Korean Sensors Society (KSS) &
Regional Leading Research Center (RLRC) –
2021 International Symposium on Advanced Sensor Technology

- Advanced Sensor Technologies for Smarter Future -

- **Venue: Online (Zoom platform)**
- **Date: Mar 26, 2021**

The importance of advanced sensor technologies is rapidly increasing in the era of Industry 4.0. The applications of smart sensors are expanding in a variety of industrial fields such as environmental, biomedical, healthcare, robot, AR/VR, and entertainment industries.
In this symposium, we focus on the advanced sensor technologies in the aspects of materials, devices, and systems. By sharing the insights and knowledges of world-renowned experts, we discuss the future and find visions for the next generation sensors. The following list includes the topics for this symposium.

- **Session 1: Advanced material/device technologies for biosensors**
- **Session 2: Advanced circuits/systems for smart sensors**
- **Session 3: Advanced material/device technologies for physical sensors**
- **Session 4: Advanced material/device technologies for chemical sensors**

Program Chair: Prof. Inkyu Park (KAIST)
Program Committee: Prof. Dong-Weon Lee (Chonnam National University), Dr. Dae-Sik Lee (ETRI), Prof. Ho Won Jang (Seoul National University), Prof. Dukhyun Choi (Kyunghee University), Prof. Soohwan Jang (Dankook University)

Hosted by

THE KOREAN SENSORS SOCIETY

심혈관 환자맞춤형 차세대 정밀의료기술 선도 연구센터
Advanced Medical Device Research Center for Cardiovascular Disease

■ Schedule

Time (Korean Standard Time; KST)	Program
09:00-09:10	Opening Remarks & Introduction to KSS **Prof. Jong-Heun Lee (Korea University), Chair of KSS**
Session 1: Advanced Material/Device Technologies for Biosensors	
09:10-10:00	Skin-Interfaced Wearable Biosensors **Prof. Wei Gao (California Institute of Technology, USA)**
10:00-10:50	Life-saving Biosensor Systems for Blood Stream Infection **Prof. Sunghoon Kwon (Seoul National University, Korea)**
10:50-11:00	Break Time
Session 2: Advanced Circuits/Systems for Smart Sensors	
11:00-11:50	Ultra-Low-Power Integrated Circuits and Physiochemical Sensors for Next-Generation “Unawearables” **Prof. Patrick P. Mercier (University of California at San Diego, USA)**
11:50-12:40	Integrated Circuits and Microsystems for Emerging Biomedical Applications **Prof. Minkyu Je (KAIST, Korea)**
12:40-13:30	Lunch Break
Session 3: Advanced Material/Device Technologies for Physical Sensors	
13:30-14:20	Deformable Artificial Skins and Healthcare Sensors **Prof. Unyong Jeong (POSTECH, Korea)**
14:20-15:10	Self-Powered Sensors for Healthcare Applications **Prof. Zong Hong Lin (National Tsinghua University, Taiwan)**
15:10-15:20	Break Time
Session 4: Advanced Material/Device Technologies for Chemical Sensors	
15:20-16:10	Ordered Mesoporous Semiconductor Metal Oxides for Gas Sensing Applications **Prof. Yonghui Deng (Fudan University, China)**
16:10-17:00	Ideas for Specific, Low-power and Cost-effective Chemical Sensors **Prof. J. Daniel Prades (University of Barcelona, Spain)**
17:00-17:10	Closing Remarks

- ✧ Pacific Standard Time (PST) = KST -17
- ✧ China Standard Time (CST) = KST -1
- ✧ Central European Time (CET) = KST -8

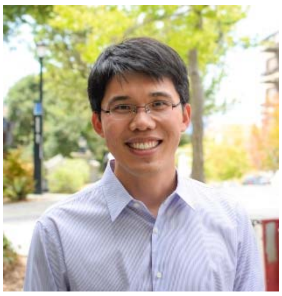
Skin-Interfaced Wearable Biosensors

Prof. Wei Gao (California Institute of Technology, USA)

Abstract

The rising research interest in personalized medicine promises to revolutionize traditional medical practices. This presents a tremendous opportunity for developing wearable devices toward predictive analytics and treatment. In this talk, I will introduce our efforts in developing fully-integrated skin-interfaced biosensors for non-invasive molecular analysis. Such wearable biosensors can continuously, selectively, and accurately measure a broad spectrum of sweat analytes including metabolites, electrolytes, hormones, drugs, and other small molecules. The clinical value of our wearable sensing platforms is evaluated through multiple human studies involving both healthy and patient populations toward physiological monitoring, nutritional monitoring, disease diagnosis, mental health assessment, and drug personalization. This talk will feature our recent works on self-powered battery-free electronic skins and mHealth-based biosensors for multiplexed COVID-19 diagnosis and management. These wearable and flexible devices could open the door to a wide range of personalized monitoring, diagnostic, and therapeutic applications.

Biography



Wei Gao is an Assistant Professor of Medical Engineering in Division of Engineering and Applied Science at the California Institute of Technology. He received his Ph.D. in Chemical Engineering at University of California, San Diego in 2014 as a Jacobs Fellow and HHMI International Student Research Fellow (2012–2014). In 2014–2017, he was a postdoctoral fellow in the Department of Electrical Engineering and Computer Sciences at the University of California, Berkeley. He is a recipient of Sloan Research Fellowship (2021), IEEE EMBS Early Career Achievement Award (2020), IEEE Sensor Council Technical Achievement Award (2019), MIT Technology Review 35 Innovators Under 35 (2016), and ACS DIC Young Investigator Award (2015). He is a World Economic Forum Young Scientist (Class 2020), a member of Global Young Academy (Class 2019), and a 2020 Highly Cited Researcher (Web of Science). He is an Associate Editor of Science Advances. His research interests include wearable devices, biosensors, flexible electronics, micro/nanorobotics, and nanomedicine.

Life-saving biosensor systems for blood stream infection

Prof. Sunghoon Kwon (Seoul National University, Korea)

Abstract

Bloodstream infection (BSI) has become a major public health challenge worldwide, causing a significant increase in patient morbidity and mortality rate. Each year, about 250,000 new BSI cases are emerging in the U.S., which commonly leads to various systemic responses, for example, sepsis. The major concern of such BSI is that, unless proper antibiotic treatment is given, the rate of patient fatality increases 9% by every hour delayed. Thus, prompt prescription and administration of correct antibiotic treatment are necessary. Current conventional process of performing antimicrobial susceptibility test (AST) requires 2-3 days. The consequences of this lengthy time are the misuse, overuse, and abuse of broad-spectrum antibiotics, which increase toxicity to the patients and promote the development of antimicrobial resistance. In this talk, I will present and discuss a direct and rapid antimicrobial susceptibility test (dRAST) platform developed in my lab and commercialized in QuantaMatrix Corp.. The end result is an integration of a microfluidic-based biosensor system that enables fast and accurate selection of antibiotics for BSI patients. Several concepts and engineering efforts, including the automated image analysis program implemented using various AI algorithms that precisely differentiate antimicrobial resistance and susceptibility, will be described which in result, reduces the sample-to-answer time by up to 2 days compared to conventional methods. Later in this talk, I will describe recent clinical studies that show the applicability of our platform that provides essential information to accelerate therapeutic decisions for earlier and adequate antibiotic treatment and patient management in clinical settings.

Biography

Sunghoon Kwon is a scientific founder and CEO of QuantaMatrix, providing life-saving diagnostic device in the field of clinical microbiology. He is also a professor of the Department of Electrical Engineering at Seoul National University, leading a Biophotonics and Nanoengineernig Laboratory in South Korea. He is a founder and scientific advisor in Celemics Inc, a company that develops high throughput gene synthesizer. His main purpose is to help life scientist with innovative technologies since he believes important scientific discovery and medical innovation starts with development of innovative tools. Kwon received many awards including the Young Scientist Award, The Korea Academy of Science and Technology (2011), Korean Young Scientist Award from the Korean President, presidential award given to 4 scientists under age of 40 (2012), IEEK/IEEE Joint Awards, IT Young Engineer Award" (2016), Young Engineer Award, the National Academy of Engineering of Korea (2018). Kwon received his B. S. in Electrical and Computer Engineering (1998) and M. S. in Biomedical Engineering (2000) from Seoul National University. He obtained his Ph.D. in Bioengineering from University of California, Berkeley (2004).

Ultra-Low-Power Integrated Circuits and Physiochemical Sensors for Next-Generation “Unawearables

Prof. Patrick P. Mercier (University of California at San Diego, USA)

Abstract

Wearable devices hold considerable promise to diagnose, monitor, and treat various medical conditions and/or track the real-time status of athletes. However, most current generation wearable devices only monitor a limited number of physical and electrophysiological parameters that are, in many cases, only peripherally related to many health conditions or fitness enterprises. Furthermore, many such wearable devices are large, bulky, and rigid, thereby precluding seamless integration into daily life.

Addressing these issues requires: 1) development of new sensor technologies that provide more actionable data in thin, flexible form factors; 2) engineering of supporting electronic infrastructure to condition, digitize, and wirelessly communicate data in an extremely energy efficient manner; and 3) new data analytics to process and understand newly generated data streams. This presentation will discuss emerging sensor technologies that can non-invasively monitor physiochemistry (e.g., glucose, blood alcohol concentration, and lactate) in thin, flexible, and energy-efficiency wearable devices, alongside a brief look at what kind of analytics are necessary to parse and understand this data. We will also cover integrated circuit building blocks and architectures that make acquisition and telemetry of sensed information so energy-efficient that that they can be easily powered from new local energy sources (e.g., wearable glucose biofuel cells). Such net-zero-power operation will ultimately enable devices that are completely autonomous and invisible to the user, to the point where users are virtually unaware of their wearable devices after placement – in other words, they are “unawearable” devices.

Biography

Patrick Mercier is an Associate Professor of Electrical and Computer Engineering and co-founder/co-director of the Center for Wearable Sensors at UC San Diego. He received his B.Sc. degree from the University of Alberta, Canada, in 2006, and the S.M. and Ph.D. degrees from MIT in 2008 and 2012, respectively. Prof. Mercier has received numerous awards, including the San Diego Engineering Council Outstanding Engineer Award in 2020, a National Academy of Engineering Frontiers of Engineering Speaker in 2019, the NSF CAREER Award in 2018, the Biocom Catalyst Award in 2017, the UCSD Academic Senate Distinguished Teaching Award in 2016, the DARPA Young Faculty Award in 2015, the Beckman Young Investigator Award in 2015, The Hellman Fellowship Award in 2014, the *International Solid-State Circuits Conference* (ISSCC) Jack Kilby Award in 2010, amongst others. He has published over 140 peer-reviewed papers in venues such as *Nature Biotechnology*, *Nature Communications, ISSCC* (22 papers), *Advanced Science*, and others. He is an Associate Editor of the *IEEE Transactions on Biomedical Circuits and Systems* and the *IEEE Solid-State Circuits Letters*, is a member of the ISSCC, CICC, and VLSI Technical Program Committees, and has co-edited three books: *High-Density Integrated Electrocortical Neural Interfaces* (Elsevier Academic Press, 2019), Power *Management Integrated Circuits* (CRC Press, 2016), and *Ultra-Low-Power Short-Range Radios* (Springer, 2015). His research interests include the design of energy-efficient mixed-signal systems, RF circuits, power converters, and sensor interfaces for wearable, medical, and mobile applications.

Integrated Circuits and Microsystems for Emerging Biomedical Applications

Prof. Minkyu Je (KAIST, Korea)

Abstract

Many factors, such as extended lifespan, prevailing obesity, and aging population are increasing the healthcare cost dramatically. Recent advances in semiconductor technologies, as well as innovations in IC design techniques, have led to microsystems with sensing and processing capabilities that can supplement, improve, or even entirely replace traditional diagnostic and therapeutic procedures. Integrated biomedical solutions based on IC technologies can offer remarkably effective ways of timely diagnosis, treatment, and management of diseases at a very low cost, never seen before.

In this talk, it will be presented how IC technologies and integrated microsystems enable emerging biomedical applications such as life-saving/changing miniature medical devices, surgical procedures with less invasiveness and morbidity, low-cost preventive healthcare solutions in daily life, effective chronic disease management, point-of-care diagnosis for early disease detection, high-throughput bio sequencing and screening for new discovery, and groundbreaking brain-machine interface from a deep understanding of human intelligence. It will also be shown that the vital role of the IC technology in biomedical microsystems is providing a seamless interface to various sensors and actuators, high-efficiency operation with various energy sources (especially, renewable ones), high-level integration and miniaturization, embedded intelligence, and connectivity.

Biography

Minkyu Je received the B.S., M.S., and Ph.D. degrees, all in Electrical Engineering, from Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea, in 1996, 1998, and 2003, respectively.

In 2003, he joined Samsung Electronics, Giheung, Korea, as a Senior Engineer and worked on multi-mode multi-band RF transceiver SoCs for GSM/GPRS/EDGE/WCDMA standards. From 2006 to 2013, he was with Institute of Microelectronics (IME), Agency for Science, Technology and Research (A*STAR), Singapore. He worked as a Senior Research Engineer from 2006 to 2007, a Member of Technical Staff from 2008 to 2011, a Senior Scientist in 2012, and a Deputy Director in 2013. From 2011 to 2013, he led the Integrated Circuits and Systems Laboratory at IME as a Department Head. In IME, he led various projects developing low-power 3D accelerometer ASICs for high-end medical motion sensing applications, readout ASICs for nanowire biosensor arrays detecting DNA/RNA and protein biomarkers for point-of-care diagnostics, ultra-low-power sensor node SoCs for continuous real-time wireless health monitoring, and wireless implantable sensor ASICs for medical devices, as well as low-power radio SoCs and MEMS interface/control SoCs for consumer electronics and industrial applications. He was also a Program Director of NeuroDevices Program under A*STAR Science and Engineering Research Council (SERC) from 2011 to 2013, and an Adjunct Assistant Professor in the Department of Electrical and Computer Engineering at National University of Singapore (NUS) from 2010 to 2013. He was an Associate Professor in the Department of Information and Communication Engineering at Daegu Gyenogbuk Institute of Science and Technology (DGIST),

Korea from 2014 to 2015. Since 2016, he has been an Associate Professor in the School of Electrical Engineering at Korea Advanced Institute of Science and Technology (KAIST), Korea.
His main research areas are advanced IC platform development including smart sensor interface ICs and ultra-low-power wireless communication ICs, as well as microsystem integration leveraging the advanced IC platform for emerging applications such as intelligent miniature biomedical devices, ubiquitous wireless sensor nodes, and future mobile devices. He is an editor of 1 book, an author of 6 book chapters, and has more than 300 peer-reviewed international conference and journal publications in the areas of sensor interface IC, wireless IC, biomedical microsystem, 3D IC, device modeling and nanoelectronics. He also has more than 50 patents issued or filed. He has served on the Technical Program Committee and Organizing Committee for various international conferences, symposiums and workshops including IEEE International Solid-State Circuits Conference (ISSCC), IEEE Asian Solid-State Circuits Conference (A-SSCC) and IEEE Symposium on VLSI Circuits (SOVC). He is currently serving as a Distinguished Lecturer of IEEE Circuits and Systems Society.

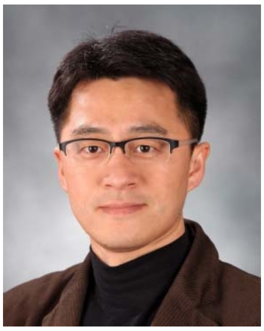
Deformable Artificial Skins and Healthcare Sensors

Prof. Unyong Jeong (POSTECH, Korea)

Abstract

Deformability is expected to be a new form factor in the next-generation electronic devices. The stretchable electronics have motivated scientists to develop deformable nanomaterials for use in electrodes, semiconductors, bio-interfaces, and sensors. To realize fully stretchable electronic devices, each component of the device must maintain its performance under stretching. This talk will present recent developments of stretchable nanomaterials and their composites, then put the focuses on the substrates, electrodes, interfacial adhesives, and circuits. This talk presents a generalized platform that can be used for a variety of stretchable devices. It will demonstrate several stretchable devices such as real-time skin-interface health monitoring sensors, haptic devices, multimodal artificial skins, and electronic skins for robots.

Biography



Unyong Jeong received a B.S. degree in chemical engineering from POSTECH in Korea (1998). He received a M.A. degree (2000) and a Ph.D. degree (2003) in polymer physics in the same department. He joined Prof. Younan Xia's group as a postdoctoral fellow to study the synthesis and applications of inorganic nanomaterials. Then, he entered Yonsei University in Korea (2006) and moved to the Department of Materials Science and Engineering at POSTECH (2015). His research aims at understanding the mechanical electrical properties of conductive materials and fabricating stretchable electronic devices based on material synthesis, assembly, and formation of nanocomposites.

Self-Powered Sensors for Healthcare Applications

Prof. Zong-Hong Lin (National Tsinghua University, Taiwan)

Abstract

As far as the development of wearable electronics is concerned, power supply has always been the bottleneck to overcome. In our group, we have utilized commercial textiles and proteins/hydrogels to fabricate biocompatible, portable, and lightweight nanogenerators to harvest biomechanical energy from human motions to directly power wearable electrochemical systems for humidity/temperature/sweat detections (ions, glucose, and lactate) and antibacterial applications. In addition, through the functionalization of devices surface, those nanogenerators evolve into self-powered bio(chemical) sensors. They can be triggered directly by biomechanical motions or body heat instead of external power supply. The varied generated electric outputs are observed when those functionalized nanogenerators detect target ions/molecules. With the simplicity (no complex circuitry or power supply involved) and low-cost fabrication process (minimal and low-priced materials required), the developed sensors and systems show their adaptability to be integrated with next-generation smart clothes.

Biography

Dr. Zong-Hong Lin received his PhD degree in Chemistry from the National Taiwan University in 2009 and continued with his postdoctoral research at the National Taiwan University and the Georgia Institute of Technology during the years of 2010-2014. Subsequently, Dr. Lin joined the Institute of Biomedical Engineering, National Tsing Hua University (NTHU) as Assistant Professor in August 2014 and was successfully promoted to Associate Professor with Tenure effective from August 2017. In recognition of his outstanding academic achievements, Dr. Lin was invited as Adjunct Associate Professor for both the Department of Power Mechanical Engineering and Frontier Research Center on Fundamental and Applied Sciences of Matters at NTHU.

Dr. Lin's research interests include the development of self-powered (bio)chemical sensors, biomedical diagnostic devices, wearable healthcare electronics, micro- and nano-electrodes/materials for in-vitro and in-vivo applications He is a productive researcher with more than 90 SCI papers (sum of the times cited: 9339, h-index: 51), as well as a multi-award winner for his acclaimed research contributions, such as Young Scholar Fellowship of the Ministry of Science and Technology (2020), IEEE-NANOMED New Innovator Award (2019) and Young Investigator Award of the National Tsing Hua University (2018). Meanwhile, Dr. Lin is devoted to turning his scientific research into industry viable solutions – with more than 20 patents as inventor and developed technologies of great commercial potential across varied healthcare market segments.

Since Dr. Lin was promoted to Associate Professor in August 2017, he has published a total of 25 SCI papers, in which 19 papers were published as the corresponding author or first author. In addition, 18 papers were published in journals with impact factor ≥10 or rank ≤5%. Related research results have also been applied for patents in United States, Taiwan, and China. From 2017 to 2021, Dr Lin has been invited for more than 80 international and 40 domestic presentations in seminars/conferences to share his research results and organized/chaired 40 symposiums/sessions in international conferences. The following is a brief introduction of selected representative works:

A. Self-powered nanosensors based on triboelectric and thermoelectric effects

B. Wearable systems for self-powered healthcare applications

C. Non-photoactive nanocatalysts for disinfection and biomedical applications

Currently/previously funded research projects

Since Dr. Lin was promoted to Associate Professor in August 2017, he has led/joined a total of 23 research projects (19 as PI, 4 as Co-PI) and the total funding budget is 65,266,760 NTD (PI of 51,161,760 NTD). The following table shows the detailed status of each project. In addition, Dr. Lin is also actively participating in the collaboration with industry to develop new products. The current collaborating companies include HMD BioMedical, TAI YUEN TEXTILE and Mitsubishi Chemical.

Ordered Mesoporous Semiconductor Metal Oxides for Gas Sensing Applications

Prof. Yonghui Deng (Fudan University, China)

Abstract

Semiconducting metal oxides (SMOs) are a family of important functional materials that have wide applications in catalysis, sensing, energy storage and conversion, etc. Nanoscale SMOs, especially those with high surface area and stable crystalline frameworks are highly desired for gas sensing applications due to their advantages of high sensitivity, low cost and easiness to fabricate miniaturized devices. In recent years, considerable efforts have been developed to exploring SMOs with high porosity for gas sensing applications. In this regards, by using lab-made amphiphilic block copolymers as the structure-directing agents, i.e. the template molecules, our group has developed versatile soft-templating synthesis methods and strategies to design highly ordered mesoporous SMOs with different compositions (e.g., WO_3, ZnO, In_2O_3, SnO_2), tunable pore sizes (10-30 nm) and high surface area (80-200 m^2/g). The obtained mesoporous SMOs exhibit superior gas sensing performance toward reducing (e.g. VOCs , H_2, CO, H_2S, alcohol, ketone) or oxidative gases (e.g. NO_x) with fast response-recovery dynamics, high selectivity and sensitivity due to the good diffusion-transport of gases within the highly interconnected uniform mesopores and the huge interfaces with highly accessible active sites, making it possible to develop mesoporous SMOs-based sensors for various applications.

Biography

Yonghui Deng received his B.S. in chemistry from Nanchang University (2000) and Ph.D in polymer chemistry and physics from Fudan University (2005). He worked as a postdoctoral researcher with Prof. Dongyuan Zhao (2005–2007), and was promoted as associate professor (2007) and full professor (2011) in Department of Chemistry at Fudan University. He worked as a visiting scholar with Prof. Peidong Yang in University of California at Berkeley (2009–2010). He has published over 150 papers in refereed journals with total citation over 13000 times and h-index of 61. His research interests focus on functional porous materials, core–shell nanomaterials and their applications in catalysis, chemical sensor, biomedicine, *etc*.

Ideas for Specific, Low-power and Cost-effective Chemical Sensors

Prof. J. Daniel Prades (University of Barcelona, Spain)

Abstract

Specificity, or the ability of detecting one single species in the presence of many others, is one of the most sought after features in chemical and gas sensors. However, attaining such a feature involves adding complexity to the detection system, normally at the expense of a higher power demand and ultimately, at a higher cost.

Our research of the last 10 years has been focused on the implementation of new approaches to improve specificity and lower power consumption at the same time. In this presentation we will review our main contributions in the context of the state-of-the-art.

First, we will show how power consumption in semiconductor devices can be lowered to just a few microwatts by means of the self-heating effect occurring in nanomaterials. Only a decade ago, this principle was proved with fully hand-made devices. Today, it is possible to achieve comparable efficiencies with devices produced in mass scale, using widely spread micro and nanofabrication techniques.

Second, we will move to light activated chemical sensors, where dramatic power savings can be achieved by combining the power efficiency of light emitting diodes (LED) with aggressive miniaturization efforts. Using industry standard technologies, it is possible to offer sub-milliwatt power demands in monolithic integrated microLED devices that can be produced in large amounts. We will also show how optical activation opens the door to complementary operation approaches, based on light energy harvesting that can enable virtually zero-power devices in the near future.

Third, we will show how the previous approaches can be combined with surface functionalization methods to achieve high specificity. In combination, with color indicators, some of these gas-specific receptors provide direct path to inexpensive optical readout systems, based on sensors printed on plastic or paper and smartphone cameras. This last approach enables massive sensing applications thanks to their potential for sub-1-euro-cent cost per sensor.

Biography

J. Daniel Prades is a Full Professor of Electronic Technology at the Universitat de Barcelona. His research interests are micro and nano optoelectronic devices and systems for sensing and monitoring, key contributions to ultra-low power devices. He has published 90+ scientific articles (4000+ citations, h-index 35), and has given 35 invited talks in international conferences. He has coordinated 30 Research Projects and Grants on device development, smart system integration and environmental monitoring; including 11 European/International Projects, 19 National Projects and other Projects with Industry. He is co-inventor of 9 patents, 2 of them under commercial exploitation. In 2018, he founded “ColorSensing” https://www.color-sensing.com, a start-up based in Catalonia devoted to smart packaging for food processing efficiency, quality, and safety. He is the EuroSensors Fellow 2017 and ICREA Academia awardee since 2018. A fully updated CV can be found at http://bit.do/dprades