8. Characterization of Advanced EMCs for FO-WLP, Heterogeneous Integration, and Automotive Electronics

Course Leaders: Przemyslaw Gromala – Robert Bosch GmbH; Bongtae Han – University of Maryland

Course Objective:
Epoxy-based molding compounds (EMCs) are widely used in the semiconductor industry as one of the most important encapsulating materials. For the advanced packaging technologies, in particular, FO-WLP technologies and heterogeneous integrations, EMCs play a more significant role than for the conventional plastically-encapsulated packages because of thin profiles and complex process conditions required for the advanced packaging technologies. In the automotive industry where demand for more advanced packaging technologies increases rapidly for autonomous and connected cars, EMCs are often used to protect not only individual IC components but also entire electronic control units (ECUs), or power modules.

The stress caused by the mismatch of the coefficient of thermal expansion (CTE) between EMCs and adjacent materials is one of the major causes of reliability problems (e.g., excessive warpage, delamination, BRL, etc.). During assembly or even operating conditions, EMCs are subjected to temperatures beyond the glass transition temperature. Around the glass transition temperature, EMCs exhibit significant volumetric and isochoric viscosity, which leads to nonlinear viscoelastic behavior. In contrast, at low temperatures, EMCs show linear viscoelastic behavior. This complex material characteristic in the full temperature range of interest renders the design of electronic devices a nontrivial task. The mechanical behavior of EMCs has to be understood clearly to offer predictive simulation strategies, which has become an integral part of product development process.

This training will address details of such strategies, summarizes the required material characterization procedure, and closes with some representative examples.

Course Outline:
1. Introduction
2. Selection of the Material (Preliminary Qualitative Analysis)
3. Material Characterization
4. Cure Kinetics
5. Curing Shrinkage
6. Coefficient of Thermal Expansion
7. Linear Viscoelastic Properties
    - Master Curve and Shift Factor of Young's Modulus
    - Master Curve and Shift Factor of Bulk Modulus
8. Viscoelastic Behavior in the Non-linear Domain
9. Summary

Who Should Attend:
Engineers and technical managers who are already involved in the material characterization and modelling, numerical modelling, process engineers and PhD students who need fundamental understanding or broad overview.

Bio:
Przemyslaw Gromala is a simulation senior expert at Robert Bosch GmbH, Automotive Electronics in Reutlingen. Currently leading an international simulation team and FEM verification lab with the main focus on implementation of simulation driven design for electronic

control modules and multi - chip power packaging for hybrid drives. His research activities focus on virtual pre-qualification techniques for development of the electronic control modules and multi-chip power packaging. His technical expertise includes material characterization and modeling, multi-domain and multi-scale simulation incl. fracture mechanics, verification techniques, prognostics and health management for safety related electronic smart systems. Prior joining Bosch Mr. Gromala worked at Delphi development center in Krakow, as well as at Infineon research and development center in Dresden. He is an active committee member of the IEEE conferences: ECTC, EuroSimE, ICEPT; ASME: InterPACK. Active committee member of EPoSS – defining R&D and innovation needs as well as policy requirements related to Smart Systems Integration and integrated Micro- and Nano systems. He holds a PhD in mechanical engineering from Cracow University of Technology in Poland.

Bongtae Han received his BS and MS degrees from Seoul National University in 1981 and 1983, respectively, and his Ph.D. degree in Engineering Mechanics from Virginia Tech in 1991. He is currently Keystone Professor and APT Chair of the Mechanical Engineering Department of the University of Maryland; and is directing the LOMSS (Laboratory for Optomechanics and Micro/nano Semiconductor/Photonics Systems) of CALCE (Center for Advanced Life Cycle Engineering). Dr. Han's research interests include: Characterization of advanced polymers; Mechanical design of photonics and microelectronics devices; Prognostics and reliability assessment of automotive electronics; Performance enhancement and reliability assessment of high-power laser diode arrays, Moisture and gas diffusion in microelectronics components and systems; Experiment al micro and nano mechanics (optical methods and methodologies).

Dr. Han has co-authored a text book entitled "High Sensitivity Moiré: Experimental Analysis for Mechanics and Materials", Springer-Verlag (1997) and edited two books. He has published 12 book chapters and over 250 journal and conference papers in the field of microelectronics, photonics and experimental mechanics. He holds 2 US patents and 4 invention disclosures. Dr. Han received the IBM Excellence Award for Outstanding Technical Achievements in 1994. He was a recipient of the 2002 (Society for Experimental Mechanics) (SEM) Brewer Award for his contributions to development of photomechanics tools used in semiconductor packaging. Most recently, he was named the 2016 American Society of Mechanical Engineering (ASME) Mechanics Award winner in Electronic and Photonic Packaging Division for his contributions to structural mechanics of electronic systems.