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Virtual Training Course Outline

Hermeticity Testing, Internal Gas Analysis (IGA) and Getters

(3 Sessions)

This virtual training course is divided into three sessions, each led by one of the instructors below and focused on hermeticity testing, IGA (Internal Gas Analysis) aka RGA, and a third session on getters. Approximate time for each topic is 2 plus hours.

Instructors: **Thomas Green, TJ Green Associates, LLC, tgreen@tjgreenllc.com**
Robert Lowry, Electronics Materials Consultant, rlowry98@aol.com
Andy Hayden, Edryne Ltd., Andy.Hayden@Edryne.com

This tutorial includes a basic review of the Mil Spec test methods in place to prevent moisture related failures in hermetically sealed microelectronics where functional reliability is of utmost importance (e.g. IC's, Hybrids and RF modules, MEMs/Sensors, Class III Medical Implants, etc.). It is intended to enlighten the student on the negative, and sometimes catastrophic consequences of too much moisture or other harmful gasses inside a hermetic enclosure. The class begins with a definition of hermeticity and a description of the latest hermeticity test methods in MIL-STD-883 TM 1014, including the standard helium-based methods, plus the new Condition A5 along with Optical Leak Test (OLT) techniques, Kr-85 and other methods. The latest developments in TM 1018 IGA (Internal Gas Analysis) and revised criteria will be discussed. Additionally, we will be introducing getter materials and overviewing the use of these materials within vacuum packages and inert gas filled hermetic devices where moisture and/or hydrogen can be detrimental to device performance and lifetime.

Topics include:

- Moisture Failure Modes and Mechanisms
- Hermeticity and Leak Testing methods and techniques
- Moisture Control and Moisture Analysis via IGA
- Getter Technology, Types and Usage

The hermeticity session begins with a quick review of what it means when a package is deemed to be "hermetic" vs. a "non-hermetic" package and the associated technical theory that governs each. The primary hermetic seal manufacturing processes (e.g. seam seal, laser weld etc.) is briefly discussed and then each of the major leak test methods is reviewed, compared and contrasted, including gross leak test methods. The emphasis is on practical issues the engineer faces and examples using a simple XLS spreadsheet brings to life the Howl and Mann equation.

A critical review of past RGA failures is intended to highlight the FA protocols, causes and corrective actions, and from this guide engineers new to this field, or those dealing with a current related problem, to understand internal water vapor measurements, interpret data, and avoid similar mistakes. Emphasis is placed on the methodology used to understand the underlying physics and chemistry that caused failures and appropriate design and mitigation strategies required to prevent future failures.

Getter materials (sometimes described as chemical pumps) have been used within electronic devices for over 100 years and were developed to solve the problems caused by various harmful gas species. Not much has changed today in terms of the requirement for mitigating against moisture, hydrogen, and other gas species, however getter technology has of course advanced tremendously to match the increasing demands of the devices/applications and their processing boundary conditions. The session on getters will overview the different families/varieties of getter materials, their working principles and how they are used for a variety of electronic packages (both vacuum and inert gas-filled devices).

INSTRUCTOR BIOS

Thomas J. Green has more than 38 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 considerably expertise in hermetic testing methods per TM 1014 and moisture related failures in general. He is a consultant to companies developing next gen medical implants, a much sought after expert witness and organizer of Minnowbrook. 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 18 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).

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.

Andy Hayden has specialized in getter materials/technologies and applications for over 23 years. He obtained a BSc in Physics and graduated with a PhD in Physics (University of Warwick UK) working in the field of Surface Science (electronic/structural properties of adsorbates on surfaces and heterogeneous catalysis) conducting experiments at the Daresbury Synchrotron Radiation Facility (UK) and in collaboration with the Institute of Physics, Zagreb (HR). After 4 years as a postdoctoral research fellow Andy joined SAES Getters in 1996 and worked with getter materials used within a wide number of applications including displays, lamps/lighting, electronic devices, photonics, MEMS, X-ray/medical, renewable energy, cryogenics/vacuum insulation, gas purification, hydrogen safety, high energy physics and printable/flexible electronics. After managing the UK subsidiary office and European sales area (industrial applications) he relocated to the US in 2010 to manage the getter related business development activities for North America. Andy left SAES in 2016 and now consults on a wide range of topics including getter applications and research project management. He has been a Chartered Physicist for over 30 years (Institute of Physics) and also holds an MBA from the Open University Business School (UK).

Suggested Reference Books Available on Amazon:

1. Physics and Chemistry of Volatile Species in Hermetic Electronic Devices by Philipp Wh Schuessler
2. Hermeticity of Electronic Packages, Second Edition 2nd Edition by Hal Greenhouse