM) and scanning electron microscopy. These solutions were found to be stable at ambient conditions for up to six months. X-ray diffraction and confocal Raman microscopy confirmed that these nanoparticles has retained their structural and chemical identity after RESS processing. This is a significant observation as raw ibuprofen is a solid powder with melting points of 76o C under ambient conditions. Besides scientific importance, our findings are expected to open up new drug delivery platforms.

Keywords—supercritical fluids, ibuprofen, RESS, micronization

17:45-18:00 WeOBO4.6

Impact of Total Ionization Doze on Substrate Biased Symmetric Lateral Bipolar Trasistor on SiGe-OI, pp. 207-210

Lourembam, Beloni Jawaharlal Nehru University

Kumar, Jitendra — Jawaharlal Nehru University
Srivastava, Asutosh — Jawaharlal Nehru University

Impact of Total Ionization Doze (TID) on substrate biased Symmetric Lateral Bipolar Transistor (SLBT) on SiGe-OI is studied. With the introduction of substrate bias the performances of the device is enhanced. This paper highlights the other side of substrate biasing when subject to TID impact by using 2D simulation study of SLBT on SiGe-OI. We observe that breakdown voltage (BVCEO) is reduced with TID impact and is further reduced when substrate bias is applied to the device. A No substrate biased device is observed to exhibit higher BVCEO even after exposure to TID of 1×10^11 cm-2 when compared to BVCEO of +1V substrate biased device before exposure to radiation.

WeOBO5 — Room 7305

Nanofabrication (Oral Session)

Chair: POTEJANA, POTEJANASAK — School of Engineering, University of Phayao

16:30-16:45 — WeOBO5.1

Large-Area, Fully Conformable, μm-Thick E-Tattoo for High-Fidelity in Situ Personal Health Monitoring, pp. 211-214

Yin, Lang — Huazhong University of Science and Technology
Deng, Pengfei — Huazhong University of Science and Technology
Ma, Jiaji — Huazhong University of Science and Technology
Shen, Yaoxin — Huazhong University of Science and Technology
Ren, Junhui — Huazhong University of Science and Technology
Zhang, Shuchang — Huazhong University of Science and Technology
Huang, Yong'an — State Key Laboratory of Digital Manufacturing Equipment and Tech

Herein we report an integrated multifunctional epidermal electronics system (EES), including disposable ultrathin sensing module and a reusable wireless data acquisition module. The sensing module cover large-scale area so that it has the ability to simultaneously collect all precordial signals of standard 12-lead ECG, body temperature and skin hydration after attached to human skin

16:45-17:00 — WeOBO5.2

Fabrication of Metallic Nano-Ring Arrays by Imprinting-Sputtering-Self Uplifting Methods with Localized Surface Plasmon Resonance Effect, pp. 215-220

POTEJANA, POTEJANASAK — School of Engineering, University of Phayao

This study proposed the efficient nanofabrication methods involve imprinting process with the non-hazardous chemical as well as Argon gas sputtering deposition process to fabricate metallic nanostructures on a substrate for optical sensing application. This manufacturing method is developing an efficient nanofabrication process of metallic nanostructures of the same size as the wavelength of visible light, such as a metallic nano-ring array on a quartz glass substrate. In this process, a polymer film mold is made by hot stamp method from a silicon wafer mother mold, and the polymer film mold is used to “chemical imprint” onto substrates. The polymer mold are very low cost and reusable. Then, a metal thin film is deposited on the stamped substrate by Argon gas spattering deposition. Finally, the nano-ring arrays are appeared on the substrate by a self-uplifting method using the vibration hot water dipping process. The optical properties of the nano-ring arrays are investigated. Most important advantages of this nanofabrication technology are “high throughput, low cost, and without the hazardous chemical in the process”. Therefore, this new fabrication method is ready to transfer to the optical plasmonic bio-sensing application.

17:00-17:15 — WeOBO5.3

Fabrication of Cross Nanoantenna with Tiny Gap by “Sketch and Peel” E-Beam Lithography, pp. 221-222

Zhang, Taiping — CAEP Microsystem & Terahertz Research Center
Liu, Qing — Hunan University
Li, Ru — CAEP Microsystem & Terahertz Research Center
Li, Ma — CAEP Microsystem & Terahertz Research Center
Sun, Song — CAEP Microsystem & Terahertz Research Center
Li, Mo — CAEP Microsystem & Terahertz Research Center
Duan, Huigao — Hunan University

We proposed an advanced nano-fabrication approach to fabricate a plasmonic cross nanoantenna (NA) with tiny gap. In this way, the gap between the opposite arms of the NA could be smaller than 30 nm.

17:15-17:30 — WeOBO5.4

Anti-Lotus Leaf Effect: Smearing Millions of Picoliter Droplets on Bio-Inspired Artificial Lotus Leaves, pp. 223-226

Du, Lin — Fudan University
Wei, Youheng — Fudan University
Riaud, Antoine — Fudan University
Zhou, Jia — Fudan University

CompCompartmentalization of aqueous samples into micro-droplets enables to study single cells or detect single molecules by performing large number of independent experiments. However, as the droplet size becomes smaller, the surface energy becomes larger so that micro-channels or surface treatments are required to break droplets below the picoliter range, resulting in an increased experimental or chemical complexity. Herein, we study the spontaneous liquid film breakup observed after smearing a mother droplet on the surface of lotus leave reversal. As the film breaks and recedes, it is mechanically trapped in single wells formed by the natural bulges on the leaf and forms picoliter droplets, which we called anti-lotus effect droplet. The bio-inspired effect has the advantage of resisting capillary forces and releasing surface tension in the three-phase interface. Using soft-lithography and spin-coating, we obtain the bio-mimetic wells array with the corrugated surface analogous with the lotus leave, which enables a deeper liquid penetration during the smearing step that results in a more efficient filling of the wells. In the present experiments, we have obtained a regular array of 2 pL droplets with a density of 62,500 droplets/cm2, which equivalents to 5.4 million droplets on the surface a 96 well plate. This bio-inspired method of forming droplet will be a convenient way to operate with no chemical treatment and seal. It undoubtedly decreases the complexity of chip manufacturing and potential interference by chemical treatments. We believe that such a method contributes to the development of the efficient micro-droplet generator with a pure physical interface and thus is applicable to biological and medical analysis.

17:30-17:45 — WeOBO5.5

*Self-Peeling Adhesion Lithography to Scaling down Nanostructures for Large Electronics**

Luo, Sihai — NTNU
Hoff, Bård Helge — NTNU
de mello, John — Imperial College

Adhesion lithography (“a-lith”) is a simple method for forming nanoscale gaps between dissimilar metals. In its usual form, a metal is patterned on a substrate, and conformally coated with an alkyl-functionalised self-assembled monolayer, rendering it non-adhesive to other metals; a second metal is then deposited uniformly over the full area of the substrate; finally, the parts of the second metal that are in contact with the self-assembled monolayer are stripped away using an adhesive tape or film, leaving the first and second metals side-by-side on the substrate,

with a nanoscale spacing between them. We show here that, by depositing onto the second metal an adhesive film with high internal strain, it is possible to induce spontaneous delamination of the peeling layer without the need for any applied force. The modified procedure simplifies implementation and eliminates external stresses that can cause unwanted widening of the gap. The resultant electrode separations of ~10 nm are amongst the smallest values achieved to date using adhesion lithography. We also shows its potential applications in electronics, such as photodetector, plasmonics.

17:45-18:00 WeOBO5.6

*Silica-Based Robust, Transparent, Superhydrophobic Coatings with Enhanced Porosity on Polymer Substrates**

zhao, xiaoxiao	Louisiana State University
Park, Daniel	Louisiana State University
Soper, Steven	University of Kansas
Murphy, Michael	Louisiana State University

One of the long-standing problems of superhydrophobic coatings on polymers surfaces is poor adhesion. For polymers with low glass transition temperatures, such as PMMA and PC, it is highly desirable to have a low temperature coating strategy to fabricate robust superhydrophobic films. Increasing the surface roughness and lowering the surface free energy are usually combined to fabricate superhydrophobic surfaces. Generating surface porosity is an effective way to enhance the surface roughness. Transparent superhydrophobic surfaces have many potential applications in windows, digital screens, and solar panels. Reducing the size of surface structures is a common approach to improving optical transmittance while maintaining sufficient surface roughness for superhydrophobicity. A facile method for fabricating robust, transparent, superhydrophobic films on polymer substrates was developed. A mixture of silica particles and silica-based oligomers was spin-coated on polymer (PMMA) substrates, annealed in an oven at 60 $^{\circ}$C, followed by an oxygen plasma treatment, and vapor deposition of 1H,1H,2H,2H-Perfluorodecyltriethoxysilane (FDTS). Silica particles were dispersed in organic oligomer solutions in a sol-gel process to form hybrid inorganic-organic networks linked by hydrogen or covalent bonds. Single-sized of 70 nm or dual-sized silica particles of 400 nm/ 70 nm and 650 nm/ 70 nm were used to generate three types of coating films, all of which showed hierarchical surface structures. For superhydrophobic coatings, the inorganic particles determine the coating's transparency and hardness, while the organic oligomers determine the porosity and adhesion strength. The resulting superhydrophobic surfaces have static contact angles of 155° and sliding angles less than 8°. The coating films had an optical transmittance of 70±15 %, and maintained contact angles greater than 150° after a tape peel test. This strategy provides a low temperature solution to improve the adhesion of superhydrophobic films on polymers with a broad range of glass transition temperatures.

Thursday, July 25th, 2019

Thursday July 25, 2019

ThPLPL Room 7201

Plenary Session II (Plenary Session)

Chair: Hu, Walter — University of Texas at Dallas
Co-Chair: Li, Xiuling — University of Illinois

09:00-09:40 ThPLPL.1

*Precise Chemical, Physical, and Electronic Nanoscale Contacts (I)**

Weiss, Paul S. — University of California, Los Angeles

09:40-10:20 ThPLPL.2

*Shrink Polymer Biosensors: Manufacturing from Micro to Nano (I)**

Cui, Tianhong — University of Minnesota

10:20-11:00 ThPLPL.3

*Materials Science with Two-Dimensional Atomic Layers (I)**

Ajayan, Pulickel M. — Rice University

ThKNKN Room 7201

Keynote Session II (Plenary Session)

Chair: Tang, Jianshi — Tsinghua University
Co-Chair: Oh, Soong Ju — Korea University

11:15-11:45 ThKNKN.1

*Flexible and Stretchable Sensing Electronics (I)**

Zhang, Ting — Suzhou Institute of Nanotech and Nanobionics, Chinese Academy of Sciences,

11:45-12:15 ThKNKN.2

*Not Your Ordinary Etching: MacEtch of Si, Ge, III-V, and Wide Bandgap Semiconductors (I)**

Li, Xiuling — UNIVERSITY OF ILLINOIS

12:15-12:45 ThKNKN.3

*Nanoimprinted Perovskite Devices towards Integrated Optoelectronics (I)**

Hu, Walter — University of Texas at Dallas

ThOAO1 Room 7201

Nanoelectronics: Graphene and Other 2D Materials, CNTs and NWs I (Oral Session)

Chair: Khalil, Ahmed S. G. — Fayoum University
Co-Chair: Zhang, Min — Peking University

14:00-14:15 ThOAO1.1

Carbon Nanotube Network Transistor for a Physical Unclonable Functions-Based Security Device, pp. 227-230

Lee, Yongwoo — Kookmin University
Yoon, Jinsu — Kookmin University
Kim, Hyo-Jin — Kookmin University
Park, Geon-Hwi — Kookmin University
Kim, Dae Hwan — Kookmin University
Kim, Dong Myong — Kookmin University
Kang, Min-Ho — National Nanofab Center
Choi, Sung-Jin — Kookmin University

Physical unclonable functions (PUFs) based on 99% semiconducting carbon nanotube (CNT) network transistors are demonstrated. We experimentally verified the possibilities of a PUF based on the CNT network transistors with the unpredictable and high randomness of the CNT-percolated network. The Hamming distance (HD) and Hamming weight (HW), which are important PUF parameters, were calculated to evaluate the uniqueness and assess the uniformity of the CNT-based PUF devices.

14:15-14:30 ThOAO1.2

Hybrid Graphene-Molybdenum Disulfide Antenna for ISM Applications, pp. 231-234

Abdul-Aziz, Mohamed R. R. — Fayoum University
Mohassieb, Shaimaa A. — Akhbar Elyom Academy
Eltresy, Nermeen A — Electronics Research Institute
Yousef, Moataz M. K. — Fayoum University
Anis, Badawi Ali — National Research Center
Khalil, Ahmed S. G. — Fayoum University

Here, Laser Induced Graphene (LIG) as a low cost and versatile technique, was utilized to fabricate coplanar waveguide fed polygon monopole antenna on glass substrates. The graphene layers were formed as a result of the laser interaction with the polymeric membranes. Hybrid MoS2-graphene based antennas were also fabricated and tested. The effect of laser power on the sheet resistance was studied. The formation of the graphene and the successful realization of the hybrid structures were confirmed by several techniques including SEM, Raman and UV-Vis spectroscopy. The graphene as well as graphene-MoS2 antennas developed in this work, showed higher gain compared to the already reported studies in literature. Detailed and optimized experiments are still needed to explore the advantages of these novel hybrid structures for ISM applications.

14:30-14:45 ThOAO1.3

*Low-Dimensional Nanomaterials for Emerging Resistive Switching Memory Devices**

Liu, Juqing — Nanjing Tech University

With the rapid development of information technology, scientists are searching for emerging memory devices beyond Moore's law to make true leaps in sustaining data storage growth for More Moore and creating functional diversity for More than Moore. Numerous emerging memory devices based on inorganic, nanomaterials, organic and polymer materials, and their composites have been reported, such as resistive-switching memories (also named memristors), phase-change memories, ferroelectric memories, and spin memories. In this presentation, the opportunities and challenges facing memory technologies will be introduced briefly, recent advances in resistive switching memories are summarized, with the merits of simple two-terminal structure, easy-way manufacturing, and multilayer stacking for high density data storage, especially for carbon-based resistive switching memories. Compared to traditional inorganic-based memories, carbon based memory materials, including low-dimensional nanocarbon materials, organic and polymer materials, and their composites, attracted increasing attention owing to their tailored structures, tunable properties, flexibility, solution process, and low-cost potentials. Then our work towards carbon-based resistive switching memory devices will be introduced in details. a class of novel resistive switching memory devices based on low-dimensional nanostructures have been successfully fabricated through composition modulation and interfacial engineering, with the function of WORM, Flash and DRAM. Furthermore, several multifunctional memory devices, including flexible and stretchable memories, multimode memories and transient memories, have been constructed. Moreover, these memory devices could be solution processed, which enable a mass-production with low-cost potential. Our study not only paves a way to design emerging memory technologies based on nanostructures, but also boosts the development of

nano-electronics and smart electronics.

14:45-15:00 ThOAO1.4

Schottky Junction Properties of Graphene with Nitrogen and Gallium Polar Freestanding GaN, pp. 235-238

Ranade, Ajinkya	Nagoya Institute of Technology
Mahyavanshi, Rakesh	Nagoya Institute of Technology
Desai, Pradeep	Nagoya Institute of Technology
Tanemura, Masaki	Nagoya Institute of Technology
Kalita, Golap	Nagoya Institute of Technology

Schottky junction properties of graphene with nitrogen and gallium polar freestanding GaN Introduction: Integration of two-dimensional (2D) layered materials like graphene with conventional semiconductors is of great interest to develop high performance optoelectronics and other electronic devices. Gallium nitride (GaN) with a direct bandgap (~3.4 eV) has been widely explored for optoelectronic and power device applications. Recently, freestanding GaN has been grown by liquid phase epitaxy. GaN device properties can be significantly changed depending on the nitrogen (N) and gallium (Ga) polar surface. In the present work, we have explored the Schottky junction properties of graphene with N and Ga polar freestanding GaN. Interestingly, Ga-polar graphene/GaN heterostructure showed higher photoresponsivity than the N-polar graphene/GaN heterostructure. Experimental: A chemical vapor deposited graphene film was transferred on both nitrogen and gallium polar freestanding GaN substrates for the Schottky diode fabrication. Further, Au and In electrodes were deposited on graphene and GaN respectively using thermal evaporator under high vacuum condition. The device properties were analyzed by current density-voltage (J-V) measurements using two-probe system and a Keithley 2401 Source Meter. Results and discussions: Excellent Schottky junction behavior with both the N and Ga polar graphene/GaN heterojunction. The two fabricated device showed photo-voltaic action under ultraviolet illumination. Both the devices showed similar open circuit voltage of around 0.13 V~0.135 V. However, significant difference was obtained in the short circuit current density (Jsc). The Ga-polar device showed a Jsc of 6.564 μA/cm2, while the N-polar device showed a Jsc of 0.737 μA/cm2. The interesting prospects of the graphene Schottky junction with the Ga and N-polar GaN will be further discussed. Conclusions: In conclusion, we have demonstrated the fabrication of the Schottky junction device of graphene with Ga and N-polar freestanding GaN. The Schottky junction behavior and ultraviolet light induced photoresponsive properties were investigated in this study.A significant difference in photoresponsivity was obtained between both devices.

15:00-15:15 ThOAO1.5

Integration and Characterization of Transparent Thin Film Transistors with Carbon Nanotubes As Aligned Channel and Electrodes, pp. 239-242

Huang, Qiuyue	Peking University
Wang, Qinghua	Peking University
Liao, Zhiqiang	Peking University
Du, Chunhui	Peking University
Zhang, Min	Peking University

Transparent top-gate aligned-channel all-carbon-nanotube thin film transistors (all-CNT-TFTs) are proposed and integrated on a polyethylene naphthalate substrate, with 99.9%-purity semiconducting carbon nanotubes (SCNTs) as channel and metallic carbon nanotubes (MCNTs) as source/drain/gate electrodes. Fabricated by Langmuir-Blodgett (LB) method, an aligned-channel all-CNT-TFT with an on/off current ratio of 3.89E4, as well as a transparency of 86% has been achieved. The ultrathin films formed by LB method were uniform on the whole sample region, which can provide stable performance of the transistors. The aligned SCNT channel and MCNT source/drain electrodes can form clear tube-tube contact, which is useful for accurate mechanism analysis.

15:15-15:30 ThOAO1.6

Crosstalk Aware Global Routing of Graphene Nanoribbon Based Circuits, pp. 243-248

Das, Subrata	Institute of Radio Physics and Electronics, University of Calcut
Pandit, Soumya	Institute of Radio Physics and Electronics, University of Calcut
Das, Debesh Kumar	Jadavpur University

Graphene nanoribbon based interconnects have several advantages over traditional interconnects in terms of power dissipation and delay. These interconnects can be bent only in {0^{circ}, 60^{circ} and 120^{circ} } angles. Hence underling routing grid of {em graphene nanoribbon} are aligned in these mentioned degrees only. This kind of routing grid is known as triangular routing grid. Routing of {em graphene nanoribbon} based circuit in triangular routing grid have already been reported in literature. But, to the best of our knowledge none of the work focuses on the crosstalk minimization. In this paper, we propose an algorithm for the construction of global routing tree of {em graphene nanoribbon} based circuit considering the minimization of crosstalk talk effect. The algorithm is tested on a random data set and the result obtained is quite encouraging.

ThOAO2 Room 7204

Invited Session: Advanced Micro/nano Robotics (Invited Session)

Chair: Lai, King Wai Chiu	City University of Hong Kong
Co-Chair: Fan, Zheng	University of Houston

14:00-14:15 ThOAO2.1

Bio-Inspired Multi Legged Soft Millirobot towards Biomedical Applications (I), pp. 249-249

Shen, Yajing	City University of Hong Kong

Developing untethered millirobots that can adapt to harsh environments with high locomotion efficiency is of interest for emerging applications in various industrial and biomedical settings. Despite recent success in exploiting soft materials to impart sophisticated functions which are not available in conventional rigid robotics, it remains challenging to achieve superior performances in both wet and dry conditions. Inspired by the flexible, soft, and elastic leg/foot structures of many living organisms, this talk reports an untethered soft millirobot decorated with multiple tapered soft feet architecture. Such robot design yields superior adaptivity to various harsh environments with ultrafast locomotion speed (>40 limb length/s), ultra-strong carrying capacity (>100 own weight), and excellent obstacle crossing ability (stand up 90° and across obstacle > 10 body height). This work represents an important advance in the emerging area of bio-inspired robotics and will find a wide spectrum of applications.

14:15-14:30 ThOAO2.2

Swarming Microrobots for Biomedicine (I), pp. 250-250

Zhang, Li	The Chinese University of Hong Kong

People have envisioned tiny machines and robots that can explore the human body, find and treat diseases since Richard Feynman's famous speech, “There's plenty of room at the bottom,” in which the idea of a “swallowable surgeon” was proposed in the 1950s. Even though we are at a state of infancy to achieve this vision, recent intense progress on nanotechnology, MEMS/NEMS technology and micro-/nanorobotics has accelerated the pace toward the goal. A number of research efforts have been recently published regarding the development of tiny swimming machines/robots from the basic principles and fabrication methods to practical applications. I will present the recent research progress in my lab on using magnetic swimming microrobots for biosensing and targeted delivery [1-6], from the design, manufacturing, functionalization and remote control, to perspective of using these small agents as a microswarm for biomedical applications in vitro and in vivo.

14:30-14:45 ThOAO2.3

Abnormal Biophysical Properties in Aβ-Induced Neurodegeneration for Disease Diagnosis and Pathogenesis (I), pp. 251-251

Lai, King Wai Chiu City University of Hong Kong

Physiological conditions of biological samples are regulated by many different parameters including mechanical and biochemical factors etc. Single-cell level in these studies is challenging by conventional bioanalysis method. However, with the recent advancement in nanotechnology, single-molecule and single-cell analysis is now much more accessible. Understanding the cell changes, such as degeneration of neurons, under different mechanisms is critical for fundamental cell research and neurosciences. Here, we investigate the mechanical behavior of biological cell using atomic force microscopy. Real-time measurement with topographic imaging and quantitative analysis of the mechanical properties of the cells using atomic force microscopy will be presented in the talk.

14:45-15:00 ThOAO2.4

2D-Material-Based Nanodevices for Microrobots (I), pp. 252-252

Dong, Lixin City University of Hong Kong

One of the current challenges in the field of micro-nanorobotic systems we must face to is their functionalization while tremendous attention has been paid to the locomotion and their steering, surface coating for biocompatibility, and various designs for cargo carrying. Today, most micro-sized robots still look like specially shaped particles or colloids. The advancement of low dimensional nanomaterials has provided possibilities to tackle the barrier in integrating these carriers with such devices as wireless energy transmitters, sensors, actuators, and tools built from them. Microrobotic agents like artificial bacterial flagella (ABF) are a particularly suitable platform due to their strain-engineering processes: 2D patterned stripes can be rolled up into 3D free-standing structures based on pre-stressed hetero thin films. This talk will briefly review our recent efforts on nanodevices that have great potentials to enable new applications of microrobots. We have demonstrated a group of segmented nanomaterial/structure based nanodevices including piconewton force/sub-nanometer position sensors and bacterial sensors based on inter-shell/layer/pod electron tunneling in carbon nanotubes, graphene, and pea-pod nanowires, passive oxygen sensors based on nanowire/film memristors, optical antennas based on helices, sphere-on-a-pillar and other plasmonic designs. Among them, 2D-material-based devices are featured with sub-10-nm down to atomic thickness and with compatible fabrication processes for ABF, particularly adaptive to the integration.

15:00-15:15 ThOAO2.5

*Nanorobotic Manipulations in the in Situ Electrochemistry Investigations (I)**

Fan, Zheng University of Houston

Even with the plethora of promising solid Li+ conductors and relatively mature cathode materials, realizing high-performance solid-state Li batteries remains challenging due to the high impedance and (for the anode side) uncontrolled Li deposition at the interfaces between active electrode materials and solid electrolytes. The lack of direct and quantitative characterization tools for the active material□electrolyte interfaces has been a major hurdle towards high-performance solid-state batteries. Most studies had to rely on indirect characterization methods to approximate the identity, distribution, and evolution of species and structures at the interfaces. The large interfacial resistance between cathode materials and electrolytes had been interpreted as the result of volume change-induced lattice mismatch, Li+ extraction-induced space charge layer growth, chemical instability-induced mutual diffusion layer formation, etc. All these proposed mechanisms come down to the formation of an interfacial layer, of which little was known except the layer being ionically resistive. Resolutions (e.g., surface coating, fine processing, etc.) were therefore largely empirical, and their effectiveness varied from system to system without universal explanations. Addressing these issues requires clear understandings and effective manipulation of the chemical compositions, structures, and mechanical properties of the interfaces, which however remain elusive. The proposed project will research, develop, and demonstrate structural diagnostics of the interfaces and their evolutions during cell operation using a nanorobotics-based in situ characterization technique for the real-time monitoring electrochemical reactions. Successful demonstration of these diagnostic tools will provide us unprecedented details on the evolution of the interfaces, their influences on battery performances, and possible ways to optimize them.

ThOAO3 Room 7205

Nano-Acoustics (Oral Session)

Chair: Jiang, Xiaoning North Carolina State University

Co-Chair: Bao, Jiming University of Houston

14:00-14:15 ThOAO3.1

Viscoelasticity Characterization of Micro-Structures at Different Depths by Photoacoustic Effect, pp. 253-255

Zhao, Wenxiu Shenyang Institute of Automation, Chinese Academy of Sciences

Yu, Haibo Chinese Academy of Sciences

wen, yangdong Shenyang Institute of Automation

Li, pan State Key Laboratory of Robotics, Shenyang Institute of Automati

Wang, Xiaoduo Shenyang Institute of Automation, Chinese Academy of Sciences

Liu, Zhu Shenyang Institute of Automation, Chinese Academy of Sciences

Liu, Lianqing Shenyang Institute of Automation, Chinese Academy of Sciences

Li, Wen Jung City University of Hong Kong

Viscoelasticity is an important parameter of mechanical structures, including bio-tissues. In the past, photoacoustic method has been used to measure the mechanical properties of samples based on the transformation time delay from thermal stress to strain derived by their viscoelasticity. This method is capable of penetrating mechanical structures and detect properties with a fine spatial resolution, but it is limited to fixed depth, i.e., all samples should be kept at the same distance to a measurement photoacoustic sensor. In this work, we have shown that the echo signal can be used to solve the depth limit by eliminating the time delay error derived from depth difference, and thus, enabling the measurement of viscoelasticity of a micron-scale thickness material at different depths.

14:15-14:30 ThOAO3.2

Joint Reconstruction of Speed of Sound and Initial Pressure in Photoacoustic Computed Tomography, pp. 256-258

Cai, Chuangjian Tsinghua University

Wang, Xuanhao Tsinghua University

Deng, Kexin Tsinghua University

luo, jianwen Tsinghua University

Ma, Cheng Tsinghua University

Photoacoustic imaging relies on diffused photons for optical contrast, and diffracted ultrasound for high resolution. As a tomographic imaging modality, often times an inverse problem of acoustic diffraction needs to be solved to reconstruct a photoacoustic image. The inverse problem is complicated by the fact that the acoustic properties, including the speed of sound distribution, in the image field of view are unknown. During reconstruction, subtle changes of the speed of sound in the acoustic ray path may accumulate and give rise to noticeable blurring in the image. Thus, in addition to the ultrasound detection

bandwidth, inaccurate acoustic modeling, especially the unawareness of the speed of sound, defines the image resolution and influences image quantification. Here, we proposed a method termed feature coupling to jointly reconstruct the speed of sound distribution and a photoacoustic image with improved sharpness, at no additional hardware cost. In vivo experiments demonstrated the effectiveness and reliability of our method.

14:30-14:45 ThOAO3.3

*Real-Time Contrast Enhanced Superharmonic (CESH) Imaging Using a Dual-Frequency Cylindrical IVUS Array**

Wang, Zhuochen Tianjin University

Jiang, Xiaoning North Carolina State University

Background, Motivation and Objective Vasa vasorum has been suggested as a biomarker of plaque vulnerability. Recent studies suggest that dual-frequency intravascular ultrasound (IVUS) transducers allow detection of contrast enhanced superharmonic (CESH) bubble signatures, enabling acoustic angiography for vasa vasorum and molecular imaging. However, rotational dual element IVUS transducers may involve challenges of multi-wire slip rings and other technical difficulties associated with the moving device. In this work, we report a dual-frequency IVUS array for CESH Imaging, which can eliminate non-uniform rotational displacements (NURDs) and decreased point spread functions by applying beamforming during reception.

Statement of Contribution/Methods The dual-frequency IVUS array consists of 8 low-frequency lateral mode transmission sub-elements (2.25 MHz) and 32 high frequency receiving elements (30 MHz), with an acoustic isolation layer built in-between two active layers. The dual-frequency IVUS array was built onto a 20-gauge (0.9-mm-diameter) stainless steel tube with a total outer diameter of 1.7 mm (5 Fr). The IVUS array was characterized by measuring the complex electrical impedances of both high-frequency and low-frequency elements, any pulse-echo responses or crosstalk from the high frequency elements, and the acoustic pressure of the low frequency transmitter. The real-time CESH imaging of the dual-frequency IVUS array was evaluated in a water tank using a Verasonics system.

Results/Discussion The pulse-echo result of a typical high-frequency element show a center frequency of 29.6 MHz with a bandwidth of 18%. The crosstalk of adjacent high-frequency elements is -29.7 dB. The peak negative pressure of the low-frequency transmitter, placed at 8 mm axially from the transducer surface, under 1-cycle of a 70 V excitation at 2.7 MHz, is 782 kPa, which is high enough to excite the microbubbles for superharmonic imaging purposes. By reconstructing two real-time 180-degree data sets, the CESH images of a 200 μm micro-tube with the dual frequency IVUS array were obtained. The axial and lateral estimates of the image resolution were calculated to be 162 μm and 1039 μm, respectively. And the CNR is 16.6 dB.

14:45-15:00 ThOAO3.4

Photoacoustic Labelling and Tracking of Stem Cell Assisted by NIR-II Organic Semiconductor Polymer Nanoparticles, pp. 259-260

WEN, GUOHUA City University of HongKong

YIN, Chao The Chinese University of Hong Kong

Bian, Liming The Chinese University of Hong Kong

wang, lidai City University of Hong Kong

In regenerative medicine field, employing the stem cell as a powerful therapy approach for different kinds of diseases has been a potential trend . Stem cells have attracted huge attention resulting from their potential and ability to differentiate into various cell lineages. Imaging, especially real-time imaging, can ensure the distribution of implanted cells i.e. the target location and quantity. Fluorescence imaging (FI), magnetic resonance imaging (MRI) and positron emission tomography (PET)/ single photon emission computed tomography (SPECT) have been applied into stem cell therapy. While, each of these imaging modalities has its own disadvantages. Photoacoustic (PA) imaging as a nonionizing and non-invasive imaging tool has recently been widely utilized in to in vitro and in vivo applications.Diverse exogenous agents for PA stem cell imaging generate specific signal. However, the limitations of conventional inorganic PA contrast agents and the narrow range of the excitation wavelength in the first near-infrared (NIR-I) window hamper the applications of PA imaging in living subjects. We herein employed our home-made photoacoustic tomography system shown in Figure1 to image an organic semiconducting polymer (OSP)-based nanoprobe (OSPN+) labeled stem cells for PA imaging and tracking of stem cells in the second near-infrared (NIR-II) window. In vitro stem cell imaging has been investigated under laser wavelength 1064 (NIR-II) and 860 (NIR-I). Stronger PA signal in NIR-II and and almost no unlabeled stem cell PA signal pave the wave into in vivo application. In vivo investigations revealed significant NIR-II PA contrast enhancement of the transplanted OSPN-labelled human mesenchymal stem cells (hMSCs) by and 20-fold in and brain imaging, respectively, compared with that of the unlabeled cells. Our work demonstrates photoacoustic tomography combined with a new class of OSP-based nanomaterials for NIR-II PA stem cell imaging to facilitate a better understanding and evaluation of stem cell-based therapies.

15:00-15:15 ThOAO3.5

Fiber-Optic Laser-Ultrasound Transducer Using Carbon Nanoparticles for Intravascular Sonothrombolysis, pp. 261-264

WU, HUAIYU NC State University

Kim, Howuk North Carolina State University

Jiang, Xiaoning North Carolina State University

Yao, Junjie Duke University

Tang, Yuqi Duke University

Ultrasound thrombolysis has shown its advantages in the improved treatment rate and safety compared with traditional administration of thrombolytic agents and mechanical methods. However, the method still has the problem in the long treatment time. Although recent studies have reported great potentials of miniaturized intravascular piezoelectric transducers for thrombolysis, the fabrication and packaging of the transducer are complicated. On the other hand, it has been reported that the laser ultrasound, having a relatively simple structure, can be used for the expedited thrombolysis with its high acoustic pressure. However, there is no testing result for small size laser ultrasound thrombolysis. Therefore, in this study, an intravascular laser ultrasound transducer was designed and fabricated, for the first time, on an optical fiber. The preliminary simulation results have shown a focal region of 0.4×0.8 mm. The measured pressure output reached 5.7 MPa under 1.5 mJ/cm2 excitation. The thrombolysis rate of the laser-ultrasound transducer will be estimated in an in vitro test later

15:15-15:30 ThOAO3.6

Quantification of Cell Adhesion Strength Using Energy Dissipation from Quartz Microbalance with Dissipation Monitoring, pp. 265-268

Monemianesfahani, Amir UNL

Rosenbohm, Jordan University of Nebraska Lincoln

Yang, Ruiguo University of Nebraska-Lincoln

We propose a mechanical model that describes the energy dissipation process in the probing of cell adhesion using quartz crystal microbalance with dissipation monitoring (QCM-D). The model considers the QCM-D disk as a harmonic oscillator and the friction between the disk and the cell is modeled as molecular bond rupturing and the fluidic slip at the interface. The bond formation and rupture events are governed by relative motion between the sensor disk and the cell membrane. We consider this interaction as the main energy dissipation channel for the oscillator, as the dynamic molecular bond rupture and the viscous damping of the trapped liquid at the cell/disk interfacial layer contribute to the most energy loss during the harmonic oscillation. The energy loss due to the frictional slip of the stress fiber/cytoplasm is insignificant compared with the bond rupture. At high bond number conditions, the energy dissipation will be dominated by the bond rupture events at the focal adhesion, and bond number and the size of focal adhesion are linearly related to the energy dissipation factors. These findings can serve as an analytical tool for QCM-D based cell adhesion assays.

ThOAO4 Room 7304

Nano/bio-Systems (Oral Session)

Chair: Cai, Xinxia	Institute of Electronics, Chinese Academy of Sciences,
Co-Chair: Bian, Liming	Chinese University of Hong Kong

14:00-14:15 ThOAO4.1

Detection of Neuron-Specific Enolase Using a Wireless Handheld Electrochemical Detector Combined with Label-Free Microfluidic Paper-Based Immunosensor, pp. 269-270

Luo, Jinping	Institute of Electronics, Chinese Academy of Sciences
Fan, Yan	Institute of Electronics, Chinese Academy of Sciences
Wang, Yang	The State Key Laboratory of Transducer Technology, Institute Of
Liu, Juntao	Institute of Electronics Chinese Academy of Sciences,
Jin, Honghan	Peking University First Hospital
Cai, Xinxia	Institute of Electronics, Chinese Academy of Sciences,

In this work, we developed a wireless handheld electrochemical detector to detect neuron-specific enolase when combined with label-free microfluidic paper-based immunosensor. The differential pulse voltammetry measurement was adopted to reduce the interference of the background current in the electrochemical detector. Because of the modification of nanocomposites with composition of amino functional graphene, thionine and gold nanoparticles as probe, the microfluidic paper-based immunosensor showed obvious currents when detected by the electrochemical detector. The detection current was reduced with the increase of the NSE concentrations in the simulated serum samples. And the detection results could be transmitted to the smartphone through Bluetooth of the electrochemical detector and shown on the smartphone screen in real time. The proposed method has potential applications in early diagnosis and diagnosis of lung cancer.

14:15-14:30 ThOAO4.2

Analysis of the Neuronal Electrical Activities Recorded by the Micro-Nano Electrode Array on Cellular Level During the Process of Inducing and Inhibiting Epilepsy in Rat, pp. 271-272

Song, Yilin	The State Key Laboratory of Transducer Technology, Institute Of
Li, Ziyue	State Key Laboratory of Transducer Technology, Institute of Elec
Xiao, Guihua	The State Key Laboratory of Transducer Technology, Institute Of
Gao, fei	The State Key Laboratory of Transducer Technology, Institute Of
Wang, Mixia	The State Key Laboratory of Transducer Technology, Institute Of
Xu, Shengwei	Institute of Electronics Chinese Academy of Sciences,
Cai, Xinxia	Institute of Electronics, Chinese Academy of Sciences,

Epilepsy is a serious neurological disease while its precise mechanisms are still unclear. It is important to detect and analyze the neuronal electrical activities in the process of epileptic seizures on cellular level. In this work, an 8-channel micro-nano electrode array probe modified with platinum nanoparticles was implanted in the hippocampus of anesthetized rat. The extracellular action potentials (spike) and local field potentials were recorded during the process of inducing and inhibiting epilepsy by pilocarpin and diazepam. Results showed that, pyramidal neurons were most sensitive to pilocarpin and the epileptiform discharges were induced with the spike firing rates of up to 34.3 Hz. The average spike firing rates of the interneurons also increased 3.4 times. The average amplitude of the spikes increased about 20 μV due to the change of the local electrical field. After diazepam injection, the neural activities recovered nearly to the normal state. This study provides an effective method for the researches of epilepsy related neuronal activities on cellular level.

14:30-14:45 ThOAO4.3

*Anisotropic Nanoscale Presentation of Cell Adhesion Ligand Enhances Mechanosensing-Dependent Differentiation of Stem Cells**

Bian, Liming	Chinese University of Hong Kong

Biomimetic extracellular matrix (ECM) has been frequently investigated to impact on the field of regenerative medicine and tissue engineering. More specifically, intensive studies have demonstrated how intricate interactions between stem cells and the microenvironment of a specific ECM structure direct cell fates in recent years.Herein, we fabricated substrate-conjugated and RGD-bearing gold nanorods (AuNRs) with different aspect ratios (ARs, 1, 2, 4 and 7) and comparable surface areas among these nanorods. The unfolded fibronectin fibrils, which present cell adhesion sites in a highly anisotropic fashion, potently modulate cell adhesion. We hypothesize that extent of anisotropy of AuNRs that present cell adhesive peptides may also influence cell adhesion and associated cellular behaviors. In our findings, cell cultured on the RGD-bearing AuNRs with larger ARs had promoted cell spreading and more mature focal adhesion toward fibrillar adhesion confirmed by immunostaining and western blotting for protein expression. Strikingly, at nanoscale we observed that F-actin close to the cell basal membrane exhibited increasing alignment along the AuNRs as the AR increased, and the number of nanopodia attached to the AuNRs also increased with larger AR of the AuNRs at the cell leading edge under scanning electron microscopy. Moreover, we demonstrated that results confirmed more substantial recruitment of -β3 and -β1 integrins at cell binding sites on AuNRs with large ARs. Consistent with the findings of cell spreading and integrin recruitment, AuNRs with large ARs significantly enhanced the nuclear translation of Yes-associated protein (YAP) and RUNX2, which are key mechanosensitive and osteogenic transcription factors, respectively, thereby promoting the osteogenic differentiation of hMSCs. Our findings showed that the nanoscale anisotropic presentation of cell adhesive peptides, which can be controlled by the nanoscopic morphology of AuNRs, modulates the recruitment of specific types of integrins, development of cell adhesion structures, activation of adhesion-dependent signaling pathways, and cellular behaviors.

14:45-15:00 ThOAO4.4

Organization Dynamics During Protein Adsorption on Thin Silica Layers Containing Silver Nanoparticles, pp. 273-273

Soumbo, Marvine	LAPLACE, Universite Paul Sabatier
Scarangella, Adriana	LAPLACE, CNRS, Toulouse
Villeneuve-Faure, Christina	LAPLACE, University of Toulouse
Bonafos, Caroline	CEMES-CNRS
Mlayah, Adnen	CEMES-CNRS, Universite Paul Sabatier, Toulouse
Monje, Marie-Carmen	LGC, INPT, Toulouse
Roques, Christine	LCG, Universite Paul Sabatier, Toulouse
Makasheva, Kremena	LAPLACE, University of Toulouse

Research and development of new biomaterials has considerably increased in the last decade. Due to the exposure and interaction of proteins with non-biological organic and inorganic solid surfaces the current strategies involve also revealing the relationship between protein structure and function. Regardless of the targeted

application, whenever a foreign material is brought to a contact with blood or physiological fluids one of the first process to occur is protein adsorption on the material surface. The conformation and arrangement of the adsorbed proteins further control the subsequent biological processes and thus determine the biological response to the material. To understand the driving mechanism of protein adsorption on solid surfaces we follow the organization dynamics of proteins deposited in two ways: by droplets or by dip coating, on silica layers without or with embedded silver nanoparticles (AgNPs). It is found that droplets containing proteins entail Marangoni effect during drying which in turn leads to concentration of the proteins on the droplet borders while the dip coating process provides thin protein layers which are homogeneously distributed on the solid surface although their continuity depends on the concentration of proteins in the solution. The presence of AgNPs alters the observed physical phenomena.

15:00-15:15 ThOAO4.5

Optical Diffraction Technique Based Study of Lateral Bending of Cantilevers Using Living and Dead E.coli Cells, pp. 274-276

BASU, AVIRU IIT KANPUR

Bhatt, Geeta IIT KANPUR

Bhattacharya, Shantanu IIT KANPUR

Cantilever based sensors have been deployed for bio-sensing mode from the last decade. The deflections are observed mostly in static bending mode or in the dynamic mode. The lateral motion of this nano-cantilever beams are not studied till now in the static mode. The optical beam deflection techniques (OBDT) is the most popular for measurement of nano-displacements of micro/nano-cantilever. But lateral bending of the cantilever in static mode is not possible to measure using OBDT technique. Here, for the first time we study the lateral bending of the polymeric SU-8 nanocantilever beams using an optical diffraction technique. The lateral bending of the cantilevers were studied using living and dead bacterial cells.

15:15-15:30 ThOAO4.6

Effect of Isoflurane-Induced Anesthesia on Dual-Mode Neural Signals in Rat Striatum Using a Nano-Modified Microelectrode Array, pp. 277-278

Xu, Shengwei Institute of Electronics Chinese Academy of Sciences,

zhang, yu The State Key Laboratory of Transducer Technology, Institute Of

Xiao, Guihua The State Key Laboratory of Transducer Technology, Institute Of

Wang, Mixia The State Key Laboratory of Transducer Technology, Institute Of

yang, gucheng State Key Laboratory of Transducer Technology, Institute of Elec

Gao, Fei State Key Laboratory of Transducer Technology, Institute of Elec

Song, Yilin The State Key Laboratory of Transducer Technology, Institute Of

Cai, Xinxia Institute of Electronics, Chinese Academy of Sciences,

Studying the effect of isoflurane-induced anesthesia on central nervous system helps to understand the mechanism of anesthesia and reduce the risk of anesthesia-induced death. In this work, a nano-modified microelectrode array (MEA) was used to detect and analyze the dopamine (DA) concentration and neuroelectric activities (local field potentials (LFPs) and action potentials) in the striatum of a rat under isoflurane-induced anesthesia. The flow rate of isoflurane was varied in two cycles according to a sequence (1.5 → 1.0 → 0.5 L/min). Afterwards, it was increased to 3 L/min until the rat died. Dynamic variations of DA, LFPs and four types of action potentials (Sort1, Sort2, Sort3, Sort4) were recorded. The results showed that anesthesia depth significantly regulated the LFPs and the firings of Sort2 and Sort3 but not the DA concentration and the firings of other types. Additionally, the dual-mode signals changed significantly during anesthesia-induced death.

ThOAO5 Room 7305

Nano/Molecular Sensors, Actuators, and Systems (Oral Session)

Chair: Li, Hui Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

Co-Chair: Oh, Soong Ju Korea University

14:00-14:15 ThOAO5.1

A Super-Sensitive Flexible Strain Sensor with Ag/PDMS Composites for Wearable Physiological Signals Detection, pp. 279-282

Zhang, Jinjie Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

Jing, Chen Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

Zebang, Luo Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

Youself, Alhandarish Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

Lei, Wang Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

Li, Hui Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

Objectives: Conductive polymers have received significant attention in biomedical field, especially physiological signals detection because of their great electronic, mechanical and processing properties. In consideration of the high flexibility, easy of molding properties of PDMS and high electrical conductivity of silver powders, a simpler and short time-consuming method of fabricating a conductive Ag-PDMS film is highly demanded and the prototype application of biomedical signal detection is needed to be tested. Methods: The conductive Ag-PDMS film was fabricated by the following steps. In step (a), the silver powders after grinding, 2-3.5 micron, 99.9% (Sigma Aldrich) was dispersed in the ethanol solution by intensive ultrasonic for 30min. Then, removing the ethanol solution floating on the top. In step (b), after the ethanol completely evaporated, adding PDMS (Sylgard 184) to the container a certain percentage. The composites were mixed in a planetary mixer (Thinky ARE-250) for 3 minutes at 2000 rpm. In step (c), the PDMS curing agent was added (respecting a 10:1 ratio between the prepolymer and curing agent) and incorporated into the mixture by mixing again for 1.5 minute at 2000 rpm. In step (d), the mixture is poured onto a silicon wafer for spin coating, and the film thickness is controlled by different spin coating speeds and time. In step (e), after being hard baked at 90℃ for 15 min, the Ag-PDMS could be peeled off from the silicon wafer. In step (f), the conductive Ag-PDMS film was obtained. Results: The average resistivity of the film with the filler content of 175wt%. the cross-sectional SEM images of Ag-PDMS films with various filler content. It can be concluded from these images that with the decrease of filler content, the dispersion of silver powders becomes more and more loose, which means the conductive pathways become less and less. Therefore, the resistance of the film increases with the decrease of filling volume. The Ag/PDMS polymer sensor GF could reach as high as 939. Besides, the Ag/PDMS sensor was used to detect finger joint movement, which shows potential for physiological signals detection applications Conclusions: This paper reports a flexible conductive Ag/PDMS film for ph

14:15-14:30 ThOAO5.2

Development of Nickel Nanowire on N-Doped Carbon Supported for Urea Measurement in Spent Dialysate for End-Stage Renal Disease Prognosis, pp. 283-288

Janyasupab, Metini	King Mongkut's Institute of Technology Ladkrabang
Asavakijthananont, Narawee	Faculty of Engineering, King Mongkut's Institute of Technology L

This study demonstrated a non-enzymatic electrochemical biosensor for urea measurement in spent dialysate as an alternative method of traditional blood-based measurement in patients with end-stage renal disease. On-site monitoring urea in dialysate is strategically cost-effective and practically robust for rapid diagnosis and treatment efficacy. Experimentally, scalable nickel (Ni) nanowire on nitrogen-doped carbon (NC) supported was synthesized and characterized morphology, elemental composition, and electrochemical performance by Field-Emission Transmission Electron Microscopy, Selected Area Energy Diffraction, X-ray Energy Dispersive Spectroscopy, and X-ray diffraction. Furthermore, electrochemical measurements were assessed by cyclic voltammetry and differential pulse voltammetry in phosphate buffer saline, simulated dialysate, and real spent dialysate from chronic kidney disease patients. Upon successive urea addition, the as-prepared Ni nanowire/NC exhibited the estimated limit of detection (LOD) of 0.408 mM and the sensitivities of 68.91 μA.cm-2.mM-1 (R2 = 0.986) and 7.57 μA.cm-2.mM-1 (R2 = 0.989) in the lower range (below 1 mM) and the upper range (1-20 mM), respectively in simulated dialysate. Furthermore, the urea determination in the 4 hour-treatment spent dialysate, obtained from three patients, was also carried out in comparison with the clinical standard test, demonstrating a comparable and practical onsite urea measurement in future prognosis.

14:30-14:45 ThOAO5.3

A Method for Improving the Detection Accuracy of Resonant Micro-Optical Electromechanical Gyroscope, pp. 289-292

Tao, Yu	North University of China
Liu, WenYao	North University of China
Pan, ZiWen	North University of China
Tang, Jun	North University of China
Xing, Guohui	North University of China
Liu, Jun	North University of China

With the development of high-precision navigation and positioning technology, the requirement of modern inertial navigation system is constantly improving, such as moving to smaller size, higher precision, larger dynamic range and higher reliability. In recent years, the resonantor micro optic gyroscope (RMOG) with optical microcavity is considered to be a high-precision gyro with the most chip integration potential, by combining the high precision of optical sensor components with the miniaturization of MEMS devices. We mainly study the resonant micro optic gyroscope from the manufacture of gyroscope core sensitive components, high-precision information solution, system integration and noise suppression. By optimizing the structural parameters of the reflective optical waveguide resonator, the optimal sensitivity gyroscope coupling structure is designed. The low-loss, high-Q optical waveguide resonator is fabricated by process optimization. The gyroscope phase modulation spectrum detection circuit is designed based on FPGA, and the high-precision multilevel laser frequency lock-in system is designed to realize the high-precision gyroscope signal solution. And then, the backscattering noise and optical power noise are suppressed, and the integrated manufacturing of the gyroscope prototype is completed. The prototype bias stability reaches 16.39°/h. By further optimizing the cavity parameters and improving the system noise suppression, the theoretical stability of the resonantor micro optic gyroscope can reach to 10-4°/h, and the sensitivity of the gyroscope can be further improved by utilizing the characteristics of the exceptional point enhancement sensitivity in the multi-cavity system. Especially the sensitivity at low angular speeds will increase by several orders of magnitude.

14:45-15:00 ThOAO5.4

Sensitivity Analysis of Silicon Nanowire ISFET Sensor with LaF3 Membrane, pp. 293-296

Kwak, Hyeon-Tak	Pohang University of Science and Technology (POSTECH)
Kim, Kihyun	Pohang University of Science and Technology
Cho, Hyeonsu	Pohang University of Science and Technology (POSTECH)
Meyyappan, M.	NASA Ames Research Center
Baek, Chang-Ki	POSTECH / CiTES

We investigate the fluoride ion sensitivity dependence on the width of silicon nanowire (SiNW) ion-sensitive field effect transistor (ISFET) sensor with polycrystalline lanthanum fluoride (poly-LaF3) sensing membrane. The poly-LaF3 sensing membrane is deposited using non-tiled thermal evaporation under substrate temperature of 600 °C. The device shows excellent electrical characteristics of low subthreshold swing (SS) and high on-off current ratio as the SiNW width shrinks. The voltage sensitivity is degraded with decreasing the nanowire diameter. This degradation is caused by reduced thermal conductivity in narrow nanowire because the deposition temperature of the poly-LaF3 film is important parameter to determine voltage sensitivity. On the other hand, the sensor exhibits the highest current sensitivity in the nanowire width of 200 nm. Although the current sensitivity is significantly affected by SS, the sensitivity is degraded when the width is less than 200 nm due to degraded voltage sensitivity. These results show that the optimized diameter of SiNW is essential for highly sensitive fluoride ion ISFET sensor.

15:00-15:15 ThOAO5.5

A Silk Fibroin and Ultra-Long Silver Nanowires Based Transparent Conductive Composite Film for Nanosensor Devices Devices, pp. 297-301

Cheng, Kai	Shanghai University
Qin, Xiangzheng	Shanghai University
Wei, Zhenzhong	Shanghai University
Peng, Yu	Shanghai University
Li, Piaopiao	Shanghai University
Liu, Ping	Shanghai University
Cao, Ning	Shanghai University
Huang, Junyi	Shanghai University
Rao, Jinjun	Shanghai University
Chen, Jinbo	Shanghai University
Wang, Tao	Shanghai University
Liu, Mei	Shanghai University

Novelty / Progress Claim(s) This paper reports a transparent conductive film based on silk fibroin (SF) and ultra-long silver nanowires (AgNWs). Compared with other conductive films, this kind of film has better conductivity and better biocompatibility, as ultra-long nanowires tend to generate less wire-wire junctions. Background / State of the Art Nowadays, flexible transparent conductive films (TCFs) have become an important part of many optoelectronic devices. Many materials such as glass, plastic and textiles are implemented as the TCFs substrate. However, due to the lack of good biocompatibility of traditional conductive substrate materials, they are difficult to be used in the research of biological medicine, implantable photoelectric equipment and devices. Therefore, researchers began using silk and some nanomaterials as alternatives to traditional TCFs substrates [1, 2]. Description of the composite film SF film is made by air-drying SF solution prepared by cocoon degumming, dissolving and dialysis [3]. Although SF has excellent biocompatibility and mechanical properties, pure SF film cannot conduct electricity, so the method of spinning coated ultra-long AgNWs and sputtering platinum is used to endow it with electric conductivity, and at the same time, part of the flexibility and light transmittance of pure SF film are retained. Ultra-long AgNWs can reduce the resistance of the junctions between wires, and the presence of platinum further improves the conductivity and strength of the composite film. For comparison, a number of composite films were prepared by

controlling the concentration of spin-coated AgNWs solution and platinum sputtering time. Experimental Results The light transmittance of the composite films was measured by a UV-VIS spectrophotometerand was in the range of 60% ~ 80%. It was found that the light transmittance decreased with the increase of sputtering time. Meanwhile, due to the shielding effect caused by the absorption and reflection of light by the silver nanowire network, the light transmittance of the coated silver nanowire is lower than that of pure silk fibroin film even without sputtering platinum[1,4]. The film sheet resistance of the composite films was also tested by a fo

15:15-15:30 ThOAO5.6

Comparison of the Permittivity Sensing Capabilities of Graphene-Based Nanohybrids and Metal Nanoparticle-Based Nanohybrids, pp. 302-305

Senevirathne, Viraj — Monash University

Premaratne, Malin — Monash University

Nanohybrid comprising of a nanoresonator and a quantum emitter have shown enhanced optical properties compared to its constituents. Such nanohybrids are highly sensitive to their surrounding medium permittivity, making them suitable for sensing applications which relies on the background permittivity. This feature is a result of the change in resonance conditions in the nanoresonator, which is part of the nanohybrid. Here we investigate how different nanoresonators affect the sensing capabilities of the nanohybrid and use that information to make recommendations on the best nanoresonator for the nanohybrid depending on the application. Our analysis is based on cavity quantum electrodynamics formalism and thus rigorous and accurate. Our results indicate that the graphene resonator based nanohybrids can be used to detect broader permittivity range than MNP based nanohybrids.

ThPSPP Hallway

Poster Session II (Poster Session)

Chair: Shen, Yajing — City University of Hong Kong

15:30-16:30 ThPSPP.1

Development and Application of Novel Microfluidic Culture Chips for Germ Cells, pp. 306-310

Huang, Tsung-Tao — Taiwan Instrument Research Institute, National Applied Research

Yu-Hsiang, Tang — Taiwan Instrument Research Institute, National Applied Research

Shiao, Ming-Hua — Instrument Technology Research Center, National Applied Research

Liu, Hung Wei — National Applied Research Laboratories

This program is to improve the traditional germ cell culture technology, and expected to develop and validate the innovative germ cell microfluidic culture technology. The main concept is to use the in vitro microfluidic chip to mimic the fluid growth environment in the living body, and to shape the growth environment of the zygote cells into a bionic concept in the uterus. The main objective is to design to the most suitable growth conditions, the importance of which is to increase the chance of zygote cell culture to maturity and greatly improve the maturity of zygotic cells. Assist Reproductive technology is a related technology for in vitro washing, culturing and storage of human germ cells. The main method is to use an artificial culture medium that mimics the human body fluid of the human reproductive system to perform in vitro washing, culture, and storage of reproductive gametophytic cells. The project will be divided into three parts: 1. Bionic microfluidic chip design and production; 2. Biocompatibility and materialization analysis; 3. Germ cell chip efficacy verification. Therefore, this project will develop a continuous microfluidic chip, using a continuous microfluidic channel to simulate the growth of human germ cells in the fertility tube to the zygotic germ cell growth environment, and hope to improve the artificial reproductive technology success rate and pregnancy rate. Reduce the cost of repeated artificial reproduction, and eventually, develop into medical-grade products and promote local technology to the international market.

15:30-16:30 ThPSPP.2

Microfluidics Based Three-Dimensional Graphene Assembly, pp. 311-312

Seo, Tae Seok — Kyung Hee University

Besides two dimensional (2D) graphene sheets which show superior electrical, thermal, and mechanical proper-ties, three dimensional (3D) graphene assembly also recently garnered great attention due to its high surface area, flexible and free-standing configuration, and facile fabrication of the graphene composite with nanomaterials in practical graphene applications. However, to date, the morphology of the 3D graphene structure has been limited to spherical shape. Herein, we demonstrated the synthesis of a variety of 3D graphene assembly including sphere, twiddle, and hemisphere. Such 3D reduced graphene oxide (rGO) structures could be manipulated by controlling the aggregation pattern of the GO sheet inside the micro-droplets. The aggregation pattern depended on the diffusion rate of the droplet solvent that were simply tuned by the amount of an oil phase. In addition to the fabrication of the versatile 3D graphene materials, their micro-porous structure was manufactured by com-positing silica beads in the rGO microparticles followed by a wet etching process. Noticeably, the 3D porous hem-ispherical rGO revealed unique surface plasmonic characteristics similar to the single layered graphene as well as a bulk plasmon effect, which were confirmed by an electron energy-loss spectroscopy (EELS) mapping. These results are the first-time demonstration showing the plasmonic properties of the 3D graphene structure which can expand the application arena of the 3D graphene materials.

15:30-16:30 ThPSPP.3

The Research Progress and Comparisons between Lithium-Ion Battery and Sodium Ion Battery, pp. 313-318

Tian, Wenchao — Xidian University

Li, Mengjuan — Xidian University

Niu, Jiahao — Xidian University

Li, Wenhua — Xidian University

Shi, Jing — Xidian University

Sustainable development and environment-friendly battery has always been the goal pursued by people. At present, lithium-ion battery (LIB) is widely used in electronic products, transportation, aerospace and other fields. However, it has a low storage of Li and uneven distribution. Recently, a new type of secondary cell, sodium ion battery (SIB), appears as novel energy source. It has attracted much attention for abundant resources, low price and friendly environment. But there is few paper about the comparison between LIB and SIB. In this paper, the research progress and classification of materials for LIB and SIB are introduced in detail. In addition, this paper compares them from the aspects of economy and electrochemical performance. Finally, novel idea for the development of SIB is illustrated.

15:30-16:30 ThPSPP.4

Heterostructures of Transition Metal Dichalcogenide Thin Films Fabricated by Sputtering and Electron Beam Irradiation, pp. 319-320

Kim, Bong Ho — Korea Institute of Ceramic Engineering and Technology

Kwon, Soon Hyeong — Korea Institute of Ceramic Engineering and Technology

Yoon, Young Joon — Korea Institute of Ceramic Engineering and Technology

Recently, versatile junctions of 2D materials such as 2D/metal, 2D/2D, and 2D/3D have attracted the attention of researchers. Since conventional doping method such as dopant diffusion and ion implantation are detrimental for atomically thin 2D materials due to inevitable crystal structure damage, vertical or horizontal van der Waals heterojunctions of different 2D materials should be required. An important issue in the study of 2D heterostructure is

the difference between a heterostructure and that of two individual layers in optical and electrical properties. In order to synthesize heterostructures, physical stacking through mechanical exfoliation and epitaxial growth using chemical vapor deposition have been reported, but no sputtering for heterostructures has been reported. In this study, we synthesized 2D TMD heterostructures by using RF magnetron sputtering and electron beam irradiation (EBI). Amorphous MoS2, WS2, and SnS2 films were deposited sequentially, and subsequently, EBI was carried out on as-deposited heterostructures. The EBI-treated heterostructures were compared with as-deposited heterostructures, as-deposited individual films, and EBI-treated individual films for structural and photoelectric properties. We believe these results should broaden perspectives about the design and understanding for 2D TMD heterostructures.

15:30-16:30 ThPSPP.5

Molecular Dynamics Simulation of Dielectric Property of Epoxy/Carbon Nanotube Composites at Different Temperatures, pp. 321-326

Ding, Mi	Shandong University
邹, 亮	Shandong University
Han, Zhiyun	Shandong University
Zhao, Tong	Shandong University
Zhang, Li	Shandong University
Wang, Jian	North China Electric Power University

The dielectric property is one of the key parameters to inhibit the surface charge accumulation of dc GIL. However, as the insulating medium for dc GIL, pure epoxy resin has limited effect on the inhibition of surface charge accumulation. Doping the carbon nanotubes is expected to be an effective measure for the suppression of surface charge accumulation. Based on molecular dynamics (MD) simulation, the dielectric property of epoxy resin/carbon nanotube composites at different temperatures was analyzed. Firstly, the MD models of pure cross-linked epoxy resin and epoxy resin doped with carbon nanotubes (non-functionalized with three lengths, amino amines functionalized with three lengths) were established. Then, the dielectric constants of seven models at different temperatures were calculated under LAMMPS. The best carbon nanotube was selected after analyzing the effects of inhibition of surface charge accumulation based on different dielectric constants.

15:30-16:30 ThPSPP.6

Visible Emission Comparison from Both ZnO Thin Films and Nanoarrays Spin-Coated with GO Layers, pp. 327-330

Chen, Haixia	Xi'an Shiyou University
Ding, Jijun	Xi'an Shiyou University
Zhang, Xuan	Xi'an Shiyou University

GO is spin-coated on ZnO films and ZnO nanoarrays, respectively. Results indicate that a strong blue emission band and two shoulder peaks are observed in PL spectra of ZnO films and ZnO nanoarrays. As GO is spin-coated on the ZnO films, the blue emission intensity decreases. However, as GO is spin-coated on the ZnO nanoarrays, the blue emission is drastically increased and attains the maximum. We proposed that the effective work function of GO sheets will also be decreased sharply as they are spin-coated on ZnO nanoarrays. In this case, the Fermi levels of GO locate above the conduction band of ZnO. The electrons on the Fermi levels of GO can easily transported to the conduction band of ZnO resulting in the increase PL emission in the GO spin-coated ZnO nanoarrays.

15:30-16:30 ThPSPP.7

*Nanomaterials for Catalytic Detoxification and Chemical Recycling of Toxic E-Waste Plastic**

Jia, Chunmiao	Nanyang Technological University
Zhao, Jun	Nanyang Technological University
Lee, Jong Min	Nanyang Technological University

Nanomaterials have been used for various applications. The waste electrical and electronic equipment (WEEE) rapidly draws the world's attention as a result of the exploding technologies and the ever-shortening product lifespans. Comparing with the traditional ways to treat the e-waste, proper chemical processes will be advantaged to convert the waste to high-value and clean fuels as well as reducing the negative influence on the environment and human health. Microwave treatment as well as nano-structured catalysts will be applied here to develop the optimized chemical process for detoxification and recycling of WEEE.

15:30-16:30 ThPSPP.8

*Hydrophobicity Enhancement Via Formation of Nanostructure for Usage in Water Purification**

Tanvanich, Teerit	Chulalongkorn University
Tanrat, Nattapat	Chulalongkorn University
Methachittipan, Apipon	Chulalongkorn University

In this study, Polyvinylidene Fluoride (PVDF) nanofiber membranes were fabricated to evaluate the hydrophobicities and assigned into groups; the uncoated membrane group, and the coated membrane group. Electrospinning technique was used to fabricate the PVDF nanofiber membrane. The hydrophobic coating suspension was prepared by mixing Octadecyltrimethoxysilane (OTMS), two sizes of TiO2 nanoparticles (25 nm and 100 nm), and ethanol together. The adhesive spray was first applied to the nanofiber membrane to enhance the adhesion of the TiO2 nanoparticles to the PVDF nanofiber membrane. Afterward, The hydrophobic coating solution was applied onto the PVDF nanofiber membrane via electrospraying technique. FE-SEM was used to evaluate the fibers' diameter, morphology and density. The hydrophobicities of both group of nanofiber membranes were evaluated by measuring the contact angles of water droplet (2μL) on samples' surface. The images of the water droplets were taken, evaluated by using ImageJ, and the contact angle values were obtained. It was clearly shown that the water contact angle (WCA) on the nanofiber surface increased from 124.6° to 128.0° after the TiO2 nanoparticles coating was applied.

15:30-16:30 ThPSPP.9

The Standard Development of Nanoparticle Exposure Assessment through SP/ICPMS Equipment, pp. 331-334

Park, Jayoung	KIST Europe
Kim, Ki Eun	KIST Europe
Koch, Marcus	INM - Leibniz-Institut Für Neue Materialien GGmbH
Jeon, Hyunpyo	KIST Europe

The development of nanotechnology, particularly of nanoparticles, is having a revolutionary effect in science and technology. Accordingly, it receives unexpected adverse effects (e.g. ecotoxicological) which can be caused by the special properties of the nanoparticles. It is important to develop with suitable physical and chemical properties of nanoparticles. In recent years, toxicity assessment method using nanoparticle in stable suspension has been emphasized in safety evaluation of nanomaterials. The nanoparticles dispersed in the aqueous solution have the possibility of creating an artifact that does not reflect the state of the dispersion aqueous solution. Confirmation of the conditions for measuring the size and size distribution reflecting the state of the dispersion aqueous solution is fundamental to reliable nanomaterial characterization. In addition, this characterization is needed to design environmentally appropriate toxicity studies and risk assessments. In this work, the size and size distributions of liquid suspension containing well-dispersed standard nanoparticles are measured by single particle inductively coupled plasma-mass spectrometry (SP/ICP-MS). SP/ICP-MS is a technology that can be applied to metal nanoparticle analysis of 20 nm or more. The required concentration in the sample has the advantage that it can be analyzed sufficiently below the ppt level. The size distribution measurements of particles are made using NIST Gold SRM. These were compared with certificate values. And we have found reliable measurement conditions through repeated measurement. Thereafter, silver nanoparticles were measured by the same method. The result can be compared to the size measured with TEM and SMPS. This study also

confirmed that SP/ICP-MS is useful for predicting and evaluating the stability of exposed silver nanoparticles under realistic environmental conditions with low particle concentrations. Through these results, the new environmental fate and exposure model of nanoparticle in different matrices can be developed through these results which contains relationships between agglomeration rates, primary size, and surface charge of the nanoparticle and the matrix.

15:30-16:30 ThPSPP.10

*Tunable Plasmon Resonances through Deformation of Gallium Nanoparticles**

Yao, Sheng-Min	National Central University
Chen, Chih-Yao	National Central University
Chen, I-Chen	National Central University

The plasmonic properties of gallium nanoparticles (Ga-NPs) attract much attention in recent years since the surface plasmon resonance (SPR) peak can be adjusted from UV to visible by changing the particle size. It is well known that Ga is a liquid at room temperature and thus can be deformed by external forces. In this study, we have demonstrated that SPR peaks of Ga-NPs are tunable by deformation of NPs through an electrochemical oxidation process. The Ga-NPs were deposited on ITO glass substrates by thermal evaporation and the electrochemical oxidation was carried out in a phosphoric acid solution. Under properly oxidation conditions, deformation of Ga-NPs occurs as the surface oxide layer reaches a critical thickness and a red-shift of 60 nm in the resonance wavelength could be observed after electrochemical oxidation. It is suggested that shifts of SPR bands could be mainly attributed to the deformation of Ga-NPs since the presence of surface oxide layers only cause a slight shift in SPR band. The correlation between the deformation of NPs and peak shift phenomenon was investigated in detail.

15:30-16:30 ThPSPP.11

Molecular Dynamics Study on Mechanical Properties of Nanocrystalline Tantalum, pp. 335-338

Wang, Xiao	XIDIAN University
Li, Kang	Xidian University
Zhu, Yingmin	Xidian University
Li, Weibing	ZNDY of Ministerial Key Laboratory, Nanjing University Of
Wang, Weidong	Xidian University

The study of nanocrystalline(NC) polycrystals is a hot topic, and the study of nanomaterial properties by molecular dynamics has become the first choice for many researchers. The purpose of this paper is to simulate the tensile tests of single and polycrystalline tantalum by molecular dynamics(MD) to obtain its mechanical properties. Firstly, the Ravelo-EAM potential was used to conduct tensile tests on tantalum in the <100> direction. Secondly, it can be seen that the elastic modulus E100 decreases with the temperature gradually increases from 1 K to 1500 K according to the simulation results. Finally, the Hall-Petch(H-P) effect based on grain size is verified from the tensile test of polycrystalline tantalum.

15:30-16:30 ThPSPP.12

A Novel Piezoelectric Transducer for Driving Underwater Robotic Finger, pp. 339-340

Yu, Pengpeng	Nanjing University of Aerounautics and Astrounautics
Wang, Liang	Nanjing University of Aerounautics and Astrounautics
Jin, Jiamei	Nanjing University of Aerounautics and Astrounautics

To eliminate the problem of the structural damage of traditional manipulators caused by depth water pressure, a novel piezoelectric actuated underwater robotic finger is proposed in this study. The robotic finger adopting an open configuration is composed of three phalanges and two joints. A novel bonded-type piezoelectric transducer employed as the actuator in each phalanx pushes the joints by friction. The geometrical parameters of the bonded-type piezoelectric transducer are determined by the finite element method, and a prototype of the proposed robotic finger is manufactured and tested. Experiment investigation is conducted to confirm the calculation results and evaluate output performances of the robotic finger prototype. Experimental results indicate that water has little effect on the driving frequency of the piezoelectric transducer. The maximum average velocities of the phalanges A and C driven by the phalanx B and the phalanx C driven by itself in water are 638 deg/s, 676 deg/s, and 689deg/s, respectively, under the excitation voltage of 500 Vpp. The maximum output torque of the phalanges A and C driven by the phalanx B and the phalanx C driven by itself in water are 10.98 mN·m, 13.18 mN·m, and 11.38 mN·m, respectively, under the excitation voltage of 450 Vpp. The proposed robotic finger exhibits potential to be employed as the underwater manipulators.

15:30-16:30 ThPSPP.13

Real-Time Registration of Organic Molecules with Low Molecular Weight and Different Functionality: LSPR vs. SPPR, pp. 341-344

Lytvyn, Vitalii	V.E. Lashkaryov Institute of Semiconductor Physics National Acad
Semeniuk, Anton	Institute of High Technologies of National Taras Shevchenko Univ
Lopatynskyi, Andrii	V.E. Lashkaryov Institute of Semiconductor Physics National Acad
Chegel, Volodymyr	V.E. Lashkaryov Institute of Semiconductor Physics National Acad

Abstract— This work is a comparative study of real-time detection of organic molecules with ultimately small weight and different functionality (urea, 60 Da and thiourea, 76 Da) using optoelectronic sensors based on LSPR (localized surface plasmon resonance) in noble metal nanostructures and SPPR (surface plasmon-polariton resonance) in noble metal thin films. The results of theoretical modeling of LSPR and SPPR response for molecular layers with thickness up to 350 nm reveal strong difference in kinetics of sensor's response. It has been experimentally determined that thiourea detection limit for LSPR technique is about 0.0002 mM/L while for SPPR it is 0.0008 mM/L, and for urea these limits are respectively 10 mM/L and 2.5 mM/L.

15:30-16:30 ThPSPP.14

Calculation Behavior of 2D Ising Spin Computing with Different Spin Decision Logics, pp. 345-348

Shimada, Moe	Tokyo University of Agriculture and Technology
Ito, Mitsuki	National Institute of Technology, Kushiro College
Hirata, Yosuke	Tokyo University of Agriculture and Technology
Kushitani, Yuki	Tokyo University of Agriculture and Technology
Miki, Tsukasa	Tokyo University of Agriculture and Technology
Shirakashi, Jun-ichi	Tokyo University of Agriculture and Technology

We proposed "prompt decision logic", which has the advantage for accelerating the ground-state searches of Ising spin model. The Ising spin model describes the behavior of magnetic spins. It consists of each spin having four-nearest-neighbor (adjacent) spins. Escaping local minimum is a key for solving combinatorial optimization problems. Actually, many of the combinatorial optimization problems can be mapped to the Ising spin model. In this report, we observed convergence properties of Ising computing with prompt decision logic, without any scheduling during energy convergence. Moreover, the prompt decision logic showed better success probability than that of majority voting logic, as the problem size grows. Therefore, the prompt decision logic is useful for Ising spin computing and able to solve the combinatorial optimization problems.

15:30-16:30 ThPSPP.15

*Intelligent Identification of Two-Dimensional Nanostructures by Machine-Learning Optical Microscopy**

Si, Zhizhong	Student in Beihang
fu, wenzhi	Beihang University
Xinhe, Wang	Beihang University
LIN, Xiaoyang	Beihang University

We report the successful application of machine-learning strategy in the optical identification of 2D nanostructures. The experimental results indicate that the MOI method enables accurate, intelligent, and large-area characterizations of graphene, molybdenum disulfide, and their heterostructures, including identifications of the thickness, existence of impurities, and even stacking order.

15:30-16:30 ThPSPP.16

Simultaneous Nanoscale Imaging and Fabrication Beyond the Diffraction-Limit Using Femtosecond Laser and Microsphere Lens, pp. 349-351

wen, yangdong	Shenyang Institute of Automation
Yu, Haibo	Chinese Academy of Sciences
Zhao, Wenxiu	Shenyang Institute of Automation, Chinese Academy of Sciences
Li, pan	State Key Laboratory of Robotics, Shenyang Institute of Automati
Liu, Lianqing	Shenyang Institute of Automation, Chinese Academy of Sciences
Li, Wen Jung	City University of Hong Kong

Electrode on chip is of great applications in extensive research fields such as measuring the electrical characteristics of material, the conductor induced short circuit of electrode would damage this function, and it would be difficult to mend the electrode if the conductor is sub-diffraction limit. In this paper, we propose a novel femtosecond laser-induced photonic nanojet(PNJ) for chip mending. The photonic nanojet is developed via a silica microsphere it could reduce the full width half maximum (FWHM) of incident laser that would reduce the laser processing resolution , and the microsphere also could realize super resolution imaging in air , this function could help to find the conductor effectively. The imaging results showed that compared to the results without superlens the resolution with microsphere has been improved obviously and the magnification factor of imaging could be 2.5, in addition, sub -diffraction limit features processed by femtosecond laser induced photonic nanojet could be created successfully on gold film. It indicates that conductors that is under diffraction limit could be removed successfully by femtosecond laser induced PNJ

15:30-16:30 ThPSPP.17

Liraglutide Peptide Assembled Micelle As a Bio-Functional Drug Delivery Platform, pp. 352-354

Sun, Yu	Tongji University
Sun, Min	Tongji University
Zhang, Mingjun	The Ohio State University
Fan, Zhen	Tongji University

Liraglutide, glucagon-like peptide-1 analog, has been widely applied in the treatment of type 2 diabetes. It would be of great value to endow the Liraglutide with additional biofunctions. Here, we first self-assemble Liraglutide into uniform micelle and further demonstrate its capability as drug delivery platform through efficiently loading with doxorubicin (DOX). By optimizing the experimental parameters, Liraglutide is able assemble into nanoparticles through hydrophobic, electrostatic and π–π interactions. Furthermore, DOX could be loaded with Liraglutide nanoparticles via π–π interactions. The morphology and DOX loading effects of Liraglutide nanoparticles were characterized using TEM and fluorescence spectrometer.

15:30-16:30 ThPSPP.18

A Better TID Hardened Dopingless Lateral Bipolar Tranisitor on SiGe-OI Design, pp. 355-358

Lourembam, Beloni	Jawaharlal Nehru University
Kumar, Jitendra	Jawaharlal Nehru University
Srivastava, Asutosh	Jawaharlal Nehru University

Impact of Total Ionization Doze (TID) on the charge plasma induced dopingless lateral bipolar transistor on SiGe-OI is studied. This paper proposes a new TID hardened charge plasma induced dopingless bipolar design – Triple Sided Charge Plasma (3SCP) Symmetric Lateral Bipolar Transistor (SLBT) on SiGe-OI. With our proposed 3SCP design we were able to show that the TID impact on the current gain is hardened as compared to the already reported charged plasma dopingless design.

ThOBO1 Room 7201

Nanoelectronics: Graphene and Other 2D Materials, CNTs and NWs II (Oral Session)

Chair: Zhang, Yan	Shanghai University
Co-Chair: Wang, Han	USC

16:30-16:45 ThOBO1.1

Liquid Exfoliated MoO3 Nanosheets for Ammonia Sensing, pp. 359-359

Sakhuja, Neha	IISc
Jha, Ravindra	IISc
Bhat, Navakanta	Indian Institute of Science, Bangalore

2D MoO3 nanosheets have been fabricated via a one-step ultrasonication assisted liquid exfoliation process. Interestingly, the resulting 2D MoO3 nanosheets were found to be hexagonal in nature unlike the source material (orthorhombic (α) MoO3). These as fabricated nanosheets were further annealed at different temperatures in air ambient for two hours. A complete phase conversion of these hexagonal nanosheets back to α-MoO3 was observed at 350oC. However, a biased anneal in flowing air environment was also done at 350oC which resulted in mixed phase MoO3. All of these showed reasonable response towards ammonia in the concentration range of 300 ppb to 3 ppm. However, the response magnitude of the mixed phase MoO3 nanosheets (at 250oC) was higher than that of the pure hexagonal (at 350oC) and pure α-MoO3 (at 350oC).

16:45-17:00 ThOBO1.2

Bio-Syncretic Light-Gated Field-Effect Transistor: Fabrication and Characterization, pp. 360-363

Yang, Jia	The State Key Laboratory of Robotics, Shenyang Institute of Auto
Wang, Wenxue	Shenyang Institute of Automation, Chinese Academy of Sciences
Li, gongxin	Jiangnan University
Li, Guangyong	University of Pittsburgh
Xi, Ning	University of Hong Kong
Liu, Lianqing	Shenyang Institute of Automation, Chinese Academy of Sciences

Biological visual system has many intrinsic functional superiorities, such as small size, high sensitivity and no heat-sink cooling, which are hard to be completely replicated by electromechanical systems. The bio-syncretic design of sensing device with living materials may provide some functional superiorities to those conventional sensing devices, and will have great potential benefits in both biomedical and engineering applications. In this study, we developed a novel bio-syncretic light-gated field-effect transistor (FET), in which optogenetically engineered cells were used as the gate substitute for conventional gate electrode, and the exposure of the cells to light irradiation results in the variation

of the transistor's channel current. The bio-syncretic transistor was fabricated by virtue of graphene film and optogenetically engineered cells, and its basic photo-responsive performance was then tested and characterized. This reference-less bio-syncretic transistor has a wide range of potential applications in photodetection and biosensing with good biocompatibility and stability.

17:00-17:15 ThOBO1.3

Analysis of Thermal Treatment Influence on Graphene Oxide Thin Film Deposited by Modified Coating Process, pp. 364-367

Kang, Xiaoxu — Shanghai IC R&D Center
Kang, Xiaozhi — State Key Laboratory of ASIC and System, School of Microelectron
Ruoxi, Shen — Shanghai IC R&D Center
Xiaolan, Zhong — Shanghai IC R&D Center

Graphene Oxide (GO) is made up of single or several closely-spaced graphene sheets with plenty of functional group, and can be considered as insulator. Recently GO material is attracting more and more interest for gas sensor application because of its excellent properties. In this work, GO dispersion was prepared by dispersing high-purity GO nanosheets into water. Isopropyl alcohol (IPA) and related solvent were used to adjust its viscosity and surface tension. Modified coating process was developed to get a more uniform GO thin film. After GO film deposition, it was then annealed to remove the residue solvent and make the film stable. Thickness uniformity was checked by Cross-Sectional SEM. For 2 inch wafer sample, 1 sigma of within wafer GO film uniformity can reach to less than 3 percent by modified coating process. XRD was used to check influence of different annealing condition on GO film. As shown in XRD data, 2Theta value of XRD peak angle was increasing with increasing temperature and time. According to Bragg's law, 2theta value is inversely proportional to lattice distance, and increasing of 2theta value means decreasing of GO film layer distance, which may indicate the decomposition and loss of oxygen-contained functional group.

17:15-17:30 ThOBO1.4

Improving the "Improved" Graphene Oxide Synthesis Method, pp. 368-369

Benzait, Zineb — Nanosicence and Nanoengineering Department, Istanbul Technical U
Trabzon, Levent — Istanbul Technical University
Chen, Pengwan — School of Mechatronic Engineering, Beijing Institute of Technolo

The synthesis of graphene oxide (GO) with both high quality and quantity is a matter of great importance for both research institutes and industries. In the present study, we report an improvement of the so-called "improved method" reported by Tour et al., which already improved the very famous "Hummers method" to a certain extent. Through an important pre-treatment step, GO with larger sheets, better structural integrity, and higher monolayers yield without sonication was obtained. furthermore, both oxidation time and temperature were reduced without reducing the high oxidation degree. Despite that some researchers have shown that low temperature is a pre-request for obtaining less defective GO in its reduced form (rGO), we found through this research that the pre-treatment step minimizes the negative effect of the moderate temperature needed to enhance the reaction rate and yield, moreover the product crystallinity and water-dispersibility, without altering the basal graphitic plane preserved as well as at low temperature. Both mechanical and electrical properties confirm the enhancement of GO quality obtained through improving the improved method.

17:30-17:45 ThOBO1.5

Experimental Measurements of Thermal Performances of Carbon Nanomaterial with Vertical Structures in Hotspot Heat Dissipation, pp. 370-373

Zhang, Yan — Shanghai University
Tan, Longwang — Shanghai University
Yin, Hang — Shanghai University
Zhang, Guoqiang — Shanghai University
Liu, Johan — Chalmers University of Technology

hermal management is a vital issue in the performance and lifetime reliability of electronic devices and products with high packaging density. The dramatic progresses in electronics development and technologies in recent years bring forwards high requests to thermal materials for quick and valid heat dissipation in limited space. Carbon nanomaterials have attracted much attention due to their distinctive structures and excellent properties. In this paper, two kinds of nanomaterials with vertically orientated structures, namely carbon nanowalls and vertically aligned carbon nanofibers, have been fabricated and then applied on the surface of a hotspot to evaluate their heat dissipation performance. A series of experimental measurement have been carried out to obtain the temperature of the hotspot with and without the vertically aligned carbon nanomaterials at the various power loadings. Comparisons of temperature values show that the utilization of both the carbon nanowalls and the carbon nanofibers can effectively decrease the hotspot temperature. And the improvement is remarkable at a high power density.

17:45-18:00 ThOBO1.6

Tube Redundancy in Statistical Evaluation of Critical Path Delay of CNFET Circuits in the Presence of Tube Variation, pp. 374-377

Vendra, Satya Keerthi — Portland State University
Chrzanowska-Jeske, Malgorzata — Portland State University

Due to limited controllability over the tube growth process, Carbon Nanotube Field-Effect Transistors (CNFET) show large variations in their behavior. These variations are primarily caused by variation in CNT diameter and the presence of metallic tubes (m-CNT) in, what it should be, purely semi-conducting (s-CNT) arrays. For proper operation of a CNFET metallic tubes have to be removed, unintentionally reducing transistor strength. This work proposes to use a calculated minimum CNT redundancy at the transistor level to improve functional yield for a given failure rate. We focus our evaluation on a critical path that in reality, due to metallic tube presence, could be a different path in each circuit. We limit the redundancy to a minimum required, to avoid unnecessary increase in the channel area. The calculated minimum number of redundant CNTs are added to each CNFET to achieve only slightly increased statistical critical path delay after m-CNT removal, compared to the ideal critical path delay. We use a statistical approach to improve prediction accuracy for both critical path delay and functional yield. With proposed minimum redundancy we are able to reduce the allowed delay degradation (tolerance) by 15-25% and still have a good functional yield. Results show a reduction of 7-10% in critical path delay variation of ISCAS'85 logic benchmark circuits with >99% functional yield (Yf).

ThOBO2 Room 7204

Invited Session: Nano Energy and Smart Systems (Invited Session)

Chair: Zi, Yunlong — The Chinese University of Hong Kong
Co-Chair: Huang, Bolong — The Hong Kong Polytechnic University

16:30-16:45 ThOBO2.1

Intrinsic Energy Conversions for Photon-Generation in Piezo-Phototronic Materials: A Case Study on Alkaline Niobates (I), pp. 378-378

Huang, Bolong — The Hong Kong Polytechnic University

The creations of photons in response to mechanical stimulus in a crystal that has noncentral symmetry are the great fundamental physics responsible for numbers of important technologies. The underlying mechanism and complete theory for a precise

explanation of the mechanical-photonic energy conversion phenomena are vitally important. We take commercial piezoelectric LiNbO3 matrics as the example to interpret the detail mechanisms of energy conversions for the photon-generation through a native point defects study. It was found the Frenkel and Schottky type complex pairs as well as the antisite pair defects acting as energy harvesting and migration centers, which are very easy to form and active. It does to be the extra deep electron or hole traps levels near the valence or conduction band edge, respectively. That is the substantial energy reduction via a spontaneous equilibrium transformation from the complementarily charged individuals into agglomerated complexes. Such energy gain for both two processes turns to be independent of the variations of synthesis chemical potentials. In addition, the complex defects actually form independent to the variations of the chemical potentials. This leads to a coupling and exchange effect by them to continuously collect and transport host charges along the path via localized states to the deep recombination levels. The initiating energy barrier is small which ambient thermal stimulation or quantum tunneling can accomplish. The native sensitizers such as VNb2O5, VLiNbO3, NbLi are also the energy conversion centers to non-radiative resonant energy transfer onto the activator center at the Oi to transfer the energy into photon emissions. A generalized energy conversion mechanism has been unraveled in this work. This gives a solid theoretical reference for developing the mechanical-photonic energy conversion materials.

16:45-17:00 ThOBO2.2

Triboelectric Nanogenerators for Self-Powered Motion Detection (I), pp. 379-379

Yi, Fang Sun Yat-Sen University

Motion detection has a myriad of applications in areas such as sports, medical care and entertainment. Under the current technological background, a majority of sensors need to be driven by external power sources and cannot work independently and sustainably, which has become one of the main factors restricting the development of sensors. One way to effectively address such challenge is to develop self-powered sensors. Triboelectric nanogenerators (TENGs) are mechanical energy harvesters that were first proposed in 2012. They can harvest mechanical energy from human body and also work as self-powered sensors to detect body motion. The self-powered motion sensors do not need any energy-supply components like battery; therefore, they can work continuously and are free from the trouble of replacement of batteries. Here, our recent studies on the TENGs as self-powered motion sensors and their potential applications will be presented. The unique working mechanisms, device structures, challenges, and prospects will also be discussed.

17:00-17:15 ThOBO2.3

Biomimetic Nanocomposites for Bio-Integrated Electronics (I), pp. 380-380

Xu, Lizhi The University of Hong Kong

Developing advanced technologies for healthcare and human-machine interfaces requires multifunctional tools that can naturally integrate with the human body. The existing systems, as exemplified by a variety of medical electronics and interventional tools, provide critical capabilities for physiological investigation and therapies. However, their rigid, static and bulky formats limit their possibility of naturally interfacing with the biological tissues that are soft, dynamic and three-dimensional. This presentation will focus on our efforts on using bio-inspired nanomaterials for building soft microsystems that can naturally interface with biological tissues. We use self-organized nanofibers to construct porous composites that resemble load-bearing soft tissues. Multiscale fabrication techniques generate reconfigurable 3D structures, allowing for integration of advanced electronic components and biomaterials into organ-compliant forms. As exemplified by artificial cartilage, kirigami optics, and cardiac electronic membranes, our efforts span across a continuous spectrum of materials science and device engineering. The integrative approaches seek to enable fully functional systems for implantable biomedical tools, tissue engineering platforms, wearable electronics, and many other applications.

17:15-17:30 ThOBO2.4

Fabrication of Stable Perovskite Nanowires and Quantum-Confined Perovskite Nanowire with High Photoluminescence Quantum Yield (I), pp. 381-381

FAN, Zhiyong Hong Kong University of Science and Technology, Hong Kong

Metal halide perovskite materials are emerging as highly promising materials for high performance optoelectronic devices thus triggered broad attention. Due to incompatibility of metal halide perovskite materials with conventional lithography techniques, it is preferable to achieve nano-perovskite material growth and assembly at the same time for further device applications. In our work, we have developed a chemical vapor deposition (CVD) process to grow ordered three-dimensional (3-D) metal halide nanowire (NW) arrays in nanoengineering templates with materials including MAPbI3, MASnI3, CsPbI3 and FAPbI3. This unique CVD process utilizes metal nanoclusters at the bottom of vertical nanochannels to initiate high quality NW growth. The 3-D NW arrays are conspicuously promising for 3-D integrated nano-electronics/optoelectronics. To further demonstrate the technological potency of the perovskite NW arrays, they have been fabricated into photodetectors and proof-of-concept image sensors. In addition, we have also discovered that the chemically and mechanically robust template can effectively protect perovskite NWs from water and oxygen invasion thus the material stability is significantly better than planar perovskite films confirmed by photoluminescence and photoelectric measurements. Meanwhile, template guided vapor phase growth method enables unprecedented control of NW diameter from the bulk (250 nm) to the quantum-confined regime (5.7 nm). Due to surface passivation, a low surface recombination velocity of 18 cm/s was measured. More importantly, there is a 56-fold increase in the internal PLQY, from 0.81 % to 45.1 %, and a 2.3-fold increase in light out-coupling efficiency to increase the external PLQY by a factor of 130, from 0.33 % up to 42.6 % in the fabricated perovskite quantum wire array.

17:30-17:45 ThOBO2.5

Direct Imaging of Electron Transfer and Its Influence on Superconducting Pairing at FeSe/SrTiO3 Interface (I), pp. 382-382

Zhao, Weiwei Harbin Insititute of Technology, Shenzhen

The exact mechanism responsible for the significant enhancement of the superconducting transition temperature (Tc) of monolayer iron selenide (FeSe) films on SrTiO3 (STO) over that of bulk FeSe is an open issue. We present the results of a coordinated study of electrical transport, low temperature electron energy-loss spectroscopy (EELS), and high-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM) measurements on FeSe/STO films of different thicknesses. HAADF-STEM imaging together with EELS mapping across the FeSe/STO interface shows direct evidence of electrons transferred from STO to the FeSe layer. The transferred electrons were found to accumulate within the first two atomic layers of the FeSe films near the STO substrate. An additional Se layer is also resolved to reside between the FeSe film and the TiOx-terminated STO substrate. Our transport results found that a positive backgate applied from STO is particularly effective in enhancing Tc of the films while minimally changing the carrier density. This increase in Tc is due to the positive backgate that “pulls” the transferred electrons in FeSe films closer to the interface and thus enhances their coupling to interfacial phonons and also the electron-electron interaction within FeSe films.

17:45-18:00 ThOBO2.6

The Breakdown Limitations and Maximized Output of Triboelectric Nanogenerators Toward Blue Energy (I), pp. 383-383

Zi, Yunlong The Chinese University of Hong Kong

Recent progress in triboelectric nanogenerators (TENGs) has demonstrated their promising potential as a high-efficiency mechanical energy harvesting technology, for example for blue energy, and plenty of effort has been devoted to improving the power output by maximizing the triboelectric surface charge

density. However, due to high-voltage breakdown, most of the enhanced surface charge density brought by material or surface optimization or external ion injection is not retainable or usable for electricity generation during the operation. Here, the existence of the air breakdown effect in TENGs is validated, and then followed by the theoretical study of the maximized effective energy output as limited by breakdown for different TENGs. The experimental demonstration of the breakdown is achieved, and the standardized characterization method is developed. This research provides a crucial fundamental study for TENG technology and its further development and applications.

ThOBO3 Room 7205

Invited Session: Nano-Acoustics (Invited Session)

Chair: Jokerst, Jesse — University of California San Diego

Co-Chair: Bao, Jiming — University of Houston

16:30-16:45 ThOBO3.1

Photoacoustic Imaging with Nanoparticle Contrast Agents for Real-Time Disease Monitoring (I), pp. 384-385

Jokerst, Jesse — University of California San Diego

Photoacoustic imaging is an ultrasound-based imaging technique that combines the high contrast and spectral nature of optics with the good temporal and spatial resolution of ultrasound. This technique is “light in/sound out” as opposed to traditional “sound in/sound out” ultrasound. Although endogenous absorbers are useful for photoacoustics, nanomaterials are often used to increase the signal of the target tissue or protein. In this presentation, I will describe four case studies that harness the power of nanotechnology and photoacoustics to improve healthcare.

16:45-17:00 ThOBO3.2

Enhanced in Situ Liver Cancer Photoacoustic Imaging and Photothermal Therapy in Mice with Red Blood Cell Membranes Camouflaged Gold Nanostars (I), pp. 386-386

Huang, Xiazi — Hong Kong Polytechnic University

Lai, Puxiang — Hong Kong Polytechnic University

Photoacoustic imaging (PAI) is a noninvasive method that is able to reveal high optical contrast for relatively thick soft tissue by combining nonionizing optical radiation with ultrasonic detection. Photothermal therapy (PTT) has gained much attention in recent years due to its regional tumor ablation and minimal damage to nearby normal tissues. As a naturally bio-membrane, red blood cell (RBC) membrane is a promising material for in vivo cancer imaging due to a host of advantages, such as immune escape ability and prolonged blood circulation. When RBC membrane encounters gold nanostars (AuNSs) that exhibit specific intrinsic optical properties, immune-evasive RBC membrane-coated GNSs (RBCm-AuNSs) are formed. Having favorable optical absorption in the NIR region, RBCm-AuNSs potentially can serve as long-lived biocompatible molecular photoacoustic probes and anti-tumor PTT media in vivo, as demonstrated in this paper. Potential applications and further improvement are also discussed.

17:00-17:15 ThOBO3.3

Laser Streaming: The Product of a Perfect Marriage of Photoacoustics and Acoustic Streaming (I), pp. 387-387

Bao, Jiming — University of Houston

This talk will introduce the principle and applications of photoacoustic laser streaming.

17:15-17:30 ThOBO3.4

Ultrasound-Enhanced Delivery of Doxorubicin-Loaded Nanodiamonds from Pullulan-All-Trans-Retinal Nanoparticles for Effective Cancer Therapy (I), pp. 388-389

Li, Huanan — Chongqing Medical University

Although nanodiamonds as drug platform are of great significance in improving cancer therapy for overcoming chemoresistance, their clinical application is severely limited by insufficient tumor vascular penetration. To overcome this limitation, pullulan-all-trans-Retinal (pullulan-ATR) self-assembled nanoparticles are proposed, for the first time, to serve as nanocarriers and construct a core-shell structure of doxorubicin and nanodiamonds (DOX-NDs) co-loading nanosystem. The obtained novel composite nanoparticles show homogeneous size distribution with high dispersity and pH-sensitive behaviour. Ultrasound is further employed to promote the intratumoral penetration of nanoparticles. As resulted, the intracellular retention of DOX through nanodiamonds was efficiently enhanced, and the distribution of DOX in the tumor tissue reached as high as 17.3% of injected dose, significantly improving the anti-tumor effect in both the DOX-sensitive HepG2 and DOX-resistant HepG2/ADR tumor models in vivo. This new strategy might serve as a powerful method for addressing limitations of nanodiamonds and provide a new idea on the development of nanoparticles for clinically effective cancer therapy.

17:30-17:45 ThOBO3.5

A Highly Sensitive Compact Liquid Sensor Based on a Circumferential Mode, pp. 390-390

lin, qin — Shenzhen Institutes of Advanced Technology Chinese Academy of Sc

cai, feiyan — Shenzhen Institutes of Advanced Technology Chinese Academy of Sc

zheng, hairong — Shenzhen Institutes of Advanced Technology Chinese Academy of Sc

Acoustic wave devices are attractive for use in sensors because the wave characteristics are sensitive to outside parameters. The ability of confining an acoustic wave in an ultra-small region can strengthen the wave-matter interaction, which results in the improvement of sensing sensitivity and reducing the amount of the sample to be measured. Here, we report a liquid sensor based on a circumferential mode in a cylindrical shell, this sensor exhibits a high sensitivity and requires a minimal amount of liquid due to the field localized at the surface of the shell. As schematically shown in Fig. (a), the system consists of a glass cylindrical shell (white) whose inner and outer radius are 120μm and 150μm, respectively. The liquid to be sensed fills the cylindrical shell (green), while the ambient liquid surrounds the cylindrical shell (blue). The normal transmission spectrum and field distribution of this system are calculated by using the COMSOL Multiphysics software. As shown in Fig. (c), there is a transmission dip at frequency of 2.238MHz. The pressure field around the cylindrical shell at the resonance frequency is illustrated in Fig. (b), which is confined at the surface of the shell and can be demonstrated that is the 3-rd of circumferential mode. To show the sensing capabilities of the cylindrical shell system, the transmission dip versus the molar ratios of NaI-water mixtures filled in the cylindrical shell are shown in Fig. (d), which showed to be dependent on the properties of NaI-water mixtures. Thus, the cylindrical shell based circumferential mode can be served as a compact and sensitive liquid sensor.

17:45-18:00 ThOBO3.6

Miniaturized Ultrasonic Transducer for Intervention Guidance and Diagnostic Imaging, pp. 391-392

Qiu, Weibao — Shenzhen Institutes of Advanced Technology, Chinese Academy of S

Miniaturized ultrasonic transducers (<1 mm) have shown significant application for intervention guidance and diagnostic imaging in many minimally invasive procedures, such as endoscopic imaging. In this work, three kind of novel miniaturized transducers have been designed and fabricated successfully using new piezo-material and new structure strategies, and showed good performance, which could improve the imaging quality and simplify the minimally invasive procedures.

ThOBO4 Room 7304

Nano-Bio-Imaging (Oral Session)

Chair: Yu, Haibo — Chinese Academy of Sciences

Co-Chair: Yang, Fang — Southeast University

16:30-16:45 ThOBO4.1

Nanoparticle Assisted Ultrasound Imaging and Therapy, pp. 393-397

Ng, Shok-Li — Academia Sinica

Chen, Nelson — National Chiao Tung University

Chan, Yung-Chieh — Academia Sinica

Lai, Tsung-Ching — Academia Sinica

Kosheleva, Olga — Academia Sinica

Hsiao, Michael — Academia Sinica

Chen, Chung-Hsuan — Academia Sinica

A novel idea in using nanoparticle to assist ultrasound for imaging and therapy was pursued. With this approach, both imaging and therapy can be achieved simultaneously. The imaging for tumor was improved and the therapy can have better efficiency in killing cancer cells more than normal cells. Since ultrasound can penetrate deep into human body, it can be used to treat most human cancers.

16:45-17:00 ThOBO4.2

Bio-Enzyme Sensitive Drug Delivery Nanoliposomes for Tumor Cells Destruction, pp. 398-399

Liu, Yang — Southeast University

Gu, Ning — Southeast University

Yang, Fang — Southeast University

This paper aims to develop a bio-enzyme sensitive liposomal system, which are capable of responding tumor microenvironment stimulates to disrupt tumor cell structure. Through nanoliposome drug delivery into the intracellular, the drug can be catalyzed by enzyme. In this study, it was observed that when the fabricated nanoliposomes was incubated with the HepG2 cells, a time-dependent bubbles in the tumor cells was produced to destruct the cell.

17:00-17:15 ThOBO4.3

Tamper Evidence of SEM Imaging Attack in Phase Change Memory Nanodevices, pp. 400-404

Noor, Nafisa — University of Connecticut

Khan, Raihan — University of Connecticut

Muneer, Sadid — University of Connecticut

Silva, Helena — University of Connecticut

Breach of security due to unauthorized access to electronic hardware devices or chips has recently become a serious concern for the internet-connected daily activities. Imaging with electron microscopy is one of the invasive techniques used to gain knowledge about a chip layout and extract secret information by the attackers. Automatic destruction or disturbance of the secret key during such invasive attacks are required to ensure protection against these attacks. We have characterized the disturbance caused to programmed phase change memory (PCM) cells by the imaging electron beam during scanning electron microscopy (SEM) in terms of the measured cell resistance. A sudden increase of resistance is observed on all imaged amorphous cells while the cells programmed to intermediate states show either abrupt increase or erratic decrease. These erratic disturbances of state are promising to mislead an attacker that is trying to acquire a stored key and leave indelible marks of tampering. Since PCM is recently being considered for implementation of various hardware security primitives, these beam-induced state change and tamper-evidence features enhance security of PCM devices against physical attacks.

17:15-17:30 ThOBO4.4

Direct Transfer of Dielectric Nanoparticles Assembled Superlens Array for Super-Resolution Imaging, pp. 405-409

Li, pan — State Key Laboratory of Robotics, Shenyang Institute of Automati

Yu, Haibo — Chinese Academy of Sciences

wen, yangdong — Shenyang Institute of Automation

Zhao, Wenxiu — Shenyang Institute of Automation, Chinese Academy of Sciences

Liu, Lianqing — Shenyang Institute of Automation, Chinese Academy of Sciences

Li, Wen Jung — City University of Hong Kong

Dielectric microsphere-based super-resolution imaging tech-nique has been extensively studied in the past decades. Eva-nescent wave plays a great role in transferring the near-field high frequency information of sample into far-field propaga-tion wave. Modulating the area and location of illuminated evanescent wave will further improve the resolution of mi-crosphere-based super-resolution microscopy. Here we pro-posed a direct transfer method to fabricate high-refractive-indexed dielectric nanoparticles assembled superlens array for super-resolution imaging. Characteriza-tion of the surface morphology of fabricated superlens show great smoothness. Super-resolution imaging of sub-diffraction-limited samples has been demonstrated. The near-field evanescent wave frequency-shift effect has been analyzed.

17:30-17:45 ThOBO4.5

Preparation of Novel Nanobubbles Based on Platelet Membrane, pp. 410-411

Li, Mingxi — Southeast University

Gu, Ning — Southeast University

Yang, Fang — Southeast University

This paper aims to prepare a novel nanobubble based on platelet membrane with good biocompatibility, which has potential for ultrasonic imaging diagnosis of thrombotic diseases. The nanobubbles were formed by cell membrane phospholipids and free bubbles through self-assembly, forming cell membranes shelled nanobubbles. It remained the natural properties of platelets and good structure stability. Due to the biomimetic shell property, these nanobubbles are expected to provide new strategies for long-term, real-time ultrasound imaging enhancement.

17:45-18:00 ThOBO4.6

Electrosynthesis of Janus Alginate Hydrogel Microcapsules with Programmable Shapes for Cell Encapsulation, pp. 412-416

Nan, Haochen — South University of Scinence and Technology

Liu, Zeyang — Nagoya University

Hu, Chengzhi — Southern University of Science and Technology

Hydrogel microcapsules provide well-defined and biocompatible platforms for 3D cell culture, which is greatly desired for replacing, or enhancing the function of damaged human tissue and in vitro tissue regeneration. Since Alginate-poly-L-lysine alginate microcapsules can provide a liquified environment for biomaterials, traditional fabrication methods such as microfluidic gelation can tune the size and biochemical properties of hydrogel microcapsule, but still, undergo tremendous challenges while tuning the morphology of the hydrogel microcapsules. In this work, we proposed a novel approach to fabricate Janus Alginate-Poly-L-lysine Alginate microcapsule with controllable shape and size based on a two-step hydrogel electrodeposition method. The microelectrode device (fluorine-doped tin oxide (FTO) glass) was etched into two insulating parts by laser processing. After the first step, the electrodeposition solution was

removed by adding HEPES solution. During secondary electrodeposition, a higher voltage was employed, since the entrapped hydrogel and unremoved HEPES solution remains upon the surface of the fluorine-doped tin oxide (FTO) glass. After the two-step deposition, the 2D hydrogel Janus structures were detached from the FTO glass. Then they were immersed in Poly-L-lysine solution. Then the 3D Alginate-poly-L-lysine alginate (APA) microcapsules were successfully fabricated and incubated for further observation. We have demonstrated a successful encapsulation of HepG-2 cells in the half of the APA hydrogel microcapsule and the cells are cultured for several days and Janus APA microcapsules are embedded with fluorescence-labelled and non-labelled HepG2 cells to monitor the cell morphology, distribution, as well as their proliferation.

ThOBO5 Room 7305

Nanoscale Metrology and Characterization (Oral Session)

Chair: Ganeshkumar, Rajasekaran	Exponent Ltd
Co-Chair: Vasyukov, Denis	METAS

16:30-16:45 ThOBO5.1

Resistance Drift and Crystallization in Suspended and On-Oxide Phase Change Memory Line Cells, pp. 417-420

Gorbenko, Anna	University of Connecticut
Noor, Nafisa	University of Connecticut
Muneer, Sadid	University of Connecticut
Khan, Raihan	University of Connecticut
Dirisaglik, Faruk	Eskisehir Osmangazi University
Cywar, Adam	Analog Devices
Shakya, Bicky	University of Florida
Forte, Domenic	University of Florida
Dijk, Marten van	University of Connecticut
Gokirmak, Ali	University of Connecticut
Silva, Helena	University of Connecticut

Resistance drift and crystallization are critical concerns for accurate distinction between different states and for data retention in phase change memory (PCM), but their underlying physical mechanisms are still not fully understood. In this work, we compared the resistance drift and crystallization of suspended and on-oxide amorphous Ge2Sb2Te5 PCM line cells. We programmed 15 cells of each type at room temperature to a resistance level of ~10 MΩ and monitored their resistance over ~3 months. The initial upward resistance drift trends were very similar for both cell types, but the later behaviour was noticeably different. The suspended cells exhibited increased variability in the upward drift after ~103 s, and at ~35-80 days some cells experienced an abrupt crystallization, some showed a saturation in the upward resistance drift, and others continued the upward resistance drift with fluctuations, possibly due to the imminent saturation. The on-oxide cells, on the other hand, demonstrated very consistent upward resistance drift during the entire measurement period. Temperature-accelerated measurements at 400 K on both type of cells also showed the early and abrupt data loss in suspended cells. The abrupt crystallization in suspended PCM cells can potentially be useful for self-destructive hardware security primitives based on the loss of the stored data after a certain time.

16:45-17:00 ThOBO5.2

Factors Influencing Ferroelectric Switching Behavior in Perovskite Nanofibers, pp. 421-424

Ganeshkumar, Rajasekaran	Exponent Ltd
Zhao, Rong	Singapore University of Technology and Design

Given the complexity in probing ferroelectricity on the nanoscale, piezo force microscopy observations have often become defacto proof of ferroelectric behavior, without considering the factors influencing the signal origination. In this work, limitations in using existing ferroelectric characterization for nanofibers are discussed. Decreasing piezo-response and shrinking hysteresis loops with increasing relative humidity were observed which could be attributed to tip-surface mechanics influenced by the testing environment.

17:00-17:15 ThOBO5.3

Concentration Dynamic Probe of Micro/Nano Aluminum Powder, pp. 425-428

Fu, ShengHua	Beijing Institute of Technology School of Mechatronical Engineer

The appropriate concentration of Micro/Nano aluminum powder cloud is a precondition of the FAE (fuel air explosive) detonation. In this paper, a pair of ultrasonic transducers was developed to measure Micro/Nano aluminum powder cloud concentration distribution during the disperse of dust in the standard 20L explosion vessel. The high gradients of aluminum powder concentration are established and the experimental results show that Nano aluminum powder particles have better cloud concentration distribution characteristics than micron aluminum powder, which provides experimental data support to improving FAE detonation energy.

17:15-17:30 ThOBO5.4

Fabrication and Measurements of Inductive Devices for Scanning Microwave Microscopy, pp. 429-432

le quang, toai	Federal Institute of Metrology
Vasyukov, Denis	METAS
Hoffmann, Johannes	Federal Institute of Metrology
Buchter, Arne	METAS
Zeier, Markus	Federal Institute of Metrology METAS

This article presents our results in fabrication and measurement of inductive devices for scanning microwave microscopy (SMM). Devices with resistance and inductance varying between 9-220 Ohm and up to 200 pH were produced on SiN membrane using using clean room processes. By combining SMM measurements performed for these devices and their simulation, we were able to test a calibration method which employs three known standards.

17:30-17:45 ThOBO5.5

Reliable and Accurate MEMS-Based Thermal Conductivity Characterization Device for Individual Nanowires, pp. 433-436

Cui, Yan	Chinese Academy of Sciences
Yang, Yang	Shanghai Institute of Microsystem and Information Technology, Ch
LI, TIE	The Chinese Academy of Sciences
Wang, Yuelin	Chinese Academy of Sciences

Precision measurement of thermal conductivity at nanoscale can facilitate the study of the pursuing thermoelectric conversion efficiency. In this work, a new reliable and accurate MEMS-based device for thermal conductivity measurement of individual nanowires was developed. Overcoming the difficulties in measuring small temperature rise at nanoscale, the measurement error of temperature rise for nanomaterials was less than 0.1360%. Besides, the effect of substrate conduction, air heat conduction and radiation heat loss on testing of thermal conductivity was basically ruled out. The thermal conductivity of VO2 (M) single crystal nanowire with diameter of 294 nm was measured to verify the reliability and accuracy of the device.

17:45-18:00 ThOBO5.6

Implanted Neural Microelectrode Array for In-Situ Extracellular Action Potential and Local Field Potential Detection in Hippocampus of Simulated Microgravity Rats, pp. 437-438

Wang, Hao	State Key Laboratory of Transducer Technology, Institute of Elec
Liu, Juntao	Institute of Electronics Chinese Academy of Sciences,
Lu, Zeying	State Key Laboratory of

	Transducer Technology, Institute of Elec
Xu, Shengwei	Institute of Electronics Chinese Academy of Sciences,
Wang, Yun	State Key Laboratory of Transducer Technology, Institute of Elec
Xie, jingyu	The State Key Laboratory of Transducer Technology, Institute Of
Song, Yilin	The State Key Laboratory of Transducer Technology, Institute Of
Wang, Mixia	The State Key Laboratory of Transducer Technology, Institute Of
Gao, Fei	State Key Laboratory of Transducer Technology, Institute of Elec
Qu, Lina	State Key Laboratory of Space Medicine Fundamentals and Applicat
Cai, Xinxia	Institute of Electronics, Chinese Academy of Sciences,

It has been well demonstrated that microgravity may lead to impairments in brain functions. However, what exactly the influence of microgravity on nerve cells has not been well understood. To this aim, we fabricated a microelectrode array (MEA) designed for in vivo multichannel electro- physiological recordings. In addition, we used the 28 days of tail-suspension methods to stimulate microgravity environment. We advanced MEA to both model rats and normal rats to record electrophysiological signals in hippocampus. After a series of experiments, we found that the neural activities in hippocampus were inhabited after 28 days of simulated microgravity.

Friday, July 26th, 2019

Friday July 26, 2019

FrPLPL Room 7201

Plenary Session III (Plenary Session)

Chair: Wang, Han USC

Co-Chair: Xie, Hui Harbin Institute of Technology

09:00-09:40 FrPLPL.1

*DNA As an Engineering Material to Bridge between MEMS and Nanotechnology (I)**

Tabata, Osamu Kyoto University

FrKNKN Room 7201

Keynote Session III (Plenary Session)

Chair: Wu, Wei University of Southern California

Co-Chair: Trivedi, Amit University of Illinois at Chicago

09:40-10:10 FrKNKN.1

*Fundamental Properties and Device Prospect of Emerging Low-Dimensional Materials (I)**

Wang, Han USC

FrPIIT Room 7201

Invited Talks I: NanoManufacturing (Invited Session)

Chair: Dong-Kyun, Ko New Jersey Institute of Technology

Co-Chair: Wang, Wenxue Shenyang Institute of Automation, Chinese Academy of Sciences

10:10-10:25 FrPIIT.1

Plasmonic Structures and Applications Fabricated Using Collapsible Nano-Fingers (I), pp. 439-440

Wu, Wei University of Southern California

We invented a technology to fabricate gap plasmon structures with atomic precision over large area based on collapsible nano-fingers. This technology enabled us to achieve the followings 1) probing the quantum tunneling effects in gap plasmon, 2) single-molecule sensing using surface enhanced Raman spectroscopy, 3) investigation of plasmonic enhancement of molecular fluorescence, and 4) high-efficiency plasmon-enhanced photo-catalysis.

10:25-10:40 FrPIIT.2

*3D Printing Ultrasound Transducers Using Nanoparticle Ceramic Power for Medical Ultrasonic Imaging and Energy Harvesting Applications (I)**

Zhou, Qifa University of Southern Ca

Piezoelectric ceramics are currently of considerable interest for their capabilities of converting compressive/tensile stresses to an electric charge, or vice versa. However, limited by traditional manufacturing methods, the ceramics is usually designed in simple geometry such as a cube or rectangle, restricting its potential applications. Additive manufacturing (AM) processes, especially stereolithography (SLA) open an effective pathway in geometrical flexibility. However, the piezoelectric properties limit the application of printed ceramics. This work demonstrates that a piezoelectric-composite slurry with BaTiO3 nanoparticles (100 nm) can be 3D printed using Mask-Image-Projection-based Stereolithography (MIP-SL) technology. After a post-process, the density of 5.64 g/cm3 was obtained, which corresponds to 93.7% of the density of bulk BaTiO3 (6.02 g/cm3). The printed ceramic exhibits a piezoelectric constant and relative permittivity of 160 pCN−1 and 1350 respectively. An ultrasonic transducer and an annular array were fabricated using novel 3D printing method, the results show promising potential in medical imaging and energy harvesting for medical stimulation on the retinal applications.

10:40-10:55 FrPIIT.3

*Bioinspired Peptide Assemblies with Tunable Optical Properties and Their Biomedical Applications (I)**

Fan, Zhen Tongji University

Due to intrinsic limitations of low biocompatibility and challenging modulation, the utilization of conventional inorganic quantum confined photoluminescent materials in bio-imaging and bio-machine interface faces critical restrictions. Meanwhile, peptide nanostructures are biodegradable and are suitable for many biomedical applications. However, to be useful imaging probes, the limited intrinsic optical properties of peptides must be overcome.

This speech present peptides serve as building blocks to further self-assemble into quantum confined supramolecular structures with diverse morphologies and photoluminescence properties. Especially, the emission can be tuned from the visible to the near-infrared region (420 nm to 820 nm) by modulating the amino acid sequence and self-assembly process, which allows the peptide assemblies to act as imaging and sensing probes. No obvious cytotoxic effect is observed for these peptide assemblies, and their utilizations for in vivo imaging and as phosphors for light-emitting diodes is demonstrated. In addition, after modification with cancer targeting peptide moieties, fluorescent peptide assemblies could combine the targeted imaging and drug delivering for cancer theranostics. Moreover, the drug delivery to tumor sites and therapeutic responses could be monitored with near-infrared fluorescence from peptide assemblies, which may lead to novel potential approaches for bioorganic fluorescence based delivering, imaging and drug release tracking. In summary, the morphologies and optical properties of the peptide assemblies can be tuned, making them potential candidates for supramolecular quantum confined materials providing biocompatible alternatives for broad biomedical and optoelectric applications.

FrOIIT Room 7201

Invited Talks II: NanoElectronics (Invited Session)

Chair: Xie, Hui Harbin Institute of Technology

Co-Chair: Dong-Kyun, Ko New Jersey Institute of Technology

11:15-11:30 FrOIIT.1

Silver Nanoflower Based High Sensitivity Adenine Sensors by SERS, pp. 441-442

Tzeng, Yonhua National Cheng Kung University

Silver nanoflowers on Cu thin films exhibit excellent enhancement factors in measured Raman scattering signals from low concentrations of adenine molecules excited by a green solid state laser and detected by an optical spectrometer. Effects of Cu surface modification by brief exposure to graphene CVD conditions on the structures and number density of silver nanoflowers and the adenine SERS enhancement factors will be discussed.

11:30-11:45 FrOIIT.2

Mixed-Mode Magnetic Tunnel Junction-Based Deep Belief Network (I), pp. 443-448

Nasrin, Shamma University of Illinois at Chicago

Drobitch, Justine Virginia Commonwealth University

Bandyopadhyay, Supriyo Virginia Commonwealth University

Trivedi, Amit University of Illinois at Chicago

We present a mixed-mode magneto tunneling junction (m-MTJ)-based Deep Belief Network(DBN). DBNs are unsupervised learning models, suitable for recognition and clustering. m-MTJ is a three-terminal magnetic device with probabilistic free layer switching controlled by the simultaneous

actions of voltage-controlled magnetic anisotropy and spin-transfer torque. While DBNs achieve high prediction accuracy even with highly imprecise single-bit weights, the key complexity lies in their activation functions which are stochastic. Using an m-MTJ, we present a novel low area/power DBN neuron with stochastic activation function. We discuss an in-memory computing architecture that allows forward and backward flow of learning dynamics and online learning. Our design achieves 88.80% accuracy for digit recognition in MNIST even under the worst case variability in nanoscaled m-MTJs.

11:45-12:00 FrOIIT.3

Nanocrystal Based Electronic Devices and Sensors (I), pp. 449-449

Oh, Soong Ju Korea University

Colloidal nanocrystals have been shown to be promising materials for device applications because of their unique size-dependent properties and solution processability. We present general methods to engineer the electronic, optoelectronic, electromechanical, and electrothermal properties of nanocrystals through their surface and interface engineering. Unconventional materials design and strategy are introduced to fabricate semiconducting devices and wearable sensors. Especially, surface design of nanocrystals are discussed in order to highly sensitive wearable strain gauges, temperature sensors, and tactile sensors with wide sensing range. Interface engineering of nanocrystal thin films are introduced for solution-based fabrication of multifunctional sensors with high pixel density. This technique provides a pathway for designing low cost, high performance, and multifunctional electronic skins or wearable devices.

12:00-12:15 FrOIIT.4

Progress and Perspectives of Carbon Nanotubes Electronics (I), pp. 450-451

Tang, Jianshi Tsinghua University

The superior electrical and mechanic properties of carbon nanotube (CNT) make it an excellent candidate for high-speed scaled logic technology and also flexible electronics. Tremendous progress has been made in both fields in the past few years, from material to device and integration. Here I will review recent advances of high-performance carbon nanotube electronics, highlight the major technical challenges, and then give a perspective for future research directions.

12:15-12:30 FrOIIT.5

*Bio-Syncretic Robotics Based on the Integration of Living Materials and Electromechanical Systems (I)**

Wang, Wenxue Shenyang Institute of Automation, Chinese Academy of Sciences

Advances of science and technology enables the human-robot interaction closer and closer. In this talk, we propose that one of the development trends in robotics is the physical and information integration of living systems and electromechanical systems at the levels of cells and tissues, which leads to bio-syncretic robots. Then we review the current research status of bio-syncretic robotics, discuss the challenges in the research of bio-syncretic robotics, and then present some research achievements of our group in bio-syncretic robotics,such as bio-actuation and bio-imaging.

12:30-12:45 FrOIIT.6

*Fluoro-Graphene and MoS2 for Transistors and Memory Devices (I)**

Lai, Chao-Sung Department of Electronic Engineering, Chang Gung University

In this talk, the scalable and one-step fabrication of single atomic-layer transistor is demonstrated by the selective fluorination of graphene using a low-damage CF4 plasma treatment, where the generated F-radicals preferentially fluorinated the graphene at low temperature while defect formation was suppressed by screening out the effect of ion and UV damage. The fluorographe was also used as decoupling for graphene as its substrate and mobility was improved much. Graphene nanodiscs (GNDs), functionalized using NH3 plasma and MoS2, as charge trapping sites (CTSs) for non-volatile memory applications have been investigated.

FrOIIS Room 7204

Invited Session: Materials Innovation for Next-Generation Spintronics (Invited Session)

Chair: LIN, Xiaoyang Beihang University

Co-Chair: Liu, Kai Tsinghua University

11:15-11:30 FrOIIS.1

Electrical Switching of Antiferromagnet (I), pp. 452-452

Song, Cheng Tsinghua University

Antiferromagnets with zero net magnetic moment, strong anti-interference and ultrafast switching speed have potential competitiveness in high-density data storage. Electrical switching of antiferromagnets is at the heart of their device application [1,2]. The antidamping torque-induced switching of Néel order is attained in a biaxial antiferromagnetic insulator NiO, which is manifested electrically via spin Hall magnetoresistance in NiO (100)/Pt bilayers [3]. The antiferromagnetic moments are switched towards the current direction, different from the vertical configuration in the fieldlike torque scenario (e.g., CuMnAs and Mn2Au) [4-6]. On the other hand, electric field is used to switch the magnetic moment of Mn2Au films grown on piezoelectric Pb(Mg1/3Nb2/3)0.7Ti0.3O3 (PMN-PT) (011) substrates. When the electric field is swept, the easy axis of Mn2Au is switched between [100] and [0-11] directions of PMN-PT (011) at room temperature, exhibiting a butterfly-like switching feature. This feature indicates that the underlying mechanism is the electric field-induced ferroelastic strain. Such a transition of the easy axis leads to the change of threshold current for the field-like torque switching of Mn2Au [7]. Electrical switching of antiferromagnetic moments pave the way for all-electrical writing and readout in antiferromagnetic spintronics.

11:30-11:45 FrOIIS.2

Electric-Field Control of Magnetism in Multiferroic Heterostructures (I), pp. 453-453

Zhao, Yonggang Tsinghua University

Antiferromagnets with zero net magnetic moment, strong anti-interference and ultrafast switching speed have potential competitiveness in high-density data storage. Electrical switching of antiferromagnets is at the heart of their device application [1,2]. The antidamping torque-induced switching of Néel order is attained in a biaxial antiferromagnetic insulator NiO, which is manifested electrically via spin Hall magnetoresistance in NiO (100)/Pt bilayers [3]. The antiferromagnetic moments are switched towards the current direction, different from the vertical configuration in the fieldlike torque scenario (e.g., CuMnAs and Mn2Au) [4-6]. On the other hand, electric field is used to switch the magnetic moment of Mn2Au films grown on piezoelectric Pb(Mg1/3Nb2/3)0.7Ti0.3O3 (PMN-PT) (011) substrates. When the electric field is swept, the easy axis of Mn2Au is switched between [100] and [0-11] directions of PMN-PT (011) at room temperature, exhibiting a butterfly-like switching feature. This feature indicates that the underlying mechanism is the electric field-induced ferroelastic strain. Such a transition of the easy axis leads to the change of threshold current for the field-like torque switching of Mn2Au [7]. Electrical switching of antiferromagnetic moments pave the way for all-electrical writing and readout in antiferromagnetic spintronics.

11:45-12:00 FrOIIS.3

Quest of High Efficiency Spintronic Terahertz Emitter with Tunable Property (I), pp. 454-454

NIE, Tianxiao Beihang University

Terahertz science and technology benefiting from the intrinsic unique property of the special frequency range (0.1-10 THz), have experienced an unprecedented rapid progress, especially under the fast development of ultrafast laser technology [1]. The terahertz technology has been envisaged as a powerful tool for

triggering novel fundamental researches and applications, such as non-destructive spectroscopy and ionization-free imaging, highly sensitive sensing and short-range wireless communication at terahertz bit rates, among others. However, hindering the development of this fascinating technology from laboratory researches to real applications lies in the lack of highly efficient terahertz sources. Recently developed spintronic terahertz emitter that are based on ferromagnetic metal (FM)/non-magnetic (NM) metal heterostructures driven by femtosecond laser pulses have turned out to be a very efficient and broadband terahertz sources [2,3]. In our work, we give a systematical investigation on optimizing the terahertz emission efficiency through tuning the laser parameters and FM/NM heterostructure configuration. Furthermore, we demonstrate broadband elliptical polarized terahertz wave generation in FM/NM heterostructure by the elaborate design of external magnetic field. Through tailoring the magnetic fields on purpose, we can efficiently control the ellipticity, chirality as well as the azimuthal angle in the emitted broadband frequency range. We believe that our demonstrated magnetic-field controlled broadband terahertz generation not only benefits for deeply understanding the ultrafast spin dynamics but also has values for the next-generation novel on-chip terahertz sources and devices.

12:00-12:15 FrOIIS.4

Magnetic Memory with Topological Insulators and Ferrimagnetic Insulators (I), pp. 455-455

Shao, Qiming UCLA

Ubiquitous smart devices and internet of things create tremendous data every day, shifting computing diagram towards data-driven. Computing and memory units in traditional computers are physically separated, which leads to huge energy cost and time delay. Novel computer architectures bring computing and memory units together for data-intensive applications. These memory units need to be fast, energy efficient, scalable and nonvolatile. We innovate new types of magnetic memory or spintronic devices to achieve ultrahigh energy efficiency and ultracompact size from a perspective of material and heterostructure design. Especially, we employ quantum materials and systems to enable potentially unprecedented technological advances. The highest energy efficiency of current-based magnetic memory requires the largest charge-to-spin conversion efficiency that allows the minimum power to manipulate the magnetization. We utilize topological surface states of topological insulators (TIs), which have unique spin-momentum locking and thus are highly spin-polarized. We discover giant spin-orbit torques (SOTs) from TIs at room temperature, which are more than one order of magnitude larger than those of traditional heavy metals. We integrate TIs into room temperature magnetic memories, which promises future ultralow power dissipation. To have the best scaling performance, we investigate emerging topological skyrmions in magnetic thin films, which are arguably the smallest spin texture in nature. While most of the skyrmions are discovered in metallic systems, insulating skyrmions are desired thanks to their lower damping and thus potentially lower power dissipation. We observe high-temperature electronic signatures of skyrmions in magnetic insulators, topological Hall effect, by engineering heterostructures consisting of heavy metals and magnetic insulators. This new platform may pave the way for exploring fundamental magnon-skyrmion physics and pursuing practical applications based on insulating skyrmions.

12:15-12:30 FrOIIS.5

Optical Control of Magnetism in Phase-Change Spintronic Heterostructures (I), pp. 456-456

LIN, Xiaoyang Beihang University

Optical methods for magnetism manipulation have been considered as a promising strategy for ultralow-power and ultrahigh-speed spin switches and have become an emergent field of spintronics [1,2]. However, a widely applicable and efficient strategy to combine optical operations with magnetic modulations is still highly desired. Here, the phase-change material VO2 is introduced to realize optical control of the magnetism in NiFe [3]. The NiFe/VO2 phase-change spintronic heterostructure features appreciable modulations in electrical conductivity, coercivity, and magnetic anisotropy via the metal-to-insulator transition (MIT) of VO2. Further analyses indicate that interfacial strain coupling plays a crucial role in this modulation. Utilizing this heterostructure, which can respond to both optical and magnetic stimuli, a phase-change controlled anisotropic magnetoresistance (AMR) device has been fabricated, and reconfigurable Boolean logic gates have been demonstrated.

The strategy also works for the phase-change control of perpendicular magnetic anisotropy (PMA). We further realize phase-change controlled PMA modulations in the VO2/(Co/Pt)2 heterostructure, where VO2 can induce an interfacial strain by its MIT [4]. A large reversible modulation of the PMA reaching 3×105 erg/cm3 is observed during this process. The calculated energy density variation of interfacial anisotropy reaches 0.85 erg/cm2, which shows significant advantage over traditional modulation strategies. Further experimental results including magnetization change versus temperature, strain buffered modulation and pre-strained sample comparison prove that the interfacial coupling between VO2 and PMA layers plays a crucial role in this modulation. Our work, demonstrating the great potential of phase-change materials in efficient magnetism modulation, would benefit the exploration of next-generation spintronic devices.

FrOAO1 Room 7201

Nanorobotics and Nanomanipulation I (Oral Session)

Chair: Yue, Tao Shanghai University

Co-Chair: Liu, Meng Chinese Academy of Sciences

14:00-14:15 FrOAO1.1

Detection of Peritoneal Metastasis Cancer Cells Based on Optically Induced Dielectrophoresis (ODEP) Microfluidic Chip, pp. 457-458

Zhang, Yuzhao Shenyang Institute of Automation, Chinese Academy of Sciences

Li, pan State Key Laboratory of Robotics, Shenyang Institute of Automati

Yu, Haibo Chinese Academy of Sciences

wen, yangdong Shenyang Institute of Automation

Liu, Lianqing Shenyang Institute of Automation, Chinese Academy of Sciences

Li, Wen Jung City University of Hong Kong

Gastric cancer is one of the cancers most likely to cause death in patients. Peritoneal metastasis is an important cause of death in patients with gastric cancer. Detection of peritoneal metastasis cancer cells plays a vital role in the treatment of gastric cancer patients. The conventional method is the detection of free cancer cells in the peritoneal cavity. However, the sensitivity of this method is low. Ascites contains a large number of mesothelial cells and a few gastric cancer cells. Here, we report a new way to detect peritoneal metastasis cancer cells. In this work, a light pattern, which can be referred as virtual electrodes, was illuminated on an ODEP (optically induced dielectrophoresis) chip. Cells are polarized in the illuminated area and can be manipulated by the dielectrophoresis (DEP) force generated in the ODEP chip. According to cell polarization model and experiments, gastric cancer cells can be quickly detected from mesothelial cells based on their different geometric and electrical characteristics, i.e., gastric cancer cells are manipulated by positive DEP force and mesothelial cells are controlled by negative DEP force in a microfluidic medium of the same liquid conductivity. In short, we have shown that ODEP could potentially be a label-free and rapid method to detect peritoneal metastasis cancer cells.

14:15-14:30 FrOAO1.2

Nanoscale Manipulation for the Fabrication of Field-Emission Air-Channel Transistors, pp. 459-462

Liu, Meng Chinese Academy of Sciences

Lei, Yu Chinese Academy of Sciences

LI, TIE The Chinese Academy of Sciences

Wang, Yuelin — Chinese Academy of Sciences

A method based on nanoscale manipulation of a single nanowire and focused ion beam etching is put forward for nanoscale field emission transistors with an air channel. The shape and size of the emitter is controllable with nanoscale precision. Material compatibility is achieved in SiC，VO2，Ge and Cu nanowires. Low voltage field-emission air-channel transistor characteristics are demonstrated with an obvious forward-directional capability.

14:30-14:45 — FrOAO1.3

Analysis and Evaluation of Micromanipulation Performance Based on Swirl, pp. 463-467

Qin, Zhang — South China University of Technology

Yang, Hao — South China University of Technology

Ou, Zhiming — South China University of Technology

In this paper, the quantitative evaluation method of micromanipulation performance based on swirl was proposed and the microfluidic dynamics model was established. The effects of various swirling flow field parameters on micromanipulation performance were analyzed by simulation. It was demonstrated that micromanipulation performance of swirling flow field was affected by swirl strength and the range of low velocity region near the stagnation point; the greater the swirl strength and the larger the low velocity region, the more easily the particles was trapped and manipulated. Matching the flow field parameters reasonably was beneficial to trap and manipulate particles stably.

14:45-15:00 — FrOAO1.4

Quantifying Nano-Scale Single Cell Mechanics for Clinical Applications, pp. 468-468

Yue, Tao — Shanghai University

While dynamics and mechanics at organ and tissue levels has been well-investigated, single cell dynamics and mechanics still lack of comprehensive understandings. Single cell mechanical properties could potentially offer unique and direct indicators of cell functions, and provide insights of cellular effects to organ and tissue levels, especially under drug treatments. This research was focused on quantifying anti-cancer drugs induced changes of mechanobiological properties on single cardiomyocytes, exploring direct evidences for revealing the therapeutic effectiveness of the drugs, contributing to optimize drug administration strategies for reducing cardiotoxicity.

This work utilized a Digital Holographic Microscope and an Atomic Force Microscope to characterize cell membrane stiffness (Young's modulus), surface beating amplitude/force and full width at half maximum, in response to doxorubicin and dexrazoxane exposures, in a time-dose-dependent manner. Primary mouse cardiomyocytes were isolated from mice and continuously monitored for about 2 hours. to gather data.

An acute increase and delayed decrease of contraction force induced by doxorubicin at single cell level, a was quantitatively characterized. Cardioprotective effects of dexrazoxane were revealed from the maintaining of beating force level and mechanical functions. Drug-combined effects were quantitatively evaluated in terms of different administration sequences. Pre-administration of dexrazoxane was demonstrated to have better cardioprotective effects against to doxorubicin, which contribute to the improvement of cardiotoxicity prevention and anticancer drug management strategies.

15:00-15:15 — FrOAO1.5

Stick-Slip Motion Style of Magnetic Field Actuated Microrobots, pp. 469-472

zheng, jianghong — FuZhou University

Zhan, Ziheng — Fuzhou University

Wei, Fanan — Fuzhou University

In this paper, we report a novel motion style of microrobots actuated by magnetic field. The instability introduced by the alternative magnetic field leads to the stick-slip pattern of microrobot movement. And, by combining two iron balls at microscale together, the dimer microrobots are fabricated and studied in the motion experiment. The dependencies of stick-slip motion speed on the frequency, waveform of actuation signal and the size of both monomer and dimer microrobots are systematically investigated to clarify the underlying mechanism of this motion style. Motion speed tends to increase as signal frequency increases first, and then decrease when the frequency goes high. Smaller size of microrobots can move faster. And waveform is demonstrated to have significant impact on the motion speed. Finally, we reveal that alternative magnetic field drive both monomer and dimer microrobots with size of hundreds of microns to move in a stick-slip style; and the motion speed can be tuned through the actuation signal frequency. Furthermore, through modulating the generated magnetic field, the motion direction is promised to be controlled as well.

15:15-15:30 — FrOAO1.6

Injection Lock Frequency Divider with Class-C Coupled VCO for Nanoelectronics Harmonic Demodulator of Fluxgate Sensing, pp. 473-476

Lai, Wen Cheng — National Penghu Univ. of Science and Technology, Taiwan

This article presents a multi-band divide-by-3 injection locked frequency divider (ILFD) and three output phases class-C voltage-controlled oscillator (VCO) to generate signal by current reused and it uses three identical single-ended current reused VCOs in a ring configuration. The proposed fluxgate magnetometer is proposed dynamic bias circuit is used to reduce the power consumption, and the back-gate BJTs in PMOSFETs are used as a phase coupling device, the circuit oscillates for nanoelectronics

FrOAO2 — Room 7204

Invited Session: Magnetic Skyrmions (Invited Session)

Chair: Wang, Kang — Beihang University

Co-Chair: Zhou, Yan — The Chinese University of Hong Kong, Shenzhen

14:00-14:15 — FrOAO2.1

Magnetic Skyrmions, Bimerons and Antiskyrmions in New Materials (I), pp. 477-477

Zhou, Yan — The Chinese University of Hong Kong, Shenzhen

n this talk, Dr. Yan Zhou will discuss his recent work of magnetic skyrmions, bimerons and antiskyrmion in new material systems, i.e., antiferromagnets, ferrimagnet and frustrated magnets [Nature Electronics, 1, 288-296, (2018); Nature Communications, 9, 959, (2018); Nature Physics, 13, 162–1169 (2017); Nature Communications, 8, 1717, (2017); Nature Communications, 7, 10293 (2016)]. It is shown that the skyrmion Hall effect can be partially or completely suppressed in ferri-, antiferro- or frustrated materials in comparison to ferromagentic materials, making magnetic skyrmions in the new systems suitable for memory applications. In addition, he will discuss many novel physics of these intriguing topological spin textures in the new materials systems and highlight their potential device applications.

14:15-14:30 — FrOAO2.2

Magnetic Bobbers in Chiral Magnet (I), pp. 478-478

Du, Haifeng — High Magnetic Field Laboratory, Chinese Academy of Science

Chiral magnetic skyrmions are nanoscale vortex-like spin textures that form in the presence of an applied magnetic field in ferromagnets that support the Dzyaloshinskii–Moriya interaction (DMI) because of strong spin–orbit coupling and broken inversion symmetry of the crystal. In sharp contrast to other systems that allow for the formation of a variety of two-dimensional (2D) skyrmions, in chiral magnets the presence of the DMI commonly prevents the stability and coexistence of topological excitations of different types. Recently, a new type of localized particle-like

object—the chiral bobber (ChB)—was predicted theoretically in such materials. However, its existence has not yet been verified experimentally. In this talk, we report the direct observation of ChBs in thin films of B20-type FeGe by means of quantita- tive off-axis electron holography (EH). We identify the part of the temperature–magnetic field phase diagram in which ChBs exist and distinguish two mechanisms for their nucleation. Furthermore, we show that ChBs are able to coexist with skyrmions over a wide range of parameters, which suggests their possible practical applications in novel magnetic solid-state memory devices, in which a stream of binary data bits can be encoded by a sequence of skyrmions and bobbers.

14:30-14:45 FrOAO2.3

Skyrmions in Curved Magnetic Film (I), pp. 479-479

Liu, Yan College of Sciences, Northeastern University

We study the nucleation, stability and movement of a skyrmion in a curved magnetic film by using micromagnetic simulations. In a nanotube, we find that skyrmions can exist stably within a moderate magnetic field range when the field is along the radial direction. The nucleation and annihilation field are both dependent on the radius of the nanotube. Also, the shape of the skyrmion in nanotube is different from the case in two dimensional films. When the skyrmion deviates from the direction of applied magnetic field, its shape and size change greatly with the angular position of skyrmion. Its topological number is dependent on the angular position of skyrmion. When the angle that the skyrmion deviates from the direction of magnetic field reaches a critical value, the skyrmion annihilates. The maximum azimuth angle that skyrmion can survive isn't affected by the circular current density, but depends on the radius of nanotube and the strength of magnetic field. Bending a magnetic film will change its hysteresis loop. The skyrmions can only be nucleated when the curvature is appropriate. The moving velocity of skyrmion in a curved nanowire is different from the case in the straight nanowire.

14:45-15:00 FrOAO2.4

Efficient Manipulation of Ferro and Ferri-Magnetic Skyrmions (I), pp. 480-480

Lei, Na Beihang University

Magnetic skyrmions are topological protected chiral spin textures, which are promising for memory and logic applications. Low energy cost of skyrmion manipulation is crucial, especially for skyrmion motion. In this talk, Dr. Na Lei will first discuss the novel ferro- and ferri-skyrmion systems based on Pt/Co/X with large spin-orbit coupling, which has the potential of lower driving current and skyrmion Hall effect. Then, she will talk about the voltage-driven skyrmion motion in a skyrmion shift device made of a simple structure with equidistant identical electrodes on a uniform -thickness nanowire, which allows voltage-driven high-speed skyrmion motion with low power.

15:00-15:15 FrOAO2.5

New Ideas and Translational Applications of Magnetic Skyrmions (I), pp. 481-481

Wang, Chen University of Electronic Science and Technology of China

A new class of magnetic solitons, the twisted skyrmions, is predicted to exist at the boundary of two antiferromagnetic coupled ferromagnetic domains. The skyrmion polarity can be efficiently reversed in such configurations, where the twisted skyrmions act as the intermediate state. The barrier of data representations in conventional skyrmion racetrack memory thus removed. One can use skyrmions with different polarities to encode data. A series of information devices are designed, including the racetrack memory and the functional complete logic gates based on skyrmions and twisted skyrmions. Besides, a new theory to solve the skyrmion-boundary problem is developed, where the image skyrmions are used.

FrOAO3 Room 7205

Invited Session: Computing with Nanotechnologies (Invited Session)

Chair: Liu, Weiqiang Nanjing University of Aeronautics and Astronautics

Co-Chair: Zhang, Yue Beihang University

14:00-14:15 FrOAO3.1

Emerging Spintronic Devices and Circuits: From Logic and Memory to Logic-In-Memory (I), pp. 482-482

Zhang, Yue Beihang University

In the post-Moore era, integrated circuits based on complementary metal oxide semiconductor (CMOS) are faced with the energy bottleneck. Spintronics is recognized as one of the most promising technologies for overcoming this issue. Here we introduce our recent work on emerging spintronic devices and circuits, for example, double-barrier double-free-layer magnetic tunnel junction (DDMTJ), diode-enhanced magnetoresistance device, all spin logic device and ring-shaped racetrack memory (RM). They can be used for building non-volatile logic and memory and high-performance logic-in-memory architectures. A systematic study has been carried out from device level to system level. Through increasing density, reducing data traffic distance, eliminating charge current and enriching functionality, the performance and energy of the applications can be improved significantly.

14:15-14:30 FrOAO3.2

DNA Computing for Combinational Logic (I), pp. 483-484

Zhang, Chuan Southeast University

With the progressive scale-down of semiconductor's feature size, people are looking forward to More Moore and More than Moore. In order to offer a possible alternative implementation process, people are trying to figure out a feasible transfer from silicon to molecular computing. Such transfer lies on bio-based modules programming with computer-like logic, aiming at realizing the Turing machine. To accomplish this, the DNA-based combinational logic is inevitably the first step we have taken care of. This timely overview talk introduces combinational logic synthesized in DNA computing from both analog and digital perspectives separately. State-of-the-art research progress is summarized for interested readers to quick understand DNA computing, initiate discussion on existing techniques and inspire innovation solutions. We hope this talk can pave the way for the future DNA computing synthesis.

14:30-14:45 FrOAO3.3

Enabling New Computing Paradigms with Emerging Memory Transistors (I), pp. 485-485

Li, Xueqing Tsinghua University

There have been emerging memory transistors such as Ferroelectric transistors (FeFETs) and Nano Electro-Mechanical Relay Transistors (NEMR). They exhibit not only promising scaling capability, but also the compact fusion of logic and memory behavior in a single device that provides opportunities for efficient memory access and in-memory computing. This talk investigates circuit opportunities that harness these intriguing device features, providing insights into new computation paradigms beyond existing solutions. At first, this talk will review the demand for higher energy efficiency for both computing and memory storage, with a special focus on a few computing and storage “walls” that hinder the fundamental improvement of existing computing systems. After this review, this talk will present a few promising nano devices, and show their intrinsic intriguing device characteristics, which enable the potential for new circuit innovations for various applications. Then, this talk will present how such potential innovations could be possible with practical considerations, by showcasing a few examples of low-power memory and compute-in-memory circuits, architectures, and co-design methodologies. These examples include nonvolatile computing, nonvolatile embedded data storage and memory-centric fabrics. Finally, by presenting the gap between existing efforts and the targeted system performance, this talk will point out possible research tracks that may provide fundamental

evolution and even revolution.

14:45-15:00 FrOAO3.4

Tunable MRAM-On-FDSOI Bit-Cell towards Energy Efficiency for In-Memory Computing (I), pp. 486-486

Cai, Hao Southeast University

The foundry announced integration of magnetic random access memory (MRAM) on fully depleted silicon-on-insulator (FD-SOI) has been reported. The spin transfer torque magnetic tunnel junction (STT-MTJ) and the next-generation voltage-controlled magnetic anisotropy MTJ are separately integrated into FDSOI process as the MRAM or magnetoelectric random access memory (MeRAM)-on-FDSOI integration. The energy-efficient bit-cell design allows low power near-memory and in-memory bitwise computing. Circuit level design strategies are explored that use FDSOI leverage and spin-device characteristic to realize writing and sensing power-delay efficiency, robust, and reliable performance in the 1T-1M MRAM/MeRAM bit-cell and sensing circuits. Process variation and aging resilience strategies, e.g., step-wise back-bias, flip-well re-configuration, and write assist, are proposed to address failure and aging degradation in the MRAM/MeRAM-on-FDSOI integration. A qualitative summary demonstrates that the MRAM/MeRAM-on-FDSOI integration offers attractive performance for future low-power non-volatile CMOS integration.

15:00-15:15 FrOAO3.5

Majority-Logic Based Approximate Computing (I), pp. 487-488

Liu, Weiqiang Nanjing University of Aeronautics and Astronautics

As a new computing paradigm, approximate computing deals with error tolerance in the computational process to improve performance and reduce power consumption of circuits and systems by introducing errors into error-resilient applications, such as multimedia signal processing, machine learning and pattern recognition. Majority logic is applicable to many emerging nanotechnologies which is different from conventional Boolean logic. Its basic building block, i.e. majority voter, has been extensively studied for digital designs. It is expected that significant improvement in power consumption could be achieved by applying approximate computing to majority logic based nanotechnologies. This presentation will cover the majority logic based approximate computing circuits, further reducing power consumption and hardware complexity. This presentation will discuss majority logic based approximate adder designs by logic reduction, as well as approximate multiplier designs by combining multiple approximate techniques with the so-called complement bits. Case studies into error-resilient applications are also presented.

FrOAO4 Room 7304

Nanobiology and Nanomedicine (Oral Session)

Chair: Cai, Xinxia Institute of Electronics, Chinese Academy of Sciences,

Co-Chair: Wang, Wenxue Shenyang Institute of Automation, Chinese Academy of Sciences

14:00-14:15 FrOAO4.1

Detection of the Neuronal Electrophysiological Activity in the Hippocampus of Rats under the Modulation of Caged-GABA Delivered by Nano-Liposomes, pp. 489-490

Xie, jingyu The State Key Laboratory of Transducer Technology, Institute Of

Song, Yilin The State Key Laboratory of Transducer Technology, Institute Of

Li, Ziyue State Key Laboratory of Transducer Technology, Institute of Elec

Dai, Yuchuan State Key Laboratory of Transducer Technology, Institute of Elec

Gao, Fei State Key Laboratory of Transducer Technology, Institute of Elec

Li, Xuanyu Beijing Engineering Research Center for BioNanotechnology, CAS K

zhang, yu The State Key Laboratory of Transducer Technology, Institute Of

Wang, Hao State Key Laboratory of Transducer Technology, Institute of Elec

Lu, Zeying State Key Laboratory of Transducer Technology, Institute of Elec

Zheng, Wenfu Beijing Engineering Research Center for BioNanotechnology, CAS K

Cai, Xinxia Institute of Electronics, Chinese Academy of Sciences,

In this work, we prepared the nano-liposomes to deliver caged γ-aminobutyric acid compounds (Rubi-GABA). Using these nano-liposomes, we modulated the neuronal electrophysiological activity in rats with real-time monitoring by microelectrode array (MEA). For the normal rats, we injected the Rubi-GABA liposomes in hippocampus of rats and neural spikes were inhibited after the blue light illumination. This method provides a new idea to modulate neural activity with nano-drug delivery systems.

14:15-14:30 FrOAO4.2

Implantable Microelectrode Arrays for Electrophysiological Activity Detection in Cortex of Sleep Deprived Rats, pp. 491-494

Lu, Zeying State Key Laboratory of Transducer Technology, Institute of Elec

Xu, Shengwei Institute of Electronics Chinese Academy of Sciences,

Wang, Hao State Key Laboratory of Transducer Technology, Institute of Elec

Liu, Juntao Institute of Electronics Chinese Academy of Sciences,

Wang, Yun State Key Laboratory of Transducer Technology, Institute of Elec

Xie, jingyu The State Key Laboratory of Transducer Technology, Institute Of

Song, Yilin The State Key Laboratory of Transducer Technology, Institute Of

Gao, fei The State Key Laboratory of Transducer Technology, Institute Of

Dai, Yuchuan State Key Laboratory of Transducer Technology, Institute of Elec

Qu, Lina State Key Laboratory of Space Medicine Fundamentals and Application

Cai, Xinxia Institute of Electronics, Chinese Academy of Sciences,

In vivo studies of neural discharge activity following sleep deprivation(SD) can help us fully understand the effects of sleep deprivation at the cellular level. The MEA was fabricated using MEMS technology to measured the electrophysiological activity in rat cortex before and after SD. The experiments showed that after SD, the average amplitude of the spike increased by 32.1% from 106.6 μV to 140.8 μV. The average firing rate increased by 186.2% from 2.2 Hz to 6.2 Hz. The power of LFPs in all frequency

band under 50 Hz increased after SD. The results indicated that the sleep deprivation had excitatory effects on the neurons and may further undermine the certain function of the brain, such as the ability of cognition and memory.

14:30-14:45 FrOAO4.3

Nanotopography-Induced Cell Growth with Enhanced Maturation on Polymer Substrates, pp. 495-496

WU, Cong	City University of Hong Kong
Jia, Boliang	City University of Hong Kong
Chan, Hoyin	City University of Hong Kong
Li, Wen Jung	City University of Hong Kong

14:45-15:00 FrOAO4.4

Catalytic Cerium Oxide Nanoparticles in Nanomedicine and Their Use in Liver Diseases, pp. 497-500

Casals, Eudald	School of Biotechnology and Health Sciences, Wuyi University, Ji
Zeng, Muling	School of Biotechnology and Health Sciences, Wuyi University, Ji
Parra, Marina	Hospital Clinic of Barcelona
Fernández-Varo, Guillermo	Hospital Clinic of Barcelona
Jiménez, Wladimiro	Hospital Clinic of Barcelona
Puntes, Victor	Vall d'Hebron Institut of Research (VHIR), Barcelona, Spain, Cat
Casals, Gregori	Hospital Clinic of Barcelona

In this work, we aim to provide a better understanding on how to analyze the results obtained using Cerium Oxide (CeO2) nanoparticles for medical applications while showing some results for the case of a liver disease (metabolic syndrome). Thus, the manuscript is divided in two main sections. First, we discuss the bibliography of the safety aspects of the use of Cerium Oxide for medicine, since we have seen discrepancies between reports on its proven anti-inflammatory activity together with other reporting toxicity. The evolution of the nanoparticles inside the body make several parameters, such as aggregation state or surface evolutions, as critical determinants that need to be carefully addressed to better understand their potential clinical benefits. Second, we show the usefulness of enhancing the stability of CeO2 nanoparticles in the physiological media for the treatment of liver diseases. Liver is the organ where nanoparticles passively accumulate and thus, a logical place to start the studies of the in vivo evolution and activity of this material.

15:00-15:15 FrOAO4.5

Estimation of Bacteria Death on the Nanostructural Surface Using Electrochemical Impedance Spectroscopy, pp. 501-503

Ito, Takeshi	Kansai University
Masuda, Kyosuke	Kansai University
Jindai, Keisuke	Kansai University
Kojima, Hiroaki	NICT
yamashita, ichiro	Nara Institute of Science and Technology
Shimizu, Tomohiro	Kansai University
Shingubara, Shoso	Kansai University

Recently, many reports described nanostructure-based bactericidal materials; for example, nanostructured surfaces of cicada wings, dragonfly wings and gecko fingers showed bactericidal properties. Bactericidal activity is not attributed to chemical properties but to physical properties of the nanostructure; cell membranes are stretched on the nanostructure surface, and then they break. These bactericidal properties depend on the physical condition of the nanostructure. We have reported that surface wettability has an impact to bacterium adhering on the surface. However, the mechanism of bacterium death on the nanostructural surface have not become clear. This paper shows the first trial to estimate bactericidal effect using nanostructural Au array electrode and electrochemical impedance spectroscopy (EIS). Our results show that nanostructural electrode has the potential to discuss the bactericidal effect on the nanostructure surface.

FrOAO5 Room 7305

Nanoelectronics (Oral Session)

Chair: Rezk, Ayman	Khalifa University
Co-Chair: Zhang, Shuye	State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology

14:00-14:15 FrOAO5.1

Impact of Silver Nano-Particles on Metal Si Schottky Contact, pp. 504-506

Rezk, Ayman	Khalifa University
Abbas, Yawar	Khalifa University
Saadat, Irfan	Khalifa University
Nayfeh, Ammar	Masdar Institute of Science and Technology
Rezeq, Moh'd	Khalifa University of Science, Technology & Research (KUSTAR)

Surface states in Metal-Si interfaces significantly impact the metal/Si junction barrier properties due to Fermi level pinning and image force lowering. In this paper, we study the influence of silver nano-particles (NPs) at the Metal-Si interface. We dispersed silver NPs on a clean n-type silicon wafer by drop casting. The NPs formed a nano-layer coating on the Si surface. The associated Schottky junction characteristics are investigated and found to be different from those of conventional non-NP based Schottky junction. This is primarily due to the lowering of the MS barrier height and narrowing the tunneling barrier, which are modulated by the presence of the NPs. This allows for overcoming the Fermi level pinning and the engineering of the Schottky barrier height (SBH). A physical explanation for this behavior is also presented.

14:15-14:30 FrOAO5.2

Atomic Layer of ZnO Deposition on Ag Nanowires for Novel Electrical Applications, pp. 507-511

Zhang, Shuye	State Key Laboratory of Advanced Welding and Joining, Harbin Ins
Liu, Xu	Harbin Institute of Technology
Lin, Tiesong	Harbin Institute of Technology
He, Peng	Harbin Institute of Technology

Transparent electrode is the key component of optoelectronic devices. Nowadays, indium tin oxide (ITO) has been widely used for transparent electrode. However, Ag nanowires (NWs) are a good alternative candidate to replace the conventional ITO. In order to improve the stability of silver nanowires electrode, ZnO with nanometer size thickness is deposited on the surface of silver nanowires electrode by atomic layer deposition (ALD) method which is a method of depositing material on a substrate layer by layer in the form of a single atomic film. As the surface of the nanowires are coated with ZnO, the overall morphology is good without fusing phenomenon. The thermal stability of the silver nanowires electrode can be significantly enhanced by depositing 50 nm thickness ZnO layer including the sheet resistances.

14:30-14:45 FrOAO5.3

Resistive Switching in Single Core-Shell Nanoparticles, pp. 512-516

Speckbacher, Maximilian	Technical University of Munich
Ji, Xinrui	TU Munich
Tornow, Marc	TU München

Resistive switching in single spherical core-shell Ag/SiOx-nanoparticles (CSNP) of diameter 150 nm is reported. These nanoparticles were contacted by interdigitated electrodes

(IDE) and exhibit either bipolar memristive or threshold switching with OFF/ON resistance ratios in excess of three orders of magnitude. A switching mechanism based on silver ion migration in the silica shell is proposed, which leads to reversible conductive filament formation and rupture. Application of CSNP as functional building blocks in future self-assembled 3D memory architectures or neuromorphic networks is proposed.

14:45-15:00 FrOAO5.4

Synaptic Behavior of Flexible IGZO TFTs with Al2O3 Gate Insulator by Low Temperature ALD, pp. 517-520

Park, Shinyoung — Kookmin University
Jang, Jun Tae — Kookmin University
Choi, Sung-Jin — Kookmin University
Kim, Dong Myong — Kookmin University
Kim, Dae Hwan — Kookmin University

Flexible InGaZnO (IGZO) thin-film transistor (TFT) with Al_2O_3 gate insulator (GI) which is deposited by low temperature (LT) atomic layer deposition (ALD) is proposed and its synaptic behavior and mechanical stability are demonstrated on a polyethylene terephthalate substrate. The change of threshold voltage under bending test is attributed to the generation of ionized oxygen vacancy resulting from the oxygen bond-breaking. In addition, the synaptic behavior is clearly observed and the convolutional neural network-based MNIST recognition rate of 87.2 % after 60,000 training is demonstrated by using the proposed IGZO TFTs. Stable synaptic behavior can be explained by the potentiation/depression pulse-dependent movement of hydrogens which the Al_2O_3 GI contains during LT ALD. Furthermore, it is found that the synaptic weight can be controlled and optimized by changing the thickness of Al_2O_3 GI.

15:00-15:15 FrOAO5.5

Silicon Nanogap Electrode Engineering for Organic Monolayer Field Effect Transistors, pp. 521-525

Pfaehler, Simon — TU München
Pathak, Anshuma — Technische Universität München
Liao, Kung-Ching — Princeton University
Schwartz, Jeffrey — Princeton University
Tornow, Marc — TU München

The fabrication and characterization of planar silicon nanogap electrode structures is described in which contact separation ≥ 30 nm was achieved. Starting from highly doped silicon-on-insulator substrates, fabrication is based on precise control of electron-beam lithography and subsequent reactive ion etching (etch rate 3.6 nm/s). A monolayer of an aromatic organophosphonate is then assembled in the etched nanogap. Conductance is greatly improved compared to a device absent the monolayer, and distinct field-effect induced modulation of the conductance is observed. Finite element simulations of the electrostatic potential distribution of the device structure supports its suitability as a three-terminal field effect device.

15:15-15:30 FrOAO5.6

*Novel Organic Metallic Hybrid Polymer of Redox Non-Innocent Tridentate Schiff's Base Organic Ligand: Study of Electrochromic and Non-Volatile Memristive Properties**

Oberoi, Deepa Ghune — IIT Roorkee
Bandyopadhyay, Anasuya — Indian Institute of Technology Roorkee, India

FrOBO1 Room 7201

Nanorobotics and Nanomanipulation II (Oral Session)

Chair: Lee, Chengkuo — National University of Singapore
Co-Chair: Zhao, Qili — Nankai University

15:45-16:00 FrOBO1.1

Experimental Verification of Guidance and Search Strategy of Nanobots under Magnetic Field Control in Grid Network, pp. 526-529

Shi, Shaolong — Southern University of Science and Technology
Xiong, Junfeng — Southern University of Science and Technology
ZHOU, YU — Beijing Institute of Collaborative Innovation
CHEN, YIFAN — The University of Waikato
Cheang, U Kei — Southern University of Science and Technology

A novel communication scheme called touchable communication (TouchCom) in the nanoscale and molecular communication area has been recently proposed. It is focused on the controllable and trackable properties of message carriers. A potential therapeutic application of TouchCom is the targeted delivery of drugs which utilizes physically transient nanobots as vehicles to deliver drug particles. Based on the same scenario, a searching scheme called touchable computation (TouchComp) has also been proposed to guide the nanobots to accurately locate the tumor in a vascular environment. Previous work on those two topics provides basic channel model and searching strategy, which all need experiment to verify the theoretical work. This paper describes the experimental validation scenarios and expected results to prepare for subsequent optimization.

16:00-16:15 FrOBO1.2

Augmented Reality-Based Precise Oocyte Enucleation, pp. 530-534

Feng, Zeyang — Nankai University
Zhao, Qili — Nankai University
Liu, Yaowei — Nankai University
Sun, Mingzhu — Nankai University
Zhao, Xiangfei — Nankai University
Cui, Maosheng — Institute of Animal Sciences
Zhao, Xin — Nankai University

Oocyte enucleation, removing nucleus and polar body in the oocyte, is a critical procedure for animal cloning. To preserve oocyte development potential, the removed cytoplasm in enucleation should be as little as possible. As the nucleus is invisible in the bright field, the operators usually have to blindly remove 1/4 to 1/3 of cytoplasm around the polar body in enucleation in order to completely remove the cell nuclei. The large amount of lost cytoplasm significantly decreases the development potential of the enucleated oocytes. The visualization of the nucleus is the key to reduce removed cytoplasm and achieve precise enucleation. In this paper, we conducted the statistics of the nucleus position relative to the first polar body for oocytes in MII stage through which the nucleus distribution area was obtained. Augmented reality was applied to superimpose the distribution area on the oocyte to visualize potential nucleus position. Using the statistical nucleus area, a micropipette penetrates the cell membrane, approaches the nucleus and extracts a set amount of cytoplasm to remove the nucleus and polar body automatically. Compared with the conventional blind enucleation method, our method increased enucleation success rate from 86.7% to 93.3% with less than 10% of cytoplasm removed. Through this, the cell survival rate after enucleation is improved from 57.1% to 91.4%.

16:15-16:30 FrOBO1.3

Augmented Multidimensional Nano-Manipulation Terminal Using Triboelectric Strip Sensors, pp. 535-540

ZHU, MINGLU — National University of Singapore Research Institute
Chen, Tao — Soochow University
Lee, Chengkuo — National University of Singapore

Triboelectric based sensors attract a lot of attentions in recent years, however, there is still limited researches of the applications on the multidimensional interactive control. In this paper, we present an ultra-stretchable triboelectric strip sensor (TSS) using triboelectric mechanism for controlling the objects in

three-dimensional space. By finger tapping on the strips with two counter terminal electrodes, the parallel sensor strips structure can realize the sensing and controlling in three degrees of freedom of linear motion and two degrees of freedom of rotational motion, and resultant sensing ranges for three axes and two angles are X, Y, Z, alpha and beta (20 mm, 20 mm, 30 mm, 36 degree, and 36 degree). In terms of manipulation, this is simpler than the conventional controller with rigid structure and includes additional space dimensions. Furthermore, the demonstration of the TSS as human-nanomachine terminal to control the nanomanipulator in scanning electron microscope (SEM) is successfully realized with the accuracy of 10 nm. The proposed TSS shows great potential for the applications in automated control, robotics control, and Internet of Things (IoT).

16:30-16:45 FrOBO1.4

Nanorobot Assisted Self-Soldering Investigation between PVP-Coated Silver Electrodes and Carbon Nanotubes, pp. 541-545

Yu, Zhiqiang	Beijing Institute of Technology
Shi, Qing	Beijing Institute of Technology
Dong, Lixin	City University of Hong Kong
Wei, Zihou	Beijing Institute of Technology
Wang, Huaping	Beijing Institute of Technology
Wang, Haojun	Michigan State University
Huang, Qiang	Intelligent Robotics Institute, School of Mechatronic Engineerin
Fukuda, Toshio	Nagoya University

Although the soldering of functional nanomaterials has been achieved by various methods, the readily oxidative properties of the nanoelectrodes and their corresponding preventing oxidation method by coating dielectric-layer make their soldering extremely difficult. Here, we report an effective method for soldering dielectric-coated nanowires to electrodes directly by vacuum contact annealing. This annealing process is performed within an environmental scanning electron microscope (ESEM) by a nanorobot-assisted nanomanipulation system. The results show that the conductivity of the soldered nanostructure is enhanced by about 1000 times after a 130s annealing process. The joining strength on the junction point was also estimated up to 112 MPa (0.22 μN), which is sufficient for the interconnection of the nanomaterials. Our recipe highlights the promise of soldering dielectric-coated readily oxidizable electrodes for fabricating nanoelectronic devices and conductive transparent films.

16:45-17:00 FrOBO1.5

Untethered Micromachines Using Magnetic Nanoparticles for Wireless Assembly of Cell-Laden Heterogeneous Micromodules, pp. 546-551

Li, Jianing	Beijing Institute of Technology
Wang, Huaping	Beijing Institute of Technology
Shi, Qing	Beijing Institute of Technology
Zheng, Zhiqiang	Beijing Institute of Technology
Cui, Juan	Beijing Institute of Technology
Sun, Tao	Beijing Institute of Technology
Huang, Qiang	Intelligent Robotics Institute, School of Mechatronic Engineerin
Fukuda, Toshio	Nagoya University

Magnetic micromanipulation has shown huge potential in biomedical research and regenerative medicine, which can be utilized to bio-assemble in-vitro tissues as pharmacological or physiological models. Here, a novel clamp magnetic micromachine was proposed for the assembly of cell-laden micromodules. The magnetic micromachine was fabricated with nickel nanoparticles and polydimethylsiloxane by mold replication. Composed of a through-hole template patterned by chemical etching and a glass substrate coated with an adhesive layer, the multi-layer mold was designed to ensure high resolution and low surface roughness. An eight-coil electromagnetic system was set up to generate a 3D magnetic field of up to 80mT. Driven by external magnetic field and its gradient, the micromachine is able to rotate with a frequency of 3 Hz or translate with a speed of 5 mm/s near the workspace center, which shows lower current supply and higher dynamic response than conventional electromagnetic systems. To evaluate the practicality of the micromachine, cell-laden hydrogel micromodules were assembled by indirect propulsion and integrated into a reconfigurable architecture with heterogeneous shape and composition. We anticipate that this system will regenerate more complex tissues with physiological importance in future tissue engineering.

FrOBO2 Room 7204

Invited Session: Low-Dimensional Materials, Devices and Applications (Invited Session)

Chair: Tang, Jianshi	Tsinghua University
Co-Chair: Kim, Jeehwan	MIT

15:45-16:00 FrOBO2.1

Stackable Electronics Enabled by Freestanding 2D & 3D Materials (I), pp. 552-552

Kim, Jeehwan MIT

2D material-based devices have received great deal of attention as they can be easily stacked to obtain multifunctionality. With their ultrathin thicknesses, such multifunctioning devices become so flexible and conformal that they can be placed onto any 3D featured surfaces. However, 2D heterostructures are typically demonstrated as stacked flakes where single or few devices can be fabricated due to lack of strategies for layer-by-layer stacking of 2D materials at the wafer scale. In this talk, I will discuss about our unique strategy to isolate wafer-scale 2D materials into monolayers and stack them into a heterostructures by using a layer-resolved splitting (LRS) technique [1,2]. This technique enables my group at MIT to explore unprecedented wafer-scale 2D heterodevices including integrated photonics, 3D neuromorphic computing, and microLEDs, which will be introduced in my talk. While 2D heterostructures promise interesting futuristic devices, the performance of 2D material- based devices is substantially inferior to that of conventional 3D semiconductor materials. However, 3D materials exist as their bulk form, thus it is challenging to stack them together for heterostructures. Obviously, conformal coating of such single-crystalline bulks on 3D features is impossible. My group at MIT has recently invented a 2D materials-based layer transfer (2DLT) technique that can produce single- crystalline freestanding membranes from any compound materials with their excellent semiconducting performance [3,4]. This technique is based on remote epitaxy of single-crystalline films on graphene followed by peeling from graphene. Stacking of freestanding 3D material membranes will enable unprecedented 3D heterostructures whose performance is expected to be superior to that of 2D heterostructures. I will talk about our group's effort to apply single-crystalline freestanding membranes for flexible, conformal electronics as well as for 3D heterostructures. Finally, I will conclude my talk by discussing perspectives of coupling 2D-3D freestanding membranes for 2D-3D mixed heterostructured devices that can be enabled by our LRS and 2DLT techniques [5]. [1] Kim et al., Science, 342, 833 (2013); [2] Shim, et al, Science, 362, 665 (2018); [3] Kim, et al, Nature, Vol. 544, 340 (2017); [4] Kong, et al, Nature Materials, 17, 999 (2018); [5] Bae, et al, Nature Materials, Accepted (2019).

16:00-16:15 FrOBO2.2

Nanoscale Devices Based on Two-Dimensional Materials and Ferroelectric Materials (I), pp. 553-553

Zhu, Wenjuan University of Illinois at Urbana-Champaign

Further scaling of complementary metal-oxide-semiconductor (CMOS) dimensions will soon lead to a tremendous rise in power consumption while limited gain in the performance of integrated circuits. “Beyond-CMOS” devices, based on new materials, device concepts and architectures, can potentially overcome these limitations and further improve the performance, reduce energy consumption, and add novel functionalities to the CMOS platform. In this talk, I will present nanoscale electronic and photonic devices based on two-dimensional (2D) materials and ferroelectric

materials. In particular, I will discuss the logic devices, RF devices, photodetectors, plasmonic devices, and tunneling devices based on graphene and transition metal dichalcogenides. I will also present our recent results on non-volatile memories and ferroelectric tunneling junctions (FTJs) based on ferroelectric hafnium oxide and 2D ferroelectric indium selenides.

16:15-16:30 FrOBO2.3

Toward High-Mobility and Low-Power 2D MoS2 Field-Effect Transistors (I), pp. 554-554

wang, xinran Nanjing University

2D transition-metal dichalcogenides are promising candidates for sub-5nm logic devices owing to their immunity to short-channel effects (SCE), but many issues regarding mobility, contact and interface still remain. We develop a series of interface engineering strategies using high-k dielectric and thiol chemical treatment to achieve high carrier mobility of 150 cm2/Vs and saturation current over 450 μA/μm in long-channel monolayer MoS2 FETs. Towards low power applications, we develop means to integrate ultrathin oxides with ~1nm EOT on 2D materials, which gives near ideal SS~60mV/dec and excellent leakage properties. We further use ferroelectric HfZrOx as gate dielectric and demonstrate hysteresis-free MoS2 negative capacitance FETs, with sub-60mV/dec SS over 6 orders of ID, minimum SS of 24 mV/dec.

16:30-16:45 FrOBO2.4

Electronic Devices Based on Two-Dimensional Materials and Heterostructures (I), pp. 555-555

Wu, Yanqing Peking University

Electronic devices based on atomic layered two-dimensional materials and related heterostructures have recently attracted great research attention due to their unique electronic properties and the feasibility of hybrid integration, which provide the unprecedented opportunities for various van der Waals heterojunctions. Systematic studies on electronic transport properties including interface scattering and carrier velocity are carried out. High frequency transistor and circuits operating at gigahertz range based on bilayer graphene, molybdenum disulfide and black phosphorus are demonstrated. Moreover, vertical heterojunction based on the combination of molybdenum disulfide and black phosphorus are demonstrated with ultrahigh rectification ratio and on-off ratio simultaneously. Lateral heterojunctions based on the above two materials exhibit unique negative transconductance and thus will result in non-traditional ternary inverters whose transition from the conventional binary CMOS inverter can be realized by the band profile alignment from drain bias. Lastly, two dimensional materials and their heterostructures are also explored for neuromorphic computing applications.

16:45-17:00 FrOBO2.5

Microelectrode Arrays for Large Scale Clinical Mapping: Electrochemical and Density Considerations (I), pp. 556-556

Dayeh, Shadi University of California San Diego

The enhanced electrochemical activity of nanostructured materials are readily exploited in energy devices, but their utility in scalable and human-compatible implantable neural interfaces is yet to be demonstrated. We utilize low-temperature process to develop 1D platinum nanorod (PtNR) arrays that are vertically aligned on top of metal leads in a process that is compatible with thin flexible films. We show that these PtNRs exhibit very low electrochemical impedances and high charge injection capacities at various length scales, are biocompatible, stable, scalable and suitable for efficient neurotechnologies. We utilize PtNR microelectrodes to demonstrate recording of brain activity with cellular resolution from the cortical surfaces in birds, mice, and non-human primates. Significantly, strong modulation of surface recorded single unit activity by auditory stimuli is demonstrated in European Starling birds, modulation of local field potentials in the visual cortex by light and electrical stimuli in a non-human primate, as well as responses to electrical stimulation in mice. To increase the channel count of microelectrode arrays, we leverage advanced display technologies on flex and further developed dual-gate indium-gallium- zinc oxide (IGZO) thin film transistors (TFTs) that exhibit high transconductances of 10mS/mm, cut-off frequencies of >150MHz, and broadband recording sensitivity from the cortical surface. Efforts on recording from the surface and depth of the human brain will also be presented.

17:15-17:30 FrOBO2.6

*Optoelectronic Devices Based on Graphene and Its Related Heterostructures (I)**

Xu, Jian-Bin The Chinese Universtiy of Hong Kong

FrOBO3 Room 7205

Invited Session: Dynamics on DNA Nanostructure (Invited Session)

Chair: Tabata, Osamu Kyoto University

Co-Chair: Yagyu, Hiromasa Kanto Gakuin University

15:45-16:00 FrOBO3.1

Nanostructures and Mechanical Properties of DNA Origami Constructed with Different Crossover/Nick Designs (I), pp. 557-557

Ma, Zhipeng Zhejiang University

DNA origami methods enable the fabrication of various nanostructures and nanodevices, but their effective use depends on an understanding of their structural and mechanical properties and the effects of basic structural features. In addition to dsDNA and ssDNA, DNA origami structures include DNA crossovers, where dsDNA strands physically intersect, and nicks, where one of the dsDNA strands is partially cut. While the physical properties of dsDNA and ssDNA are well understood, the physical properties of DNA crossovers and nicked dsDNA helices are as yet rarely studied. Further measurements of the local properties of DNA origami in ionic solutions are clearly required to explicitly reveal the effects of crossovers and nicks. To meet these requirements, we fabricated a variety of planar DNA origami structures incorporating different crossover and nick designs, measured their properties in an aqueous solution using high-resolution frequency-modulation atomic force microscopy (FM-AFM) and force-controlled atomic force microscopy (AFM), and learned how electrostatic forces cause these structures to deviate from idealized representations. This method allows comparative and simultaneous measurements of the structural and mechanical properties of the DNA origami structures and reveals the structural and mechanical consequences of adding DNA crossovers and nicks. The structural and mechanical properties of DNA origami and the effects of crossovers and nicks revealed in this paper can provide information essential for the design of versatile DNA origami structures that exhibit specified and desirable properties.

16:00-16:15 FrOBO3.2

Mechanical Analysis and Design for DNA Nanostructures (I), pp. 558-558

Kim, Do-Nyun Seoul National University

In this talk, our recent mechanical analysis and design methods of constructing DNA origami nanostructures to achieve a fine control over their geometrical shape and mechanical properties will be introduced. We develop modular blocks serving as a mechanical hinge whose stiffness is tuned by controlling the dsDNA and ssDNA segments, use nicks as mechanically weak points whose density and position are programmed to modulate the overall bundle properties, and design the location of inserted/deleted base pairs to introduce various level of mechanical strains to helices enabling a precise tuning of twisted shape. Multiscale analysis is highly used in our design process where molecular level simulation is performed to characterize the unknown mechanical properties of structural components that are fed into a coarse-grained, mechanical model, CanDo, for rapid prediction of their effect on overall shape and properties. We expect our mechanical analysis and design strategies offer a versatile way of controlling both the shape and the mechanical properties (and hence the derived properties) with precision.

16:15-16:30 FrOBO3.3

Coarse-Grained Molecular Dynamics DNA Model for DNA Origami Nanostructures (I), pp. 559-559

Yagyu, Hiromasa Kanto Gakuin University

DNA origami is the most promising method for developing nanoscale structures (nanostructures), which can be used self-assemble functions. This technology, which is applied to combine a large number of single stranded DNA chains using complementarity of bases in the DNA chain, enables the production of two-dimensional and three-dimensional nanostructures. To design DNA nanostructure, we developed a new simulation tool to analyze the relation between structure and mechanical properties in complex DNA origami structures with a few thousand base pairs. The tool uses the new coarse-grained molecular dynamics double-stranded DNA model (nCG-dsDNA model) with an improved beads-spring model. In this model, nucleotide comprising phosphate, sugar, and base group were replaced by a single bead. The double stranded model with 202 base pairs was created to tune the parameters of the bond, the non-bond, stack, angle bending, and electrostatic interaction. The average twisted angle and the persistence length of the model without electrostatic interaction were calculated at 35° and 120bp, confirming that the proposed model successfully realized the experimentally observed double-stranded DNA structure. Moreover, the model with electrostatic interaction was discussed. From calculation results, we confirmed that the dependency of the salt concentration on the persistence length of the nCG-dsDNA model at the 30% charge is in good agreement with the Poisson–Boltzmann theoretical model. This presentation will show the modelling of nCG-dsDNA model, and mechanical properties of the model such as stretching, bending, twisting modulus. Also, it will discuss the future direction of the nCG-dsDNA model thorough the examples of complex three-dimensional DNA origami nanostructure using the nCG-dsDNA model with a converted coordinate and sequence of the beads from caDNAno/CanDo.

16:30-16:45 FrOBO3.4

Surface-Enhanced Raman Spectroscopy of DNA with Single-Molecule Sensitivity Using Gold Nanoparticle Dimer (I), pp. 560-560

Sugano, Koji Kobe University

Surface-enhanced Raman spectroscopy (SERS) is an extremely useful analytical tool of bio/chemical molecules because Raman spectra provide molecular structural information, enabling label-free identification of molecules. Raman scattering can be strongly enhanced by a nanogap between metal nanostructures, less than 1 nm, which is called the “hot spot”. A nanoparticle dimer has frequently been considered as the nanostructure which achieves the highest enhancement of particle–particle contact when the connection direction of the particles is matched to the polarization direction of the incident light. Single-molecule sensitivity can be achieved using this geometry. This reports an SERS of a single-stranded DNA toward SERS-based DNA sequencing. The Raman enhancing hotspot with 1-nm nanogap in the single dimer of gold nanoparticles has a space for only single DNA oligomer. Arranging gold nanoparticles on a substrate, the detection of a single adenine in a single DNA oligomer was demonstrated. The electrical detection of the single DNA oligomer was also demonstrated for analyzing the behavior of DNA oligomers using a plasmonic nanogap structure. The optical excitation caused plasmonic dielectrophoresis or/and thermophoresis of molecules to the nanogap due to huge gradient of an electric field. The single-molecule electrical measurement was confirmed using the nanogap electrodes irradiated by a He-Ne laser. The behavior of DNA oligomers at the nanogap was considered from the current-time profiles.

16:45-17:00 FrOBO3.5

Rapid DNA Origami Assembly by Fast Heat Exchange and Small Diffusion Length (I), pp. 561-561

Kawai, Kentaro Osaka University

DNA nanostructures, called DNA origami, which consists of a long single-strand DNA (scaffold) and hundreds of complementary oligonucleotides (staples), can construct various designs and sizes of 2D/3D nanostructures. DNA origami are self-assembled through DNA hybridization by annealing process from denaturing temperature of the component DNAs. General annealing process using microtube and commercial thermal cycler, however, takes a long annealing time for precise and high yield DNA hybridization. For example, 2D nanostructures require 1 or 2 hours and 3D multi-layer nanostructures require over 24 hours. Therefore several researchers have reported rapid folding process by optimize annealing conditions such as temperature, cation concentration. Sobczak et al. use constant temperature annealing process which can fabricated 2D rectangle DNA origami at 53 °C for 5 minutes and 3D DNA origami gear at 49 °C for 45 minutes. Fu et al. use single-step annealing process of DNA origami nanotube and nanoribbons with proteins which shorten annealing time from 2 days of general two-step annealing process to 20 minutes. Myhrvold et al. use wide-range constant temperature annealing from 15°C to 70°C which can assembling single-stranded tile (SST) structures under various Mg2+ concentration within 12 hours. However these rapid annealing process needs the optimum annealing conditions, some of them depends on the sequences of each origami designs. We present a general folding process using effects of temperature distribution in microtube and microchannel, and diffusion length in different staple concentration in folding process of DNA origami.

FrOBO4 Room 7304

Modeling and Simulation (Oral Session)

Chair: Yeow, John T.W. University of Waterloo

Co-Chair: Dong-Kyun, Ko New Jersey Institute of Technology

15:45-16:00 FrOBO4.1

SPICE Compact Model of IGZO Memristor Based on Non-Quasi Statically Updated Schottky Barrier Height, pp. 562-565

Jang, Jun Tae Kookmin University
Min, Jungi Kookmin University
Kim, Donguk Kookmin University
Park, Jingyu Kookmin University
Choi, Sung-Jin Kookmin University
Kim, Dong Myong Kookmin University
Kim, Dae Hwan Kookmin University

A SPICE compact model based on non-quasi statically updated Schottky barrier is proposed and demonstrated in an IGZO memristors with Pd/IGZO/Mo structure. Our model combines the thermionic emission-based conduction and the potentiation/depression based on the Schottky barrier height modulation resulting from the oxygen ion migration or the electron trapping/detrapping at separate interface between the metal electrode and the switching layer. A stretched exponential function is used for non-quasi static update of the Schottky barrier. Proposed model reproduces the time-varying current, the DC *I-V*, and potentiation/depression characteristics very well with concrete parameter-extracting procedure. Our result is potentially useful in the design of devices and circuits for the oxide memristor-based neuromorphic computing.

16:00-16:15 FrOBO4.2

Development of Design Models for Nanomagnetic Logic Based Combinatorial Subsystem, pp. 566-571

Oraon, Neha International Institute of Information Technology Bangalore
Rao, Madhav International Institute of Information Technology Bangalore

Magnetic logic (ML) is considered a feasible alternative to the current CMOS technology, which is constantly shrinking in size to accommodate more circuitry in a chip. In ML, the magnetic domains are considered to render logic levels instead of electric charge used in CMOS based digital circuits. The spins in single domain magnetic dots are used to represent logic levels and magnetic coupling between neighboring dots is employed to

realize the computational output. The ML design involves arranging dots along ferromagnetic and antiferromagnetic ordering to achieve a desired digital output. The optimum dimensions with shape of the dots, spacing between the dots, and few primitive digital gates were extensively studied in the past. In this paper, magnetic dots were arranged to exhibit carry ripple based full adder circuits. One bit and two bit full adder circuit was designed in an open source micromagnetic simulator and transient energy profile is used to propose footprint, delay and energy models for ML based higher order adder subsystems. The proposed ML based adder circuit was compared with other CMOS technology related adder circuits. The proposed model offers insights to design a large ML based digital system.

16:15-16:30 FrOBO4.3

The Field Emission Properties of a New Design: Multi-Pixel Carbon Nanotube Field Emitter for Imaging Application, pp. 572-575

Yeow, John T.W.	University of Waterloo
Sun, Yonghai	University of Waterloo
Cheraghi, Elahe	Department of Systems Design Engineering, University of Waterloo
Liu, Jiayu	University of Waterloo
Chen, Siyuan	University of Waterloo

Abstract— In this study, a patterned cathode, on an n-type doped silicon resistor with a doping concentration of 1014 cm-3 and a cross-section area of 1μm2, is designed for multi-pixel X-ray source with one anode. In this regard, individual carbon nanotube (CNT) field emitter arrays (FEAs) is fabricated by plasma enhanced chemical vapor deposition (PECVD) method on the Si cathode. The cathode has a density of 100×100 CNT arrays, and it is tested for x-ray generation at high voltage, the current and radiation dose are measured during the experiment. At the end of this work, we investigate a 3×3 multi-pixel X-ray source and see if the power of each X-ray pixel can be easily controlled and have more potential to achieve high resolution. For this purpose, COMSOL Multiphysics is used to simulate the electric field.

16:30-16:45 FrOBO4.4

Performance Enhancement of MEMS Based Piezoelectric Pressure Sensor Using Multistep Configuration, pp. 576-579

Bhargava, Mudit	SRM Institute of Science and Technology
Tamboli, Alkausil	SRM University
Kandhasamy, Sivanathan	SRM Institute of Science and Technology

The work presents performance enhancement of MEMS-based piezoelectric pressure sensor using multistep stack configuration. This structural optimization of the piezoelectric sensor exhibited a sensitivity enhancement of 85% for a range of applied pressure compared to the multilayered sensor made from the same volume of Zinc Oxide. We also further investigate the design and analysis of multistep piezoelectric stack configuration of this MEMS sensor for significant characteristic improvisation using COMSOL Multiphysics. The multistep configuration results in the increase of coupling coefficient which ultimately contributes to the increase in sensitivity. The analysis of the evaluated parameters can be used for design and optimization of these MEMS-based sensors for various bio-sensing applications due to the biocompatibility of ZnO. The obtained results for the output voltage of Multistep arrangement at an applied pressure of 2.5kPa was 2.69 V as compared to 0.203V and 0.0186V for Multilayered and Single layered configuration respectively.

16:45-17:00 FrOBO4.5

Highly Symmetrical Cross Nanoantenna Enhanced Random-Oriented Dipole Emission, pp. 580-582

Sun, Song	CAEP Microsystem & Terahertz Research Center
Li, Ma	CAEP Microsystem & Terahertz Research Center
Zhang, Taiping	CAEP Microsystem & Terahertz Research Center
Li, Mo	CAEP Microsystem & Terahertz Research Center

We systematically investigated the emission characteristics of an arbitrarily oriented dipole enhanced by a highly symmetrical plasmonic cross nanoantenna. For a dipole emitter with random orientation, the cross configuration yields much higher average emission enhancement comparing with that of a conventional dimer counterpart. In addition, the intrinsic polarization feature of the dipole source is well-preserved in the far field by using the cross nanoantenna, which cannot be achieved with the dimer configuration.

FrOBO5 Room 7305

Nano-Optics, Nano-Optoelectronics, and Nanophotonics (Oral Session)

Chair: Baek, Chang-Ki	POSTECH / CiTES
Co-Chair: ZHOU, HANG	Peking University Shenzhen Graduate School

15:45-16:00 FrOBO5.1

Interface Engineering to Enhance Photoresponse of Core-Shell Silicon Nanowire Photodetectors, pp. 583-586

Kim, Kihyun	Pohang University of Science and Technology
YOON, SOL	Pohang University of Science and Technology
Cho, Hyeonsu	Pohang University of Science and Technology (POSTECH)
Meyyappan, M.	NASA Ames Research Center
Baek, Chang-Ki	POSTECH / CiTES

The core-shell silicon nanowire photodetector has been reported with enhanced responsivity. The interface traps play critical role to determine the performance of core-shell photodetector. The effect of interface quality on the photo response has been investigated using crystalline silicon and polysilicon shells. The device with single-crystalline silicon shell exhibits higher responsivity than that with polysilicon shell. The performance degradation of polysilicon device is caused by the grain boundaries, which are defect sources. Based on these results, the single-crystalline silicon shell was used for fabricating core-shell silicon nanowire photodetector. The photodetector exhibits the maximum responsivity of 0.51 A/W, which is 10% higher than the planar photodetector. Consequently, the core-shell homogeneous silicon nanowire structure can be a promising component for photodetector application.

16:00-16:15 FrOBO5.2

Size Effect of Inkjet Printed Glycerol-Based Superlenses in Super-Resolution Imaging, pp. 587-588

Jia, Boliang	City University of Hong Kong
Chan, Hoyin	City University of Hong Kong
Wang, Feifei	Stanford University
Zhang, Guanglie	City University of Hong Kong
Li, Wen Jung	City University of Hong Kong

This work investigates the size effect of a novel inkjet printed glycerol-based superlens for super-resolution imaging. The size of superlenses were controlled by number of drops per lens and the jetting voltage. Good consistency of image quality was found the tested superlenses from tens to more than a hundred micrometers in diameter.

16:15-16:30 FrOBO5.3

Patterning Perovskite Thin Film Via CYTOP Assisted Photolithography Process, pp. 589-592

Yan, Lizhi	Peking University Shenzhen Graduate School
Zou, Taoyu	Peking University Shenzhen Graduate School

Liu, Xiyuan — Peking University Shenzhen Graduate School
ZHOU, HANG — Peking University Shenzhen Graduate School

In this study, perovskite patterning is realized by solution-processed with the help of perfluoro (1-butenyl vinyl ether) polymer CYTOP. The CYTOP hydrophobic pattern is prepared by a semi-solidification photolithographic lift-off method. The perovskite precursor is then deposited on the CYTOP free area of the substrate surface. The morphology of the patterned perovskite pattern is characterized. Our results reveal that the perovskite pattern prepared by this method shows good crystallinity and sharp edge. For demonstration, arrays of diodes with a structure of ITO/perovskite/PCBM/BCP/Ag are fabricated.

16:30-16:45 FrOBO5.4

Strongly Enhanced Second and Third-Harmonic Generation in Graphene Metasurfaces, pp. 593-594

You, Jian Wei — University College London
Qun, Ren — University College London
Panoiu, Nicolae — UCL

Using a new homogenization technique, we demonstrate that the effective second- and third-order nonlinear susceptibility of a graphene sheet can be enhanced by more than 100 times by patterning it into a graphene metasurface. This giant enhancement of the nonlinear optical response of graphene metasurfaces is attributable to excitation of surface plasmons on the graphene components of the metasurface. This work may open new avenues to explore novel physical properties of metasurfaces based on graphene.

16:45-17:00 FrOBO5.5

Localized Surface Plasmon Resonance Scanning Microscopy with Optical Antenna on Fiber Taper, pp. 595-597

Chen, Cheng — Shanghai Jiao Tong University
Li, Hongquan — Stanford University
Li, Hui — Shanghai Jiao Tong University
Lei, Zeyu — Shanghai Jiao Tong University
Yang, Tian — Shanghai Jiao Tong University

An 100 nm gold nanosphere integrated at the apex of a fiber taper is used as a scanning probe to map the localized surface plasmon resonance of the samples. With a home-built converted microscope and quartz tuning fork feedback system, high quality LSPR signals and scanning microscopy results have been achieved for a gold nanosphere object.

17:15-17:30 FrOBO5.6

Silver Selenide Colloidal Quantum Dots for Low-Cost Mid-Wavelength Infrared Optoelectronics, pp. 598-599

Shihab Bin, Hafiz — New Jersey Institute of Technology
Michael, Scimeca — New York University
Ayaskanta, Sahu — New York University
Dong-Kyun, Ko — New Jersey Institute of Technology

Monodispersed silver selenide colloidal quantum dots with tetragonal crystal structure were synthesized using hot-injection technique. Optical characterization using Fourier-transform infrared spectroscopy showed a distinct absorption feature in the mid-wavelength infrared. Photoconductive photodetectors based on ligand-exchanged CQD thin film were fabricated via solution processing and device characterization was performed using a lock-in technique. At room temperature, peak reponsivity of 0.4 mA/W were measured at 4.5 μm under 0.25 V bias.

Author Index

Author Index

C,CC: Session Chair

M

N

X

Y

Z

ieeenano.org

IEEE NANO

Nanotechnology Council®

The IEEE Nanotechnology Council (NTC) is a multi-disciplinary group supporting the theory, design, and development of nanotechnology and its scientific, engineering, and industrial applications.

The NTC provides you with opportunities to keep technically up to date through our publications and conferences, network with like-minded colleagues, and take advantage of our educational materials.

The Council sponsors three publications and seven well-recognized conferences, in addition to the Quarterly Newsletter.

For a full list of NTC's sponsored publications and conferences, please visit the NTC website at **ieeenano.org**.

Publications

- **IEEE Transactions on Nanotechnology**
- **IEEE Nanotechnology Magazine**
- **IEEE Transactions on NanoBioscience (T-NB)**
- **IEEE Open Journal on Nanotechnology**
- **IEEE Journal of Photovoltaics (J-PV)**

Conferences

- IEEE International Conference on Nanotechnology (NANO)
- IEEE International Conference on Nano/Micro Engineered and Molecular Systems (NEMS)
- IEEE Nanotechnology Materials and Devices Conference (NMDC)
- International Conference on Manipulation, Manufacturing and Measurement on the Nanoscale (3M-NANO)
- IEEE International Conference on Nano/Molecular Medicine and Engineering (NANOMED)
- International Conference on Manipulation, Automation and Robotics at Small Scales (MARSS)
- Nanotechnology for Instrumentation and Measurement Workshop (NANOfIM)
- IEEE International Conference on Nanomaterials: Applications & Properties (NAP)
- IEEE International Conference on Micro/Nano Sensors for AI, Healthcare, and Robotics (IEEE-NSENS)

Through the Council's sponsored activities, participants have the opportunity to publish and collaborate on research, connect with colleagues, stay current on news and events, develop standards, and participate in educational activities.

Social Media

For more information about these and other NTC activities, please visit our Facebook page at **http://bit.ly/2IwORez**.

Get Involved!

- Networking opportunities on the local level through our Chapters, with technical experts around the world where you can participate in local activities.
- Participate in one of NTC's Technical Committees as a member, write a paper for the Transactions or Magazine, or present a paper at a NTC conference.

The IEEE Nanotechnology Council is part of Division I – Circuits and Devices and is made up of 22 member societies:

- Aerospace & Electronic System Society (AES),
- Antennas & Propagation Society (AP),
- Circuits & Systems Society (CAS),
- Communications Society (COM),
- Electronics Packaging Society (EPS),
- Computational Intelligence Society (CI) [Formerly Neural Networks (NN) Society],
- Computer Society (C),
- Control Systems Society (CS),
- Dielectrics and Electrical Insulation Society (DEIS),
- Electron Devices Society (ED),
- Engineering in Medicine & Biology Society (EMB),
- Electromagnetic Compatibility Society (EMC),
- Industrial Electronics Society (IE),
- Instrumentation & Measurement Society (IM),
- Photonics Society (PS),
- Magnetics Society (MAG),
- Microwave Theory & Techniques Society (MTT),
- Reliability Society (RL),
- Solid State Circuits Society (SSC)
- Robotics & Automation Society (RA),
- Systems, Man, & Cybernetics Society (SMC),
- Ultrasonics, Ferroelectrics, & Frequency Control Society (UFFC)

NANO

2019

Macau SAR, China

IEEE