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Virtual Training Course Outline

Design and Test of Non-Hermetic Microelectronics

(3 Sessions, 2 hrs each)

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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 barrier and package interfaces. 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.

This course begins with a brief overview of hermetic packaging and associated testing methods that have been developed over the years, some of which are applicable to cavity style non-hermetic enclosures. Then the focus is primarily on the materials used to build non-hermetic packages and the variety of testing methods available to evaluate the non-hermetic package. A review of the techniques and methods to evaluate a "non-hermetic" approach is discussed with a special emphasis on cleaning of the device prior to encapsulation and alternate test methods to evaluate reliability.

This course is intended for process engineers, designers, quality 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 Class 3 medical implants.

Course Outline

- **What is "hermeticity" and how to test for it (brief overview)**
- **How is it different from "non-hermetic" packaging**
  - Cavity and non-cavity non-hermetic packages
  - Drivers for lower cost high reliability "non-hermetic" packages
  - Applicable MIL-STD-883 test methods

- **Moisture problems in microelectronics**
  - Review of classic moisture related failure mechanisms in both mil and high reliability Class 3 medical products
- **Surface Cleanliness**
  - Importance of ionic contamination and control
  - Cleaning Methods
    - UV ozone, plasma, “snow cleaning”, solvents
  - How to identify and evaluate surface contamination
    - Surface hydrophobicity testing (contact angle goniometry)
    - Water-soluble ionics in/on materials, extraction/ion chromatography
    - Other analytical methods e.g. Auger, SIMS, XRF etc.
    - UV and blue light to identify organic surface contaminants
- **Materials and Processes for non-hermetic packages**
  - Thin film/vapor deposited coatings
    - ALD (Atomic Layer Deposition), Adamantine
    - Parylene …materials and deposition processes
  - Kapton
  - Cavity/non-cavity packages
    - PEEK, LCP, PDMS, epoxies
  - Silicones- bio-compatible organic coatings
  - Acrylics, polyurethanes
- **Coating material evaluation, testing and effectiveness**
  - Conformance to surface topography
  - Permeability/diffusion properties
  - Pinholes/cracks/adhesion
- **IPC -CC-830 Moisture and Insulation testing**
- **Moisture diffusion rate testing WVTR per ASTM F-1249 Inherent moisture content of materials TGA/TML**
  - Moisture uptake (absorption) by materials
- **RGA for non-hermetic devices**
  - Ampule testing
- **TM 5011 and NASA out gassing Specs Moisture sensors both wired and wireless**
- **Near- Hermetic Packaging and Testing**
  - Ficks law of moisture diffusion
- **Qualification test methods and standards**
  - A Critical Review of Waterproof Testing Standards
  - IEC Standards and IP “Ingress Protection” ratings 67/68
  - ASTM, NEMA Specs
- **Military Specs applicable to non-hermetics**
  - The Class Y qualification program for space qualified non-hermetics

- Mil-PRF-38534 Appendix D “non-hermetic” packages
- Mil-Prf-19500 JEDEC Task Group on non-hermetics

- **JEDEC STANDARDS**
  - JESD22-A101/A102 and A110
- **GEIA STANDARDS SSB-1 “Guideline for Using Plastic Encapsulated Microcircuits and Semiconductors in Rugged Applications”**
- **Course Summary**
- **Student Feedback and Course Critique**

INSTRUCTOR BIOS

Thomas J. Green has more than 43 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, 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 and is an expert in the visual inspection criteria for hybrids and microcircuits Mil-Std-883 TM 2010 and TM 2017. 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.

Bob Lowry is an electronic materials consultant. After obtaining BS/MS degrees in Chemistry he worked for 32 years at Radiation, Inc., Harris Semiconductor, and Intersil Corp. He was responsible for materials analysis and was Senior Scientist in charge of Analytical Services at Harris and Intersil. He did failure analysis work on early moisture-related failures of NiCr and aluminum-metallized IC’s. He patented a surface conductivity dewpoint sensor and helped draft Test Method 1018. He established a DSCC-suitable facility at Harris for statistical control of hermetic sealing capable of the moisture limit thereby assuring compliant product. He conducted extensive split-lot studies of correlations between two different mass spectrometers. He also helped characterize a “consensus standard” circulatable single sample cylinder using humidified gas to improve moisture measurement correlation between laboratories. His consulting work includes package hermeticity and sealed headspace-related failure mechanisms, gas gettering technology, process and materials improvements for manufacturing reliable electronic components, counterfeit component identification and avoidance, and applied electronic materials and components analytical methods to identify problems and improve product quality/reliability.