8. Reliable Integrated Thermal Packaging for Power Electronics

Course Leader: Patrick McCluskey – University of Maryland and Damena Agonager – NEIT Laboratory, University of Maryland

Course Description:
Power electronics are becoming ubiquitous in engineered systems as they replace traditional ways to control the generation, distribution, and use of energy. They are used in products as diverse as home appliances, cell phone towers, aircraft, wind turbines, radar systems, smart grids, and data centers. This widespread incorporation has resulted in significant improvements in efficiency over previous technologies, but it also has made it essential that the reliability of power electronics be characterized and enhanced. Recently, increased power levels, made possible by new compound semiconductor materials, combined with increased packaging density have led to higher heat densities in power electronic systems, especially inside the switching module, making thermal management more critical to performance and reliability of power electronics. This course will emphasize approaches to integrated thermal packaging that address performance limits and reliability concerns associated with increased power levels and power density. Following a quick review of active heat transfer techniques, along with prognostic health management, this short course will present the latest developments in the materials (e.g. organic, flexible), packaging, assembly, and thermal management of power electronic modules, MEMS, and systems and in the techniques for their reliability assessment.

Course Outline:
1. Motivation for Integrated Thermal Packaging for Power Electronics and Heterogeneous Integration
2. Simulation and Assessment of Active Thermal Management Techniques
3. Application of Thermal Management to Commercial Power Systems
4. Durability and Reliability Assessment
5. Thermal Packaging and Reliability of Active Devices
6. Thermal Packaging and Reliability of Modules
7. Reliability and Packaging at the Board and System Level
8. Flexible Materials, Packaging, and Thermal Management
9. Reliability of Additive Manufactured Systems and Materials
10. AI/ML for Prognostics of Power Electronics

Who Should Attend:
Engineers and Managers who want to learn more about the thermal limitations and reliability concerns involved in the heterogeneous integration and packaging of power electronic devices and systems.

Bio: Dr. Patrick McCluskey is a Professor of Mechanical Engineering at the University of Maryland, College Park and the Department's Director of Undergraduate Studies. He has over 25 years of research experience in the areas of thermal management, reliability, and packaging of electronic systems for use in extreme temperature environments and power applications. Dr. McCluskey has co-authored three books, 5 US Patents, and over 200 peer-reviewed technical articles with nearly 4000 citations. He is an associate editor of the IEEE Transactions on Components, Packaging, and Manufacturing Technology, a member of the board of governors of the IEEE Electronic Packaging Society, a fellow and member of the Executive Council of IMAPS, and a member of ASME.

Bio: Dr. Damena Agonager (Ph.D., Mechanical Science and Engineering, University of Illinois Urbana-Champaign) is an Associate Professor of Mechanical Engineering at the University of Maryland, College Park. He earned his PhD at the University of Illinois Urbana-Champaign, where he was supported by the Alfred P. Sloan fellowship, Graduate Engineering Minority Fellowship, and NSF Center of Advanced Materials for Purification of Water with Systems (WaterCAMPWS). After his PhD, Damena joined Professor Ken Goodson's Nanoheat lab as a Stanford University Postdoctoral Scholar in the Mechanical Engineering Department. Before joining the University of Maryland, Damena was an Assistant Professor in the Department of Mechanical Engineering at Washington University in Saint Louis. He is a faculty member in the Center for Advanced Life Cycle Engineering (CALCE), the Maryland Energy Innovation Institute, and the Maryland Energy Innovation Institute.

He is a recipient of the Google Research Award, Sloan Research Fellowship Award, Cisco Research Award, NSF CAREER Award, ASME Early Career Award, and ASME K-16 Outstanding Early Faculty Career in Thermal Management Award. He was also one of 85 early-career engineers in the US selected to attend the 2021 National Academy of Engineering's 26th annual US Frontiers of Engineering symposium.