Professional Development Courses

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PDC#1: **Electronic Packaging for 5G Microwave and Millimeter Wave Systems**

Presenter: Rick Sturdivant, Ph.D., Azusa Pacific University, USA

ABSTRACT: Electronic packaging at microwave and millimeter wave frequencies is an important capability required for modern communication systems. This is because performance of the systems depends upon successful interconnections between subsystems, components, and parts. Since 5G systems rely on frequency bands approaching 100GHz, special care must be exercised in their design that is not required for 3G/4G systems. Therefore, this professional development course will provide attendees with the knowledge required for interconnects and packaging at the integrated circuit, circuit board, and system level. This includes essential information on materials, fabrication methods, transmission lines, interconnection methods, transitions, components, and integration methods such as 3D packaging. The course will start with specifics on 5G microwave and millimeter-wave communication systems, and major subsystems such as antennas and transmit/receive modules. This will be followed by details of technologies and solutions. The talk will conclude with a short review and predictions on the future directions of packaging technology. At the end of this course, attendees will have practical knowledge about electronic packaging for 5G systems.

BIO: Dr. Rick Sturdivant is a recognized expert in the field of electronic packaging, transmit/receive modules, and phased arrays. He is coeditor of *RF and Microwave Microelectronics Packaging II* (Springer Publishing, 2017), coauthor of *Transmit Receive Modules for Radar and Communication Systems* (Artech House, 2015), coauthor of *Hands On Guide To Heat Transfer For Microwave and Millimeter-wave Electronics* (Amazon.com eBook, 2015), and author of *Microwave and Millimeter-wave Electronic Packaging* (Artech House, 2013). He has also contributed several book chapters, numerous journal papers and conference papers. He holds seven U.S. patents. From 1989 to 2000 he engineered transmit receive modules for Hughes/Raytheon where he received the engineering excellence award for developing the world's first tile array module. Since the year 2000, he has started several successful technology companies providing solutions for wireless, microwave, millimeter-wave, and high-speed products. He is an Assistant Professor at Azusa Pacific University Founder and Chief Technology Officer of MPT, Inc. He earned the Ph.D. degree from Colorado State University, M.A. degree from Biola University, M.S.E.E. degree from the University of California at Los Angeles, B.S.E.E. degree from the California State University at Long Beach, and the B.A. degree from Vanguard University. For more up to date information, visit his website at ricksturdivant.com.

Dr. Rick Sturdivant

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PDC#2: **Automotive electronics – requirements and reliability**

Presenter: Dr. Mervi Paulasto-Kröckel, Aalto University, School of Electrical Engineering, Finland

ABSTRACT: Automotive electronics has been a reliability driver for the semiconductor devices since decades. Only mature packaging technologies has been accepted for production to make sure any reliability risks are minimized. Autonomous vehicle with its sensing and communication needs as well as e-mobility requirements will change this paradigm and new packaging technologies will be entering automotive market faster. Also, autonomous driving will increase the on-time of electronics demanding ever higher reliability components and assemblies. This presentation will review the implications of current trends to package development and reliability engineering, show examples of failure mechanisms in small volume interconnects and present methodological improvements needed to avoid reliability issues in automotive electronics packaging.

Bio: Professor Mervi Paulasto-Kröckel is chairing Electronics integration and reliability at Aalto University School of Electrical Engineering in Finland. She has broad experience in microelectronics packaging development specifically for automotive and power electronics market. Before transferring into the academic world in 2008, she worked over 12 years in the semiconductor industry in various R&D and management positions.

Prof. Paulasto-Kröckel began her studies at the Helsinki University of Technology in 1985. She studied materials science and engineering as her major and semiconductor technology as minor. After graduation as Master of Science in Technology in 1990 she continued her studies in the Technical Universities of Aachen (RWTH Aachen) and Helsinki and attained her doctoral degree in 1995.

After a 2-years post-doctoral appointment at the Joint Research Centre of European Commission in the Netherlands, her professional career continued in the electronics industry. She was a Staff Principal Engineer at Motorola Semiconductor Products Sector in Munich. In 2004 Paulasto-Kröckel joined Infineon Technologies where she was Director Package Development responsible for semiconductor assembly and interconnect development for automotive products worldwide.

Her current research focus is on advanced materials and interconnect technologies for MEMS/NEMS and power electronics, as well as multi-material assemblies behavior under different loads and their characteristic failure mechanisms. Her group has extensive experience in studying interactions and interfacial reactions between dissimilar materials, such as different oxide and nitride materials, metals and semiconductors.

The group has developed a combined methodology approach to solve multi-materials compatibility issues in microelectronics and microsystems. Prof. Paulasto-Kröckel has over 100 international publications in fields of microelectronics packaging and interfacial compatibility of dissimilar materials. She co-authored the book "Interfacial Compatibility in Microelectronics – Moving Away from the Trial and Error Approach" and she is a co-editor for the "Handbook of Silicon Based MEMS Materials and Technologies". Since 2012 she served as a Member at Large Region 8 of the CPMT Board of Governors. She is CPMT Distinguished Lecturer and a member of Finnish Academy of Technical Sciences.

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PDC#3: **MEMS Fabrication: from theory to packaging**

Presenter: Dr. Liu Aiqun, School of Electrical and Electronic Engineering, Nanyang Technological University (NTU), Singapore

ABSTRACT: This course aims to provide a deep understanding of the fundamental principles underlying the core technology of MEMS devices for researchers and students, and build-up stong fundamental capability in MEMS device design, fabrication and analysis.

After pursuing the course, we expect researchers and students, to have (i) a good knowledge on the fundamental theories, design, simulation, and fabrication processes relating to electronic device for different applications; (ii) motivation to apply device design and innovation to applications of their own interests and relate to their own individual research areas.

In order to follow this course, researchers and students should have a good background in electronic and microelectronics, materials and semiconductor processes, basic concepts in applied physics and electronic design and fabrication.

Prof. Liu

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Dr. Liu Profile

Education

PhD National University of Singapore 1995

MS Beijing Univ of Posts & Telecommun 1989

BE Xi'an Jiaotong University 1977

Research Grant

A*STAR SERC AME Programmatic Fund - Quantum Technologies for Engineering (2017-) [by A*STAR Science & Engineering Research Council (SERC)]

Academic Research Fund Tier 1 (2017-2019) [by Ministry of Education (MOE)]

Environment & Water Industry Development Council (2012-) [by Environment & Water Industry Development Council (EWI)]

Environment & Water Industry Development Council (2012-2017) [by Public Utilities Board (PUB)]

Environment & Water Industry Development Council (2013-) [by Environment & Water Industry Development Council (EWI)]

NRF Competitive Research Program (2015-2020) [by National Research Foundation (NRF)]

NRF OSTIn Space Research Program (2016-2018) [by A*STAR Institute of Microelectronics (IME)]

NTU Internal Funding - College of Engineering (2017-2018) [by Nanyang Technological University]

NTU Internal Funding – Nanyang Institute of Technology in Health & Medicine (NITHM) (2017-2019) [by Nanyang Institute of Technology in Health and Medicine (NITHM)]

Current Projects

Acoustophoretic Microfluidic System For Microbial Preconcentration and Fractionation

Microvesicle/ Exosome Purification Chip-miRNA Profiling for Personalized Medicine in Diabetes Theranostics

Nano-Opto-Fluidic System (NOFS) for rapid Single Viral Detection and Sorting Via Optical Force

Novel Fano type and Asymmetric Metallic Nanostructures for Non-Intrusive in Vivo Imaging Monitoring

On-Chip Elementary Quantum Logic Unit: SiC Spin-Photon Entanglement

On-Chip Spectrometer based on Integrated Silicon Photonics for Environmental Sensing and Monitoring

Optical Force Induced Nano-Opto-Mechanical (NOM) Mass Cytometry for Biotioxin (Botulinum Toxin) Detection and Identification

Optofluidic Nano-Cytometer for Virus Purification, Sorting And Quantification As An Assistive Toolkit for Virus Diagnosis

Optofluidic System For Bacteria Detection and Identification

Optofluidic-ultra-filter System For Virus Manipulation

Photonic Integrated Device and Continuous-variable Quantum Key Distribution (CV-QKD)

Quantum Engineering & Science

Wafer-level Optically-fed Steerable Antenna for Low-mass Satellite Communication System

Selected Publications

Y. Z. Shi, S. Xiong, L. K. Chin, J. H. Wu, T. N. Chen and A. Q. Liu. (2017). Particle trapping and hopping in an optofluidic fishnet. SPIE Optics and Photonics.

Y. Z. Shi, S. Xiong, L. K. Chin, J. H. Wu, T. N. Chen and A. Q. Liu. (2017). Sorting and measurement of single gold nanoparticles using an Optofluidic Chip. SPIE Optics and Photonics.

Y. Z. Shi, S. Xiong, L. K. Chin, J. H. Wu, T. N. Chen and A. Q. Liu. (2017). Single Gold Nanoparticle Trapping using an Optofluidic Chip. cleo.

Xueling Feng, Gong Zhang, Peng Chen, Hong Cai, Yuandong Gu, Ai Qun Liu, Bo Liedberg. (2016, July). Detection of matrilysin activity using silicon nanophotonic ring resonator. Paper presented at Optofluidics2016, Beijing, China.

Q. H. Song, W. Zhang, H. Cai, Y. D. Gu, P. C. Wu, W. M. Zhu, Q. X. Liang, Z. C. Yang, Y. F. Jin, Y. L. Hao, D. L. Kwong, T. Bourouina, Y. Leprince-Wang, and A. Q. Liu. (2016). A tunable metamaterial for wide-angle and broadband absorption through meta-water-capsule coatings. 36th International Conference on Lasers and Electro-Optics (CLEO 2016)San Jose, USA.

PDC#4: **Fan-Out Wafer-Level Packaging and 3D Packaging**

Presenter: Dr. John H Lau, ASM

ABSTRACT: Recent advances in, e.g., fan-out wafer/panel level packaging (TSMC's InFO-WLP and Fraunhofer IZM's FO-PLP), 3D IC packaging (TSMC's InFO_PoP vs. Samsung's ePoP), 3D IC integration (Hynix/Samsung's HBM for AMD/NVIDIA's GPU vs. Micron's HMC for Intel's Knights Landing CPU), 2.5D IC Integration (Xilinx/TSMC's CoWoS and TSV-less interconnects and interposers), embedded 3D hybrid integration (of VCSEL, driver, serializer, polymer waveguide, etc.), 3D CIS/IC integration, 3D MEMS/IC integration, and Cu-Cu hybrid bonding will be discussed in this presentation. Emphasis is placed on various FOWLP assembly methods such as chip-first with die-up, chip-first with die-down, and chip-last (RDL-first). Since RDLs (redistribution layers) play an integral part of FOWLP, various RDL fabrication methods such as Cu damascene, polymer, and PCB (printed circuit board) will be discussed. A few notes and recommendations on wafer vs. panel, dielectric materials, and molding materials will be provided. Also, TSV-less interposers such as those given by Xilinx/SPIL, Amkor, SPIL/Xilinx, ASE, MediaTek, Intel, ITRI, Shinko, Cisco/eSilicon, Samsung, and Sony will also be discussed. Furthermore, new trends in semiconductor packaging will be presented.

BIO: With more than 38 years of R&D and manufacturing experience in semiconductor packaging, John has published more than 450 peer-reviewed papers, 30 issued and pending patents, and 18 textbooks on, e.g., Advanced MEMS Packaging (2010), Reliability of RoHS compliant 2D and 3D IC Interconnects (2011), TSV for 3D Integration, (2013), and 3D IC Integration and Packaging (2016), all by McGraw-Hill Book Company. John is a Fellow of IEEE, ASME, and IMAPS.

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PDC#5: **Reliability from a Semiconductor Supplier's Perspective**

Presenter: Dr. Stevan Hunter, Center for Advanced Life Cycling Engineering, University of Maryland, USA

ABSTRACT: This tutorial will explore and highlight the current reliability space from the perspective of the semiconductor supplier. Semiconductor components and ICs have generally had good reliability lifetimes, and manufacturers are still driven in their relentless efforts to eliminate defects to improve yield and reliability. The concepts of Design for "X" (DfX) are easier said than done in the supplier's cost- and schedule-constrained environment. Reliability test and qualifications costs, schedule, and effectiveness are continually being scrutinized due to increasing customer expectations and more stringent industry standards. Lean six sigma practices are widespread in semiconductor manufacturing. Semiconductor reliability improvements are typically made by "guardbanding" or tightening process or test limits, not through a fundamental improvement that eliminates the "physics of failure". Field returns data is important, but often difficult to obtain in sufficient detail, and is clouded with processing by the sequence of customers after parts are out of the semiconductor supplier's control. Customers have the responsibility to preserve the built-in reliability of semiconductors, especially by preventing EOS and ESD in their operations. The risks of previously unknown or untested "physics of failure" mechanisms increase as devices continue to shrink, new processes are introduced, and integration escalates with 3-D packaging.

BIO: Stevan G. Hunter, PhD, is a Member of Technical Staff, for Quality and Reliability, at ON Semiconductor, Phoenix, AZ. He has 39 years semiconductor industry experience, teaches Lean Six Sigma courses at ON, teaches at BYU-Idaho and Arizona State University as adjunct, and is an adjunct faculty member at the University of Maryland CALCE. Stevan holds certifications as Six Sigma Blackbelt, Reliability Engineer, and ESD Factory Control Manager. He is a Senior Member of IEEE and ASQ, member of IMAPS, and serves on the EOS/ESD Association Industry Council and various committees.

Dr. Stevan Hunter

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PDC#6: **Packaging of UV Light-Emitting Diodes for Non-Lighting Applications**

Presenter: Prof. Shi-Wei Ricky Lee, Chair Professor of Mechanical & Aerospace Engineering, HKUST

Director of Center for Advanced Microsystems Packaging

General Director of HKUST Shenzhen Research Institute

Director of HKUST LED-FPD Technology R&D Center at Foshan

ABSTRACT: Light-emitting diodes (LED) have become the 4th generation light source since the turn of the century. In the past decade, people witnessed more and more applications of general lighting applications using LEDs. There is no doubt that solid-state lighting has become commodity in the comercial markets. Many people are wondering about what next waves of LED R&D should be focused on. Based on the speaker's observation, there are three emerging areas worth noting, namely, UV-LED, visible light communications (VLC), and micro-LED display. All of these are for non-lighitng applications. This presentation will briefly touch on these emerging areas and then focus on UV-LED. The intention is to bring the on-going technology trend to the awareness of active researchers on LED so that they can put their resources and efforts on the hot spot. In addition to the fundamentals of UV-LED and relevant concerns in packaging, certain applications will be introduced to demonstrate the features of UV-LED which are different from conventional general lighting.

BIO: Ricky Lee received his PhD degree from Purdue University in 1992. He joined the Hong Kong University of Science & Technology (HKUST) in 1993. During his career of tenure-track faculty at HKUST, Dr Lee once was on secondment to serve as Chief Technology Officer of Nano & Advanced Materials Institute (NAMI) for two and a half years. Currently Dr Lee is Chair Professor of Mechanical & Aerospace Engineering and Director of Center for Advanced Microsystems Packaging (CAMP) at HKUST. He also has a concurrent appointment as General Director of HKUST Shenzhen Research Institute and Director of HKUST LED-FPD Technology R&D Center at Foshan, Guangdong, China. Due to his technical contributions, Dr Lee received many honors and awards over the years. In addition to being the recipient of 12 best/outstanding paper awards and 5 major professional society awards, Dr Lee is Life Fellow of ASME and IMAPS, and Fellow of IEEE and Institute of Physics (UK). He is also a Distinguished Lecturer and the Senior Past-President of the IEEE Electronics Packaging Society (IEEE EPS, formerly IEEE CPMT).

Prof. Shi-Wei Ricky Lee

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