EPTC 2025 – Professional Development Courses (PDCs)

1. Advanced Packaging for Chiplets, Heterogeneous Integration, and Co-Packaged Optics

Speaker: John H Lau, Unimicron Technology Corporation

Course Objectives:

In this lecture semiconductor advanced packaging is defined. The kinds of advanced packaging are ranked based on their interconnect density and electrical performance and are grouped into 2D, 2.1D, 2.3D, 2.5D, 3D. 3.3D, and 3.5D IC integrations, which will be presented and discussed. Chiplet communication such as bridges embedded in build-up package substrate and in fan-out epoxy molding compound (EMC) with RDLs (redistribution layers) will be discussed. The fundamentals of hybrid bonding will be briefly mentioned and high-volume products with hybrid bonding will be presented. High bandwidth memory (HBM) and customized HBM (cHBM) are one of the key elements of high-performance computing (HPC) products driven by artificial intelligence (AI) will be discussed. Glass-core substrates and glass-core interposers will be presented. Some recommendations will be provided. The contents of this lecture are shown below.

- **Introduction**
- **Advanced Packaging**
- **2D IC Integration**
- **2.1D IC Integration**
- **2.3D IC Integration**
- **2.5D IC Integration**
- **3D IC Integration**
- **3.3D IC Integration**
- **3.5D IC Integration**
- **Bridges Embedded in Build-up Substrates**
- **Bridges Embedded in Fan-Out EMC with RDLs**
- **Hybrid Bonding**
- **HBM and cHBM**

- **Glass-Core Substrates and Glass-Core Interposers**
- **Co-Packaged Optics**
- **Summary and Recommendations**

Lecturer Bio

John H Lau, with more than 40 years of R&D and manufacturing experience in semiconductor packaging, has published more than 535 peer-reviewed papers (385 are the principal investigator), 52 issued and pending US patents (31 are the principal inventor), and 24 textbooks. John is an elected IEEE fellow, IMAPS Fellow, and ASME Fellow and has been actively participating in industry/academy/society meetings/conferences to contribute, learn, and share.

Who Should Attend?

If you (students, engineers, and managers) are involved with any aspect of the electronics industry, you should attend this course. It is equally suited for R&D professionals and scientists. The lectures are based on the publications by many distinguish authors and the books (by the lecturer). Each attendee will receive more than 250 pages of lecture notes.

2. Photonic Components and Packaging Technologies for Data Center, Communication, Sensing, and Displays

Speaker: Torsten Wipiejewski, Huawei Technologies

Course Objective:

This course will provide an overview on the various photonic components and packaging technologies that enable optical interconnects, communication, sensing, and modern display applications. These applications are key for the information and communication technology of today and path a way to the future. High speed optical interconnects from board level in data centers to long haul transmission systems requires photonic components with high speed and high reliability. We will discuss the main components such as laser diodes of various types including VCSELs, high speed optical modulators and photodetectors.

AI has become a major driver to increase data throughput in data centers and high-performance computing. Optical interconnects offer a large bandwidth and can help to reduce energy consumption for data transfer. Bringing the optical engine close to the GPU/ASIC core is the target of co-packaged optics (CPO) solutions replacing the electrical signal lines on board level. Packaging technologies play a key role in the implementation of optical solutions, because the cost of the system is typically dominated by the assembly and packaging cost. Integration schemes such as photonic integrated circuits PICs have become mainstream technologies for cost and size reduction. Therefore we will discuss optical waveguides and the coupling of optical waveguides and components to optical fibers. This is a key challenge in optical packaging because of the tight alignment tolerances.

Photonic technologies are also widely used as sensors for various applications including health monitoring. One key advantage is the potential for non-invasive measurements that facilitates the usage by end-users without specific medical knowledge. Displays are the main media nowadays for bringing information to people. They range in size from smart watches to smart phones, laptops and tablets all the way to large screen TVs and video walls. We review current technologies and new developments such as quantum dots and micro LEDs as well as some features of 3D displays. In particular, micro LEDs for large size displays require novel assembly technologies to mount chips of only several micro meter in size with extremely high yield at very low cost. The mass transfer of thousands of chips simultaneously is an option to achieve this challenging target.

Course Outline:

- Fundamental properties of photonic components
- Light sources: LEDs, laser diodes, VCSELs, others
- Transmitter and receiver components in optical data communication systems: lasers, modulators, photodetectors, passive optical components, optical modules, co-packaged optics (CPO)
- Monolithic and hybrid integration, photonic integrated circuits PICs, silicon photonics, optical waveguides and optical fiber coupling, assembly and packaging.
- Optical sensing elements and applications: spectrometers, light sources, photoacoustic sensors, frequency combs
- Display technologies: liquid crystal displays LCD, organic light emitting diode OLED displays, quantum dot emissive layers, micro LED arrays and large size displays using chiplet mass transfer and bonding, 3D displays
- Summary and outlook

Lecturer Bio:

Dr. Torsten Wipiejewski joined Huawei Technologies in 2014 and is responsible for the European technology sourcing of Huawei's Hardware Engineering Institute. His interest covers all hardware aspects for products ranging from smart watches to optical communication systems. He has also been appointed as Technical Advisor to the President of Huawei's European Research Institute. Previously, Torsten was an investor in renewable energy, CEO at Optogan (Germany, Finland) making blue LEDs, and COO at Firecomms (Ireland) making optical transceivers for automotive applications. He also held management positions at ASTRI in Hong Kong, Agility Communications in Santa Barbara, CA, USA as well as Infineon, Osram, and Siemens in Germany. Torsten received a "summa cum laude" Ph.D. degree in electrical engineering from the University of Ulm, Germany and has been an executive member of several international conferences. He was the General Chair of ECTC 2008 and has lectured several courses at conferences and universities. He holds more than 30 patents and has published over 100 scientific papers and presentations.

Who Should Attend:

The course addresses engineers, scientists and students who would like to get a general overview of various photonics technologies used in todays products and future developments. The aim is to describe which photonic technologies can be used in various applications and what current limitations are and which new technologies are being developed for further improvements or aiming at technology break throughs.

3. Advanced Packaging for MEMS and Sensors

Speaker: Horst Theuss, Infineon Technologies AG

Course Objectives

Sensors are everywhere! They create data and provide the “food” for the Internet of Things.

Which specific requirements distinguish MEMS and sensor packaging from standard assembly? How are these challenges being tackled? Do we need advanced packaging technologies for MEMS? These are just a few questions which are addressed in the course.

From a general introduction into package platforms, MEMS-specific challenges will be derived – e. g. the need for low package induced stress and its impact to MEMS performance, the necessity to create cavities or the implementation of MEMS-specific package materials and processes. The course reviews the state of the art, but also explores some topics in more detail. These topics refer to case studies comprising pressure and impact sensors, microphones, mirrors, magnetic sensors, and Radar devices. A further section elaborates on robustness requirements and approaches for risk mitigation in harsh environments.

A discussion on advanced packaging contains developmental studies on integrating MEMS-microphones or RF-antennas into Fan-Out-Wafer-Level-Packages.

The concluding chapter deals with systems and heterogeneous integration. Where is the overlap of the processor-driven world of advanced packaging and the MEMS/Sensor world? Where are differences, how can we overcome them and where will the future lead us?

Lecturer Bio:

Horst Theuss received his Ph.D. degree in Physics from the University of Stuttgart, Germany in 1993. His research was awarded a “Otto Hahn Medal for Young Scientists” by the Max Planck Society. As a research staff member at the Max Planck Institute for Metal Research he concentrated on magnetic properties of superconductors and amorphous materials. Within a post-doctoral assignment at the IBM

Almaden Research Center in San Jose, CA, he worked on magneto-optical properties of exchange-coupled thin layers. In 1996, he started his industrial career at Vacuumschmelze GmbH, Hanau/Germany as a product marketing manager for alloys with special magnetic properties. Horst Theuss joined Infineon Technologies, Regensburg, Germany in 2000. Since then he has been developing package concepts and processes in the fields of discrete semiconductors, wafer level packaging, cavity packaging, materials and system integration. As a Senior Principal he is today responsible for predevelopments with a focus on MEMS and sensors. Over the years, Horst has continuously contributed to a variety of conferences and magazines with presentations, papers and seminars. He holds more than 100 patents and is co-editor of the “Handbook of Silicon based MEMS Materials and Technologies”. Horst gives regular lectures on Advanced Packaging at the University of Applied Science in Regensburg, Germany.

Who should attend?

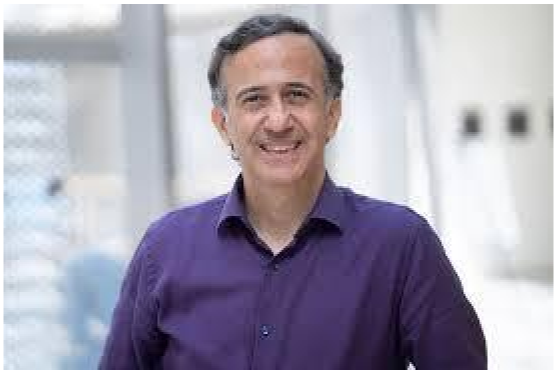
The course is intended for engineers and technical managers working in the field of MEMS or sensors. It gives an overview on the MEMS packaging landscape but also elaborates more fundamentally into selected topics. It will as well welcome students and newcomers, who are interested to broaden their MEMS-specific knowledge.

4. Overview of Characterization Techniques for 3D Heterogeneously Integrated Circuit Packaging

Speaker: ***Dr Ali Shakouri, Purdue University***

An overview of structural, mechanical, and thermal characterization techniques for advanced integrated circuits and 3D heterogeneously packaged chips will be given. This includes characterization of thin film materials and interfaces in complex ICs. Optical inspection, X-ray computed tomography, scanning acoustic microscopy, and optical pump-probe imaging are used for passive IC packages. Thermal imaging, deformation/stress analysis, and magnetic current imaging are performed on active ICs during operation. Key focus will be on the buried structures and 3D geometries. As feature sizes decrease, an overview of emerging ultrasonic and scanning probe techniques will also be presented. We highlight challenges in extracting key material and interface physical parameters, identifying buried defects, and the limits in spatial resolution and measurement times. Wafer-scale characterization of bonding interfaces, multi-layer interconnects, multi-chip modules, and through-silicon vias is particularly challenging, and rapid scanning techniques will be highlighted.

Lecturer Bio



Dr Ali Shakouri is an electrical and computer engineering professor and associate dean of research and innovation at Purdue College of Engineering. He received his Diplome d'Ingenieur in 1990 from Telecom Paris, France, and his Ph.D. in 1995 from the California Institute of Technology. He was a faculty at the University of California in Santa Cruz before moving to Purdue in 2011 to lead the Birck Nanotechnology Center for ten years. He has worked extensively in nanoscale heat transport and electrothermal energy conversion. His group has developed and commercialized a novel lock-in imaging technique to obtain thermal maps of integrated circuits and active devices with submicron spatial and nanosecond time resolution. At the Birck Center, he led the SMART consortium focused on low-cost printed sensors and IoT networks to expand the collaboration between engineering, agriculture, pharmacy, and veterinary medicine. He currently leads an NSF Future

Manufacturing project with colleagues at Purdue, Harvard, and Tuskegee University focused on deploying artificial intelligence techniques in small and medium manufacturers.

Who Should Attend

This course is designed for engineers, researchers, and students involved in structural, thermal, and materials characterization of advanced ICs and 3D heterogeneously integrated packages. It is especially relevant for those working on failure analysis, interface evaluation, and high-resolution inspection of buried structures, thin films, and wafer-scale interconnects.

5. Design-on-Simulation Technology for Reliability Prediction of Advanced Packaging

***Speaker:** K. N. Chiang - National Tsing Hua University, Taiwan*

Course Description

The electronic packaging community has widely adopted the Design-on-Simulation (DoS) methodology for designing new packaging structures, with a focus on fatigue, fracture, and reliability life prediction. Artificial intelligence (AI)/machine learning approaches can be combined with DoS for better accuracy and efficiency. This course aims to illustrate the fundamentals of physics associated with various failure mechanisms, particularly solder interconnect failure, and the corresponding solution methodologies for reliability assessment. This course will also introduce the procedure for generating a large database for AI training, as well as the performance of AI training over various machine learning algorithms. This course will describe how to combine AI and finite element simulation to estimate the reliability life and obtain the best structure combination of each packaging component using wafer-level packages as demonstrations.

Course Outline:

1. Introduction to advanced packaging
2. Fatigue and fracture
3. Plasticity and creep theories
4. Mesh size control methodology
5. Failure prediction empirical models
6. Conventional simulation and Design-on-Simulation approach
7. Empirical model vs. AI model
8. AI-assisted design-on-simulation methodology
9. Case study: solder joint reliability life cycle prediction empirical equations

Lecturer Bio:

Professor K.N. Chiang received his PhD from the Georgia Institute of Technology in the United States. He is the Chair Professor at the National Tsing Hua University in Hsinchu, Taiwan. After graduating from Georgia Tech, he worked for four years as a senior researcher at MSC/NASTRAN, a world-famous finite element system. From 2010 to 2013, he served as General Director of the National High-Performance Computing Center, which is the National Strategic Research Center of Taiwan. He has received outstanding research awards from the Ministry of Science and Technology of Taiwan three times and has published more than 450 technical papers in international journals and conference proceedings. He has been granted more than 50 invention patents. Among the major awards Professor Chiang received are the Excellence in Mechanics Award from ASME (2022) and the Outstanding Sustained Technical Contribution Award (2020) from IEEE-EPS. He was Editor-in-Chief of the Journal of Mechanics, IEEE Transactions on Advanced Packaging, and Senior Area Editor of the IEEE Transactions on CPMT. Currently, he serves as Academic Editor of Materials and Associate Editor of the Journal of Electronic Packaging. He is an IEEE, ASME, STAM, AIIA, AIAA, and iMAPS Fellow, as well as an academician of the International Academy of Engineering (IAE). He has made significant achievements in simulation-based science and technology.

Who Should Attend:

This course is designed for technical managers and staff members, reliability engineers, scientific researchers, and graduate students involved in mechanical modeling, package design, material selection, qualification, and reliability assessment of chip-package interactions, as well as package and package/board interactions.

6. Current and Future Challenges and Solutions in AI & HPC System and Thermal Management

Speaker: Gamal Refai-Ahmed, Ph.D., Member, U.S. National Academy of Engineering; Life Fellow, Canadian Academy of Engineering; Fellow, Engineering Institute of Canada; Fellow & Distinguished Lecturer, IEEE; Life Fellow, ASME; Senior Fellow & Chief Thermo-Mechanical Architect, AMD; Research Faculty Professor, SUNY Binghamton

Course Description:

In the rapidly evolving fields of Artificial Intelligence (AI) and High-Performance Computing (HPC), thermal management and packaging play critical roles in system reliability and performance. This course, led by Dr. Gamal Refai Ahmed, Ph.D., FIEEE, LFASEM, Fellow Canadian Academy of Engineering, Fellow Engineering Institute of Canada, AE, and member of the National Academy of Engineering, addresses the current and future challenges in these areas, presenting innovative, state-of-the-art thermo-mechanical solutions backed by patents and publications. Dr. Refai-Ahmed, renowned for his groundbreaking work in thermal management, silicon and power architecture, and advanced packaging technologies, will share insights based on his latest IEEE publications (2020-2024), exploring the Heterogeneous Integration Roadmap (HIR) and Advanced Packaging Technologies (MAPT) by SRC. The course will introduce the Seven Principles defining the next generation of thermal management architecture, with practical examples demonstrating the architecture of decoupling mechanical tolerances and coupling thermal management from a system level. Detailed discussions will cover first-line and second-line cooling solutions, direct liquid cooling, immersion cooling, and microfluidic approaches, addressing manufacturing, assembly, and reliability limitations from both package and system perspectives. Techniques to enable thermal loads beyond 1 kW will also be explored. Attendees, including thermal, mechanical, reliability, and assembly engineers, will engage in interactive discussions and gain practical, hands-on experiences that can be applied to their daily engineering practices. This course promises to be highly interactive and practical, drawing on industrial developments from first principles of engineering and showcasing advanced thermal-mechanical solutions. Join us to explore the forefront of AI and HPC system thermal management and gain knowledge that will propel your career forward.

Key Takeaways:

- A comprehensive understanding of the current and future challenges in thermal management and packaging.
- Exposure to innovative solutions and cutting-edge technologies.
- Practical insights that enhance daily engineering practices and drive industry advancements.

This course promises to be highly interactive and practical, drawing on industrial developments from first principles of engineering and showcasing advanced thermal-mechanical solutions. Join us to explore the forefront of AI and HPC system thermal management and gain knowledge that will propel your career forward

Lecturer Bio:

Dr. Gamal Refai-Ahmed is a world-renowned technical executive whose contributions to thermal management, advanced packaging technologies, and high-performance computing have significantly shaped industries including telecommunications, automotive, AI, and HPC. His pioneering work has established him as a leader in 3D heterogeneous integration, silicon and power architecture, and innovative cooling technologies, driving next-generation advancements in data centers and AI-enabled systems.

Dr. Refai-Ahmed's professional achievements are marked by numerous accolades, including election to the National Academy of Engineering (NAE) in 2024 and receipt of the Distinguished Alumni Medal for Professional Achievement from the University of Waterloo. He is a Xilinx Fellow, a title recognizing the pinnacle of technical leadership, and an IEEE Fellow, highlighting his exceptional contributions to engineering and technology. Other honors include the prestigious Presidential Medal for Innovation Leadership from Binghamton University, the IEEE Canada R.H. Tanner Industrial Leadership Silver Medal, and ASME's Calvin Lecture Award for advancing engineering best practices globally. He is also a recipient of the Mahboob Khan Award from SRC and the Excellence in Thermal Management Award from ASME, cementing his legacy as a transformational innovator.

Dr. Refai-Ahmed holds over 150 international patents and has authored more than 120 peer-reviewed publications, demonstrating his prolific contributions to thermal modeling, advanced cooling systems, and heterogeneous integration. His roles in professional societies include Associate Editor for the IEEE Transactions on Components, Packaging, and Manufacturing Technology and the ASME Journal of Electronic Packaging. He has held leadership positions such as Chair of ASME's Electronics and Photonics Packaging Division, Vice Chair of the IEEE EPS Emerging Technology Committee, and a member of the IEEE Fellow Committee.

In industry, Dr. Refai-Ahmed has held influential roles at Nortel, ATI Technologies, AMD, and Xilinx, spearheading transformative technologies such as vapor chamber cooling, TSV, and lidless FPGA designs. His work as a Senior Technology Architect at GE Global Research Center and his advisory roles with key organizations like the Semiconductor Research Corporation highlight his impact on shaping future technological directions.

Academically, Dr. Refai-Ahmed serves as an Adjunct Professor at both the University of Toronto and SUNY Binghamton, fostering collaboration between academia and industry. He holds a B.Sc. and M.Sc. in Mechanical Engineering from Alexandria University and a M.A.Sc. and Ph.D. from the University of Waterloo, specializing in heat transfer and thermal management for electronics.

A Fellow of the Canadian Academy of Engineering and a Life Fellow of ASME, Dr. Refai-Ahmed continues to push the boundaries of engineering innovation, blending technical excellence with visionary leadership to shape the future of AI, HPC, and electronics packaging.