The 14th IEEE International Conference on Nano/Molecular Medicine and Engineering

VIRTUAL IEEE-NANOMED

2020

TECHNICAL PROGRAM

IEEE

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December 14-16, 2020

Virtual IEEE-NANOMED 2020 Technical Program

December 2020

Design: Min Kim

Virtual IEEE-NANOMED 2020

December 2020

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Virtual IEEE-NANOMED 2020

The 14th IEEE International Conference on Nano/Molecular Medicine & Engineering
December 14-16, 2020

IEEE

IEEE Nanotechnology Council®

On behalf of
the IEEE Nanotechnology Council
& the conference organizing
committee

WELCOME

Welcome all of you to the 14th IEEE International Conference on Nano/Molecular Medicine and Engineering (IEEE NANOMED 2020) as held on-line from December 14-16, 2020. IEEE NANOMED is an annual conference organized by the IEEE Nanotechnology Council, to attract together scientists, engineers, and even for medical doctors, etc. Due to Covid-19 pandemic, the conference must be operated virtually at this moment.

This conference has managed to invite leading scientists to give 3 plenary talks, 3 keynote talks, and 11 invited session presentations for the topic reviews and future perspectives of NANOMED fundamentals and applications. We will invite some presentations to publish their research works in special issues, including Biomicrofluidics, Micromachines, IEEE Nanotechnology magazine and IEEE Open Journal of Nanotechnology. We hope these special issues of Journals can inspire more people to present their excellent research results in Nano/Molecular Medicine and Engineering fields.

Before we kick-off IEEE NANOMED 2020, we want to express our appreciativeness to every attendance who contributed your works. Without your brilliant ideas and elegant works, the conference cannot be attractive. We also want to thank our conference organizers, technical program committee members, our sponsors and the great organizing committee members. We hope all of you can enjoy this virtual conference.

Please don't forget being ready for IEEE NANOMED 2021 at Okinawa, JAPAN.

Your Conference General Chair,

Jeffrey Da-Jeng YAO
Nat'l Tsing Hua Univ., Hsinchu, Taiwan

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Virtual IEEE-NANOMED 2020

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December 14 [Monday]		
Time (TWN)	RM 001	
08:30-08:50	**Opening Ceremony**	
08:50-09:35	**Plenary Lecture 1**: Tza-Huei (Jeff) WANG, Johns Hopkins Univ., USA (Chair: Da-Jeng YAO) *"Advancing DNA Analysis and Diagnostics by Micro- and Nano-Technologies"*	
09:35-10:10	**Keynote Lecture 1**: In-Kyu PARK, Korea Advanced Inst. of Science & Technology, Korea (Chair: Da-Jeng YAO) *"Biomedical Needles Integrated with Flexible Physical/Chemical Sensor Array Towards Advanced Clinical Procedures"*	
10:10-10:20	*Break (10 min)*	
10:20-11:50	RM 001	RM 002
	Invited Session 1: Micro/Nano-Engineered Devices for Advanced Biosensing Chair: Inkyu PARK	**Invited Session 2**: Technologies for Diagnostic & Therapeutic Applications Chair: Aaron OHTA
11:50-12:00	*Break (10 min)*	
12:00-13:30	RM 001	RM 002
	Invited Session 3 Micro/Nano Diagnostics & Therapeutics Chair: Yi ZHANG	**Invited Session 4** Micro/Nano Devices for Biomedical Sensing & Actuation Chair: Ting-Hsuan CHEN

December 15 [Tuesday]		
Time (TWN)	RM 001	
08:30-09:15	**Plenary Lecture 2**: Pengtao LIU, Univ. of Hong Kong, China (Chair: Jin-Woo KIM) *"Establishment of Mammalian Expanded Potential Stem Cells"*	
09:15-09:50	**Keynote Lecture 2**: Takahiro ARAKAWA, Tokyo Medical & Dental Univ., Japan (Chair: Jin-Woo KIM) *"Wearable Biosensors & Bio-imaging System of Volatile Organic Compounds for Healthcare Monitoring"*	
09:50-10:00	*Break (10 min)*	
10:00-11:30	RM 001	RM 002
	Invited Session 5: Nanomaterials and Nanodevices for Healthcare Applications Chair: Zhong-Hong LIN	**Invited Session 6**: Nanomaterials and Nanodevices for Biosensing Applications Chair: Jungmok SEO
11:30-11:40	*Break (10 min)*	
11:40-13:10	RM 001	RM 002
	Invited Session 7: Micro/Nano Technology for Bio/Chemical Applications Chair: Chien-Fu CHEM	**Invited Session 8**: Micro/Nano Engineering for Bio- & Medical Applications Chair: Yoshikazu HIRAI

IEEE-NANOMED Virtual Sessions are all in time zone in Taiwan
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December 16 [Wednesday]		
Time (TWN)	RM 001	
08:30-09:15	**Plenary Lecture 3**: Chao-Min CHENG, Nat'l Tsing Hua Univ., Taiwan (Chair: Pak Kin WONG) *"IL-6 Diagnostic Device for COVID-19 and Its Clinical Validations"*	
09:15-09:50	**Keynote Lecture 3**: Samuel YANG, Stanford Univ., USA (Chair: Pak Kin WONG) *"Absolute Quantification of SARS-CoV-2 RNAemia by Digital PCR Predicts Severity & Extrapulmonary Complications"*	
09:50-10:00	*Break (10 min)*	
10:00-11:30	RM 001	RM 002
	Invited Session 9: Advances in Soft Nano/Bio Materials for Bioengineering & Medicine Chair: Jin-Woo KIM	**Invited Session 10**: Biosensing for Biomedical Applications Chair: Thomas LEI
11:30-11:40	*Break (10 min)*	
11:40-13:10	RM 001	RM 002
	Invited Session 9: Cont.	**Invited Session 11**: Microfluidics, Analytical Chemistry & Biosensing Chair: Pin-Chuan CHEN

IEEE-NANOMED 2020

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Plenary & Keynote Sessions

PL1 Advancing DNA Analysis & Diagnostics by Micro- & Nano-Technologies
PL Speaker: **Tza-Huei WANG**, Johns Hopkins Univ., USA
Session Chair: Da-Jeing YAO, Nat'l Tsing Hua Univ., Taiwan | Time: 08:50-09:35 (TWN), December 14, 2020 (Room 001)

PL2 Establishment of Mammalian Expanded Potential Stem Cells
PL Speaker: **Pengtao LIU**, Univ. of Hong Kong, China
Session Chair: Jin-Woo KIM, Univ. of Arkansas, USA | Time: 08:30-09:15 (TWN), December 15, 2020 (Room 001)

PL3 IL-6 Diagnostic Device for COVID-19 & Its Clinical Validations
PL Speaker: **Cao-Min CHENG**, Nat'l Tsing Hua Univ., Taiwan
Session Chair: Pak Kin WONG, Pennsylvania State Univ., USA | Time: 08:30-09:15 (TWN), December 16, 2020 (Room 001)

KN1 Biomedical Needles Integrated with Flexible Physical/Chemical Sensor Array Towards Advanced Clinical Procedures
KN Speaker: **In-Kyu PARK**, Korea Advanced Institute of Science & Technology, Korea
Session Chair: Da-Jeing YAO, Nat'l Tsing Hua Univ., Taiwan | Time: 09:35-10:10 (TWN), December 14, 2020 (Room 001)

KN2 Wearable Biosensors & Bio-Imaging System of Volatile Organic Coumpounds for Healthcare Monitoring
KN Speaker: **Takahiro ARAKAWA**, Tokyo Medical & Dental Univ., Japan
Session Chair: Jin-Woo KIM, Univ. of Arkansas, USA | Time: 09:15-09:50 (TWN), December 15, 2020 (Room 001)

KN3 Absolute Quantification of SARS-CoV-2 RNAemia by Digital PCR Predicts Severity & Extrapulmonary Complications
KN Speaker: **Samuel YANG**, Standford Univ., USA
Session Chair: Pak Kin WONG, Pennsylvania State Univ., USA | Time: 09:15-09:50 (TWN), December 16, 2020 (Room 001)

Invited Sessions

IS1 Micro/Nano-Engineered Devices for Advanced Biosensing
Session Chair: In-Kyu PARK, Korea Advanced Inst. of Science & Technology, Korea
Time: 10:20-11:50 (TWN), December 14, 2020 (Room 001)

IS2 Technologies for Diagnostic & Therapeutic Applications
Session Chair: Aaron OHTA, Univ. of Hawaii, USA
Time: 10:20-11:50 (TWN), December 14, 2020 (Room 002)

IS3 Micro/Nano Diagnostics & Therapeutics
Session Chair: Yi ZHANG, Nanyang Technological Univ., Singapore
Time: 12:00-13:30 (TWN), December 14, 2020 (Room 001)

IS4 Micro/Nano Devices for Biomedical Sensing & Actuation
Session Chair: Cecil CHEN, City Univ. of Hong Kong, China
Time: 12:00-13:30 (TWN), December 14, 2020 (Room 002)

IS5 Nanomaterials & Nanodevices for Healthcare Applications
Session Chair: Zhong-Hong LIN, Nat'l Tsing Hua Univ., Taiwan
Time: 10:00-11:30 (TWN), December 15, 2020 (Room 001)

IS6 Nanomaterials & Nanodevices for Biosensing Applications
Session Chair: Jungmok SEO, Yonsei Univ., Korea
Time: 10:00-11:30 (TWN), December 15, 2020 (Room 002)

IS7 Micro/Nano Technology for Bio/Chemical Applications
Session Chair: Chien-Fu CHEN, Nat'l Taiwan Univ., Taiwan
Time: 11:40-13:10 (TWN), December 15, 2020 (Room 001)

IS8 Micro/Nano Engineering for Bio- & Medical Applications
Session Chair: Yoshikazu HIRAI, Kyoto Univ., Japna
Time: 11:40-13:10 (TWN), December 15, 2020 (Room 002)

IS9 Advances in Soft Nano/Bio Materials for Bioengineering & Medicine
Session Chair: Jin-Woo KIM, Univ. of Arkansas, USA
Time: 10:00-11:30 (TWN), December 16, 2020 (Room 001)

IS10 Biosensing for Biomedical Applications
Session Chair: Thomas LEI, Chang Gung Univ., Taiwan
Time: 10:00-11:30 (TWN), December 16, 2020 (Room 002)

IS11 Microfluidics, Analytical Chemistry & Biosensing
Session Chair: Pin-Chuan CHEN, Nat'l Taiwan Univ. of Science & Technology, Taiwan
Time: 11:40-13:10 (TWN), December 16, 2020 (Room 002)

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ABSTRACTS

Plenary & Keynote Sessions

Advancing DNA Analysis and Diagnostics by Micro- and Nano-Technologies

PL1: 08:50 – 09:35
Monday, December 14, 2020
Location: RM 001

Tza-Huei (Jeff) WANG

Johns Hopkins University, USA
thwang@jhu.edu

Abstract

Molecular analysis of biomarkers including genetic and epigenetic markers underpins modern disease detection and diagnostics. This talk will introduce three technology platforms that advance DNA analysis for clinical diagnostic applications. I will first talk about the implementation of silica nanomaterials for improving DNA sample preparation. Two examples will be introduced including an integrated DNA extraction and bisulfite conversion method for enhanced methylation detection of cancer, and an ultrahigh molecular weight DNA extraction method for long read DNA sequencing application. I will then present a digital detection platform that integrates microfluidic digital PCR and high-resolution melt (HRM) techniques for highly sensitive detection and discrimination of heterogeneous DNA methylation of cancer in liquid biopsy. Finally, I will describe a droplet magnetofluidic technology that facilities fully integrated sample preparation and DNA detection on a portable device for point-of-care diagnostic applications exemplified by detection of infectious diseases.

Short Bio

Jeff Wang is a professor in Mechanical and Biomedical Engineering at JHU, where he has served on the faculty since 2002. He earned his doctorate in mechanical engineering from UCLA in 2002. His research focuses on the development of new technologies for molecular analysis and biomedical research via advances in micro- and nano-scale sciences. He has contributed to developments in single-molecule fluorescence spectroscopy, microfluidics and nano-biosensors for genetic and epigenetic biomarker-based diagnostics of cancer, infectious disease and an array of other diseases. Wang is an inventor of 20 patents, and has authored 130 research articles and 120 abstracts and oral presentations. He received the NSF CAREER Award in 2006, CSR Jorge Heller Award in 2007, ASGR Excellence in Research Award in 2007, the JALA Ten Award in 2011. He is a Fellow of the American Institute for Medical and Biological Engineering (AIMBE), American Society of Mechanical Engineering (ASME), Institute of Electrical and Electronics Engineers (IEEE) and Royal Society of Chemistry (ROC).

Establishment of Mammalian Expanded Potential Stem Cells

PL2: 08:30 – 09:15
Tuesday, December 15, 2020
Location: RM 001

Pengtao LIU

The University of Hong Kong, HK, China
pliu89@hku.hk

Abstract

Mouse embryonic stem cells (ESCs) derived from the epiblast contribute to the somatic lineages and the germline upon reintroduction to the blastocyst but are excluded from the extraembryonic tissues that are derived from the trophectoderm (TE) and the primitive endoderm (PrE). By inhibiting signal pathways implicated in the immediate post-ZGA embryo development, we established cultures of expanded potential stem cells (EPSCs) from individual 4- or 8-cell embryo blastomeres, by direct conversion of mouse embryonic stem cells (ESCs) and by reprogramming somatic cells. A single EPSC can contribute to both the embryo proper and the TE lineages in the chimera assay. Bona fide trophoblast stem cell (TSC) lines, extraembryonic endoderm stem (XEN) cells, and ESCs could be directly derived from EPSCs in vitro. Molecular analyses of the epigenome and single-cell transcriptome revealed enrichment for blastomere-specific signature and a dynamic DNA methylome in EPSCs. The EPSC concept has enabled establishing EPSCs of other mammalian species including human, and pig and cow where robust ESCs are not currently available. The EPSCs across species share similar molecular features, and can differentiate to extra-embyonic as well as embryonic cell lineages in vitro, and in vivo in the case of pig and cow EPSCs. The successful generation of EPSCs produces new tools for investigation of embryonic development, and opens a wealth of avenues for translational research in biotechnology, agriculture, and genomics and regenerative medicine.

Short Bio

Dr. Liu graduated from Henan Normal University in China. He obtained his MPhil from Institute of Genetics, Chinese Academy of Sciences, and received a Ph.D. from Baylor College of Medicine USA. Dr. Liu did his postdoc training at National Cancer Institute USA. He is currently a Professor in stem cell biology at the University of Hong Kong. Prior to joining the HKU, he was a Senior Group Leader at Wellcome Trust Sanger Institute in Cambridge, U.K. Dr. Liu's laboratory studies stem cells, development, genomics, immunity and cancer. His research group has successfully isolated new stem cells that display totipotency features from multiple mammalian species including mouse, human and pig. These stem cells offer new tools for studying embryonic development and human disease, and open avenues for translational research in cancer therapy, regenerative medicine, biotechnology and agriculture.

IL-6 Diagnostic Device for COVID-19 and Its Clinical Validations

PL3: 08:30 – 09:15
Wednesday, December 16, 2020
Location: RM 001

Chao-Min CHENG

National Tsing Hua University, Taiwan
chaomin@mx.nthu.edu.tw

Abstract

The COVID-19 severity test strip is based on lateral flow immunoassay, which may help the clinicians to assess the severity of COVID-19 patients. The test strip targets a cytokine in patient serum known as Interleukin-6 (IL-6). Researches have shown that IL-6 may play an important role in development of respiratory failure, shock, multi-organ dysfunction, or even cytokine storm. Therefore, taking serum IL-6 as the targeting biomarker, can help predicting disease progression. As a result, the gold nanoparticles accumulate on the test line to perform color signal. Through test strip modification and in coordination with a reader, a cutoff value can be defined which is related to the color signal. In clinical situation, if the testing value reaches the cut-off value, this means that the patient may be in danger of respiratory dysfunction, and immediate actions such as intubation is required.

Short Bio

Chao-Min Cheng received his Ph. D. in 2009 from Carnegie Mellon University (Biomedical Engineering Department). He then did his post-doctoral training with Prof. George M. Whitesides at Harvard University where he helped develop paper diagnostic systems to address global public health concerns. He is currently a tenured professor at National Tsing Hua University, Taiwan, where he started in the summer of 2011, and recently has been selected as the Fellow of Royal Society of Chemistry. He has been blessed to receive "Ta-You Wu Memorial Award" and "Outstanding Research Award" from Taiwan's Ministry of Science and Technology. He was also an invited attendee for the NAS Sackler Colloquium at the National Academy of Sciences, and his research was highlighted in the National Academies–Keck Futures Initiative, Scientific American, Chemistry World, New York Times, and Lab on a Chip (along with a number of other media outlets). He has been currently an Associate Editor in Journal of Cellular and Molecular Medicine, and an Editorial Board Member in Sensor Letters, Diagnostics and Scientific Reports. He also has served as a consultant for biotechnologically relevant companies around the world with several Taiwan, U.S. and China patents granted.

Biomedical Needles Integrated with Flexible Physical / Chemical Sensor Array Towards Advanced Clinical Procedures

KN1: 09:35 – 10:10
Monday, December 14, 2020
Location: RM 001

Inkyu PARK

KAIST, Korea
inkyu@kaist.ac.kr

Abstract

Recently, clinical procedures require higher precision based on quantitative measurement data, and thus the needs of advanced detection systems are rapidly increasing in this field. Furthermore, with the advent of internet of things (IoT) and related sensor technologies, integrated sensors such as miniaturized pressure sensors in catheter and implantable glucose sensors are being widely adopted in the clinical applications. In this talk, we introduce our recent development on the flexible biophysical/biochemical sensors that can be integrated on medical needles for cancer diagnosis and treatment procedures. In the first part, we explain about a multiplexed biophysical and biochemical sensor array for the quick diagnosis and differentiation of tumor lesion from the normal tissue during the image-guided biopsy procedure [1]. A flexible device with an electrical conductivity sensor, a pH sensor, a glucose sensor, and a lactate sensor was fabricated on a thin flexible polyimide substrate. Then, the sensor was directly integrated onto the surface of biopsy needle. The capabilities of dual-modal and multi-modal sensing were demonstrated by tests with a liver cancer mimicking hydrogel phantom, a solution sample, and porcine liver tissue with exchanged parameters. In the second part, we explain about a multi-layered sensor array for the in-situ measurement of pressure and temperature during the radio-frequency (RF) ablation procedure of cancer tissues [2]. In this research, an ultrathin, biocompatible, and flexible pressure sensor with a wide pressure range has been developed and applied in biomedical applications. The pressure sensing mechanism is based on the variation of contact resistance between an electrode and a three-dimensional microstructured polyimide/carbon nanotube composite film. It was verified that the developed sensor shows real-time detection of steam popping phenomena both in bovine liver and human liver tissues during pre-clinical and clinical tests.

[1] J. Park, Y. Jeong, J. Kim, J. Gu, J. Wang, and I. Park, "Biopsy needle integrated with multi-modal physical/chemical sensor array", Biosens. Bioelectron., Vol. 148, pp. 111822, 2020
[2] Y. Jeong, J. Park, J. Lee, K. Kim, I. Park, "Ultrathin, biocompatible, and flexible pressure sensor with a wide pressure range and its biomedical application", ACS Sensors, Vol. 5, pp. 481-489, 2020

Short Bio

Prof. Inkyu Park received his B.S., M.S., and Ph.D. from KAIST (1998), UIUC (2003) and UC Berkeley (2007), respectively, all in mechanical engineering. He has been with the department of mechanical engineering at KAIST since 2009 as a faculty and is currently a KAIST Endowed Chair Professor and Full Professor. His research interests are nanofabrication, smart sensors, nanomaterial-based sensors and flexible & wearable electronics. He has published more than 120 international journal articles (SCI indexed) and 160 international conference proceeding papers in the area of MEMS/NANO engineering (h index=37, total citation >7400). He is a recipient of IEEE NANO Best Paper Award (2010), HP Open Innovation Research Award (2009-2012), KINC Fusion Research Award (2016, 2018), Grand Prize of KAIST School of Engineering Research Innovation Award (2020), and Excellent Researcher Award from the Society of Micro/Nano-Systems (2020).

Wearable Biosensors and Bio-imaging System of Volatile Organic Compounds for Healthcare Monitoring

KN2: 09:15 – 09:50
Tuesday, December 15, 2020
Location: RM 001

Takahiro ARAKAWA

Tokyo Medical and Dental University, Japan
arakawa.bdi@tmd.ac.jp

Abstract

A measurement of biophysical quantities of human body has been investigated for the medical and healthcare fields. Many wearable sensors have been developed and commercialized in the world because of their perspectives for human monitoring of relevant parameters in healthcare, sports and medical applications. Utilization of biophysical information with the systems are expected to provide proactive management of health that can improve public health and reduce medical expenditure. I introduce two topics of wearable biosensors: tear and saliva glucose biosensors. Our group have developed soft contact lens biosensor for tear chemicals, and oral cavity biosensors such as mouthguard biosensor for salivary analysis. I'll present the challenges regarding the integration of biosensors into monitoring for biological information and daily medicine of human body. In addition, progress in analytical devices has enabled to measure minute amounts of odorous material and volatile chemical compounds in recent years. Human breath and skin volatile in particular, such as gases from halitosis and body odor, contain compounds produced by metabolic processes and ailment-specific compounds. Measurement of these volatile biological compounds is expected to simplify metabolic capacity evaluation, medical diagnostics, and disease screening. We have developed a novel two-dimensional fluorometric imaging system for ethanol vapor released from human breath and palm skin. This imaging system measures ethanol vapor concentrations as intensities of fluorescence of nicotinamide adenine dinucleotide (NADH) through an enzymatic reaction induced by alcohol dehydrogenase. This NADH fluorometric imaging system achieved the two-dimensional real-time imaging of ethanol vapor distribution at ppb level concentration. We applied the imaging system for measurement of breath ethanol vapor and skin ethanol vapor from a human palm. The system showed a rapidly and accurately responses and a visible measurement, which could lead an analysis to metabolism function at real time in the near future.

Short Bio

Dr. Takahiro Arakawa is currently a Junior associate professor of Department of Biomedical Devices and Instrumentation at Tokyo Medical and Dental University. He received his BS, MS degrees from Waseda University in 2002 and 2004, respectively. He finished the Ph.D. course in Nano-science and Nano-engineering, and received the Ph.D. degree in "Microfluidic system for cell analysis" Waseda University in 2007. In 2008, he joined a post-doctoral research fellow of Japan Society for the Promotion of Science (JSPS, PD) at the Laboratory of Bioanalytical Chemistry the University of Tokyo. Since 2009, he was an Assistant professor of Tokyo Medical and Dental University. He has been a Junior Associate Professor since 2014. He joined Departments of Electrical Engineering and Bioengineering at University California Los Angeles as a visiting researcher from 2017 to 2018. Dr. Arakawa holds 10 issued patents, and is also the co-author of more 20 books in Japanese and 5 books in English, and the co-author of 80 peer-reviewed publications in scientific journals. His research interests include micro electromechanical system, biosensors, optical system, microfluidics, and bio microsystems for medical and healthcare applications.

Absolute Quantification of SARS-CoV-2 RNAemia by Digital PCR Predicts Severity and Extrapulmonary Complications

KN3: 09:15 – 09:50
Wednesday, December 16, 2020
Location: RM 001

Samuel YANG

Stanford University, USA
syang5@stanford.edu

Abstract

SARS-CoV-2 has caused over 50 million infections and 1 million deaths and is associated with many extrapulmonary complications. Digital PCR (dPCR) offers improved sensitivity, precision, reproducibility, and quantification compared to conventional quantitative PCR (qPCR). In addition to assessing the performance characteristics of dPCR in detecting and quantifying SARS-CoV-2 RNA, we describe its potential prognostic role in predicting both overall clinical severity and extrapulmonary complications of COVID-19 from viral RNA measurements in plasma at the time of patient presentation. RNA was extracted from serial nasopharyngeal (NP) swabs and plasma from 310 patients with suspected COVID-19 (184 clinically positive) and tested using the same multiplex viral RNA assay performed on both qPCR and array based digital PCR (dPCR) platforms. We characterized the bivariate relationships between detectable RNAemia and overall clinical severity or extrapulmonary complications (EPCs) using chi-squared tests, and between absolute viral RNA load and severity using Pearson's correlation. We used elastic-net regularized regression to quantify the impact of RNAemia in predicting severe disease and EPCs, conditional on other demographic, past medical, symptomatic, and laboratory features. We found that the multiplex dPCR was more sensitive and consistent between targets than qPCR in detecting viral RNA in both NP swabs and plasma. Of the 83 serially collected (day 0, 3, 7, 30) NP swabs from COVID-19 positive patients, dPCR had a 43% higher detection rate than qPCR. dPCR also detected viral RNA in 3/79 COVID-19 negative NP samples that were also missed by qPCR. Among the 18 inconclusive NP results by qPCR, 15 were correctly resolved by dPCR. At time of enrollment, 24% of NP qPCR positive patients had RNAemia by dPCR. Viral RNAemia can be detected as early as day 0 from symptom onset. Both the presence and level of viral RNAemia were associated with severity of disease (WHO score 5-8). Viral RNAemic patients also tended towards higher rates of extrapulmonary complications, with hepatobiliary and immunological complications being the most significantly correlated. Controlling for demographic, historical, and laboratory findings on presentation, RNAemic patients had 3.26 times greater odds than non-RNAemic patients of developing severe disease (95% CI, 1.03 – 10.43), and 4.9 times greater odds of developing EPCs (95% CI, 1.57 – 17.04). These results suggest a potential role of hematogenous viral dissemination in the pathogenesis of COVID-19 and its complications, and quantify the prognostic benefit of RNAemia independent of previously described risk factors for severe COVID-19.

Short Bio

Samuel Yang is an Associate Professor of Emergency Medicine at Stanford University School of Medicine. He received his B.S. at Massachusetts Institute of Technology and M.D. at UCLA School of Medicine. He received residency and research fellowship training in Emergency Medicine at Johns Hopkins Hospital before joining faculty at Johns Hopkins University School of Medicine. He is currently a practicing attending physician in the Emergency Department at Stanford Hospital. His research laboratory is focused on developing precision diagnostics and predictive analytics for acute infections. He has successfully led highly complex interdisciplinary research and has made significant scientific contributions in several areas, including molecular diagnostics, biomedical engineering, genome science, computational biology, and translational medicine. His research has been well supported through federal grants. He is currently leading the COVID-19 Biobank effort at Stanford University.

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ABSTRACTS

Invited Sessions

Micro/Nano-engineered Devices for Advanced Biosensing

IS1: 10:20-11:50
Monday, December 14, 2020
Location: RM 001

Session Chair: **Inkyu PARK**
Korea Advanced Institute of Science and Technology (KAIST), Korea

Description

The importance of biosensing is rapidly increasing in the era of internet of things (IoT), smart medicine, and ubiquitous healthcare technologies. In this context, this session focuses on the micro/nano-engineering enabled structures and devices for the advanced biosensing applications. The topic includes tissue engineering, neural probes, 2D nanomaterial based sensors, electrochemiluminescence sensors, SERS based biosensors, implantable glucose sensing, hydrogel biosensors, biodegradable electronics, etc.

IS1.1 Anisotropically Aligned 3D Collagen Scaffolds for Neural Tissue Engineering, Nakwon CHOI, Korea Institute of Science and Technology (KIST), Korea

Abstract

In native tissues, cellular and acellular components are anisotropically organized and often aligned in specific directions, providing structural and mechanical properties for actuating biological functions. Thus, engineering alignment not only allows for emulation of native tissue structures but might also enable implementation of specific functionalities. However, achieving desired alignment is challenging, especially in three-dimensional constructs. By exploiting the elastomeric property of polydimethylsiloxane and fibrillogenesis kinetics of collagen, here we introduce a simple yet effective method to assemble and align fibrous structures in a multi- modular three-dimensional conglomerate. Applying this method, we have reconstructed the CA3–CA1 hippocampal neural circuit three-dimensionally in a monolithic gel, in which CA3 neurons extend parallel axons to and synapse with CA1 neurons. Furthermore, we show that alignment of the fibrous scaffold facilitates the establishment of functional connectivity. This method can be applied for reconstructing other neural circuits or tissue units where anisotropic organization in a multi-modular structure is desired.

Short Bio

Nakwon Choi is Principal Researcher at Brain Science Institute, Korea Institute of Science and Technology (KIST). He received his B.S. in chemical engineering from Seoul National University in 2004, and later M.S. and Ph.D. in chemical engineering from Cornell University in 2008 and 2010. He continued at Cornell University as a postdoctocal associate. Then, he moved to Novartis Institutes for Biomedical Research (NIBR) and Massachusetts Institute of Technology (MIT) as a NIBR presidential postdoctoral fellow. Since 2012, he has started his laboratory at KIST and been focusing on developing enabling technology platforms such as 3D neural culture models.

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IS1.2 Miniaturized and Portable Electrochemiluminescence Biosening Platform with Laser-Induced Graphene based Electrodes, Sanket GOEL, Birla Institute of Technology and Science, Pilani-Hyderabad Campus, India

Abstract

The rising need of miniaturized point-of-care (POC) devices has led to the cost-effective solutions due to their simple operation and fast response. For such devices, amongst various detection mechanisms, Electrochemiluminescence (ECL), a combination of electrochemistry (EC) and chemiluminescence (CL), has proven to be a highly sensitive method providing excellent specificity, cost-efficiency and flexibility. Such ECL systems have wide range of applications such as environmental monitoring, food control and biomedical diagnostics. With this impetus, herein, CO2 Laser-Induced Graphene (LIG) based ECL system, integrated with Bipolar Electrode (BPE) and Single Electrode (SE), has been developed. Further, its application for enzymeless sensing of various biomarkers, such as H2O2, Glucose (G), Xanthine (X), Dopamine (D) and vitamin B12, has been validated. Low-cost and easily available flexible polyimide (PI) sheet has been effectively used for the fabrication of such device. The electrodes were fabricated on PI substrate by creating optimized LIG in a single-step. With optimized speed and power of CO2 Laser, non-conducting portion of PI gets converted into conducting zone (electrodes) for ECL imaging. A 3D printed miniaturized portable system was developed to detect and monitor the ECL signals. Further, bulky external power supply was replaced by android smartphone, which was used to not only supply power to ECL sensor through DC to DC buck boost converter but also to capture the ECL images. With miniaturized portable 3D printed platform, sensing of these biomarkers was accomplished by different sets of ECL platforms for the extended linear range. Excellent limit of detection (LOD) was measured for different biomarkers beyond the benchmarked values. Therefore, developed 3D printed portable miniaturized ECL platform can be used in broad areas such as food control, biomedical applications and in point of care testing (POCT) systems.

Short Bio

Sanket Goel headed the Department of Electrical and Electronics Engineering Department at BITS-Pilani (2017-2020), and R&D department at the University of Petroleum & Energy Studies (UPES) (2011-2015). Sanket did his BSc (H-

Physics) from Ramjas College, Delhi University; MSc (Physics) from IIT Delhi; PhD (Electrical and Computer Engineering) from University of Alberta, Canada in 1998, 2000, and 2006 respectively. He has worked with Institute of Plasma Research, Gandhinagar (2000-2001) and DEBEL-DRDO, Bangalore (2006). Sanket did his postdoc at Stanford University (2006-2008) and was a PI with ASTAR, Singapore (2008- 20011). His lab focusses on MEMS, Microfluidics and Nanoelectronics for Energy and Bio Applications, where he has been implementing several Indian and overseas funded projects. Sanket has won several awards, like Fulbright fellowship (2015), American Electrochemical Society's Best students paper award (2005) and University of Alberta PhD thesis award (2005). Sanket has >180 publications and 12 patents to his credits, and has delivered >70 invited talks and guided/guiding 25 PhD students. He is an Associate Editor of IEEE Transactions on NanoBioscience, IEEE Sensors Journal, IEEE Access and Applied Nanoscience. He is also a Visiting Associate Professor with UiT, The Arctic University of Norway.

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IS1.3 Implantable SERS Device for Glucose Detection, Daejong YANG, Kongju National University, Korea

Abstract

Diabetes is a chronic disease, 463 million patients in the world suffer from it in 2019. That means one in 11 adults has diabetics. In order to prevent complications, continuous glucose monitoring is the most effective and simple method to control the glucose level. However, patients are feeling reluctant to draw blood several times a day. Many methods have been developed to alleviate the pain, and we would like to introduce a novel non-invasive measurement for glucose level sensing by using surface-enhanced Raman-scattering (SERS). We have developed a high-sensitive and uniform SERS substrate consisting of 3D stacked gold nanoparticle clusters. The substrates were fabricated by the hydrothermal synthesis of ZnO nanowire template and repeated liquid phase deposition of Au nanoparticles. To connect glucose molecules and the SERS substrate mercaptophenylboronic acid (MPBA) was coated on the substrate to act as a linker molecule. Bonding of glucose to MPBA suppresses the breathing mode of MPBA and promotes the constrained-bending mode. Due to the vibration mode change, the most dominant SERS peak of MPBA located at 1071 cm-1 moves toward larger wavenumbers. The SERS-peak shifts mechanism was analyzed by numerical simulations based on density functional theory and verified by experimental measurement. We have implanted the SERS disk in the anterior chamber of rabbit eyes and successfully measured glucose concentration in aqueous humor.

Short Bio

Daejong Yang is an Assistant Professor in the Department of Mechanical and Automotive Engineering and the Department of Future Convergence Engineering at Kongju National University in the Republic of Korea since 2018. He is a member of the board of directors of the IT Convergence division, Korean Society of Mechanical Engineers (KSME). He researched flexible sensor devices based on nanomaterials in the Department of Nanoengineering at the University of California, San Diego (UCSD) from 2014 to 2015 and also researched optical biosensors in the Department of Medical Engineering at the California Institute of Technology (Caltech) from 2015 to 2018. Based on these researches, his research group has developed novel fabrication methods for 0 and 1-dimensional nanomaterials for applications in bio and chemical sensors.

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IS1.4 Multifunctional Hydrogel Microparticles for Biomedical Sensing Applications, Hiroaki ONOE, Keio University, Japan

Abstract

Theranostics is a new medicine field, which integrates specific "diagnosis" and "therapy" into one system. This field is gathering attention because devices of theranostics can obtain in-body information and deliver therapeutic drugs at the same time. This property makes it possible to carry out appropriate therapy to the local point depending on the diagnostic results. Therefore, we can reduce the drug dose and mitigate the burden to the patients [1][2].

For the application of theranostics, multi-materials need to be contained in microdevices, such as hydrogel particles and micelles. However, currently reported theranostic microparticles contain multiple materials in a single location without any protection layer [3], since it is difficult to fabricate structure-controlled microparticles. This leads to a limitation of material combination and causes adhesion to medical tools and leakage of encapsulated materials. Even if the particles are compartmentalized and encapsulate different materials, multiple preparation steps are often required. In this presentation, I introduce a one-step fabrication of core-shell Janus microparticles for the application of theranostics. Our microparticles can contain two functional hydrogels and encapsulate material in each hemisphere covered by the biocompatible hydrogel shell. The Janus structure together with the core-shell structure in one particle was formed by ejecting a pre-gel solution of mixed acrylate monomer with sodium alginate followed by photo-polymerization and ionic crosslinking, simultaneously. To demonstrate this concept works, microparticles that have a glucose detection hemisphere, a drug model (FITC-dextran) release hemisphere and an alginate protection layer was fabricated and examined by implanting these microparticles in biological tissue for transdermal detection of glucose and release of the encapsulated FITC-dextran driven by external stimuli.

[1] S. S. Kelkar and T. M. Reineke, "Theranostics: Combining imaging and therapy," Bioconjug. Chem., vol. 22, no. 10, pp. 1879–1903, 2011.

[2] Y. Wang, M. S. Shim, N. S. Levinson, H. W. Sung, and Y. Xia, "Stimuli-responsive materials for controlled release of theranostic agents," Adv. Funct. Mater., vol. 24, no. 27, pp. 4206–4220, 2014.

[3] D. Park, Y. Cho, S. H. Goh, and Y. Choi, "Hyaluronic

acid-polypyrrole nanoparticles as pH-responsive theranostics," Chem. Commun., vol. 50, no. 95, pp. 15014–15017, 2014.

Short Bio

Hiroaki Onoe, received his Ph.D. in Mechano-Informatics at The University of Tokyo under the supervision of Prof. Isao Shimoyama in 2006. Since 2007, he moved to University of California Berkeley and worked with Prof. Richard Mathies in Department of Chemistry as a visiting scholar. Since 2009, he began to work with Prof. Shoji Takeuchi at Institute of Industrial Science at The University of Tokyo as an assistant professor. Since 2014, he has joined to Keio University, Japan, and is now an associate professor in the Department of Mechanical Engineering. He received Igarashi Award from The Institute of Electrical Engineers of Japan in 2012, and The Young Scientist's Prize, The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology in 2017. His research interests include microfluidics, biofabrication, functional materials and self-assembly technologies.

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IS1.5 Biodegradable Electronic Stimulator for Peripheral Nerve Regeneration, Jahyun KOO, Korea University, Korea

Abstract

Biodegradable electronic stimulators have rapidly high interest as unusual therapeutic platforms, as a type of implantable devices, for treating disease states, accelerating wound healing processes and eliminating infections. Here, we present advanced materials that support required modes of operation over clinically relevant timeframes, and then harmlessly biodegrade to yield benign products without residues, thereby eliminating the need for surgical extraction. Our findings overcome key challenges of biodegradable electronic devices by extending operational lifetimes that create novel clinical protocols. This technology enables long-term electrical stimulation wirelessly on an injured peripheral nerve site and brings great outcome for regeneration.

The devices constitute of biodegradable radio frequency coil to harvest energy, electrode to deliver therapeutic stimulation, active components (e.g., diode). We describe the underlying features and chemical design considerations for this polymer, and the biocompatibility of the constituent materials and their ability to provide a stable, long-lived operation demonstrates the potential for maintaining muscle receptivity and enhancing functional recoveries.

Short Bio

Jahyun Koo is an assistant professor in School of Biomedical Engineering at Korea University. He received his B.S. and M.S. degrees in Nuclear & Quantum Engineering from KAIST, Korea (2010 and 2012, respectively). He received his Ph.D. degree in Materials Science and Engineering from KAIST, Korea (2017). He was visiting researcher in Materials Research Laboratory at University of Illinois at Urbana-Champaign (UIUC; 2015-2016). He was post-doc. in Center for Bio-Integrated Electronics at Northwestern University (2017-2020). His research interests include biodegradable device, implantable electronics, and alloy design of biodegradable materials.

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Technologies for Diagnostic & Therapeutic Applications

IS2: 10:20-11:50
Monday, December 14, 2020
Location: RM 002

Session Chair: **Aaron OHTA**
University of Hawaii at Manoa, USA

Description

This invited session covers topics related to the diagnosis and treatment of medical conditions using nano/microfabricated devices, surgical tools, and advanced imaging.

IS2.1 Manipulation, Separation and Characterization of Biocolloids using Chemical Gradients, Sangwoo SHIN, University of Hawaii at Manoa, USA

Abstract

Conventional electrophoretic manipulation, separation, and characterization of biocolloids such as cells, vesicles, macromolecules, and nanoparticles require electrodes, power supplies, and other bulky/expensive peripherals that often limit its utility and cause drawbacks such as electrolysis and Joule heating. Diffusiophoresis, which describes the motion of colloidal particles induced by chemical gradients, is free from all of these downsides and thus potentially suitable for portable, wireless, and point-of-care diagnostics platforms. Despite the long history of diffusiophoresis, it is only recently that diffusiophoresis has gained a renewed interest in the soft matter community. Such a resurgence is, in part, due to the recognition that diffusiophoresis may enable useful applications that are otherwise difficult to achieve or can be augmented by it such as bioseparation and bioanalysis. In this talk, I will showcase several examples in which localized chemical gradients in microfluidic devices can be exploited to manipulate the motion of biocolloids via diffusiophoresis for achieving low-cost separation and characterization.

Short Bio

Sangwoo Shin received his B.S. and Ph.D. in Mechanical Engineering from Yonsei University in 2005 and 2012, respectively. He is currently an Assistant Professor in the Department of Mechanical Engineering at the University of Hawaii

at Manoa. Prior to joining University of Hawaii, he was a Postdoctoral Research Associate at Princeton University from 2013 to 2016. His research focuses on understanding and utilizing the non-equilibrium dynamics of complex fluids and soft matter in biomedical and energy/environmental systems.

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IS2.2 Soft, Skin-Interfaced Microfluidic Systems for Clinical Diagnostics, Tyler RAY, University of Hawaii at Manoa, USA

Abstract

Cystic fibrosis (CF) is among the most common life-shortening genetic disorders. Early diagnosis via quantitative assessment of chloride in sweat allows prompt initiation of care and is critically important to extend life expectancy and improve quality of life. In practice, the collection and analysis of sweat using conventional wrist strapped devices and iontophoresis can be cumbersome, particularly for infants with fragile skin, who often have insufficient sweat production. Here, we introduce a soft, epidermal device ("sweat sticker") with capabilities tailored for simple and rapid collection and analysis of sweat via an intimate skin-compatible microfluidics construct. This intimate, conformal coupling with the skin supports nearly perfect efficiency in sweat collection, without leakage. Real-time image analysis of chloride reagents allows for quantitative assessment of chloride concentrations using a smartphone camera, without the need for extraction of sweat or external analysis. Clinical validation studies involving CF patients and healthy subjects, across a spectrum of age groups, support clinical equivalence in terms of accuracy, and demonstrate meaningful reductions in rates of leakage compared to existing device platforms. The wearable microfluidic technologies and remote-based analytics reported here establish the foundation for diagnosis of CF in nearly any environment.

Short Bio

Tyler R. Ray is currently an Assistant Professor of Mechanical Engineering at the University of Hawaii at Manoa. He received his B.S. and M.S. in Mechanical Engineering from the University of South Carolina (in 2008 and 2010, respectively) and his Ph.D. in Mechanical Engineering from the University of California, Santa Barbara in 2015. He received his postdoctoral training as a fellow at Northwestern University in the Rogers Research Group from 2016- 2019. Professor Ray's research focus is at the intersection of materials science, additive manufacturing, and wearable sensors. He seeks to exploit novel nanoscale properties in multiscale materials for advanced sensors and diagnostic tools.

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IS2.3 Towards an Ultrasound-Guided Needle Insertion System for Prostate Brachytherapy, Bardia KONH, University of Hawaii at Manoa, USA

Abstract

Needle insertion techniques have been used in several minimally invasive procedures for diagnostic and therapeutic purposes. For example, in prostate brachytherapy, hollow slender needles are used to implant radioactive seeds inside the prostate to kill the cancerous tissue locally. However, it is often challenging to guide and track the needle in a desired path to reach the target precisely, while avoiding sensitive organs or large arteries. Typical difficulties that complicate precise execution of the implant plan include organ dislocation, unknown deformation and motion of tissue, unpredictable device motion, tissue inhomogeneity, intraoperative edema, instrumentation and calibration errors, needle deflection, and human errors. These difficulties have caused average practitioners to get unsuccessful outcomes. Needle steering has been an active field of research in the past decade. Researchers have introduced passive and active needles to improve navigation and targeting inside the tissue. This work introduces a novel active "cable-driven" steerable needle capable of bending inside the tissue in multiple directions to reach target. A motorized manipulation system is developed and programmed to pull the cable tendons and control the needle deflection inside tissue. A robotic needle insertion system has been used to insert and manipulate the active needle inside tissue. For real-time tracking of the needle tip during a needle insertion task, a robot-assisted ultrasound tracking method has been developed. The position of the needle tip is an important information for closed-loop control of the needle inside tissue.

Short Bio

Bardia Konh is the director of the Advanced Materials and Medical Instruments (AMMI) Laboratory at the University of Hawaii at Manoa (UHM). He joined the Department of Mechanical Engineering at UHM as an Assistant Professor in 2016, after receiving his PhD in Mechanical Engineering at Temple University, Philadelphia, PA. He received his BSc and MS degrees both in Mechanical Engineering from K. N. Toosi University of Technology and Free University of Science and Research in Tehran, Iran, in 2007 and 2011, respectively. His group is currently working on developing meso-scale medical robots to perform surgical tasks more accurately and less invasively to improve medical outcomes.

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IS2.4 Iterative Neural Networks for Inverse Problems in Medical Imaging, Il Yong CHUN, University of Hawaii at Manoa, USA

Abstract

To prevent the spread of COVID-19, chest X-ray computational tomography (CT) became an important tool by reducing false negatives of the widely-used RT-PCR test — a.k.a. the swab test. Population exposure to medical radiation via CT is a significant concern, motivating research on lowering the dose of CT. However, it is challenging to acquire high-quality images in low-dose CT. Duel-energy CT has been increasingly used in many clinical applications such as kidney stone characterization. Dual-energy CT acquires measurements with two different energy spectra, and thus can characterize different constituent material. Achieving accurate material decomposition is critical to maximize the benefit of dual-energy CT.

Iterative neural networks (INN) are rapidly gaining attention for solving inverse problems in imaging, image processing, and computer vision. INNs combine regression NNs and an iterative model-based image reconstruction (MBIR) algorithm that considers imaging physics/image formation and noise statistics in measurements. INNs can apply to a wider range of previously unseen data, compared to non-iterative deep regression NNs; they showed outperforming reconstruction quality over state-of-the-art deep regression NNs and existing MBIR optimization methods. Two INN architectures developed by my group, BCD-Net and Momentum-Net, can improve reconstruction accuracy and/or speed compared to existing INNs, while guaranteeing convergence under some mild conditions. BCD-Net and Momentum-Net have been successfully applied to diverse imaging problems, including low-dose CT, dual-energy CT, low-count emission tomography, magnetic resolution imaging, light-field photography (simply put, 4D camera imaging).

This talk will briefly review the BCD-Net and Momentum-Net architectures, explain how they are applied to low-dose CT reconstruction and dual-energy CT decomposition, and introduce their benefits over state-of-the-art deep regression NNs and conventional MBIR methods.

Short Bio

Il Yong Chun is a tenure-track Assistant Professor of Electrical Engineering at the University Hawai'i, Mānoa. He received B.Eng. degree from Korea University in 2019, and Ph.D. degree from Purdue University in 2015, both in electrical engineering. Prior to joining UHM, he was a Postdoctoral Research Associate in Mathematics, Purdue University, and Research Fellow in Electrical Engineering and Computer Science, The University of Michigan, from 2015 to 2016 and from 2016 to 2019, respectively. During his Ph.D. he worked in Intel Labs, Samsung Advanced Institute of Technology, and Neuroscience Research Institute, as a Research Intern of a Visiting Lecturer. His research interest include machine learning & artificial intelligence, optimization, compressed sensing, and adaptive signal processing, applied to medical imaging, computational photography, biomedical image computing, and autonomous systems. He has over ten peer-reviewed publications in top-tier journals or conferences and over five invited conference publications.

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IS2.5 Electrically Gated Nanoporous Membranes for Smart Molecular Flow Control, Sungho KIM; Jeffrey WELDON, University of Illinois at Urbana-Champaign; University of Hawaii at Manoa, USA

Abstract

Advances in nanofabrication techniques have allowed producing fluidic channels of sub-100nm dimensions with a multitude of potential applications for biosensing, on-chip analytics, and drug delivery. When the dimension of the fluidic channel is comparable to the electrical double layer (EDL) thickness, known as the Debye length, an overlap of EDL is generated in the nanochannel. In the overlap of EDL, there exists an enrichment of counter-ions and the exclusion of co-ions that are caused by electrostatic interactions. In this talk, we will present a novel conductive nanoporous membrane platform that is based on the electrical control of the diffusive transport of charged molecules through gated nanopores by altering the EDL with an external gate voltage. A computational model of the single gated nanochannel was established to quantitatively predict the field-effect gating of the charged molecule transport through the nanochannel. Based on the results of the simulation, we developed a novel conductive nanoporous membrane and achieved electrical control of the molecular flow through the membrane. We sputter-deposited chromium (Cr) – gold (Au) – chromium (Cr) on top of the commercial anodic aluminum oxide nanoporous membrane. The exterior chromium layer was left to oxidize creating the insulation layer for the gate electrode. The novel conductive nanoporous membrane was utilized to create a nanofluidic diode and a novel double-gated nanoporous membrane structure for a biomimetic AND nanofluidic logic gate.

Short Bio

Sungho Kim is a postdoctoral research associate of Holonyak Micro and Nanotechnology Laboratory at University of Illinois at Urbana-Champaign. He received a B.S. and M.S. degree in electrical engineering from Seoul National University, Seoul, Korea, in 2011 and 2013, respectively and the Ph.D. in Electrical and Computer Engineering from Carnegie Mellon University. His research interests include nanofluidics, drug delivery, nanofabrication, and biomedical devices. Currently he is working on developing the silicon neural probes that can be implanted into the brain to collect chemical information on neural activity.

Jeffrey Weldon is an associate professor in the Department of Electrical Engineering at the University of Hawaii at Manoa. Dr. Weldon joined the faculty at the University of Hawaii in 2017. Prior to joining the faculty he was the

Sathaye Early Career Professor in the Department of Electrical and Computer Engineering at Carnegie Mellon University. Jeffrey Weldon received the B.S. degree in engineering physics from the University of California, Berkeley and the Ph.D. degree in electrical engineering from the University of California, Berkeley, in 2005. From 2006 to 2010 he was a postdoctoral scholar at the Center for Integrated Nanomechanical Systems. His doctoral research in the area of RF CMOS integrated circuits has been widely adopted by industry and is frequently cited in journals and conferences. His postdoctoral research on the carbon nanotube radio was extensively covered by the popular and scientific press, including Scientific American. His current research interests include nanoscale device design in emerging technologies, heterogeneous integration with CMOS for data-intensive applications and applications of nanotechnology to biomedical devices. Dr. Weldon received the 2001 ISSCC Lewis Winner Award for Outstanding Paper and was the recipient of the 1998 ISSCC Jack Kilby Award for Outstanding Student Paper.

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Micro/Nano Diagnostics & Therapeutics

IS3: 12:00 -13:30
Monday, December 14, 2020
Location: RM 001

Session Chair: **Yi ZHANG**
Nanyang Technological University, Singapore

Description

Micro and nanotechnologies play an essential role in disease diagnostics and therapeutics. Many novel micro/nano platforms and materials have greatly advanced our capability of detecting, containing and treating diseases, which leads to better clinical outcomes and more effective public health strategies. This session focuses on the latest development and findings at micro nano and molecular scale and their biomedical applications.

IS3.1 Harnessing Mechanics at Nano-bio Interface for Enhanced Delivery of Nanomedicine, Changjin HUANG, Nanyang Technological University, Singapore

Abstract

Nanoparticle-based drug delivery systems have emerged as next-generation medicines in the last two decades due to their great potential to achieve superior specificity and high delivery efficiency. While the specificity is achieved via the lock-and-key molecular recognition by decorating nanoparticles with the ligands that can specifically bind to the surface receptors overexpressed on target cells, the delivery efficiency is largely mediated by the complex interactions between nanoparticles and cell membrane at the nano-bio interface. Through combined theoretical, computational and experimental approaches, we have established a physical framework that allows us to identify the key biophysical parameters that affect cellular uptake efficiency. In this talk, I will elucidate how mechanics at the nano-bio interface can be harnessed to enhance the delivery efficacy of nanomedicines and to enable biased targeting of nanoparticles towards malignant cells based on their distinctive mechanical states. Our study suggests a new targeting strategy, termed mechanotargeting, which can work in concert with the existing chemotargeting strategy to further enhance the targeting specificity and efficiency of nanomedicines.

Short Bio

Dr. Changjin Huang is currently an Assistant Professor at Nanyang Technological University (NTU). He is affiliated with both School of Mechanical and Aerospace Engineering (MAE), and School of Chemical and Biomedical Engineering (SCBE). He received his B.ENG. degree in Thermal Energy and Power Engineering from University of Science and Technology of China (USTC) in 2008, and then Ph.D. degree in Engineering Science and Mechanics from Pennsylvania State University in 2014. Before joining NTU, he worked as a Postdoctoral Fellow in the Department of Mechanical Engineering at Northwestern University from 2014-2015, and then as a Postdoctoral Research Associate in the Department of Biomedical Engineering at Carnegie Mellon University (CMU) from 2016-2018. Dr. Huang's research interests generally lie at the intersection of mechanics, materials, engineering and biology, including mechanics at nano-bio interface, mechanobiology, and mechanics of cells and soft materials. He is devoted to identifying the underlying physical principles that control biological systems and developing innovative biomimetic systems with the improved understanding. Dr. Huang has published >20 peer-reviewed articles in various prestigious journals, including Advanced Materials, Science Advances, Nano Letters, PNAS, etc.

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IS3.2 Direct Ink Writing (DIW) 3D Printing in Embedding Media, Michinao HASHIMOTO, Singapore University of Technology and Design, Singapore

Abstract

Embedding media, such as surrounding fluids and microparticulate gels, offer unique physicochemical environments to the printed materials, which greatly enhances the capability of three-dimensional (3D) printing. This talk discusses our recent progress in 3D printing of liquid materials using embedding media. We present a novel approach of 3D printing to fabricate 3D porous models in one step. We termed the process immersion precipitation 3D printing (ip3DP). In ip3DP, we printed polymeric inks directly in a bath of a nonsolvent and solidified them in situ via immersion precipitation. Spontaneous solidification via immersion precipitation generated porosity at micro-to-nano scales. The porosity of the 3D printed objects was readily controlled by

the concentrations of polymers and additives and the types of solvents. This work is the first demonstration of three-dimensionally controlled immersion precipitation based on digitally controlled depositions of materials. The same approach was extended for freeform fabrication of thermoplastics in microparticulate gels. Overall, a wide selection of printable materials, and the ability to tailor their morphologies and properties, make ip3DP a versatile method of 3D printing.

Short Bio

Michinao Hashimoto is an assistant professor at Singapore University of Technology and Design leading Soft Fluidics Group. With the overarching research topics of microfluidics, the group works on various cross-disciplinary themes in biomedical engineering, organ-on-chip, 3D printing, food engineering, and soft robotics. Michinao received his B.S. degrees in Chemistry and Biochemistry/Biophysics from Oregon State University (2003), and Ph.D. degree from Harvard University (2009), followed by postdoctoral training at Massachusetts Institute of Technology and Children's Hospital Boston.

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IS3.3 Challenges of Integrated Low-Cost, Disposable Devices for Type 2 Diabetes Mellitus Patients based on Leukocyte Studies, Chayakorn PETCHAKUP; Hui Min TAY; Rinkoo DALAN; Han Wei HOU; Holden LI, Nanyang Technological University, Singapore

Abstract

Advanced management of dysmetabolic syndromes such as diabetes will benefit from a timely mechanistic insight enabling personalized medicine approaches. The integrated microfluidics technology enables such testing methodology, which facilitates high throughput single-cell quantification of leukocytes in a lab-on-a chip setting. To develop such platform, it is important to understand the pros and cons of various microfabrication techniques, their challenges for integration and the ability to be scaled up for large scale production.

In this talk, the various techniques like blood plasma extraction, blood cells separation, study of multi-way microvalves, micro-mixers, single cell impedance measurement are compared and analyzed. Based on our studies, we have achieved a novel microfluidic strategy for rapid (< 1 h) label-free leukocyte sorting and impedance-based profiling to determine cell activation in type 2 diabetes mellitus (T2DM) using whole blood. Leukocytes were first size-fractionated into different subtypes (neutrophils, monocytes, lymphocytes) using an inertial spiral sorter prior to single-cell impedance measurement in a microfluidic device with coplanar electrode design. Significant changes in membrane dielectric properties (size and opacity) were detected between healthy and activated leukocytes (TNF-α/LPS stimulated), during monocyte differentiation and among different monocyte subsets (classical, intermediate, non-classical). As proof-of-concept for diabetes testing, neutrophil/monocyte dielectric properties in T2DM subjects (n = 8) were quantified which were associated with cardiovascular risk factors including lipid levels, C-reactive protein (CRP) and vascular functions (LnRHI) ($P < 0.05$) were observed. Overall, these results clearly showed that T2DM subjects have pro-inflammatory leukocyte phenotypes and suggest leukocyte impedance signature as a novel surrogate biomarker for inflammation.

Short Bio

Holden Li graduated in NUS with a Bachelor of Engineering (Honors) in 1997. In 2000 Holden enrolled in Stanford University for his graduate studies under Professor Thomas Kenny. During his PhD studies, Holden was actively involved in MEMS process development in finding suitable packaging solutions to MEMS and BioMEMS devices. Besides, he worked closely with several industrial partners who benefited from the on-going research activities in Kenny's group at that time. He was awarded his MSc and PhD in Mechanical Engineering in 2001 and 2005 respectively. Back in Singapore in September 2005, Holden started to lead a research team in MEMS sensors research effort in the area of MEMS R&D and reliability study. He is currently holding a concurrent appointment of Micro Sensors Research Director in Temasek Laboratories at NTU. Beyond this, Holden's passion for research and development in microelectronics and BioMEMS, coupled with his strong academic interest in the area of micro and nanotechnology propelled him to seek for funding opportunity in these areas. He is currently working closely with several senior faculties in the area of microelectronics and MEMS research both in NTU and Temasek Laboratories at NTU.

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IS3.4 Nanostructured Surface for SERS Detection of Diseases, Tianxun GONG, University of Electronic Science and Technology of China, China

Abstract

Surface Enhanced Raman Spectroscopy (SERS) is able to provide "fingerprints" information of the molecules in biosamples, even in ultra-low concentration. To obtain high enhancement from the near field resonance, also consider different characteristics of the samples, various SERS platforms need to be developed. Our group designed and fabricated optical fiber and substrate platforms to detect samples such as cancer cells, enzymes, and blood serum. Specific detection was achieved by careful manipulation of the antibodies, peptides, and functional groups. Furthermore, machine learning was adopted to analyze the characteristic peaks of the samples from complex Raman spectra. These SERS platforms were used in the applications on diseases detections, such as vascular disease and colorectal cancer.

Short Bio

Tianxun Gong obtained his Ph.D. degree from Nanyang Technological University, Singapore in 2015. He also performed collaborated research in Singapore Bioimaging Consortium, A*STAR from 2012 to 2016. Tianxun Gong is currently working at University of Electronic Science and Technology of China, his research focus is nanosensors and its applications on biomedical detections. He is a senior member of the biomedical photonics branch of the Chinese Society of Biomedical Engineering. He has published over 40 peer-reviewed articles with more than 700 citations.

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IS3.5 Modular Magnetic Digital Microfluidic Platform with 3D-Printed LEGO-Like Building Blocks for On-Demand Bioanalysis, Yi ZHANG, Nanyang Technological University, Singapore

Abstract

Magnetic digital microfluidics (MDM) manipulates fluids in the form of droplets on an open substrate, and incorporates surface energy traps (SETs) to facilitate the droplet manipulation. Conventional MDM devices are fabricated monolithically, which makes it difficult the modify the device configuration without completely overhauling the original design. In this talk, we present a modular MDM architecture that enables rapid on-demand configuration and reconfiguration of MDM platforms for customized bioanalyses. Each modular component contains a SET and a Lego-like antistud that fits onto a base board with Lego-like studs. We illustrate the versatility of the modular MDM architecture in biomarker sensing, pathogen identification, antibiotic resistance determination and biochemical quantification by demonstrating immunoassays, phenotypical assays and enzymatic assays on various modular MDM platforms configured on demand to accomplish the fluidic operations required by assorted bioanalytical assays. The modular MDM architecture promises great potential for point-of-care diagnostics by offering on-demand customization of testing platforms for various categories of diagnostic assays. It also provides a new avenue for microfluidic assay development with its high configurability which would significantly reduce the time and cost of the development cycle.

Short Bio

Yi Zhang is currently an assistant professor at the School of Mechanical and Aerospace Engineering at Nanyang Technological University, Singapore. He is an affiliated faculty member of Singapore Center for 3D Printing, NTU-HP Digital Manufacturing Corporate Lab, NTU Quantum Science and Engineering Center, and Sino-Singapore International Joint Research institute. He received his Ph.D. in Biomedical Engineering from Johns Hopkins University School of Medicine, USA in 2013 and B.Eng in Bioengineering from Nanyang Technological University, Singapore in 2007. He received his postdoc training in the Institute of Bioengineering and Nanotechnology, the Agency of Science Technology and Research (A*STAR), Singapore from 2013−2015, and subsequently worked there as a Research Scientist from 2015−2016. Yi's research focuses on developing and validating novel assays, platforms and materials using advanced micro/nanotechnologies. His research aims to bridge the gap between engineering advancement and current medicine practice.

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Micro/Nano Devices for Biomedical Sensing & Actuation

IS4: 12:00-13:30
Monday, December 14, 2020
Location: RM 002

Session Chair: **Ting-Hsuan CHEN**
City University of Hong Kong, Hong Kong SAR

Description

Leveraging the micro/nanotechnology enables unprecedented accessibility for research in the small scale. In this invited session, we provide a venue for discussing an array of micro/nano devices with factors ranging from fluidic, optic, and nanomaterials for investigation of biomedical sensing and actuation, such as detection of biomarkers, cell-niche interaction, and biosensors. It is anticipated to bring inspiration propelling researches with new perspectives

IS4.1 Comprehensive Study of Ion Concentration Polarization (ICP) in Microfluidic Channel for Protein Preconcentration, Yu-Jui FAN, Taipei Medical University, Taiwan

Abstract

Preconcentration of biomolecules for detection on microfluidic platforms based on electrical kinetic trapping (EKT) through ion concentration polarization (ICP) has been well developed in the past decade. Biomolecules can be entrapped due to the equilibrium of forces between electroosmosis and ICP when applying a voltage to the system. In this talk, we will investigate the general ICP phenomena including Faradic and non-Faradic ICP. we will also introduce a triboelectric nanogenerator (TENG)-driven nanofluidic preconcentrating device that is able to trigger ICP and subsequently cause the EKT of the biomolecules without using a conventional electrical power source. Several biosensors that are potential to integrate with ICP based preconcentrator will also be introduced.

Short Bio

Dr. Yu-Jui Fan received his Ph. D from National Taiwan University, Institute of Applied Mechanics in 2014. He was

a research assistant at University of California, Los Angeles, Mechanical and Aerospace Engineering, USA, during Mar. 2009 – Feb. 2013. He joined Taipei Medical University, School of Biomedical University as an assistant professor in December 2016. He currently is an associate professor. Dr. Fan's research focuses on investigating multiphysics-interacted novel phenomena in microsystems for versatile applications. Several topics are currently moving on including (1) Development of micro environmental platform for elucidating collective cell mechanotransduction. Moreover, building up a vessel mimicking microfluidic system for studying mechanism of vessel thrombosis, and drug screening. (2) Development of a large cargo delivery into cell system for mitochondrial cell therapy. Especially focus on stem cell therapy. (3) Development of advanced multiplex microfluidics technology, e.g. enzymatic analysis, DNA analysis, and proteomics, and in chemical synthesis.

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IS4.2 Quantitative Single Cell Biology via Intelligent Drop-Screen, Chia-Hung CHEN, City University of Hong Kong, Hong Kong SAR

Abstract

Single-cell analysis is essential to precisely analyze bioprocesses in physiological systems to evaluate clinical situations. In this study an intelligent Drop-Screen system was developed to rapidly determine single cell phenotypes, which provide a valuable insight into functional heterogeneity indicating disease progressions, such as tumor metastasis. To reach this goal, we designed an integrative platform employing droplet-based technology, imaging technology, and data driven computational method for high-throughput continuous-flow single-cell assays. The single cells and chemical sensors were encapsulated within the droplets via microfluidics. A system with high-speed fluorescence analysis of single cells and a high rate of data transmission between modules and software was developed for continuous flow cell analysis. Analog voltage signals from the Photomultiplier tubes (PMTs) were converted to digital form through a data acquisition (DAQ) system (National Instruments, USA) at a sampling rate of ~12,500 samples/s. To perform high throughput cell type identification, a library (data base) of different cell lines was constructed. With this data base, k-NN algorithm was conducted to identify the species of unknown single tumor cells for rapid tumor profiling. For example, multiple clinical enzyme (protease) activities in single cells were measured by compartmentalizing colored enzymatic substrates (showing distinguished emissions) and individual cells in the droplets. After incubation, droplets were uploaded to a Droplet-Screen system for high-throughput single cell analysis in a continuous-flow manner (~100 droplets per second) to evaluate tumor's migration capabilities. Similar approach was also used to indicate/sort drug resistant of single cells in a tumor.

Short Bio

Dr. Chen is focused on developing integrative platforms for biomedical applications. Compared with most platforms using gene sequence for quantitative biology, integrative functional assay offers unique advantages for the rapid characterization of biological samples for diagnosis and timely precision medicine. With the possibility of high-throughput biological sample screening and cell sorting using the integrative platform, statistically information could be obtained for effective quantitative biological analysis. For example, an intelligent system that integrated imaging technology, multiplexed chemical sensors and a computational data-analysis method was previously developed to analyze small amounts of physiological samples to determine the disease progression of individual patients with cancer. Before joining City University of Hong Kong, Dr. Chen worked at National University of Singapore and Massachusetts Institute of Technology. He received his Ph.D. degree at University of Cambridge. He earned his M.S. degree at Harvard University, and earned his B.S. degree at National Taiwan University.

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IS4.3 Microfluidic Culture Platform Combined with Transcriptomic Profiling Reveals Molecular Signatures That Promote 3D Vascular Network Growth and Maturation, Sin Yen TAN; Ziuwin LEUNG; Angela Ruohao WU, Hong Kong University of Science and Technology, Hong Kong SAR

Abstract

Compared to conventional flask- or well-based culture systems, microfluidic cell culture platforms are a highly controllable and tunable microenvironment for 3D cell cultures, enabling researchers to create precise experimental perturbations that lead to deeper understanding of biological mechanisms. With recent technological and biological advancements in creating more and more physiologically relevant organ-on-chip models, the need is also emerging for the creation of more sophisticated 3D microfluidic vasculature-on-chip culture. Current on-chip vascular culture often does not reach maturity as in-vivo vasculature does; on-chip vessels also often regress and die within 1-2 weeks, making long term experiments challenging and unpredictable. Co-culture with fibroblasts can improve on-chip vascular cultures in promoting maturation and substantially increasing survival time, but it is unclear how the fibroblasts and vascular endothelial cells interact, and whether further improvements could be made to more closely mimic in-vivo conditions. We establish vascular endothelial cells in monoculture and in co-cultures with fibroblasts in microfluidic devices and allow them to grow on-chip. We then extract the cells from the device at different time points and perform RNA sequencing to profile the gene expression of each cell type, in order to compare the difference in their molecular signatures with and without fibroblast co-culture over time. By combining microfluidic platform technology with transcriptomic profiling techniques in this systems biology approach, we identified ligand-receptor pairs that are up- or down-regulated over the course of endothelial cell self-assembly and vascular maturation, revealing key pathways in the endothelial cells that appear

regulated by paracrine signaling from the fibroblasts. We also identified factors secreted by fibroblasts that appear intended for crosstalk with immune cells, which are currently absent from the microfluidic system. This suggests that addition of immune cells to the on-chip culture system could be an important next step to generate more physiologically relevant vascular cultures in-vitro.

Short Bio

Angela Ruohao Wu is an assistant professor in the Division of Life Science and the Department of Chemical and Biological Engineering at The Hong Kong University of Science and Technology. Angela obtained her B.S. in Bioengineering from the University of California, Berkeley, her M.S. and Ph.D. degrees in Bioengineering from Stanford University, and her post-doctoral work also at Stanford University. In 2015, Angela co-founded Agenovir Corporation, a CRISPR-based therapeutics company targeting infectious diseases for a complete cure. Her research group is passionate about the development of new microfluidics and genomics technologies at the interface of basic biology and engineering, and using these interdisciplinary approaches to investigate biological mechanisms and human diseases. As recognition of her achievements in technology and innovation, Angela was named one of MIT Technology Review Innovators under 35 Asia in 2016, and a World Economic Forum Young Scientist in 2018.

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IS4.4 Highly Swellable Microneedles to Rapidly Extract Skin Interstitial Fluid for for Timely Metabolic Analysis, Chenjie XU, City University of Hong Kong, Hong Kong SAR

Abstract

Hydrogel microneedle patch enables the withdrawal of skin interstitial fluid (ISF) through in situ swelling in a minimally invasive manner without assistance of extra devices. However, existing hydrogel microneedles require tens of minutes to collect sufficient volume (>1 ☐L) for effective analysis. This study introduces an osmolyte-powered hydrogel microneedle patch that can extract ISF three times faster than the existing platforms. The microneedle patch is composed of osmolytes (i.e. maltose) and hydrogel (i.e. methacrylated hyaluronic acid) and made through the template-molding method. Once in the skin, hydrogel swells while ISF diffuses through dermis and then partitions into the hydrogel matrix. Along the process, the osmolytes dissolve in the matrix and provide osmotic pressure to increase the diffusion of ISF from skin to the hydrogel matrix. The patch with 100 microneedles can extract 7.90 μL of ISF from pig skin ex vivo and 3.82 μL of ISF from mouse skin in vivo within 3 minutes while the control (i.e. hydrogel microneedle without osmolytes) requires >10 minutes to achieve similar results. Finally, the extracted ISF allows the quantification of biomarkers like glucose and cholesterol and drugs like insulin in vivo through integration with the 3D printed wearable electronics.

Short Bio

Dr. XU is an associate professor of biomedical engineering at City University of Hong Kong, adjunct principal investigator at National Dental Centre of Singapore. He is dedicated to the development of transdermal drug delivery formulations and devices (especially nucleic acid-based nanoparticles and microneedle-based skin patch). He is well known for the development of skin patch for keloid treatment, anti-obese skin patch, skin patch for skin interstitial fluid extraction etc. He has published more than 140 peer-reviewed articles (citation is 11k with H index of 45), edited two books, holding 10 international patents. His research is supported by a wide range of public and private foundations including Singapore Minister of Education, Singapore A*Star, Continental Corp (German), Bill & Melinda Gates Foundation, Hong Kong University Grants Committee, National Natural Science Foundation of China, etc.

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IS4.5 Microfluidic Techniques for Isolation and Analysis of Floating Cells, Raymond H. W. LAM, City University of Hong Kong, Hong Kong SAR

Abstract

Isolation and analysis of floating cells has been technically challenging, including the cell positioning and characterization of the cells in the floating state. For example, isolation of floating rare cells, such as circulating tumor cells, has low abundance and limited time-frames of expressions of relevant cell characteristics. Deep phenotyping of single cancer cells for both the mechanical and biochemical properties is of critical importance in the era of precision medicine to advance understanding of relationships between gene mutation and cell phenotype and to elucidate the biological nature of tumor heterogeneity. On the other hand, quantitative and dynamic analyses of immune cell secretory cytokines are essential for precise determination and characterization of the "immune phenotype" of patients for clinical diagnosis and treatment of immune-related diseases.

In this presentation, the speaker will present a couple microfluidic techniques for the floating cell analysis: 1) a hydrodynamic mechanism to sequentially trap and isolate floating cancer cells in biosamples through a series of microsieves to obtain up to 100% trapping yield and >95% sequential isolation efficiency, 2) a microfluidic elasticity microcytometer for multiparametric biomechanical and biochemical phenotypic profiling of free-floating, live single cancer cells for quantitative, simultaneous characterizations of cell size, cell deformability/stiffness, and surface receptors, and 3) a microfluidic sensing chip integrated with cytometric fluorescent microbeads for real-time and multiplexed monitoring of immune cell cytokine secretion dynamics, consuming only a negligible sample volume without interrupting the immune cell culture.

Short Bio

Raymond H. W. Lam is currently working as an Associate Professor in the Department of Biomedical Engineering at

City University of Hong Kong. He has obtained a first honor B.Eng. degree and an M.Phil. degree in Automation and Computer-Aided Engineering from Chinese University of Hong Kong, and a Ph.D. degree in Mechanical Engineering from Massachusetts Institute of Technology. Before joining CityU, he was a postdoctoral fellow in the Department of Mechanical Engineering at University of Michigan. He has interdisciplinary research experience in cell mechanobiology, bacteriology, microfluidics, microfabrication, computational methods, software development and circuit/device design. His overall research objective is to bridge science and engineering knowledge and currently he aims at developing/applying microengineering techniques to advance the cell biology research.

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Nanomaterials & Nanodevices for Healthcare Applications

IS5: 10:00-11:30
Tuesday, December 15, 2020
Location: RM 001

Session Chair: **Zong-Hong LIN**
National Tsing Hua University, Taiwan

Description

Nanomaterials and nanodevices with various advantages in comparison to conventional ones have triggered increasing research efforts from both industry and academia. Many intelligent or medical nanomaterials and nanodevices have shown their capabilities to continually analyze different activities and help to predict diseases before serious conditions happen. For examples, active/self-powered sensors with no external input power, are mini-sized and lightweight. The development of these smart nanomaterials and nanodevices have pushed their feasible applications in a wide range of fields. This session will attempt to cover the recent achievements of nanomaterials and nanodevices for healthcare applications, which include nanoisozymes, physical/chemical sensors, biosensors, microfluidics for medical & biological applications, and self-powered sensors/systems.

IS5.1 Surface Understanding at Atomic Scale Guides The Rational Design of CeO_2 Nanoisozymes for Biosensing, Yung-Kang PENG, City University of Hong Kong, Hong Kong SAR

Abstract

Recently, ceria (CeO2) nanoparticle has been shown a potential artificial enzyme in mimicking natural enzymes such as phosphatase and peroxidase. However, the origin behind its enzyme-mimetic property is still unclear nowadays. Different interpretation even disagreement regarding the role of surface Ce4+/Ce3+ ratio can be often found in literature. From our point of view, this is due to reactant molecules interact only with Ce cations on topmost surface while XPS collects target information few nanometers from surface. Herein, CeO2 shapes with terminal (111), (110), (100) facet were tested in these two reactions. Octahedron (111) shows the highest activity in phosphatase mimicking among three shapes while it is nearly inactive in mimicking peroxidase. In stark contrast, cube is inert in the former reaction but very active in the latter one. No apparent difference in their XPS spectra as expected. Instead, using TMPO-31P NMR for surface investigation, we have successfully correlated the observed activity in these two reactions with surface Ce electron density in the order of cube (100) > rod (110) > octahedron (111). The excellent peroxidase-like activity of cube was further combined with glucose oxidase/redox dye for glucose/glutathione detection.

Short Bio

Dr. Will Yung-Kang Peng obtained his bachelor's degree in Chemistry in 2009 from National Chung Cheng University (Taiwan) and graduated as a Master of Science in 2011 from National Taiwan University. After a year of military service (R.O.C.) and research assistant, he started PhD study in 2013 at Wolfson Catalysis Centre of Inorganic Chemistry Laboratory at University of Oxford (UK) under the supervision of Prof. Dr. S. C. Edman Tsang, for which he received a Clarendon scholarship from University of Oxford (top 3% Oxford admitted graduates of 2013 year). He obtained his PhD degree in 2017 and stayed in the same group for postdoc. During his stay in Oxford, he has developed a new route to study catalysts' surface which has led to publications in some respectable journals such as Nature Catalysis, Nature Communication, JACS, Chemical Science, Materials Today etc. He joined the City University of Hong Kong as an Assistant Professor in May 2018. His current research interest is working on the understanding of material surface for the rational design of hetero(photo) catalysts for catalytic nanomedicine and biosensing.

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IS5.2 Generation of Microscale Triboelectric Signals for Development of Self-triggered Sensors, Dongwhi CHOI, Kyung Hee University, Korea

Abstract

Triboelectricity, which is generated from sequential contact and separation of two different materials including liquid, is highlighted as a novel mechanism for development of various types of self-powered sensors. In this study, two types of self-triggered sensors, where the operation mechanism is based on the triboelectricity, are proposed. Considering that the surface to volume ratio becomes large in microscale systems and thus, the phenomenon at the interface becomes dominant, the triboelectricity can generate considerable amount of the electric signals in microfluidics.

In this regard, the self-triggered gas slug sensor, which enables us to inform various characteristics of the gas slug in microfluidic channels, is proposed. Since the electric signal can be generated without any other external power sources, the present sensor can be considered as self-triggered. Furthermore, the solid-solid contact/separation is utilized to develop the smart gear. Gear is one of the most ordinary and effective components for transmitting mechanical power as a core component of machines. Given that the operation of the gear in power transmission is based on sequential contact and separation between two engaged gear teeth, the simple modification of the outermost surface of the conventional gear enables us to spontaneously generate triboelectric signal during ordinary power transmission. The present approach to utilize microscale triboelectric signals could open new application fields with various types of self-triggered sensors.

Short Bio

Prof. Dongwhi Choi received his Ph. D. in department of mechanical engineering from the Pohang University of Science and Technology (POSTECH), Korea in 2016 and continued with his postdoctoral research at the POSTECH during the years of 2016-2018. Subsequently, Prof. Choi joined the department of mechanical engineering, Kyung Hee University, Korea as an assistant professor in 2018. His main research interest is based on development of various novel types of polymer based platforms/devices considering mechanical properties of materials to advantageously utilize spontaneously generated electric signals from various mechanisms including triboelectricity and piezoelectricity. As core application fields, the energy harvesters and self-triggered sensors are intensively studied in his group.

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IS5.3 Design of Wearable Triboelectric Nanogenerator for Self-powered Healthcare and Biomedical Sensing, Yannan XIE, Nanjing University of Posts and Telecommunications, China

Abstract

Recently, wearable sensors have experienced a rapid development and are greatly desirable for commercial, medical, and military applications. Among them, the self-powered sensing technology has been recognized to be a promising sub-category and exhibit vast potential in healthcare and biomedical monitoring, prosthesis development, sport sensing, and human-machine interfacing. The self-powered active sensor will generate electricity as a response to the external stimuli and the electric signal can reversely reflect the impact of the outside trigger. Therefore, it is able to effectively and independently work without any external power sources. Originated from Maxwell's displacement current, triboelectric nanogenerator (TENG) based on a coupling of triboelectric effect and electrostatic induction has been developing rapidly for self-powered active sensor. Here, we report a series of TENG structures for self-powered healthcare and biomedical sensors. Firstly, a stretchable, flexible and wearable kinesio-tape-based TENG (KT-TENG) has been demonstrated relying on the lateral sliding working mode as a self-powered active human motion sensor. This type of device does not require a macro-scale air gap inside or triboelectric layers to be stretchable, exhibiting numerous advantages including simple fabrication, compact structure without air gap, superior stretchability and flexibility, and excellent conformable contact with skin. Secondly, a seesaw structure TENG (SS-TENG) has been proposed based on vertical contact-separation working mode. Thanks to the asymmetric structure, the SS-TENG can be adopted to monitor the motion direction and velocity of moving objects. Being integrated with shoes or insoles, the SS-TENG can detect the foot posture under natural human motion. Thirdly, a self-powered breath sensor based on the angle-shaped TENG has been demonstrated to monitoring the pulmonary function of human. Therefore, the above discussed wearable TENGs may provide a new prospect for self-powered active healthcare and biomedical sensors and have potential applications in the fields of healthcare monitoring, human-machine interfacing, and prosthesis developing.

Short Bio

Dr. Yannan Xie is currently a Professor in Institute of Advanced Materials at Nanjing University of Posts & Telecommunications. He received his B.S. degree in Applied Physics from Nanjing University of Science and Technology and Ph.D. degree in Microelectronics from Xiamen University. His research interests focus on nanogenerators, self-powered systems, and energy harvesting technology. He has authored and co-authored over 30 peer reviewed journal articles (including *Advanced Materials*, *Nano Energy*, *ACS Nano*, *Nature Communications* etc.) with a citation of 3400 and an h-index of 23. He also serves as a peer reviewer for over 20 journals, including *Advanced Functional Materials*, *Nano Energy*, *ACS Nano*, *Applied Physics Reviews*, *Nano-Micro Letters*, *Applied Energy* etc.

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IS5.4 Flexible/Wearable Sensors Based on Triboelectric Nanogenerators, Fang YI, Sun Yat-sen University, China

Abstract

Flexible/wearable electronics that exceed the scope of rigid, brittle and planar nature of traditional micro/macro electronics are an emerging class of electronics receiving significant attention. They can conform to complex, curvilinear surfaces while maintaining levels of performance, which enable a wide range of applications such as electronic skins, implantable devices, robotics, smart textiles, and prosthetics. In the meanwhile, triboelectric nanogenerators (TENGs) are mechanical energy harvesters that were first proposed in 2012, which can harvest mechanical energy

and also work as self-powered sensors. Owing to the advantages including various working modes, abundant material choices, and low cost, triboelectric nanogenerators have been applied as flexible/wearable sensors and gained intensive attention. Here, our recent studies on the TENGs as flexible/wearable sensors and their potential applications will be presented. The unique working mechanisms, device structures, challenges, and prospects will also be discussed.

Short Bio

Fang Yi received her B.S. degree from Central South University, and Ph.D degree from University of Science and Technology Beijing, in Prof. Yue Zhang's group. She was a visiting student at Georgia Institute of Technology, in Prof. Zhong Lin Wang's group, from 2013-2015. She was a postdoc at Peking University, in Prof. Zhongfan Liu's group, from 2016-2018. She is now a professor at Sun Yat-sen University. Her research interest focuses on energy conversion and storage, flexible/wearable materials and devices, and self-powered power systems.

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IS5.5 Self-charging Ingestible Polysaccharide Battery for Controllable Disinfection System, Tzu-En LIN, National Chiao Tung University, Taiwan

Abstract

Modern development of miniaturized wearable devices for health monitoring plays a crucial role in point-of-care diagnosis or in treatment for various diseases. However, the power source of these devices usually are batteries made from toxic metals and hazardous electrolytes, and hen it may cause injuries once swallowed. Chargeable ingestible battery invented in this research hold the advantages as it can offer high biocompatibility, non-poisonousness, and worldwide environmental sustainability. Thus, we built up a hydrogel-based ingestible battery which utilizes the selective ionic diffusion resulting from the saltiness gradient. Agarose hydrogels absorbed with potassium-chloride were utilized for making diverse saltiness difference. A cation- selective gellan gum (GG) film permits the cations to transport from hydrogels with high salinity across the membrane to hydrogels with low salinity, subsequently producing an open-circuit potential difference up to 177 mV. The geometry and shape of the battery were structured by a 3D printer so it can adjust to a variety of devices. The battery can be charged by through a triboelectric nanogenerator (TENG) charger bringing about the enough voltage about 300 mV. We applied the power to stimulate the bacterial solution containing *E.* coli, inhibiting or deactivating about 90% of the microorganisms. Subsequently, this innovation is promising for battling antibiotic-resistant bacteria in the gastrointestinal tract, such as the oral cavity, as well as for giving an innocuous energy source to medical devices.
[1] Lin, Zong-Hong, et al. "Ingestible polysaccharide battery coupled with a self-charging nanogenerator for controllable disinfection system." Nano Energy 2021, 79,105440.

Short Bio

Dr. Tzu-En Lin is currently an Assistant Professor at the Institute of Biomedical Engineering, National Chiao Tung University, Taiwan. She received her Ph.D. in Chemistry and Chemical Engineering from the École Polytechnique Fédérale de Lausanne (EPFL), Switzerland, with a specialization in electrochemistry. She obtained her master's and bachelor's degree from National Taiwan University. She was a postdoc researcher in the Department of Chemistry and Chemical Engineering, EPFL, and was an exchange student in the Department of Chemical Engineering, Stanford University, U.S.A.

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Nanomaterials & Nanodevices for Biosensing Applications

IS6: 10:00-11:30
Tuesday, December 15, 2020
Location: RM 002

Session Chair: **Jungmok SEO**
Yonsei University, Korea

Description

This session aims to provide leading scientists working in the field of nanomaterials and nanodevice technologies and their applications with a novel biosensing platform in which to share and discuss the latest research and to promote advancement of this exciting and rapidly changing field. We hope to encourage discovery across the discipline as we present in this session, as listed below:

IS6.1 Precise Capture and Dynamic Relocation of Nanoparticulate Biomolecules through Dielectrophoretic Enhancement by Vertical Nanogap Architectures, Yong-Sang RYU, Korea Institute of Science and Technology, Korea

Abstract

Toward the development of surface-sensitive analytical techniques for biosensors and diagnostic biochip assays, a local integration of low-concentration target materials into the sensing region of interest is essential to improve the sensitivity and reliability of the devices. As a result, the dynamic process of sorting and accurate positioning the nanoparticulate biomolecules within pre-defined micro/nanostructures is critical, however, it remains a huge hurdle for the realization of practical surface-sensitive biosensors and biochips. A scalable, massive, and non-destructive trapping methodology based on dielectrophoretic forces is highly demanded for assembling nanoparticles and biosensing tools. Herein, we propose a vertical nanogap architecture with an electrode-insulator-electrode stack

structure, facilitating the generation of strong dielectrophoretic forces at low voltages, to precisely capture and spatiotemporally manipulate nanoparticles and molecular assemblies, including lipid vesicles and amyloid-beta protofibrils/oligomers. Our vertical nanogap platform, allowing low-voltage nanoparticle captures on optical metasurface designs, provides new opportunities for constructing advanced surface-sensitive optoelectronic sensors.

Short Bio

Yong-Sang Ryu is a Senior Researcher in Sensor System Research Center, Korea Institute of Science and Technology (KIST). He received his first B.S./M.S./Ph.D degrees in Electrical and Computer engineering department from Seoul National Univ. He was a Postdoctoral researcher in Electrical and Computer engineering department in University of Minnesota, Twin Cities, U.S.A for 3 years and moved to Korea Institute of Science and Technology (KIST) from 2016. His research focus is in the area of Bio/Nano Technology including designed of device platform/chip via nano/biochip fabrication, simulation, detection, & analyzation for nano/bio material using optical/electrical instrument. He is an young scientist trying to mix and converge the IT-NS and bio-med fields.

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IS6.2 Low-dimensional Nanomaterials for Chemical and Biological Sensing, Keng-Ku LIU, National Tsing Hua University, Taiwan

Abstract

In this talk, I will talk about the low-dimensional nanomaterials including gold nanostructures, hollow plasmonic nanostructures, and graphene for chemical and biosensing. Hollow and porous metal nanostructures are a novel class of plasmonic nanostructures that exhibit extraordinary optical and catalytic properties compared to their solid counterparts, due to a higher surface to volume ratio and the facile tunability of the LSPR wavelength over a broad range from visible to parts of near infrared. We demonstrate that hollow and porous plasmonic nanostructures exhibit a significantly higher refractive index sensitivity compared to other solid nanostructures of similar size, leading to LSPR sensors with higher sensitivity and lower limit-of-detection compared to biosensors based on solid counterparts. For the first time, we demonstrate that the large refractive index sensitivity and small electromagnetic decay length of gold nanocages (AuNCs) make them excellent candidates for label-free plasmonic biosensing. Compared to gold nanorods, molecularly imprinted AuNCs could easily detect kidney injury biomarker (neutrophil gelatinase-associated lipocalin, NGAL) from synthetic urine with more than an order of magnitude lower.

Porous core-shell plasmonic nanostructures host electromagnetic hotspots between the core and the shell, offering significantly higher SERS enhancement as compared to other solid nanostructures of similar size. Through a systematic study, we unveil the influence of size, shape, and orientation of the porous core-shell plasmonic nanostructures on the optical properties and SERS enhancement. Furthermore, the SERS-active substrate based on gold nanoparticles-decorated chemical vapor deposition (CVD)-growth graphene for the multiplexing detection of DNA will also be discussed. The combination of plasmonic nanomaterials and graphene dramatically enhanced the Raman signals of the DNA-labeled dye. Moreover, a simple and universal method based on flexible elastomeric film with adsorbed plasmonic nanostructures will be introduced for the large and uniform fluorescence enhancement. The novel fluorescence-based immunoassays improve the sensitivity of existing analytical methods for the biomarker detection and disease diagnosis in an easy to handle and cost-effective manner.

Short Bio

Keng-Ku Liu received the B.S and M.S. degrees in the department of engineering and system sciences from National Tsing Hua University, Taiwan, and the Ph.D. degree in materials sciences and engineering from Washington University in St. Louis, MO, USA in 2017. He is currently an assistant professor with the department of biomedical engineering and environmental sciences at the National Tsing Hua University, Taiwan. His research interests include the biosensors, low-dimensional nanomaterials, plasmonics, nanomedicine, electronic and optoelectronic devices.

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IS6.3 Nanomaterial-modified Hybrid Platforms for Highly Efficient Cancer Spheroid Formation and Drug Screening, Tae-Hyung KIM, Chung-Ang University, Korea

Abstract

Recently, three-dimensional in vitro cell culture has been emerged as a method to better mimic in vivo solid tumors and their microenvironment. Here, we report a new type of platform that enables both highly efficient cancer spheroid formation and rapid drug testing. Graphene oxide was chosen as a key nanomaterial and selectively coated onto the sidewall of each cell-adhesion-repulsive micro-well (vGO-MP), which prevents planar cell growth and forces the vertical expansion of the cancer cells. Using this platform, various cancer cell spheroids (e.g. liver cancer, neuroblastoma, and glioblastoma) with uniform size and shape were generated. Moreover, due to spheroid-size and array uniformities, the effects of various anticancer compounds (e.g. cisplatin, hydroxyl urea, and curcumin) on cell viability were effectively assessed based on the reductions in the sizes of each spheroid. Besides an attempt to generate cancer spheroids in a highly efficient manner, precise detection of spheroids viability is another important issue for drug screening. Interestingly, we found that a highly conductive gold nanostructure (HCGN) generated on a transparent electrode surface is effective in generating multicellular brain cancer spheroids, and is also capable of measuring spheroids viability based on the electrochemical detection

method. We have previously reported the cell type-specific redox signals are extremely sensitive to the changes in cell viability. Remarkably, such electrochemical signals of cancer cells were also found to be highly sensitive to measure cell viability in three-dimensional (3D) spheroids than conventional colorimetric assay under drug treatment conditions. Specifically, a decrease in 3D spheroid cell viability at a low curcumin concentration (30 μM) was detectable using this new method (29.4%) but not with a conventional colorimetric assay. Taken together, it can be concluded that the nanohybrid platforms developed by our group are highly promising for rapid and precise anticancer drug screening based on 3D and multicellular cancer models.

Short Bio

Tae-Hyung Kim is a director of Bionano Engineering and Sensing Technology (BEST) Laboratory and an associate professor of the School of Integrative Engineering at Chung-Ang University, Seoul, Korea. He received his B.S. in Chemical Engineering from Sogang University and a Ph.D. in Chemical and Biomolecular Engineering from Sogang University. He was a postdoctoral researcher of the Department of Chemistry and Chemical Biology, Rutgers University, U.S.A. His research focus is in the area of cellular engineering, with a particular focus on the use of various nanomaterials to control and to monitor cellular behaviors in a non-destructive and non-invasive manner. He has published over 65 peer-reviewed articles, over 50 presentations with over 30 invited presentations. He holds journal editorial board memberships of several international journals including Managing Editor of Nano Convergence, Associate Editor of Biochip Journal, and Editorial Board Member of Biotechnology and Bioprocess Engineering.

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IS6.4 Magnetic Tweezers: Measuring the Stickiness of Marine Extracellular Polymeric Substances, Chi-Shuo CHEN, National Tsing Hua University, Taiwan

Abstract

Organic particle dynamics in the surface ocean plays a critical part in the marine carbon cycle. Aggregation of marine organic particles drives their downward transport to support various marine organisms on their transit to the sediments. Extracellular polymeric substances (EPS) from various microbes are a major contributor to the oceanic organic particle pool. The stickiness of EPS is expected to play a determining role in the aggregation process of particles; however, stickiness parameters are usually indirectly estimated through data fitting without direct assessment. Here a magnetic tweezer method was developed to quantitatively assess the stickiness of three model EPS produced by: *Amphora* sp., (diatom), *Emiliania* huxleyi (coccolithophore), and *Sagittula* stellate (bacteria), under different in vitro environmental conditions (salinity or EDTA complexed cations) and surface matrices (EPS-EPS and bare glass). Our results showed the stickiness of three microbial EPS decreasing for S. stellata>E. huxleyi >Amphora sp., in line with their decreasing protein-to-carbohydrate (P/C) ratios (related to their relative hydrophobicity). The data not only emphasize the importance of hydrophobicity on EPS stickiness, but also demonstrates that salinity and the nature of the substrate surface can influence the stickiness. Furthermore, we investigated stickiness between various types of EPS, and the observed selective stickiness of EPS between species may shed light on the interactions among heterogeneous marine microorganisms. Overall, this newly developed system provides a platform to assess the EPS stickiness to advance our understanding of the aggregation and sedimentation process of organic particles that are critical for the fate of organic carbon as well as for biofilm formation and microbial colonization of surfaces in the ocean.

Short Bio

Chi-Shuo Chen is an Assistant Professor of Department of Biomedical Engineering and Environmental Sciences at National Tsing Hua University. He received his B.S in Atomic Science and the M.S in Molecular Biophotonics from National Tsing Hua University, and Ph.D. in Biological Engineering from University of California, Merced. He was the Postdoctoral Researcher in Dermatology at Feinberg School of Medicine, Northwestern University. His current research focus is to study how mechanical signals propagate between cells from cell-matrix and cell-cell contacts, and the related mechanotransduction responses at cellular level. By integrating with various engineering platforms, such as microfluidic, optical tweezers system, and different microscopy technologies, the works developed in his laboratory aims to further understand the impacts of physical microenvironments on cell physiology.

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IS6.5 Facile Biofouling-free Lubricant-skin Coatings for Biomedical Implants and Biosensors, Jungmok SEO, Yonsei University, Korea

Abstract

Implantable biomedical devices and biosensors have been widely adopted and developed for clinical for continuous monitoring of patients' health status. When the biomedical biosensors are introduced to patient's body, foreign body reaction occurs diminishing immune system, and the body becomes highly vulnerable to bacterial infection and complications. When bacteria adhere to the implants forming impenetrable biofilm to antibiotics, removal and treatment require reoperation accompanied by pain and economic burden. Also, fibrotic capsule due to immune response surrounds the implant hindering detection of bio-signals. Hence, anti-biofouling coating which could prevent adhesion of bacteria and immune cells has been of great interest. However, the durability, and the complex fabrication systems such as high vacuum chamber limited its usage.
Here, we developed anti-biofouling coating for biomedical

implants including orthopedic implants and urethral catheter, neural probe with chemical modification. The developed coating exhibits excellent durability and anti-biofouling property while being facile to be coated on any materials with complex shapes. Briefly, the developed lubricant skin coating consists of three different layers; an adhesive polydopamine layer, perfluoropolymer (PFP) layer, and slippery lubricant layer to make surface highly repellent to biosubstances. All the fabrication process was done via liquid phase deposition allowing even 3D complex structure can be easily coated. The developed coating can be easily applied on currently used biomedical sensors and medical implants (i.e. orthopedic implants, urethral catheter, neural probe) while exhibiting super antibiofouling, and antibacterial property. The results demonstrate its great potential for clinical purposes, and biomedical biosensors where antibiofouling coating is highly demanded to prevent biosubstances adhesion, and bacterial infection. It will be important to determine the functional lifetime of the coating in representative physiological conditions to validate it further.

Short Bio

Prof. Jungmok Seo is an assistant professor in the electrical and electronic engineering department at Yonsei University. He received his Bachelor's and a Ph.D. degree in Electrical and Electronic Engineering, Yonsei University. Then, he served as a postdoctoral research fellow at Brigham and Women's Hospital and Harvard Medical School. His research has been focused on the development of functional systems for bio-integrative applications using a nature-inspired approach. Especially, He is currently working on the development of electronic drugs using stimuli-responsive drug delivery systems and integrated biosensors as well as strategies to reduce implant foreign body response and bacterial infection which improve the longevity of the implantable devices.

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Micro/Nano Technology for Bio/Chemical Applications

IS7: 11:40-13:10
Tuesday, December 15, 2020
Location: RM 001

Session Chair: **Chien-Fu CHEN**
National Taiwan University, Taiwan

Description

Five outstanding researchers introduce the latest micro/nano technologies for bio/chemical applications

IS7.1 Development of Diffusiophoretic Methods for Solid-State Nanopore DNA Sequencing, Wei-Lun HSU, The University of Tokyo, Japan

Abstract

To combat pandemics, exploring simple and fast molecule sequencing alternatives to labor-intensive and time-consuming polymerase chain reaction methods is of urgent importance for mitigating the burden of the already overloaded healthcare systems. Resistive pulse sensing using artificial solid-state nanopores, possessing the advantages of mechanical strength, flexible geometric capability, and stable chemical properties over biological nanopores, is considered to be a solution for high accuracy and low instability DNA sequencing. However, its development has confronted obstacles of both insufficient spatial and temporal resolutions, limiting the practical sequencing applications. In this regard, nanopores made of two-dimensional (2D) materials, whose thickness coincides with the distance between nucleotides, have been widely adopted to overcome the constraints of the spatial resolution, although the temporal resolution remains low due to the fast translocation speed of DNA molecules. In this study, we propose a novel approach based on diffusiophoretic migration of DNA molecules in a 2D nanopore that effectively reduces the DNA translocation velocity for sequencing applications. It is shown that the mild diffusiophoretic force on the molecules results in smooth DNA translocation, thus revealing the structural information of ssDNA molecules. Computational simulation indicates that a reverse flow outside the nanopore inlet occurs under a salt concentration gradient which facilitates the molecule capture. In the meanwhile, the sudden decrease of the diffusiophoretic force on the molecules in the nanopore remarkably decelerates the molecule translocation speed, providing a new pathway to directly sequence DNA molecules using solid-state nanopores.

Short Bio

Dr. Wei-Lun Hsu is a Lecturer belonging to the Thermal Engineering Laboratory at the Department of Mechanical Engineering, The University of Tokyo. He received his BSc and MSc degrees from National Taiwan University in Chemical Engineering in 2007 and 2009, respectively. In 2015, he obtained his PhD in Chemical and Biomolecular Engineering from the University of Melbourne. He then moved to Japan for his postdoctoral training at the Department of Mechanical Engineering, The University of Tokyo. In 2017, he started working as faculty in the same institute. His principal research interests lie in colloid and interface science, micro/nanofluidics, electrokinetics in ultrathin nanopores for bio-nanosensing and water adsorption in mesoporous materials with application to desiccant-based air-conditioning systems.

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IS7.2 Single Nanoparticle Impact Electrochemistry for Highly Sensitive Cancer Protein Detection in Human Serum, Yi-Ge ZHOU, Hunan University, China

Abstract

Protein quantification with high throughput and high sensitivity is essential in the early diagnosis and elucidation of molecular mechanisms for many diseases. Conventional approaches for protein assay often suffer from high costs, long analysis time and insufficient sensitivity. The recently emerged nano-impact electrochemistry (NIE), as a contrast, allows in situ detection of analytes one at a time with simplicity, fast response, high throughput and the potential of reducing the detection limit down to single entity level. This talk will present a NIE-enabled electrochemical immunoassay using silver nanoparticles (AgNPs) as probes for the detection of CYFRA21-1, a typical protein marker for lung carcinoma. This strategy is based on the measurement of the impact frequency and the charge intensity of the electrochemical oxidation of individual AgNPs before and after they are modified with anti-CYFRA21-1 and in turn immunocomplexed with CYFRA21-1. Both the frequency and intensity modes...

Short Bio

Prof. Yi-Ge Zhou received her B.S. and M.S. degrees in Chemistry from Nanjing University (China). She then continued her study at the University of Oxford and obtained her PhD degree in Chemistry in 2013. After that, she worked as a postdoctoral fellow at University of Toronto and Northwestern University (USA). She is currently a professor at Hunan University (China). Her research focuses on single nanoparticle electrochemistry and dip-pen nanolithography based nanofabrication.

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IS7.3 A Study on The Therapeutic Role of Chinese Medicine on The Corneal Injury using a Microfluidic Eye-on-a-chip, Yau Kei CHAN, The University of Hong Kong, Hong Kong SAR

Abstract

Corneal refractive surgeries are popular nowadays for vision correction. However, these surgeries may lead to the upregulation of transforming growth factor-beta 1 (TGF-β1), which triggers subsequent secretion of inflammatory cytokines and upregulation of profibrotic proteins. These physiological events may lead to corneal scarring if the situation gets worse.[1] Under such injury, corneal cells in the stroma of cornea will proliferate and phenotypically differentiate into myofibroblasts which are opaque.[3] This is known as corneal haze, which highly affects the vision.

Lycium barbarum polysaccharide (LBP), a daily supplement, is a mixture of different polysaccharides extracted from wolfberries.[4] Many studies have already shown its various therapeutic effects such as anti-aging, neuroprotective and anti-cancer,[5-8] and also anti-fibrotic and anti-inflammatory.[9, 10] Hence, we hypothesized that LBP can be a natural pretreatment to reduce corneal scar formation with minimal cellular toxicity, and have recently justified the hypothesis in our proof-of-concept in-vitro 2D culture study.[11]

In this study, an eye-on-a-chip model was used, as a more physiologically representative in-vitro model, to further understand the therapeutic potential of LBP and the underlying mechanism on reducing corneal scarring. Corneal stromal cells were cultured in a 3D collagen type I-based hydrogel within the chip. The cells were pre-treated with LBP solution for 24 hours, followed by a 24-hour incubation with TGF-β1 to induce relevant physiological events after corneal injury. The results in this study showed that LBP reduced both pro-fibrotic proteins and pro-inflammatory cytokines on TGF-β1 induced events within the eye-on-a-chip model. We suggest that LBP, in the form of a topical solution, may potentially be a novel pre-treatment option prior to corneal refractive surgeries with an improved prognosis.

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4. Luo, Q., et al., Hypoglycemic and hypolipidemic effects and antioxidant activity of fruit extracts from Lycium barbarum. Life Sci, 2004. 76(2): p. 137-49.
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9. Gan, F., et al., Lycium barbarum polysaccharides improve CCl4-induced liver fibrosis, inflammatory response and TLRs/NF-kB signaling pathway expression in wistar rats. Life Sci, 2018. 192: p. 205-212.
10. Wu, P.S., et al., Hot water extracted Lycium barbarum and Rehmannia glutinosa inhibit liver inflammation and fibrosis in rats. Am J Chin Med, 2011. 39(6): p. 1173-91.
11. Kwok, S.S., et al., Lycium barbarum Polysaccharide Suppresses Expression of Fibrotic Proteins in Primary Human Corneal Fibroblasts. J Clin Med, 2020. 9(11).

Short Bio

YK Chan has a biomedical engineering background and dedicates himself to apply bioengineering technologies in the field of ophthalmology. His research interest lies on the design and testing of ophthalmic biomaterials, surgical tools and diagnostic tools, and the development of eye-on-a-chip microfluidic platforms for physiologically relevant studies in eye research. In the meantime, he is also exploring the use of all-aqueous immiscible liquid-liquid system as platforms to form cellular structures for potential cell transplantation purposes in the cornea. He also works very closely with many ophthalmologists, and gets involved in many clinical studies of the treatments for glaucoma and other retinal diseases.

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IS7.4 Multifunctional Nanoparticle for Cancer Theranostics and Drug Delivery, Ren-Jei CHUNG, National Taipei University of Technology, Taiwan

Abstract

Gliomas display a poor disease prognosis causing death within 15 months after diagnosis. Chemotherapy has offered some hope to target this, however, it is majorly ineffective due to the low therapeutic window, poor efficacy and high cytotoxicity. To overcome these challenges, we conjugated Angiopep-2, a cell penetrating peptide (CPP) to Iron Gold (Fe-Au) alloy nanoparticles and investigated the ability of Ang-Fe-Au Nps conjugate to limit glioma growth via magnetic field induced hyperthermia. Our results show that 6.44nm sized conjugated Fe-Au Nps were superparamagnetic, enhanced negative Glioma image contrast and displayed a 12°C temperature elevation when magnetically stimulated, indicating applications in medical imaging and hyperthermia-based therapy. Angiopep-2 conjugation resulted in 1.5-fold higher ingestion by C6 glioma cells than L929 fibroblasts, indicating specific glioma targeting and resulting in 90% decrement in cell viability due to magnetic field induced hyperthermia. Immunohistochemical analysis showed an enhanced coagulative necrosis, glial fibrillary acidic protein (GFAP) expression and decreased Ki67 labelling index in rat treated with Ang-Fe-Au Nps which translated to a 5-fold decrement in tumor volume, consequently resulting in an increased survival time by 7 days. The dual application of this platform opens new doors towards cancer theranostics with minimal invasiveness.

Short Bio

Dr. Ren-Jei Chung is Professor in the Department of Chemical Engineering and Biotechnology at National Taipei University of Technology (Taipei Tech), and also serves as the Director in the Advanced Materials Research Center. He has his research interests in Biomaterials, Biomedical Applications of Nanotechnology, Tissue Engineering and Biosensors. He has been awarded for Young Investigator Award from 2014 International Symposium of Materials on Regenerative Medicine; Dr. Shechtman Young Researcher Award from Taipei Tech in 2015; 2017 Excellent Young Member of Taiwan Ceramic Society; 2017 Excellent Junior Research Investigators Award from Association of Chemical Sensors in Taiwan; 2018 Excellent Research Award from Taipei Tech College of Engineering; 2019 Excellent Research Award from Taipei Tech; 2019 Young Scholar Award from Taiwan Association for Coatings and Thin Film Technology; and granted for 2019 Project for Excellent Junior Research Investigators from Ministry of Science and Technology (MOST Taiwan).

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IS7.5 Dry Adhesive Tape Bonding: a Simple, Low-Cost, and High Throughput Bonding for Multilayer and Hybrid Microdevice Integration, Chia-Wen TSAO, National Central University, Taiwan

Abstract

With the 30-years development of microfluidic technology, it has been applied in various applications, including biomedical, chemistry, energy, and environmental applications [1]. Originated from micro-electrical mechanical system (MEMS) and semiconductor microfabrication techniques, the microfluidic devices are mainly fabricated from glass and silicon substrates. The microstructures and microfluidic channels are generated by standard UV lithography, dry/wet etching, and deposition process on these substrates. In 2000~2010 period, polymer (polydimethylsiloxane and thermoplastic) and paper materials have introduced as alternative low-cost disposable material for microfluidics. Currently, thermoplastic, paper, and polydimethylsiloxane have become major materials for microfluidic device and it also plays a critical role for device commercialization due to their low-cost advantage [2].

In microfluidic fabricaiton, post-end bonding process is a critical last step that determine the yield and success of the the device. Thus, a effective, low fabrication cost (facility cost and material cost) and high throughput approach sealing these (thermoplastic, polydimethylsiloxane or paper) materials is required to be investigated. Among all of existing bonding techniques, dry ahesvie bonding is the most simple and straightforward approach. It also present good capability hybrid integrating/bonding thermoplastic, polydimethylsiloxane or paper materials for various advanced applications. In NanoMED 2020, we discussed about the bonding phenomena and its potential for multi-layer and hybrid fabrication based on the thermoplastic-based microfluidic platform using dry adhesive tapes bonding.

[1] N. Convery and N. Gadegaard, "30 years of microfluidics," Micro and Nano Engineering, vol. 2, pp. 76-91, 2019/03/01/ 2019.

[2] C.-W. Tsao, "Polymer Microfluidics: Simple, Low-Cost Fabrication Process Bridging Academic Lab Research to Commercialized Production," Micromachines, vol. 7, p. 225, 2016.

Short Bio

Dr. Chia-Wen Tsao is now a Professor in Department of Mechanical Engineering, National Central University, Taiwan. And Director of CAIC (Center for Academia and Industrial Collaboration), National Central University, Taiwan form 2018-2020. Dr. Tsao got his M.S. degree in Department of Mechanical Engineering in University of Colorado at Boulder in 2004 and a Ph.D. degree in Department of Mechanical Engineering in University of Maryland at College Park in 2008. He joined National Central University as assistant professor in 2008 after graduation. Before join university as professor, he also worked in industrial as mechanical engineer and MEMS process integrator for four years. His research interests include polymer microfluidic microfabrication technologies, Lab-on-chips device, MEMS, and mass spectrometry technologies.

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Micro/Nano Engineering for Bio- & Medical Applications

IS8: 11:40-13:10
Tuesday, December 15, 2020
Location: RM 002

Session Chair: **Yoshikazu HIRAI**
Kyoto University, Kyoto, Japan

Description

Micro/Nano Engineering researchers interact across disciplines to enhance and strengthen the potential of their technologies in revolutionizing the fields of medicine and biological sciences. This session is organized six energetic researchers in Japan and highlights recent advances in the field of Micro/Nano technologies such as Nanomaterials, Sensors, and Integrated microfluidic platforms for precision medicine.

IS8.1 Microphysiological Systems Based on Microfluidics for Cell-Based Assays, Hiroshi KIMURA, Tokai University, Japan

Abstract

We will present integrated microfluidic platforms, which allow precise control of the cell culture environment on microphysiological systems. Maintenance and replication of physiological functions of cells cultured in vitro are extremely difficult in conventional cell-based assay methods during life science and medical applications. Microfluidics is an emerging technology with the potential to provide integrated environments for maintenance, control, and monitoring the environment around cells. We work mainly in fundamental technologies of microfluidic devices and systems, and their applications to biological sciences. A physiological environment in vitro can be replicated by fabrication of microstructures and control of microfluidics in these devices. Moreover, functional components, such as sensors, valves and pump, can be integrated into the devices by microfabrication methods. We performed cell-based assays to evaluate the function of these devices. Because cells cultured in vitro could be maintained and measured, these devices may be applied to medical, pharmaceutical, and biological sciences.

Short Bio

Dr. Hiroshi Kimura graduated with a PhD in bioengineering from the University of Tokyo in Japan, and with postdoctoral degrees from Institute of Industrial Science (IIS), the University of Tokyo. Currently, he is an associate professor at Tokai University since 2012. His research interests are mainly in fundamental technologies of microfluidics, and their applications to biological sciences including microphysiological systems.

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IS8.2 Surface-Enhanced Raman Spectroscopy Using Gold Nanoparticle Dimers Formed by DNA Origami as a Sacrificial Nanostructure, Naoki YAMASHITA, Kyoto University, Kyoto Japan

Abstract

DNA origami is a nanoscale molecular structure formed by folding a longer single-stranded DNA template into a target structure by annealing it with hundreds of shorter single-stranded DNA. DNA origami can assemble various kind of nanomaterials including nanoparticle, protein, fluorescent label, and much more. DNA origami is now finding application uses in many fields such as bio/chemical-sensing, drug delivery, nano-device, and so on. In this research, to create a nanogap-based device for single-molecule label-free detection using surface-enhanced Raman spectroscopy (SERS), a new technique utilizing DNA origami as a sacrificial nanostructure is proposed. In this technique, 30-nm diameter gold nanoparticles (AuNPs) are precisely connected to form a dimer structure on opposite faces of a DNA origami sheet structure with 2-nm thickness. The conjugates of two AuNPs and a DNA origami are fixed on a silicon chip supporting an amino-terminated monolayer, and then the DNA origami is selectively removed using vacuum ultraviolet light and ultrapure water rinsing. X-ray photoelectron spectroscopy measurements and SERS analyses performed in air without any analyte confirmed the successful removal of the DNA origami and formation surface-clean AuNP dimers. The performance of SERS-based molecular detection of AuNP dimers created using the proposed technique with a 30-nm AuNP diameter has been evaluated. The Raman signals from the target molecules (4,4'-bipyridine) were greatly enhanced and thus successfully detected.

Short Bio

Naoki Yamashita is a postdoctoral researcher at machine

element laboratory in department of mechanical engineering and science, Graduate School of Engineering, Kyoto University. He received his M.S. in Engineering from Doshisha University, and the Ph.D. in Engineering from Kyoto University, studying under Prof. Osamu Tabata's supervision. His research focus is in the area of surface chemistry based on nanoscale evaluation. His research aims to develop high-sensitivity surface analysis and characterize surface properties for biology, chemistry, and machinery. He specializes in nanomaterials such as DNA and metal nanoparticles, and surface imaging with atomic force microscopy, and surface analysis with various spectroscopic systems.

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IS8.3 Excitation Light Confinement in Nano-Slits for Single-Molecule Observation of the Interaction Between Kinesin and Nucleotide, Kazuya FUJIMOTO, Kyoto University, Japan

Abstract

Single-molecule observation has been utilized to explore a mechanism of motor protein such as kinesin that moves on microtubules fueled by hydrolysis of adenosine tori-phosphate (ATP). Researchers have been observed binding and dissociation of individual fluorescently labelled nucleotides and kinesin to establish a shared understanding of how chemical reaction and mechanical displacement correlate. Conventional experiment setups, however, suffer from low concentration available for observation because background noise from a high concentration of fluorescently labelled molecule disables to detect the signal from an individual molecule. For example, total internal reflection microscopy (TIRFM), which is the most widely used setup for single-molecule observation, permit only ~100 nM of concentration. This limitation results in low observation efficiency and discrepancy of experimental condition from in vivo, where the concentration is higher in order of magnitude.

A nano-scale device called zero-mode waveguides (ZMWs) broke the concentration limit by utilizing nano-optical effect by which excitation light for fluorescent microscopy is confined in small pits formed on a thin metal layer. They are used in various fields from an application such as gene sequencing to pure biophysical studies. However, the size of the cytoskeletal filaments on which motor proteins move has hindered them from the utilization of ZMWs.

To conquer this limitation, we developed linear-shaped ZMWs (LZMWs) compose of nano-slit structures. LZMWs can confine excitation light whose polarization direction is parallel to the slits, enabling the usage of higher concentration of dyes while allowing the introduction of filamentous objects such as microtubules. We established the experimental system to observe interactions between labelled ATP and kinesin accompanied by microtubule gliding motility assay in nano-slits. It achieved the use of 500 nM of labelled ATP concentration, way higher than past reported condition. Observation results indicated the existence of microtubule effect to the binding rate of ATP to kinesin.

Short Bio

Kazuya Fujimoto is an assistant professor at the Department of Micro Engineering, graduate school of Kyoto University. He received his B.S., in 2011, M.S., in 2013 and Ph. D. in 2016 at Kyoto University. In Ph. D course, he was selected to JSPS Research Fellowship for Young Scientists (DC1). After getting Ph. D., he worked as a postdoctoral researcher at Kyoto University. After that, he also worked for a company as a software engineer and a machine learning researcher. His research has been focused on measurement and control of motor protein systems such as kinesin and microtubules, with expertise in multiple technical fields including micro-nano fabrication technology, an optical system for microscopy, and, numerical simulation of micro–nano scale phenomenon. His research interest also includes image processing, machine learning, and automated systems, toward an overarching goal establishing autonomous artificial systems composed of highly ordered elements like organisms.

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IS8.4 Detection of Small Nucleic Acids Using Electrochemical Devices for Liquid Biopsy, Miyuki TABATA; Yuji MIYAHARA, Tokyo Medical and Dental University, Japan

Abstract

Liquid biopsy has got attention by clinicians to diagnose or control disease through minimally-invasive body fluid testing. Circulating small nucleic acids in patient's blood are known as potential diagnostic biomarkers in liquid biopsy targeting cancers. For example, the concentration of cell-free DNA is higher in diseased than healthy individuals, and the relationship between microRNA (miRNA) expression and type of cancer strictly correlates. These nucleic acids are detected with fluorescence dyes such as intercalating reagents (e.g., SYBR Green) or sequence-specific reporter probes to quantify the amplicons. On the other hand, electrical/electrochemical sensing methods without labeling agents for nucleic acid detection are also attracting attention owing to the advantage in miniaturization of instrument's size, which is an unnecessary optical detection system such as laser excitation systems and fluorescence detectors.

In this research, we proposed a simplified chip for isothermal nucleic acid amplification and electrochemical detection aiming at application to future liquid biopsy platforms. For the amplification method, three-way junction primer-generation rolling circle amplification (3WJ PG-RCA), was employed and the increase in protons released during the polymerase extension reaction was detected before and after the reaction as pH change using miniaturized Ir/IrOx chip. IrOx is known as an excellent pH-responsive

material and the output potentials are converted to a function of the proton concentration (pH) according to the Nernst equation. Our data indicate that miRNAs were successfully amplified with 3WJ PG-RCA and the pH value decreased after the reaction in the presence of target miRNA. Nucleic acid amplification monitoring devices in which combining biology/medical field and electrochemical technology are strongly effective for simplifying of the measurement process, miniaturization of the measurement system, and cost reduction.

Short Bio

Miyuki Tabata received her Ph.D. in Graduate School of Pure and Applied Sciences from University of Tsukuba in 2012. She joined the Tokyo Medical and Dental University in the laboratory of Bioelectronics (Prof. Yuji Miyahara). Her research focuses on developing electrical/electrochemical biosensing devices and the medical applications.

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IS8.5 Lab in Bento Box: Development of a Compact Automated Microfluidic Enzyme-Linked Immunosorbent Assay System, Yoshiaki UKITA, University of Yamanashi, Japan

Abstract

In the world wide pandemic of Corona virus in 2020, the importance to prepare various simple to advanced testing techniques such as PCR, antigen testing, antibody testing, etc., not only pandemic situation but also normal times, has become widely recognized. Not only from the viewpoint of preventing the spread of infection in pandemics, but also considering aging society and limited human resource in the medical field, there is a strong demand for the establishment of next-generation's medical infrastructure such as home medical care and telemedicine. Remote technology based on existing information and communication (ICT) infrastructure such as remote medical examinations has been steadily developing, and diagnostic technology utilizing artificial intelligence (AI) is also growing rapidly.

On the other hand, with regard to the blood test technology that is the basis of various diagnoses, it is essential to collect blood manually, and there is a problem that is essentially incompatible with the above ICT technology. Therefore, it is essential to develop a ubiquitous blood testing technology in parallel with the above technology. In order to achieve this, it is important to realize a safe operation, sufficiently economical, and small testing device.
We have been developed a microfluidic system for miniaturized enzyme-linked immunosorbent assay (ELISA), which is suitable for miniaturization and lower cost, based on original centrifugal microfluidic controlling concept. In this talk I will introduce basic of the controlling principle of the microfluidic system and latest result of the development.

Short Bio

Yoshiaki Ukita was born in 4th Mar 1982 in Japan. He received Dr. degree from University of Hyogo in 2009 and became research fellow of Laboratory of Advanced Science and Technology for Industry (LASTI), University of Hyogo and Japan Society for Promotion of Science (JSPS). He became assistant professor of Japan Advanced Institute of Science and Technology (JAIST) in 2010. He became assistant professor of University of Yamanashi and have his own laboratory as principle investor from 2014. He became associate professor of University of Yamanashi in 2019. His research interest is development of microsystems and biomolecular sensing system.

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IS8.6 Principles and Applications of Intelligent Image-Activated Cell Sorting 2.0, Akihiro ISOZAKI, The University of Tokyo, Japan

Abstract

We recently proposed a new term, AI on a chip, for a growing research field of a combination of artificial intelligence (AI) technology and lab-on-a-chip technology [Isozaki et al., Lab on a Chip 20, 3074 (2020)]. In this invited talk, I introduce an AI-on-a-chip technology we previously reported as "Intelligent Image-Activated Cell Sorting (iIACS)" [Nitta et al., Cell 175, 266 (2018); Isozaki et al., Nature Protocols 14, 2370 (2019)]. The iIACS machine builds on a fundamentally new architecture that makes image-based intelligent cell sorting possible at an ultra-high throughput manner. This technology integrates four components on a hybrid software-hardware data-management infrastructure: a homemade high-speed microscope, cell focuser, high-speed sorter, and deep learning-based image processer, which enables real-time automated operation for data acquisition, data processing, intelligent decision-making, and actuation. Recently, we improved the state-of-the-art iIACS machine and, at the beginning of this year, reported an upgraded version of the iIACS machine that shows higher system performance, expanding the range of applications and discoveries enabled by the technology [Isozaki et al., Lab on a Chip 20, 2263, (2020)]. Specifically, the upgraded iIACS machine gives a high sensitivity of ~50 molecules of equivalent soluble fluorophores (MESFs) and a high throughput of 2,000 events per second. I introduce the details of its principles in this invited talk. Furthermore, we are applying this technology to a diverse range of applications (e.g., immunology, cancer biology, hematology, microbiology, and synthetic biology). I introduce some of these applications conducted in our laboratory.

Short Bio

Akihiro Isozaki received his B.S. in mechanical engineering from Meiji University in 2006, and his M.S. in mechano-informatics from the University of Tokyo in 2008. From 2008-2010 he conducted studies at Panasonic Corporation prior to receiving his Ph.D. in mechano-informatics from

the University of Tokyo in 2014. He then conducted post-doctoral studies in the Department of Chemistry of the University of Tokyo until 2019 and took his current position as an assistant professor in the same year. He is currently engaged in the development of novel high-throughput cell sorting devices and their applications.

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Advances in Soft Nano/Bio Materials for Bioengineering & Medicine

IS9: 10:00 -11:45
Wednesday, December 16, 2020
Location: RM 001

Session Chair: **Jin-Woo KIM**
University of Arkansas, USA

Description

This session will cover recent advances in developments and applications of novel soft nano/bio materials for bio/nano medicine and bioengineering.

IS9.1 Hybrid Donor-Acceptor Polymer Particles for Fluorescent Identification and Photothermal Treatment of Cancer, Nicole LEVI; Elizabeth GURYSH; Eleanor MCCABE-LANKFORD; Chris MACNEILL; Santu SARKAR, Wake Forest School of Medicine, USA

Abstract

Donor acceptor polymer particles (DAPPs) are routinely designed to altering their optical absorption properties for detection and treatment of breast or colorectal cancer. DAPPs were composed of poly[4,4-bis(2-ethylhexyl)-cyclopenta[2,1-b;3,4-b']dithiophene-2,6-diyl-alt-2,1,3-benzoselenadiazole-4,7-diyl] (PCPDTBSe), which generates heat upon NIR stimulation. This was combined with poly[(9,9-dihexylfluorene)-co-2,1,3-benzothiadiazole-co-4,7-di(thiophen-2-yl)-2,1,3-benzothiadiazole] (PFBTDBT10), which is a fluorescent polymer that allows for in vivo detection of the nanoparticles. Cytotoxicity assays were then done to evaluate the effect of the DAPPs on breast or colorectal cancer cells, with and without infrared stimulation. Photothermal ablation assays in 2D or 3D were performed to determine the concentrations of nanoparticles needed to induce cell death. Then mammary fat pad tumors were induced in Balb/c mice using the bioluminescent 4T1 murine breast cell line. DAPPs were delivered systemically without a tumor specific ligand, and then the animals were imaged to examine the overlap of the fluorescence of the nanoparticles with the bioluminescent cancer cells. Photothermal ablation was then performed by exposing the tumors to 3-5 W /cm2 of 800 nm light. Alternatively CT26 murine colorectal cancer cells were used to develop micro-metastasis in the abdomen of Balb/C mice. Peritoneal delivery identified that DAPPs localized to tumors to identify where NIR stimulation needed to be applied in an open abdomen. NIR stimulation led to selective photothermal ablation of the breast tumors, leading to prolonged animal survival. A significant advantage is that polymer nanoparticles can localize to breast tumors without the need of a tumor-guiding molecule. Photothermal ablation was not possible for widespread treatment of disseminated colorectal cancer, due to the optical absorption of the abdominal vasculature. However, the nanoparticles may be useful for fluorescently detecting tumors for resection during surgical procedures. Donor acceptor polymer nanoparticles are stable, inert, not subject to oxidation, and can be heated and imaged repeatedly without loss of their fluorescence or heat generating capacity.

Short Bio

Nicole Levi, Ph.D., is an Associate Professor and Director of Materials Research Innovation and Development in the Department of Plastic and Reconstructive Surgery. She has training in Physics and Biomedical Engineering, with specific expertise in the field of nanotechnology. The primary focus of her research is on the development of heat-generating materials. One facet of her research involves the synthesis of nanoparticles composed of donor-acceptor conjugated polymers that can both fluoresce, and be optically-stimulated to generate heat. She is the PI of a DOD-supported study to evaluate these nanoparticles in cancer models for detection, ablation and chemo-sensitization of breast and colorectal cancer. Dr. Levi-Polyachenko's strength is the development of innovative materials to solve medical problems, and she has eleven patents on her work to date.

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IS9.2 Radionuclide Mediated Stimulation of Photodynamic Agents for Precision Phototherapy, Nalinikanth KOTAGIRI, University of Cincinnati, USA

Abstract

The management of aggressive malignancies often include combination treatment strategies to achieve optimal cell killing. Several chemotherapeutic drugs are a substantial part of many multimodal treatment schedules for metastatic cancers that includes radiotherapy. Thus, the risk of parallel use of both radiotherapy and drug usage is high due to accidental overlap of radiation-drug interactions. Concomitant chemotherapy and radiation therapy is an established treatment regimen for many neoplasms. For example, paclitaxel (Taxol) has been shown to be antiangiogenic and it also has been shown to enhance the therapeutic effects of ionizing radiation in clinical trials. Therefore, there is a need for systematic examination of drug-radiation interactions and more fundamentally, photochemical and biological interactions between different classes of drugs and radiation. In this study, we screened various FDA approved drugs and evaluated their synergy with different types of

radiation sources to determine drugs that exhibit significantly higher toxicity against cancer cells in combination with radiation. Previous studies have explored how energy from radionuclides can be harnessed by certain compounds and nanoparticles for photoactivated therapy. In this study we demonstrate how several FDA approved drugs can potentially be used synergistically with radionuclides for enhanced cancer therapy. Moreover, we also demonstrate how diagnostic radionuclides, such as ^{18}FDG, through ionizing photons, can be repurposed as a radiotherapeutic after cell "priming" by radiosensitizers.

Short Bio

Nalinikanth Kotagiri is an Assistant Professor of Pharmaceutical Sciences in the College of Pharmacy at University of Cincinnati. After training as a Medical Doctor in Andhra Medical College, India, he received his Ph.D in Cell & Molecular Biology from the University of Arkansas. He then worked as a Postdoctoral Fellow in the Mallinckrodt Institute of Radiology at Washington University School of Medicine in St. Louis. He has developed novel optical-nuclear probes for molecular imaging and site-selective activation of therapeutic events. He pioneered the development and use of a clinically translatable depth- and oxygen-independent phototherapy platform using radiopharmaceuticals. His work is published in high-impact journals such as *Nature Nanotechnology, Nature Communications and Angewandte Chemie*. He has received several research awards including the Dan Bugher Thinking Outside the Box Award and has one granted and two pending patents. He has served as Award Committee co-Chair for the IEEE-Nanomed 2019.

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IS9.3 Engineering Outer Membrane Vesicles for Multivalent Vaccine Delivery, Yehou Michel Davy GNOPO, Cornell University, USA

Abstract

Vaccines prime our immune system to fight potential pathogenic infections. Their effectiveness is highest when the right antigen is used in their formulation. Historically, vaccine formulations that rely on inactivated or killed forms of whole pathogens have been the most potent. However, with many safety concerns, subunit vaccines have become more popular. In most cases, the immune response elicited by the antigens in subunit vaccine formulations on their own is weak, thus requiring a boost given by chemical or biological agents known as adjuvants through a variety of mechanisms. The resulting immune protection in these cases may not be long-lasting, further requiring booster shots. Understandably, a solution to this vaccine efficacy problem that is currently being explored is the co-delivery of multiple antigens. The question is then should the delivery mirror the pathogen by using a delivery vehicle that contains multiple antigens, or is the immune response sufficient if the antigens are administered as a simple mixture? This presentation will discuss our work in answering this question through the engineering of a co-delivery platform based on promising vaccine delivery vehicles known as outer membrane vesicles (OMVs).

OMVs are spherical lipid bilayers, nanometers in size, that naturally bud from the outer membrane of bacteria. Due to their origin, they contain biomolecules that can aid in modulating the immune response, thus acting as adjuvants themselves. Previous work done by our group has shown that this vaccine engineering approach is successful in preventing a lethal influenza infection in rodents. To engineer the OMV platform to co-deliver multiple antigens, we use a process known as membrane fusion to create hybrid vesicles. Membrane fusion is a naturally occurring biological process that we induce under controlled conditions such as a combination of salt, pH, and temperature pertaining to the specific type of vesicle used in the fusion reaction. The hybrid vesicles we engineered can play a major role in rethinking the current approach to vaccine formulation.

Short Bio

Yehou Michel Davy Gnopo is an incoming Senior Scientist in the Vaccine Process Development and Commercialization (VPDC) group at Merck. He received his B.S. in Chemical and Biomolecular Engineering from Lafayette College and his Ph.D. from the Robert F. Smith School of Chemical and Biomolecular Engineering at Cornell University. He completed his dissertation in the laboratory of Dr. David Putnam combining colloidal chemistry and molecular biology to lead the development of outer membrane vesicles for multivalent vaccine delivery. He is a current Fellow of the Cornell's Engineering PhD Commercialization Fellowship program and an Africa Fund Fellow of the Cornell Graduate School. He was also a Graduate Fellow of the Cornell's Kavli Institute for Nanoscale Science and a Fleming scholar of the Cornell's Robert F. Smith School of Chemical and Biomolecular Engineering.

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IS9.4 Tissue-Specific Bioinks for 3D Bioprinting of Cancers-on-Chips, Hee-Gyeong YI. Chonnam National University, Korea

Abstract

Microphysiological systems are emerging tools for modeling cancers in vitro to explore advanced anti-cancer approaches. Conventional cancer models have failed in capturing the underlying mechanisms of how cancer reacts to the current anti-cancer treatments due to the lack of similarities with the resistances developed in original cancers. Although it has been elucidated that cancer microenvironment influences the development of cancer resistance and the pathological behaviors, the challenge is construction of the cancer and its milieu as it is extremely complicated with heterogeneous components. Recently, biofabrication technologies have provided ways to spatially control multiple types of cells and biomaterials to mimic the native physiology of human tissue. In particular, 3D cell-printing facilitates to build bioinks, hydrogels containing live cells, as building blocks, and therefore, it enables to construct tissue-like

structure composed of various types of cells and biomaterials. Moreover, the use of organ-derived extracellular matrix (ECM) hydrogel as bioink has been proved it is promising to preserve the unique composition of biomolecules varying between each organ and to provide tissue-specific matrix environment. Therefore, the resulting tissue-specific bioink and and 3D bioprinting technology become powerful platforms to create highly biomimetic cancers-on-chips to perform test of anti-cancer compounds. In addition, this approach has shown the possibilities in modeling various types of cancers for future cancer research.

Short Bio

Prof. Hee-Gyeong Yi awarded a Ph.D. from the Department of Mechanical Engineering at Pohang University of Science and Technology (POSTECH) under the supervision of Prof. Dong-Woo Cho in Republic of Korea (Aug. 2018). After that, she had co-worked with teams of College of Medicine at Seoul National University and Department of Mechanical Engineering at POSTECH to perform her project funded by The Young Researcher Program of Korea NRF as a Principal Investigator (2019 – present). She then joined Chonnam National University in the Fall of 2020 as an Assistant Professor in the Department of Rural and Biosystem Engineering, College of Agriculture and Life Sciences. Ever since she was a kid, she has raised interests in engineering interdisciplinary approaches for biological applications, and she has focused on 3D bioprinting technologies for various biomedical applications such as organs on chips for drug discovery, living tissue implants for organ regeneration, and cell/drug delivery system. Her current research explores advanced bio-manufacturing technologies for building biosystems for the bioengineering/agricultural applications.

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IS9.5 Textile based Wearable Polymer Solar Cells for Medical/healthcare Applications, Seok Ho CHO, Chonnam National University, Korea

Abstract

Among wearable electronics, textile-based wearable electronics, so called smart textile, are receiving a great attention as a next generation technology. Because textiles are closely connected with humans in daily life, integrating electronic devices into textiles allows maximum convenience. In particular, a lot of research has been conducted to utilize smart textile technology for medical and healthcare area. To achieve the successful commercialization of smart textile, integration of power sources to the smart textile should be implemented because all electronic components integrated into smart textile require continuous power supply. The ideal power source for smart textile applications must satisfy both high flexibility and light weight. From this point of view, polymer solar cells(PSCs) are one of the attractive candidate for lightweight, extremely flexible and flat power source that can be integrated into various textile platform for supplying electrical power. However, relatively low energy conversion efficiency and washing durability are considered as disadvantages of PSCs.
In this presentation, we will discuss about the way for improving energy conversion efficiency and washing durability of PSCs by using nanomaterials and nanophotonics. Through these improvements, it will be expected that the successful commercialization of smart textile technology for medical and healthcare is promoted.

Short Bio

Seok Ho Cho received the B.S. and Ph.D. degrees from Korea Advanced Institute of Science and Technology (KAIST), Daejeon, South Korea, in 2010 and 2016, respectively, all in electrical engineering. He is currently an Assistant Professor with the Department of Clothing and Textiles, Chonnam National University, Gwangju, South Korea. His research interests include organic electronics and textile/fiber based electronics for various applications.

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IS9.6 Plasma-assisted Multiscale Topographic Scaffolds for Soft and Hard Tissue Regeneration, Jangho KIM, Chonnam National University, Korea

Abstract

The design of transplantable scaffolds for tissue regeneration requires gaining precise control of topographical properties. Here, we propose a methodology to fabricate hierarchical multiscale scaffolds with controlled hydrophilic and hydrophobic properties by employing capillary force lithography in combination with plasma modification. Using our method, we fabricated biodegradable biomaterial (i.e., polycaprolactone (PCL))-based N2 gas (N-FN) and O2 gas plasma-assisted flexible multiscale nanotopographic (O-FMN) patches with natural extracellular matrix-like hierarchical structures along with flexible and controlled hydrophilic properties. In response to multiscale nanotopographic and chemically modified surface cues, the proliferation and osteogenic mineralization of cells were significantly promoted. Furthermore, the O-FMN patch enhanced regeneration of the mineralized fibrocartilage tissue of the tendon–bone interface and the calvarial bone tissue in vivo in rat models. Overall, the PCL-based O-FMN patches could acceleratesoft and hard tissue regeneration. Thus, our proposed methodology was confirmed as an efficient approach for the design and manipulation of scaffolds having a multiscale topography with controlled hydrophilic property.

Short Bio

Dr. Jangho Kim is an Associate Professor of Biosystems Engineering and a Director of Center for IT-Bio Convergence System Agriculture at Chonnam National University. Prior to joining the current position, he studied as a Senior Researcher of the Research Institute for Agriculture and Life

Sciences, Seoul National University. He also studied as a Researcher in the Thin Film & Charged Particles Research Laboratory at Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign. His research interests include 1) biomaterials and biofabrication, 2) biologically inspired engineering systems, 3) cell and tissue engineering, and 4) agricultural micro- and nanotechnology. He has published over 110 peer-reviewed journal publications, over 30 invited presentations, and over 10 patents pending or granted. He has received many research awards such as Young Scientist Award (Korean and Japan Society for Biomaterials, 2012), Young Plenary Speaker (TERMIS-AP conference, 2013), Samsung HumanTech Paper Award (Samsung Electronics, 2014), Keynote Speaker (TERM STEM 2014), Promising Young Scientist (Korean Society of Mechanical Engineers, 2016), and Excellent Young Professor Award (Chonnam National University, 2017). He has served as organizing committees for several international conferences as well as editorial member for several journals including associate editor of Engineering in Agriculture, Environment and Food (Elsevier).

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IS9.7 Nanocellulose as Nanoscale Building Blocks for Nano/Bio-Hybrid Soft Materials in Bio/Nano Medicine, Jin-Woo KIM; Gurshagan Kandhola, University of Arkansas, USA.

Abstract

Various soft nanoscale materials have proven effective as functional materials, offering immense promise to advance diverse fields, ranging from optoelectronics and nanophotonics to molecular/nano sensing, biosecurity, and bio/nano medicine. Great interest has been focused on their promising attributes for manipulating into multifunctional hybrid nanostructured materials with tailored size, shape and functionality. Despite recent progress, there still is plenty of room for improvement and many untapped resources for innovative strategies to be developed. This presentation will focus on recent advances in our group to design, fabricate, and characterize such biohybrid nanocomposites with nanocelluloses as building blocks, i.e., cellulose nanocrystals and cellulose nanofibrils, derived from cellulose, the most abundant biopolymer on Earth. It will discuss our current results as well as future directions of the controlled assembly of nanocellulose-based composites to realize highly functional and tunable bio-hybrid systems in desired patterns and geometries, and drive innovations in novel hybrid fused technologies in bio/nano medicine.
This work was supported in part by the National Science Foundation (OIA-1457888) and the National Institute of Health (1R21HG010055).

Short Bio

Jin-Woo Kim is a Director of Bio/Nano Technology Group and a Professor of Biological Engineering, Biomedical Engineering and Nanoscience & Engineering at University of Arkansas. He is an Adjunct Professor of Electrical Engineering at Pohang University of Science & Technology (POSTECH). He received his first B.S. in Chemical Technology (currently Chemical & Biological Engineering) from Seoul National University, the second B.S. in Microbiology from University of Iowa, the M.S. in Biology from University of Wisconsin, and the Ph.D. in Biological Engineering from Texas A&M University. He was a Visiting Professor of the School of Engineering and Applied Sciences at Harvard University and the Center for Functional Nanomaterials at Brookhaven National Laboratory. His research focus is in the area of Bio/Nano Technology, i.e., biologically inspired nanotechnology, which spans interdisciplinary fields of biological engineering, biomedical engineering, biology, chemistry, and nanotechnology. Learning from biological systems in nature, his research aims to develop more effective and efficient routes to "panoscale" (i.e., 'any' scale) system integration of multifunctional hierarchical structures for biomimetic advanced materials and devices. He has generated over 130 peer-reviewed publications, over 230 presentations with over 85 invited presentations, and 5 patents granted or pending. He received several teaching and research awards, holds guest editorships and journal editorial board memberships for several journals, including co-Editor-in-Chief of IEEE Open Journal of Nanotechnology, and has been ad-hoc reviewers for leading journals, including Science, PNAS, and Nature Nanotechnology. He held leadership positions for international societies, including Vice President for Conferences (2021-2022) and Vice President for Publications (2017-2019) of IEEE Nanotechnology Council, is a steering committee chair of IEEE-NANOMED, and has served as organizing committees for several international conferences, including general chairs (2015 and 2019), general co-chairs (2011 and 2017) and program chair (2010) of IEEE-NANOMED, general chair (2023) and general co-chair (2019) of IEEE-NANO, general chair (2020) of IEEE-NEMS, etc. He is a Fellow of the American Institute of Medical & Biological Engineering (AIMBE) and IEEE Nanotechnology Distinguished Lecturer (2017-2018).

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Biosensing for Biomedical Applications

IS10: ***10:00-11:30***
Wednesday, December 16, 2020
Location: RM 002

Session Chair: **Kin Fong LEI**
Chang Gung University, Taiwan

Description

This session recruited 5 leading scientists to present cutting-edge research on biosensing for biomedical applications. Based on the mature development of microfabrication and microfluidics technology, micro systems became a powerful tool for various clinical analysis in recent years. A

lot of demonstrations related to biomedical applications have been reported because of their advantages associated with miniaturization, automation, sensitivity, and specificity.

IS10.1 Development of Janus Particles Enabled Rotational Diffusometry for Ultrasensitive Biosensing, Han-Sheng CHUANG, National Cheng Kung University, Taiwan

Abstract

Brownian motion is a self-driving natural phenomenon in which tiny particles show rapid and random movement in liquids. Brownian motion features high robustness, high sensitivity, high reliability, and ease of use. Recently, this technique has also been extended to biomedical applications, such as an investigation of microorganisms and rapid diagnosis of diseases with specific biomarkers. Unlike the conventional translational Brownian motion, rotational Brownian motion appears to show high sensitivity in the change of particle diameter according to the Debye-Stokes-Einstein relation. By taking advantage of this powerful relation, we aimed to quantify the rotational diffusivity by developing functionalized Janus particles. With Janus particles, ultrasensitive detection with a biomarker, tumor necrosis factor alpha (TNF-α), was then conducted for demonstration in this research. Janus particles were fabricated by coating half side of 1-μm fluorescent polystyrene (PS) particles with a 50-nm gold film and purified with filter papers. The signal of rotational Brownian motion was expressed on the Janus particles in terms of blinking fluorescence. The particles were conjugated with capture anti TNF-α IgG to enable sandwiched immunocomplexes comprising capture antibody-antigen-probe antibody in the presence of TNF-α. The probe antibody was later conjugated with 200-nm PS particles to enhance the diameter change. Correlation time was derived from the blinking frequency by the cross-correlation algorithm. Significant blinking frequencies were observed between immunocomplexed and plain Janus particles. A calibration curve exhibited that the correlation time declined with the increased concentrations of TNF-α. The optimal limit of detection of TNF-α measured by the rotational diffusometry achieved as low as 1 pg/mL. Enhancement was also observed on the comparison of Janus particles with and without the 200-nm PS particles. The rotational diffusometry provides an insightful ultrasensitive biosensing capability for early-stage diseases with trace analytes.

Short Bio

Han-Sheng Chuang is currently a full professor in the Department of Biomedical Engineering at National Cheng Kung University, Taiwan. Dr. Chuang received his bachelor and master degrees from the Department of Mechanical Engineering at NCKU in 1998 and 2000, respectively. He worked with Professor Steve T. Wereley for advanced microfluidics and received his Ph.D. from the School of Mechanical Engineering at Purdue University in 2010. After graduation, he received an appointment as a postdoctoral researcher at University of Pennsylvania and worked with Professor Haim H. Bau. Since starting the current position in 2011, he has received the 2014 and 2019 Young Researcher Career Grants from the Ministry of Science and Technology, the 2015 Young Scholar Award from the TCUS, and the 2016 Excellent Teaching Award as well as the 2020 Excellent Research Award from NCKU. In addition, he is currently president of the Association of Chemical Sensors in Taiwan. Dr. Chuang's research interests are mainly focused on bio-micro/nano-fluidics, Bio-MEMS/NEMS, optical diagnostics, and *C. elegans*.

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IS10.2 A Near Infrared Dual-emitting/absorbing LRET Sensor for Homogeneous Detection of Avian-origin Viruses, Joonseok LEE, Korea Institute of Science and Technology, Korea

Abstract

Conventional optical biosensing systems mostly use a single responsive signal in the region of visible light, limiting their practical applications because the signal can be easily perturbed by external environmental factors such as target-independent signal error, light-scattering, and auto-fluorescence. To date, classical visible light-based LRET techniques using organic dyes and/or inorganic-based complexes have been developed for various biosensing applications by taking advantage of their simplicity and versatility. Nonetheless, these techniques often have problems that affect visible region-based applications (e.g., autofluorescence and light-scattering), organic dye-based applications (e.g., photo-bleaching and poor chemical stability), and inorganic-based applications, such as gold nanoparticles and quantum dots (e.g., broad absorption spectrum). In this study, near-infrared (NIR)-based self-calibrating luminescence resonance energy transfer (LRET) system was developed for detection of analytes in homogeneous sandwich-immunoassays. The LRET pair consisted of NIR dual-emitting lanthanide-doped nanoparticles (LnNPs) as donor and NIR-absorbing LnNPs as acceptor. Single-chain variable fragments (scFvs) were screened and used as a target avian influenza virus (AIV)-binding antibody to increase LRET efficiency in homogeneous sandwich-immunoassays. Proposed compact LRET sensor platform successfully detected AIV nucleoproteins with limit of detection of 0.38 pM in HEPES buffer and clinical samples, such as oropharyngeal and cloacal swabs. These results demonstrated that inorganic LnNPs could be used as a self-calibrating LRET system in the NIR region. Furthermore, compact scFv-type homogeneous assays enabled convenient, highly sensitive detection of avian-origin viruses in clinical samples.

Short Bio

Joonseok Lee, Senior Research Scientist, +82-2-958-5079, jslee@kist.re.kr/ Materials Science and Engineering, Hanyang University (BS), Materials Science and Engineering, KAIST (MS, Ph.D.)/ Research area: Functional nanomateri-

als, Healthcare applications/ Homepage: www.nanobiointerfaces.com

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IS10.3 Fiber-based Soft Mechanical Sensors for Wearable and Biomedical Applications, Jaehong LEE, Daegu Gyeongbuk Institute of Science and Technology, Korea

Abstract

Electronic devices with stretchable and wearable features have been attracting a huge interest because of their potential applications in wearable electronics, electronic skins, biomedical engineering, and in-vivo bioelectronics. Among various types of soft and wearable electronic devices, textile electronics which combine conventional textiles and electronic devices is one of promising fields because clothes are essential at all times for all humans regardless of age or gender. However, conventional planar electronic devices have been limited to being woven into flexible textiles or integrated onto complex nonplanar substrates. Such limitation has hindered their use in textiles electronics or advanced wearable electronics. In this regard, stretchable and wearable electronic devices in fiber (1D) form, which can be directly integrated into daily clothes or textiles without any inconsistency are greatly promising for future wearable electronics. In addition, the fiber-based electronic devices can successfully overcome practical limitations (e.g. structural mismatching, suturability. etc.) of previous planar soft electronics in in-vivo applications.

In this talk, fiber-based (1D) soft pressure and strain sensors based on metallic nanomaterials, which can overcome the existing limitations of previous 2D electronic devices, are presented. The research starts with the development of stretchable conductive fibers with outstanding conductivity (>20,000 S/m), stretchability (>450%) and stability over 10,000 stretching cycles using metallic nanoparticles. Based on the conductive fibers, various fiber-based mechanical sensors such as pressure, strain, and multimodal sensors are fabricated for smart textile and wearable applications. In addition to their successful demonstrations in wearable applications, this research is also focusing on considering practical issues in current implantable electronics which is important for clinical applications but have been barely considered so far.

Short Bio

Jaehong Lee is currently working as an assistant professor in the Department of Robotics Engineering at Daegu Gyeongbuk Institute of Science and Technology (DGIST), Republic of Korea. He received his B.S. (2011) and Ph.D. degree (2017) in electrical and electronic engineering from Yonsei University in Republic of Korea. He worked as an ETH postdoctoral research fellow (2018-2020) at the Laboratory of Biosensors & Bioelectronics (LBB) at ETH Zurich, Switzerland. His research focuses on one-dimensional soft electronics for wearable and in biomedical vivo applications. As one of earlier scientists in the field of fiber electronics, he has over 25 peer-reviewed papers with over 1750 citations, ~20 presentations with 9 invited presentations despite the short career in his research field.

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IS10.4 Improving the Purity of Negative Selection-/immunomagnetic Microbeads-based Circulating Tumor Cells (CTCs) Isolation by Optically Induced Dielectrophoresis (ODEP)-based Microfluidic Device, Min-Hsien WU; Po-Yu CHU, Chang Gung University, Taiwan

Abstract

Circulating tumor cells (CTCs) are those cells that escape from the primary tumor tissue and present in the blood circulation. The isolation and purification of CTCs holds great promise for the subsequent cells-, or molecules-based analysis for fundamental research or precision cancer care. By removing the red blood cells (RBCs) and leukocytes in a blood sample, negative selection-based CTC isolation is able to harvest viable, label-free, and clinically meaningful CTCs from the cancer patients' blood. However, its main shortcoming is its inability to isolate high-purity CTCs, restricting subsequent CTC-related analysis and applications. To tackle the technical hurdle, this study proposed a two-step optically-induced dielectrophoresis (ODEP) cell manipulation to process the cell sample harvested by negative selection-/immunomagnetic microbeads-based CTC isolation. The working mechanism is that the ODEP force acting on the cells with and without magnetic microbeads binding is different. Accordingly, the use of ODEP cell manipulation in a microfluidic system was designed to first separate and then isolate the cancer cells from other magnetic microbead-bound cells. Immunofluorescent microscopic observation and ODEP cell manipulation were then performed to refine the purity of the cancer cells. In this study, the optimum operating conditions for effective cell isolation were determined experimentally. The results revealed that the presented method was able to further refine the purity of cancer cell in the sample obtained after negative selection-based CTC isolation with high cell purity (81.6~86.1%). Overall, this study proposed the combination of immunomagnetic bead-based cell isolation and ODEP cell manipulation for the negative selection-based isolation of CTCs.

Short Bio

Min-Hsien Wu is currently a Distinguished Professor in the Graduate Institute of Biomedical Engineering at Chang Gung University, Taiwan. He received his B.S. and M.S. degrees from the Department of Food Science at Tung-Hai University, Taiwan in 1994 and in Applied Biomolecular Technology from the University of Nottingham, UK in 2002, respectively. He received his Ph.D. from the Department of Engineering Science at the University of Oxford, UK in 2005. His research focus is in the area of microfluidic

technology (e.g., for high-throughput perfusion 3-D cell culture and for circulating tumor cell study) and bio-sensing (e.g., nucleic acid amplification and detection). He has published over 90 peer-reviewed articles, and over 15 patents granted. He received several national innovation awards, holds journal editorial board memberships for several journals.

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IS10.5 Quantification of Three-dimensional Cancer Cell Responses, Kin Fong LEI, Chang Gung University, Taiwan

Abstract

In order to achieve high predictive value of cell chemosensitivity test for the clinical efficacy, cancer cells encapsulated and cultured in hydrogel can mimic the natural microenvironment of tumors. Cells suspended in hydrogel were cultured in a standard multi-well microplate. Because of the volume of the cells/hydrogel construct, unequal chemical concentration may be induced within the hydrogel. Also, cellular responses are difficult to be observed and quantified in the hydrogel. In this work, a novel platform for conducting 3D cell culture and analyzing cell viability has been developed for high throughput drug screening. Cells were encapsulated in the hydrogel and cultured in the microfluidic systems. The substrate was then immersed in the culture medium containing drug for 2 days. Cell viability of two human hepatoma cell lines (Huh7 and Hep-G2) was quantitatively investigated by the impedance measurement under the treatment of two drugs (doxorubicin and etoposide). The results represented by IC_{50} values revealed that Huh7 cells had a higher drug resistance than Hep-G2 cells and doxorubicin had a higher efficacy than etoposide for treating hepatocellular carcinoma. The current work has demonstrated a high throughput, convenient, and quantitative platform for the investigation of chemosensitivity of cancer cells cultured in 3D environment.

Short Bio

Dr. Kin Fong Lei is a Professor in Biomedical Engineering at Chang Gung University (CGU), Taiwan. Prior to joining CGU, he was a Lecturer at The Hong Kong Polytechnic University, Hong Kong (2007-2010). He received B.S. degree from National Tsing-Hua University, Taiwan (1998), and Ph.D. degree from The Chinese University of Hong Kong, Hong Kong (2005), both in mechanical engineering. In 2006, he was a post-doctoral fellow at the University of Western Ontario, Canada. Dr. Lei has made significant original contributions to research in bio-microfluidics, biosensing, and molecular diagnostics. He has published over 100 academic articles and was invited to contribute in 8 book/book chapters. Dr. Lei is a Fellow of Royal Society of Chemistry (RSC) and Institute of Physics (IOP), Senior Member of Institute of Electrical and Electronics Engineers (IEEE), Member of American Society of Mechanical Engineers (ASME), and Member of Society for Laboratory Automation and Screening (SLAS). He serves as a Chair of IEEE-EMBS Technical Committee on Bionanotechnology and BioMEMS (BNM) in 2020 and Associate Editor at EMBS Conference Editorial Board in 2020. He also served as an organizing committee member for many IEEE conferences for MEMS/microfluidics researchers. Dr. Lei is an Associate Editor for *IEEE Access*, and *IEEE Transactions on NanoBioscience*, and Editorial Board Member for *Scientific Reports*.

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Microfluidics, Analytical Chemistry & Biosensing

IS11: 11:40-13:10
Wednesday, December 16, 2020
Location: RM 002

Session Chair: **Pin-Chuan CHEN**
National Taiwan University of Science and Technology, Taiwan

Description

This session is a multidisciplinary and applications-oriented, which presents the results of original research or development across all of microfluidics fields of interest, particularly in the fields of analytical chemistry or biochemistry.

IS11.1 Manufacturing Microlens Array (MLAs) by Using Micromachining and Expandable Elastomer, Pin-Chuan CHEN, National Taiwan University of Science and Technology, Taiwan

Abstract

Microlens arrays (MLAs) nowadays are critical micro-optical components and it can be applied in many application fields, such as optical communication systems and flat panel display modules. This article describes a novel approach to the fabrication of tunable polydimethylsiloxane (PDMS) MLAs. A polydimethylsiloxane (PDMS) membrane is bonded to a micro-milled poly(methyl methacrylate) (PMMA) microfluidic chip and exposed to silicone oil of a specific viscosity. Molecules in the oil insert themselves into the molecular structure of the PDMS membrane, causing it to swell and subsequently form dome-shaped MLAs. From our experiments, we derived the following conclusions: (1) The homogeneous swelling of the PDMS resulted in MLAs with a high numerical aperture (0.5), high uniformity lighting, clear imaging, and high stability; (2) The shorter molecular chains in low-viscosity oils diffused more readily into the PDMS membrane, which increased the effects on swelling, resulting in MLAs with higher sag height and higher numerical aperture. For example, the 5cst silicone oil resulted in sag height of 191μm with NA of 0.50, whereas, the 100cst silicone oil resulted in sag height of 86μm with numerical aperture of 0.33; (3) The integrated mixer module enabled the simultaneous tuning of the 7x7 MLAs simply by adjusting injection flow rates of the constituent silicone oils.

Short Bio

Pin-Chuan Chen is a Director of Mini/Micro/Manufacturing Lab and a Professor of Mechanical Engineering Department at the National Taiwan University of Science and Technology (Taiwan Tech), Taipei, Taiwan. He received his Ph.D. in 2009 from Mechanical Engineering Department of Louisiana State University, Baton Rouge, Louisiana, USA. After graduation, Dr. Chen worked for two years as a Researcher in the Microfluidics Manufacturing Programme of the Singapore Institute of Manufacturing Technology (SIMTech, Singapore) before joining Taiwan Tech as an Assistant Professor in 2011. He was admitted as a fellow of The Royal Society of Chemistry (FRSC) in February 2020. His current research interests focus on building lifelike biomodels via novel fabrication processes, using additive manufacturing (3D printing) to create micro/mill fluidic devices for chemical/biochemical applications (new psychoactive substances (NPS), cell response to drugs), manufacturing of polymer/paper microfluidics for chemical/biochemical applications, novel bonding method for homogeneous/heterogeneous substrates for creating microfluidic devices.

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IS11.2 Thermosensitive Nanovesicle for Direct Trap and Release of Drugs Couple to LC-PDA and Nano LC-MS, Pai-Shan CHEN, Graduate Institute of Toxicology, National Taiwan University, Taiwan

Abstract

A thermosensitive nanovesicle-cloud point microextraction technique has been developed for the determination of drugs with a broad range of polarity in field water and human urine. Liquid-liquid extraction (LLE) is generally applied for this purpose, but it requires large volumes of organic solvents and multiple extraction steps. The analytes of interest generally come with a lot of interferences in extraction phase. The current trends in environmental technology focus on simplifying extraction procedures with low technical demands. The single-drop microextraction method and liquid-phase microextraction techniques have been proposed by them a solvent-minimized sample pretreatment in which a few-µL droplet of organic solvent is immersed in an aqueous solution to extract analytes. Although these inspiring methods have been developed to extraction analytes in field waters, there is no suitable one to extract both polar and nonpolar substances at the same time. Based on thin-film hydration, the conformation of nanovesicles formed by a binary mixing system with the nonionic surfactants was evaluated using regular and cryogenic transmission electron microscopy. The multilayered nano-spherical structure was able to capture polar and nonpolar compounds simultaneously. Analgesic drugs were detected by ultra-performance liquid chromatography (LC) coupled to photodiode array detection and further to nano LC-mass spectrometry. Under optimal conditions, linear calibration curves were obtained over the range of 50 to 8000 µg L^{-1}. The coefficient of determination (R^{2}) ranged from 0.9953 to 0.9995, with detection limits of 10 to 100 µg L^{-1}. The relative recoveries obtained from one industrial wastewater sample and two field water samples ranged from 86.1% to 108.1%. In the human urine analysis, three volunteers ingested 1500 mg of acetaminophen. After 4 hours, the concentration of acetaminophen in the urine was found to range from 87.0 to 197.9 mg L^{-1}.

Short Bio

Dr Chen was an Associate Professor in Department and Graduate Institute of Forensic Medicine, National Taiwan University. She received the B.S. in Chemistry, National Taiwan Normal University., Taiwan, M.S. in Chemistry, National Tsing Hua University, Taiwan, and the Ph.D. in Environmental Sciences and Department of Forensic and Analytical Science, King's College London, U.K. Dr. Chen's research interests have involved in forensic toxicology and method development. Current research work in her laboratory are relative to three aspects: (1) developing liquid phase microextraction techniques to concentrate organic compounds including pesticides, drugs or environmental toxins in food, biological and environmental samples; (2) investigating metabolism of drugs of abuse in forensic medicine; and (3) studying differential mobility spectrometry-tandem mass spectrometry to analyze chemically similar drugs in gas phase. She has been focusing on analytical toxicology since her PhD. She is the editor in chief of the Taiwan Journal of Forensic Medicine (Taiwan) (2012-till now); She is the Supervisor (2012-2016) and Secretary General of Taiwan Society of Forensic Medicine (2016-till now).

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IS11.3 Development of Printed-Circuit-Board Based Industry-Compatible Point-of-Care Biosensing and Bioprocessing Technology with Applications, Hsiu-Yang TSENG, National Taiwan University of Science and Technology, Taiwan

Abstract

Printed circuit board (PCB) technology is adopted in this work to facilitate the performance and translation of point-of-care (POC) biosensing and bioprocessing devices toward practical products. Key features of the proposed technology are a universal, standardized platform and a set of techniques, featuring integrated functional units, three-dimensional (3D) configurations, convenient device-instrumentation interconnections, and industry-compatible precision manufacturing. The developed technology aims to incorporate and fabricate multiple functional units into a POC device with a compact configuration to perform bio/chemical sensing or processing that requires complex experimental conditions. Three example biosensing and bioprocessing applications has been realized for proof of concept. The first demonstrator is a glucose-6-phosphate dehydrogenase (G6PD) deficiency assay with integrated pH sensing units and temperature control units on boards. The

assay is found to determine the G6PD level of a sample within 2 minutes. The second demonstrator is a molecule-based quantitative polymerase chain reaction (qPCR) device. A method is employed in this work to produce arrays of electrochemical biosensors and thermal cyclers using a three-metal PCB technology. The qPCR experiments are performed with 95% PCR efficiency and the detection limit of 59 deoxyribonucleic acid (DNA) copies. The third demonstrator is a cell-based on-board cooling rate controlled cryopreservation device. The possibility of meso-scale integration between the platform, sample storage and instrumentation is demonstrated in this work. On-board cooling-rate-controlled cryopreservation devices for use in low-temperature (-80°C) environments were able to maintain a stable cooling rate as low as 1°C per minute. Based on the work presented, the future development plan and possible business models for the proposed technology are envisioned from academic and industrial perspectives to realize POC biosensing and bioprocessing applications toward commercialization.

Short Bio

Dr. Hsiu-Yang Tseng is currently an assistant professor at the Department of Mechanical Engineering in the National Taiwan University of Science and Technology. Dr. Tseng receives his PhD from the Simon Fraser University in 2015, and M.S./B.S. both from the University of Washington in 2010. His research field covers interdisciplinary subjects of biosensing, microfluidics, and heat & mass transfer.

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IS11.4 Interfacial Growth of Mesoporous Materials for Biomarker Sensing,

Yi-Hsin LIU, National Taiwan Normal University, Taiwan

Abstract

Mesoporous materials functionalized with plasmonic and graphene-analogous can be employed as optical and electrical sensors to detect drugs and biomarkers. Here we develop a new synthetic approach to grow mesoporous zeolite nanoparticles and thin films having intrinsic high surface area (>800 m^2/g) and tunable pore size (5-10 nm). The thermal-stable zeolite materials can serve as excellent hard templates for growing and confining various plasmonic and semiconductor nanoparticles (Au, Ag, Ag_2S) of defined sizes (< 10 nm). Additionally, graphene oxides (GOs) are also chemically synthesized via a CVD process to enhance electrical properties. Structural and optical characterizations (HRTEM, XRD, GISAXS, BET, Raman, PL, XPS) are used to confirm size information, mesoporosity and more material properties. Various applications, including SERS and CV for biomarker sensing down to 10^{-9} nM, integrated to microneedle and microfluidic devices are currently under development for sensing of important biomarkers, such as dopamine and its derivatives.

Short Bio

Dr. Liu received his PhD degree in Chemistry from Washington University (St. Louis, MO, USA). Currently, his researches mainly focus on the synthesis and characterizations of mesoporous and semiconductor materials with unique optical, electrical, magnetic and spintronic properties. Current research covers board topics of nano-material applications, including surface-enhanced Raman scattering (SERS), CO_2 reduction reactions (CO_2RR), diluted magnetic semiconductors (DMS) in fundamental aspects.

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IS11.5 Volumetric Visualization of Acoustic Streaming by Digital Inline Holographic Microscopic Particle Tracking Velocimetry,

Wei-Hsin TIEN, National Taiwan University of Science and Technology, Taiwan

Abstract

Rapid advances in microfluidics have led to the requirement for more complicated flow phenomena, and the use of advanced manufacturing techniques such as 3-D printing helps to design and build more sophisticated flow channels. Traditional 2-D $\mu - \mathrm{PIV}$ technique has limitations in measuring the 3-D flow patterns in these flow, and volumetric methods for visualizing the 3-D flow patterns in microscale becomes critical in the development of these new designs of microfluidics. In this study, a volumetric imaging technique using Digital Inline Holographic Microscopy (DIHM) is developed and applied to visualizing the 3-D flow patterns of an acoustic streaming in a microchannel. Illuminated by a 450nm continuous laser, the magnified holography of the motion of tracer particles was recorded by a low-cost industrial microscope with a machine vision camera. The first solution of Reyleigh-Sommerfield in Huygens-Fresnel theorem was adopted to reconstruct the 3-D locations of the tracer particles, and 3-D particle tracking is then performed to obtain the volumetric flow field. The measurement range was evaluated as $550 \times 685 \times 840\ \mu m^3$, and the 3-D reconstruction algorithm was calibrated and the measurement accuracy in the depth location was verified with a calibration target. Using the proposed reconstruction algorithm with holographic images, 3-D locations of the out-of-focus particle images can be resolved and the diffraction information can be preserved, which was discarded as noise in the traditional 2-D PIV method. Compared to some 3-D techniques using diffraction ring patterns for 3-D reconstruction, the proposed method is more robust in dealing with the overlapped diffraction ring patterns from different particles, and higher particle image density can be achieved. As a proof of concept, this method was applied to measuring the 3-D flow patterns of acoustic streaming induced by a triangular obstruction that was unable to be visualized before with the 2-D $\mu - \mathrm{PIV}$ technique before.

Short Bio

Wei-Hsin Tien received his PhD degree at University of Washington in 2013 and joined National Taiwan University of Science and Technology since 2014. He is currently an assistant professor in the department of mechanical engineering. His main research interest is to develop advanced flow visualization techniques to resolve complex flow phenomena in microscale. He is currently working on the development of Temperature Sensitive Tracer Particles, 3-D volumetric imaging methods using Digital Inline Holographic Microscopy (DIHM) and post-processing techniques for Particle-Tracking Velocimetry (PTV) and Particle Streak Velocimetry (PSV). He is also interested in acoustofluidics, especially the complicated flow patterns induced by acoustic streaming and ultrasonic standing wave (USW).

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* Best paper competition: A full paper (4 to 6 pages) is required by August 15, 2021 to enter best paper contests.

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OCTOBER 20, 2021

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(Only required to publish papers in Xplore)

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