Design and Test of Non-Hermetic Microelectronics for Military and Space

Instructors: Thomas J Green, TJ Green Associates LLC, tgreen@tjgreenllc.com
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Note to attendee: Class includes coffee and pastries in the morning and a full sit-down lunch at noon.

Class Time (0800- 1530 hrs)

COURSE SUMMARY

Packages made from polymeric materials as opposed to traditional hermetic materials (i.e. metals, ceramics, and glasses) require a different approach from a design, production, testing, and qualification standpoint. The problem is now one of moisture diffusion through the polymers that protect the sensitive microchips. Water vapor will quickly diffuse through most plastics and collect at the interface of the molding compounds and the IC/MMIC surface and possibly interact with contaminants along the way. Fick's law of diffusion and the interaction of moisture and other gases with the plastic package, with or without a cavity, is of primary importance for reliability of next generation microcircuits used in military and space products.

This course will focus on the materials and processes used to build non-hermetic packages and the variety of testing methods available to evaluate the non-hermetic package with a special emphasis on test methods to evaluate reliability. We'll also review underfills, molding compounds, moisture barriers, encapsulants etc. contrasting advantages/disadvantages and provide valuable insight on how to test and qualify for high rel applications.

This course is intended for process engineers, designers, quality engineers, component engineers and managers responsible for design, test and production of cavity and non-cavity style non-hermetic packages intended for use in high reliability military and space applications.

Introduction and Overview of "Non-Hermetics" for Mil and Space (0800-0930)

- Terminology overview: PEMS, plastic parts, "non-hermetics"
- What is "non-hermetic" packaging and how is it different from traditional hermetic parts?
  - Cavity and non-cavity non-hermetic packages
  - Plastic package design considerations
- Drivers for lower cost high reliability plastic packages
  - Temp range, mission life, extreme environments and availability of advanced devices
- Military Specs applicable to non-hermetics
  - Microcircuits Class Y Space qualified microcircuits, Class P
  - Mil-PRF-38534 Hybrids Appendix D "non-hermetic" packages
  - Mil-Prf-19500 JEDEC Task Group on Non-hermetics
  - NASA COTS EEE parts
- Overview of Industry Specs for Qual of plastic parts

- J-STD-020, AEC Q100/101
- JESD47K Stress driven qualification
- JESD22-A101/A102 and A110
- Review of SSB-1

➢ Near- Hermetic Packaging Theory
- Fick's law of moisture diffusion
- Quasi Steady state model to predict moisture ingress

Materials and Processes for Non-Hermetic Packaging (1000-1200)

➢ Overview of polymers used in electronic packaging
- Unique advantages and potential drawbacks

➢ Epoxy mold compounds (EMC)
- Chemical composition and typical mold compound formulation
- Filler packing density considerations
- Transfer molding and compression molding

➢ Underfills
- Capillary underfill challenges
- Composition and formulation of underfills
- Role of fillers
- Underfill process

➢ Recent advances in advanced packaging
- Polymer related challenges in Fan Out Wafer Level Packages (FOWLP)
- Transition to Fan Out Panel Level Packages (FOPLP)

Lunch (1200-1300)

Materials and Processes for Non-Hermetic Packaging (continued) (1300-1330)

➢ Other materials and processes for Non-hermetic packages
- Thin film vapor deposited coatings – Parylene
- Kapton (polyimide)
- Thermoplastics for cavity/non-cavity packages
    - Polyether ether ketone (PEEK), liquid crystal polymers (LCP)

Stress Driven Qualification for Non-Hermetic Packaging (1330- 1415)

➢ Overview of electronic packaging reliability
- JEDEC standards for package reliability
    - Moisture preconditioning (Moisture Sensitivity Level (MSL) with description of the solder reflow profile
    - High Temperature Storage
    - Highly accelerated stress test (HAST) and biased HAST
    - Temperature cycling
- Failure analysis (scanning acoustic microscopy, cross-sectional analysis)

➢ Stress driven qualification for Plastic Encapsulated Microcircuits (PEM)
- Overview of temperature humidity models
- Determination of the expected lifetime using field use condition of -55 to 125°C

Additional Testing Consideration and What to Worry About (1430-1530)

- Surface Cleanliness
  - Importance of ionic contamination and control
  - Cleaning Methods
    - UV ozone, Plasma, “snow cleaning”, solvents
- Moisture diffusion rate testing WVTR per ASTM F-1249
- Applicability of MIL-STD-883 TM 5011 and NASA outgassing spec
- Inherent moisture content of materials TGA/TML
  - Moisture uptake (absorption) by materials
- Moisture failures in plastic microelectronics
  - Examples of plastic part failure modes and analysis

Class Wrap Up and Q&A

INSTRUCTOR BIOS

Thomas J. Green has more than 40 years combined experience in industry/academia and the DoD. He earned a B.S from Lehigh University in Materials Engineering and an MEA from Univ of Utah. He is a recognized expert in materials and processes used to assemble hybrids, RF microwave modules/5G, Class III medical implants, optoelectronics, and other types of hermetic/non-hermetic packaged microcircuits and sensors. He has considerable expertise in hermetic testing methods per TM 1014 and moisture related failures in general. He is a consultant to companies developing next gen microelectronics for military and space. Serving as a Research Scientist at the U.S. Air Force Rome Air Development Center, Tom worked as a reliability engineer analyzing component failures and in industry he was the process engineer at Lockheed Denver. He has invaluable experience in wirebond, die attach, hermetic sealing, FA and root cause identification, For the last 20 years, Tom’s expertise has helped position TJ Green Associates, LLC as a recognized industry leader in teaching and consulting services for high-reliability military, space, and medical device applications. Tom is a Fellow of IMAPS (International Microelectronics and Packaging Society) and retired LtCol USAFR with 28 years of service.

Jeff Gotro, Ph.D., is the President and Founder of InnoCentrix, LLC. InnoCentrix provides a wide range of consulting services to the polymer industry. Jeff has over forty years of experience in polymers having held scientific and leadership positions at IBM, AlliedSignal, Honeywell Electronic Materials, National Starch Electronic Materials, and InnoCentrix. He has published five book chapters including *Thermosets* in the Encyclopedia of Polymer Science & Technology, John Wiley & Sons, 2017. Jeff has authored or co-authored over 61 papers in technical journals and conference proceedings. Dr. Gotro holds 15 issued US patents. Jeff has a Bachelor of Science in Mechanical Engineering and Materials Science from Marquette University and a Ph.D. in Materials Science from Northwestern University with a specialty in polymer science (polymer chemistry, physics, and characterization).