Technical Workshop of Biomedical Sensor and Network Project in International Joint Research Laboratory between NCTU and Tohoku Univ

Date: November 30 (Friday), 2018

Venue: WPI-AIMR Main Building (B01), Katahira campus, Tohoku Univ.
(www.tohoku.ac.jp/en/about/map_directions.html)

10:00-10:05	Opening remarks
10:05-10:15	Introduction of International Joint Research Laboratory [Prof. Seiji SAMUKAWA]
10:15-10:35	Overview on the Research Projects in Biomedical Electronics Translational Research Center (BETRC) of NCTU [Prof. Morris (Ming-Dou) KER]
10:35-11:00	Integrated Biomedical Micro/Nano Devices with 3D-IC Technology [Prof. Tetsu TANAKA]
11:00-11:25	Self-Photovoltaics-Powered 256-Pixel Subretinal Implants: CMOS Chip Design and Animal Tests [Prof. Peter (Chung-Yu) WU]
11:25-11:50	Micro/Nano Sensors for Health Care Applications [Prof. Takahito ONO]
11:50-13:20	Lunch
13:20-14:20	Lab tour
14:25-14:50	AI-Enabled Mobile Health-Care Applications [Prof. Chen-Yi LEE]
14:50-15:15	Atmospheric Pressure Plasma Flow for Bio-medical Applications [Prof. Takehiko SATO]
15:15-15:40	Power Management for Implantable Medical Devices [Prof. Po-Hung CHEN]
15:40-15:50	Break
15:50-16:15	Model of Tissue with Mechanical Properties for Edu-Tech [Prof. Makoto OHTA]
16:15-16:40	A Fully Integrated Closed-Loop Neuromodulation SoC with Wireless Power and Bi-Directional Data Telemetry for Real-Time Human Epileptic Seizure Control [Dr. Cheng-Hsiang CHENG]
16:40-16:55	Discussion of joint research project
16:55-17:00	Closing remarks [Prof. Morris (Ming-Dou) KER]
17:00-	Dinner

Title of Talk :

Overview on the Research Projects in Biomedical Electronics Translational Research Center (BETRC) of NCTU

Speaker:

Prof. Morris (Ming-Dou) Ker

(1) Distinguished Professor, Institute of Electronics, National Chiao-Tung University (NCTU), Taiwan

(2) Director, *Biomedical Electronics Translational Research Center* (BETRC), NCTU, Taiwan.

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Abstract of Talk :

The bioelectronics for biomedical applications has been regarded as a new medical technology to treat the neuro-disorder diseases. The integrated circuit chip with biocompatible package has been implanted into the body to provide electrical stimulation for neuromodulation treatment. To treat the intractable neurological disorders by conducting inter-disciplinary researches, a research group with comprehensive technology platforms to develop the implantable bioelectronics systems for medical applications has been built in National Chiao Tung University (NCTU), called as "Biomedical Electronics Translational Research Center (BETRC)". The major on-going projects in this BETRC/NCTU include (1) Self-Powered Sub-Retinal Prosthesis, (2) Closed-Loop Epileptic Seizure Control System, (3) Bone-Guided Cochlear Prosthesis, and (4) Closed-Loop Parkinson Deep Brain Stimulation System. The key achievements and up-to-dated research results are introduced in this talk. We also seek for international collaborations on all technology items for developing implantable bioelectronics systems.

Brief Biography of Speaker:

Prof. Morris (Ming-Dou) Ker received the Ph.D. degree from the Institute of Electronics, National Chiao-Tung University (NCTU), Hsinchu, Taiwan, 1993. He ever worked as a Department Manager with the VLSI Design Division, Industrial Technology Research Institute (ITRI), Hsinchu, Taiwan. Now, he has been the Distinguished Professor in the Institute of Electronics, NCTU; and the Director of the Biomedical Electronics Translational Research Center (BETRC), NCTU, working on the Biomedical Electronics Translational Research projects. His current research interests include the circuits and systems for biomedical applications, as well as the reliability design for integrated circuits and microelectronics systems.

Prof. Ker has served as member of the Technical Program Committee and the Session Chair of numerous international conferences, including the IEEE Symposium on VLSI Circuits and IEEE International Solid-State Circuits Conference (ISSCC). He ever served as the Associate Editor for the *IEEE Transactions on VLSI Systems* (2006-2007), Distinguished Lecturer in the IEEE Circuits and Systems Society (2006–2007), and Distinguished Lecturer in the IEEE Electron Devices Society (2008–2018). Currently, he is the Editor of *IEEE Transactions on Device and Materials Reliability*, and Associate Editor of *IEEE Transactions on Biomedical Circuits and Systems*. Prof. Ker has been a Fellow of the IEEE, since 2008.

Title of Talk :

Integrated Biomedical Micro/Nano Devices with 3D-IC Technology: Fully Implantable Retinal Prosthesis & Intelligent Si Neural Probe

Speaker:

Prof. Tetsu TANAKA

(1) Professor, Graduate School of Biomedical Engineering, Tohoku University, Japan

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Abstract of Talk :

3D-IC/TSV is the most promising candidate for high performance and low power computing devices since they have lots of advantages such as short wiring length, small pin capacitances, high packing density, ultra-parallel operation, etc. Among several types of 3D-IC technologies, multiple chips-to-wafer (MCtW) stacking can be used to stack known-good-chips fabricated with different technologies and different sizes, which leads to true 3D heterogeneous system. We have been developing a fully implantable retinal prosthesis with a 3D-stacked retinal prosthesis (RP) chip. In the 3D-stacked RP chip, photoreceptor chip and stimulus current generator with image processing circuits are vertically stacked and electrically connected by lots of TSVs. By implanting the 3D-stacked RP chip into the eyeball, the patients can employ their own lens and cornea, and can shift a gaze point by moving the eyeball, leading to high speed visual information processing by using saccadic effects. As the 3D-stacked RP chip has layered structure similar to human retina, more than 1000 pixels can be fabricated in the retinal chip. This leads to small chip size, light weight, large fill-factor, high resolution, and the resultant high quality of life for the patients. We have been also developing a various kinds of intelligent Si neural probes with electrodes, sensors, microfluidic channels, and optical waveguides to investigate neuronal functions in nerve system. Recently, we have successfully fabricated a 3D-stacked Si neural probe for cubic spatial recording. In this talk, I'll briefly introduce our research activities and an outline of graduate school of biomedical engineering, Tohoku University.

Brief Biography of Speaker:

Prof. Tetsu Tanaka received the B.S. and M.S. degrees in electronics engineering and the Ph.D. degree in machine intelligence and systems engineering from Tohoku University, Sendai, Japan, in 1987, 1990, and 2003, respectively. In 1990, he joined Fujitsu Laboratories, Ltd., where he was engaged in the research of the highly-scaled MOS devices including SOI devices. From 1994 to 1995, he was a Visiting Fellow with University of California, Berkeley, where he studied a device characterization and modeling with Professor Chenming Hu. He invented a p+-n+ double-gate SOI MOSFETs in 1993, and developed 1T-DRAM with GIDL current writing method in 2003. In 2005, he moved to the Tohoku University as an Associate Professor, and became a Professor of Graduate School of Biomedical Engineering, Tohoku University in 2008. He is now working on the development of integrated biomedical micro/nano devices and systems using semiconductor technologies and neural engineering. His current research topics include (1)Intelligent Si neural probe, (2)Fully-implantable retinal prosthesis, (3)3D integration technology and analog/digital LSI design, and (4)Flexible hybrid electronics for wearable healthcare.

He has published more than 150 technical journal papers and given more than 30 invited talks. He was jointly awarded the 2010 Outstanding Paper Award of the 60th Electronic Components and Technology Conference (ECTC) in 2010, and IEEE Solid-State Circuits Society (SSCS) Kansai Chapter Academic Research Award in 2013. He has or had served as a technical committee member or an editor of various international conferences and journals, such as IEEE Electron Devices Society (EDS) Japan Chapter Treasurer (2006~2007), IEEE EDS Japan Chapter Secretary (2008~2009), International Interconnect Technology Conference (IITC, 2008~), International Conference on Solid State Devices and Materials (SSDM, 2008~), Symposium on VLSI Technology (2009~), International Electron Devices Meeting (IEDM, 2011~2012), Japanese Journal of Applied Physics (JJAP, 2009~2011), International Technology Roadmap for Semiconductors (ITRS, 2006~2016), and International Roadmap for Devices and Systems (IRDS, 2017~).

Title of Talk :

Self-Photovoltaics-Powered 256-Pixel Subretinal Implants: CMOS Chip Design and Animal Tests

Speaker:

Prof. Peter (Chung-Yu) Wu

(1) Chair Professor, *Institute of Electronics*, National Chiao-Tung University (NCTU), Taiwan

(2) General Director, *Biomedical Electronics Translational Research Center* (BETRC), National Chiao Tung University, Hsinchu City, Taiwan

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Abstract of Talk :

In this talk, the improved design of CMOS 256-pixel self-photovoltaics-powered subretinal prosthetic chip with charge pump circuit and its in vitro experimental results with Rd1 mice will be presented. With the chip area of 3.2 mm×3.2 mm, the photovoltaic (PV) cells, charge pump, control circuits, and a 256-pixel array with active pixel sensors (APSs), stimulators, and electrodes are integrated to generate the biphasic constant current stimulation (CCS) pulses from the incident infrared (IR) and image lights. To increases the charge injection, a high-efficiency fully-integrated 4× charge pump is designed to boost the PV-cell voltage to above 1V. An equivalent circuit model is derived to find the maximal number of pixels in the proposed chip considering the chip size constraint and the required stimulation charges. The proposed chip is designed and fabricated in 180-nm CMOS image sensor (CIS) technology and post-processed with biocompatible IrO_2 coating and parylene-C packaging. The measured stimulation frequency is 25.8 Hz with the equivalent electrode impedance load. The measured injected charges per pixel is 6.38 nC under signal light intensity of 1160 lux and IR intensity of 86.7 mW/cm2. The function of the chip is further validated with the in-vitro experimental results by recording the electrophysiological response of RGCs from isolated wild type (WT) and retinal degeneration (rd1) mice retinas using a multi-electrode array (MEA).

Brief Biography of Speaker:

Prof. Peter (Chung-Yu) Wu received the M.S. and Ph.D. degrees in electronics engineering from National Chiao Tung University, Hsinchu City, Taiwan, in 1976 and 1980, respectively.

Since 1980, he has been a Consultant to high-tech industry and research organizations and has built up strong research collaborations with high-tech industries. From 1980 to 1983, he was an Associate Professor with National Chiao Tung University. From 1984 to 1986, he was a Visiting Associate Professor with the Department of Electrical Engineering, Portland State University, Portland, OR. Since 1987, he has been a Professor with National Chiao Tung University. From 1991 to 1995, he served as the Director of the Division of Engineering and Applied Science, National Science Council, Taiwan. From 1996 to 1998, he was bestowed as the Centennial Honorary Chair Professor of National Chiao Tung University. From 2007 to 2011, he served as the President of National Chiao Tung University. He is currently a Chair Professor of National Chiao Tung University and General Director of Biomedical Electronics Translational Research Center, Taiwan. He has authored or coauthored over 300 technical papers in international journals and conferences. He holds 47 patents, including 23 U.S. patents. His research interests are implantable biomedical integrated circuits and systems, intelligent bio-inspired sensor systems, RF/microwave communication integrated circuits, neural network, analog/mixed-signal integrated circuits.

Dr. Wu is a member of Eta Kappa Nu and Phi Tau Phi. He was a recipient of the 1998 IEEE Fellow Award and a 2000 Third Millennium Medal. He was also the recipient of numerous research awards presented by the Ministry of Education, the Ministry of Science and Technology, and professional societies/associations in Taiwan.

Title of Talk :

Micro/Nano Sensors for Health Care Applications

Speaker:

Prof. Takahito ONO

(1) Professor, Graduate School of Engineering, Tohoku University, Japan

(2) Director, Microsystem Integration Center, Tohoku University, Japan

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Abstract of Talk :

Various kinds of sensors for health care monitoring and nanobiological science have been developed. Thermal biological sensors utilizing enzyme were developed for detecting biological materials in urine for a smart toilet application. The principle employs the heat generation due to the biological catalytic reaction of the enzyme. Magnetic resonance force sensors were developed for detection of radials in a body. The radials are harmful to health. Resonant photoacoustic sensors are developed for invasive detection of biological substance, where acoustic wave caused by photoacoustic excitation is detected by a micro resonant sensor with pulse laser from a laser diode. Also a micro power generator and a super capacitor are required for future body area network, in which many sensors are attached on a human body to monitor the health condition. For this purpose, micro thermoelectric devices based on electrodeposition have been developed and evaluated. The super capacitor utilizes CVD-synthesized carbon nanowall for enhancing the capacitor performance.

Brief Biography of Speaker:

Prof. Takahito Ono received the D.E. degree in mechatronics and precision engineering from Tohoku University in 1996. During 1996−1999, he has been a Research Associate in the Department of Mechatronics and Precision Engineering, Tohoku University. During 1999-2009, he has been an Associate Professor.

He is currently a Professor at Department of Mechanical Systems Engineering in Tohoku University. Also he was a professor of Department of Mechanical Engineering, Graduate School of Engineering at The University of Tokyo during 2013-2016. He was director of Micro/Nanomachining education center, Tohoku University during 2012-2014. He is the vice-director of The Micro System Integration Center, Tohoku University. Since 2017, He is the director of The Micro System Integration Center, Tohoku University.

His expertise is in the area of microelectromechnical systems (MEMSs), nanoelectromechanical systems (NEMSs), silicon based nanofabrication, ultra-sensitive sensing based on resonating device, scanning probe technologies, nanoprobe sensing for nanoscale science and engineering. Recent interests cover nanomaterials and their integration into the microsystem for applications of IoT sensors, environment monitoring, biomedical sensors, nano-energy, and scientific instrumentation.

Title of Talk :

AI-Enabled Mobile Health-Care Applications

Speaker:

Prof. Chen-Yi Lee

Professor, *Department of Electronics Engineering,*
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Abstract of Talk :

As Artificial Intelligence (AI) becomes a new drive force for many emerging medical applications, it's very necessary for researchers from both industry and academia to learn this mainstream technology and investigate different learning models for better detection/diagnosis accuracy and service quality. In this talk, two basic modules related to AI will be first addressed, namely data generation and learning networks. Then several mobile health-care applications based on AI approaches will be demonstrated to see how to achieve better solutions by combining data sensing and machine-learning techniques. In the end, some research opportunities related to semiconductor designs will be highlighted for those who are interested in this topic and related medical applications.

Brief Biography of Speaker:

Prof. Chen-Yi Lee received the B.S. degree from National Chiao Tung University (NCTU), Hsinchu, Taiwan, in 1982, and the M.S. and Ph.D. degrees from Katholieke University Leuven (KUL), Leuven, Belgium, in 1986 and 1990, respectively, all in electrical engineering.

In February 1991, he joined the department of electronics engineering and from 2003-2006, he was the chairman. During 2000-2003, he was the director of National CHIP Implementation Center (CIC) and the coordinator of Microelectronics Program of Engineering Division, NSC, Taiwan. He was the dean of office of research and development in 2007-2010, National Chiao Tung University (NCTU). His research interests mainly include VLSI algorithms and architectures for high-throughput DSP applications. He is also active in various aspects of micro sensing, low-power system-on-chip, and deep learning.

Title of Talk :

Atmospheric Pressure Plasma Flow for Bio-medical Applications

Speaker:

Prof. Takehiko SATO

(1) Professor, Institute of Fluid Science, Tohoku University
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Abstract of Talk :

New medical treatments and equipment using a plasma flow have been developing rapidly and "plasma medicine" which is a new field, is now being established. Advantageous points of plasma treatments are non-contact, low temperature, safety and low cost because plasma is capable of generating specific reactive species and charged particles with a flow and those species are effective on activation, inactivation and induction for cell responses. In this talk, the following topics will be addressed: first, the effect of stable chemical species generated by the plasma irradiation to culture medium on cellular responses, and second, plasma sterilization devices for contact lenses using small and low voltage plasma flow.

Brief Biography of Speaker:

Obtained a Ph.D. in Engineering (Mechanical Engineering) from Tohoku University and joined in Matsushita Electric Works, Ltd. in 1995. Joined as a research associate in Institute of Fluid Science, Tohoku University in 1998. Promoted to a lecturer in 2002. Promoted to an associate professor in 2004. Since April 2011, he has been a full professor at the Institute of Fluid Science, Tohoku University. His research interests are bio-medical applications using plasma flows and their fundamentals. Fundamentals of steamer propagation and bubble behaviors for plasma in water, and plasma-induced flow are also research targets. He visited as a Japanese Overseas Research Fellow sponsored by the Ministry of Education and Science to USA, Canada, Korea and the Netherlands in 2003 and 2004. From September 2005 to February 2006, he joined as a Visiting Researcher in Max-Planck Institute for Extraterrestrial Physics in Germany. From September to October in 2009, he joined as a Visiting Professor in Swiss Federal Institute of Technology in Lausanne, Switzerland. His significant scientific achievements earned him the Best Paper Award of Japan Society of Mechanical Engineers (2001), the Encouragement Research Award of Japan Thermal Spraying Society (2001), the Best Paper Award of Japan Society of Multiphase Flow (2002), the 1st Prime in the Competition on fundamental investigations in the Institute of Theoretical and Applied Mechanics, Siberian Branch of Russian Academy of Sciences for 2003 (2003), the Research Achievement Award of Environmental Engineering Division, Japan Society of Mechanical Engineers (2011), the Best Paper Award of the Institute of Electrostatics Japan (2015), and a “Fellow” of the Japan Society of Mechanical Engineers since 2014.

Title of Talk :

Power Management for Implantable Medical Devices

Speaker:

Prof. Po-Hung Chen

Associate Professor, *Department of Electronics Engineering,*
National Chiao Tung University, Hsinchu, Taiwan

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Abstract of Talk :

Replacing the battery in biomedical implants exposes patients to a risk of serious complications. To effectively increase the battery lifetime, wireless power transmission and high efficiency power management circuits are necessary. In this talk, I will introduce our recent research progress on design of wireless power transmission as well as the power converters for implantable medical devices. It includes a 13.56 MHz wireless power transfer system with offset compensation, high-efficiency single-inductor dual-output (SIDO) buck converter, and fully-integrated light harvesting circuits for retina prosthesis.

Brief Biography of Speaker:

Prof. Po-Hung Chen was born in Hsinchu, Taiwan. He received the M.S. degrees in institute of electronics from National Chiao Tung University, Taiwan, and the Ph.D. degree in electrical engineering from the University of Tokyo, Japan, in 2007, and 2012, respectively.

He studied low-voltage low-power circuit design techniques and startup techniques in energy harvesting power converter during his graduate studies in Tokyo University. In 2011, He was a visiting scholar at the University of California, Berkeley, where he conducted research in fully-integrated power management circuits for RISC-V processor. From 2012, he joined the Institute of Electronics in National Chiao Tung University, where he is now an associate professor.

Dr. Chen’s research focuses on power management integrated circuits, with special emphasis on energy harvesting, battery management, battery charger, and wireless power transmission.

Title of Talk :

Model of Tissue with Mechanical Properties for Edu-Tech

Speaker:

Prof. Makoto OHTA

(1) Professor, Institute of Fluid Science, Tohoku University
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Abstract of Talk :

A model with realistic geometry of artery and its mechanical properties has a potential for education of medical devices, analysis of blood flow, training of medical devices. We develop a model of artery with mechanical properties and surface friction similar to a real artery. The model is made of PVA-H (Poly (vynil alcohol) hydrogel) and reaches the realistic. Now, the model is used for mechanical testing of medical devices such as catheter, simulator, stent, MRI, and Ultrasound. Recently, a circulation system for observing blood flow pattern using PIV (Particle Image velocimetry) for quantitative evolution. The model can be useful for a tool of education of young medical doctors as an education technology.

Brief Biography of Speaker:

Prof. Makoto Ohta got PhD at Kyoto University, Japan on 2001. During his PhD student, he worked for increasing wear resistance of Ultra High Molecular Weight Polyethylene (UHMWPE) using an oriented crystalline phase method.

After moving to Geneva University as a post doctoral fellow on 2001, he developed an intracranial aneurysmal model using (Poly (vinyl alcohol) Hydrogel, PVA-H). The hydrogel has unique mechanical properties of elasticity and the model is applied for performing mechanical tests of stent. And he also started Computational Fluid Dynamics of blood flow in intracranial aneurysm.

He got a position of Associate professor of Tohoku University, Institute of Fluid Science in 2005 and became professor of the institute on 2017. He published more that 100 papers and developed the field of performing mechanical tests of medical devices using models. He led the development of a standard on mechanical properties of bone model in 2017 in ISO 19213. Now, he is a convener of ISO/TC150(Implant for surgery)/WG 14(Models of tissues for mechanical testing of implants).

Title of Talk :

A Fully Integrated Closed-Loop Neuromodulation SoC with Wireless Power and Bi-Directional Data Telemetry for Real-Time Human Epileptic Seizure Control

Speaker:

Dr. Cheng-Hsiang Cheng

Postdoctoral Research Fellow,

Biomedical Electronics Translational Research Center (BETRC),

National Chiao Tung University, Hsinchu City, Taiwan.

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Abstract of Talk :

This talk presents a 16-channel closed-loop neuromodulation SoC for human seizure control. The SoC includes a 16-channel neural-signal acquisition unit, a bio-signal processor, a 16-channel high-voltage-tolerant stimulator, and wireless telemetry. The signal acquisition unit achieves 3.78 NEF and shares electrodes with the stimulator. The seizure detection latency is 0.76s and delivered 0.5-3mA biphasic current stimulation to suppress seizure onset. The SoC is powered wirelessly and bidirectional data telemetry is realized through the same pair of coils in 13.56MHz. The functionality of the fabricated closed-loop neuromodulation SoC in 0.18μm CMOS technology was verified with the animal test of a mini-pig. The closed-loop neuromodulation SoC is demonstrated to be a feasible solution for treating human epilepsy.

Brief Biography of Speaker:

Dr. Cheng-Hsiang Cheng received the M.S. and the Ph.D. degrees from the Institute of Electronics, National Chiao Tung University, Taiwan, in 2014, and 2018, respectively.

He studied analog-front-end circuits for neural-signal acquisition and wireless power/data telemetry for implantable medical devices during his graduate studies in National Chiao Tung University. Now, He is a Postdoctoral Research Fellow in the Biomedical Electronics Translational Research Center (BETRC), National Chiao Tung University, Hsinchu, Taiwan.

Dr. Cheng's research focuses on analog integrated circuits, with special emphasis on low-noise analog-front-end amplifier and wireless bi-directional data telemetry.