FALL/WINTER 2008

calceNEWS

CENTER FOR ADVANCED LIFE CYCLE ENGINEERING (CALCE)
WWW.CALCE.UMD.EDU, TEL: 301-405-5323

INSIDE

Mission Statement

To develop scientifically based innovative methodologies that decrease life-cycle risks for the next generation of electronic products and systems, and to create and maintain an educational and technology transfer infrastructure for their rapid dissemination and utilization.

In this newsletter, CALCE has put together a list of our clients (customers) over the last few years; there were more than 200! The researchers and engineers at CALCE are honored to have worked with so many world-class organizations, and we want to give our thanks for letting us provide you with our services and research.

Over the years, CALCE has also been a resource of talent for many companies. CALCE faculty are extremely proud that so many former CALCE students and post-docs are working at the top electronics companies around the globe, and many of them have started their own companies. The CALCE core faculty and researchers clearly have experience that can provide reliability analysis, guidance, and training to your organization. We are confident that our expertise and sophisticated test and failure analysis capabilities can help you cost-effectively and efficiently solve your problems.

Michael Pecht, Ph.D., PE
Director of CALCE
Chair Professor and Director of CALCE

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CALCE Electronic Products and Systems Consortium Technical Review Meeting

The CALCE Electronic Products and Systems Consortium (EPSC) will hold its Technical Review and Project Kick-off Meetings October 14-16, 2008 in Samuel Riggs Alumni Center on the University of Maryland College Park campus.

All current members of the Consortium are invited to attend. Organizations interested in becoming CALCE EPSC members and wishing to attend the meeting should contact Dr. Michael Osterman at osterman@calce.umd.edu. The fee to attend the meeting for non-members is $1,500. The agenda for this event is available at www.calce.umd.edu under Upcoming Events.

The following projects will be presented at the meeting:

- Factors Affecting Flex Cracking and Moisture Sensitivity of Standard and Flexible Termination Multilayer Ceramic Capacitors
- Comparative Analysis of Interconnect Degradation Using RF Impedance and DC Resistance
- Mitigation Measures for Electrochemical Migration on Lead-Free Assemblies with Low-Profile Components
- Reliability of Embedded Capacitors
- calcePWA Shock Model Improvements–Load Sequencing
- Fundamental Understanding of MEMS Structures Subjected to High Shock
- Electronic Component Failure Categorization under Gun-Launched High-G Loading
- Field Programmable Gate Arrays (FPGA) Antifuse Aging during Storage
- Identification of Sources of Counterfeit Parts
- Derating Guideline Evaluation for Electronic Products
- Lead-free Solders in High Temperature Applications
- Solder Joint Reliability of Solder-Dipped (SAC/SnPb) and SnBi Leaded SMT Packages in a Sn37Pb Assembly Process
- Effect of Cyclic Fatigue Damage Accumulation on Properties of SAC Solders
- Effect of Impact Pulse Parameters on PWA Drop Durability
- Model-based Design Guidelines for Shock and Drop Loading
- Durability Assessment of an Advanced Power Electronics Module
- Physics-of-Failure Qualification of Electronic Systems
- Microvia Non-destructive Inspection and Qualification
- Acceleration Parameters of Highly Accelerated Life Tests: Combined Effect of Moisture and Temperature on PEMS Reliability
- Physics of Failure of Cu/Low-k Silicon Devices
- Accelerated Testing Guideline of a COF Package Assembly
- Evaluation of Residual Stresses of PEM Induced by Effective Chemical Shrinkage of Polymer Materials
- PoF-Based Design for Optimum Reliability of High Power LED
- Virtual Qualification of Engine Control Modules
- Reliability Investigation of Power Electronic Inverter Design
- Sustainment Stovepipe Analysis and Avoidance
- Stress Relaxation in Stamped Metal Land Grid Array Sockets
- Characterization of Halogen-free PCB Laminate Materials
- Tin Whisker Shorting Propensity and Growth Assessment
- Thermal Performance and Reliability of Thermal Interface Materials
- Lead-free Synthesis
- Reliability of Pb-free and Reballed PBGAs in SnPb Assembly Process
- Solder Joint Reliability of Reworked/Repaired SMT Assemblies
- Vibration Fatigue Life of Pb-free Interconnects
- Thermal Aging Effect on Reliability of Pb-free Interconnects
- Modeling Mechanical Torsion of PWA in calcePWA

CALCE and Benchmark Electronics to Examine Package-on-Package (PoP) Reliability

CALCE and Benchmark Electronics are initiating a study to examine the reliability of Package-on-Package (PoP) assemblies. PoP is a relatively new development in terms of packaging technology for semiconductors. It is particularly useful in combining discrete logic with memory. The PoP involves stacking two or more ball grid array (BGA) packages. The base package appears like a traditional BGA except it has pads on the top surface for mounting a perimeter BGA. In assembly, the top and bottom PoP parts may be prestacked and reflowed. This method, while potentially more costly, requires no additional equipment and allows the prestacked PoP to be inspected. After inspection, the prestacked PoP can be placed on the board and reflowed like a normal BGA. In the second assembly method, the base PoP is placed on the board like a normal BGA. The second PoP (top) is dipped in a solder flux and then positioned on top of the base. The PoP assembly is then subjected to conventional reflow; joints are formed between the base PoP and the printed wiring board and between the top PoP and the base PoP.

PoP technology is finding use in mobile applications and will likely move to industrial and other applications. For this transition to occur, the reliability of the PoP technology must be evaluated under severe environmental conditions.

The CALCE study will compare prestacked PoP assemblies to an assembly process stacking PoP assemblies. Reliability testing is expected to include temperature cycling, random vibration, and mechanical torsion. For more information on this study, contact Dr. Michael Osterman at osterman@calce.umd.edu.

General Motors Joins CALCE

General Motors has joined the CALCE Electronic Products and Systems Consortium and the CALCE Prognostics and Health Management Consortium. Through CALCE EPSC and PHMC, GM will participate with other world-leading organizations in proactively addressing electronics reliability. GM joins other CALCE members focusing on lead-free alternatives to create high-reliability systems. If your organization is interested in joining a CALCE consortium contact Dr. Michael Osterman at osterman@calce.umd.edu.

Virtual Qualification Software Workshop

On October 15, 2008, CALCE will be offering a one-day workshop with hands-on training in the use of the current calcePWA and calceFAST software and a discussion of real-world applications, online resources, and future directions.

Go to www.calce.umd.edu or contact Dr. Michael Osterman at osterman@calce.umd.edu for more information on the workshop.

CALCE Web Seminars

Over the last six months, CALCE researchers have presented five webinars on topics such as hot solder dip, BGA reballing, total cost of ownership, RF impedance detection of interconnect degradation, and part derating. To find more about future CALCE web seminars visit: http://www.calce.umd.edu/seminars/seminars.htm.

CALCE Prognostics and Health Management Consortium Technical Review Meeting

The CALCE PHM Spring Review was held March 20-21, 2008. The focus of this meeting was to overview the data-driven techniques being investigated at CALCE and their application to electronics. The CALCE PHM team presented addressing aging effects on electronics, problems in obtaining data and defining baselines for training data, and interpretating anomaly detection results to system faults. PHM implementation in component testing applications was presented with insight into the physical behavior associated with degradation and failure mechanisms. Several case studies were included in this spring Consortium meeting, including a PHM cost modeling study utilizing the ROI tool version 2 for a fleet of Boeing 737s. The ROI tool is available to PHM Consortium members on our website, located at http://www.prognostics.umd.edu/.

The Fall 2008 CALCE Prognostics Consortium meeting is scheduled for October 16-17. In this meeting, CALCE will focus more on physics-of-failure techniques and hybrid techniques. More details on agenda and location will be posted on the website. The Consortium now has fifteen members. If you would like to participate in the Consortium contact Prof. Michael Pecht at pecht@calce.umd.edu.

PHM Cost Modeling (Version 2 Release)

CALCE has developed a new stochastic decision model that determines when scheduled maintenance makes good business sense. The model enables the optimal interpretation of life consumption monitoring damage accumulation or health monitoring and applies to failure events that appear to be random or clearly caused by defects. A case study representing commercial aviation using PHM for improved maintenance for a Boeing 737 was demonstrated during the spring review meeting. Using the operational profile, implementation cost, and maintenance cost data of the aircraft, the costs of using PHM over the system support life were computed and then compared to the cost of using unscheduled maintenance.

Several extensions to the original PHM ROI tool are included in this release, including cost calculations (recurring, non recurring, and infrastructural costs), operational profile specifications (the impact of unscheduled maintenance actions is a function of when they occur relative to the operational requirements for the system), monetary costs and automatic ROI calculations relative to unscheduled maintenance. In addition, this version has a full user's guide that includes a tutorial and complete field and button references.

CALCE Book on Prognostics and Health Management

"Prognostics and Health Management of Electronics" is in press and will be published by Wiley Publishing Co, NY, in August 2008. This book discusses the state-of-the-art in sensor systems for in-situ health and usage monitoring, the various data-driven-/-statistical models and algorithms, the use of canaries, and the approaches to physics-of-failure based prognostics. The book also presents an overview of implementation costs, including recurring, non-recurring and infrastructure costs, and the cost avoidance possible with PHM. It also provides a roadmap based on the current challenges and opportunities for research and development of PHM, and discusses the activities of the major players in the prognostics research field including companies, academic institutions, and government organizations.

CALCE Paper Receives IEST Award

The paper, "Virtual Remaining Life Assessment of Electronic Hardware Subjected to Shock and Random Vibration Life Cycle Loads," authored by Sony Mathew, Diganta Das, Michael Osterman, and Michael Pecht, was awarded the 2008 Maurice Simpson Technical Editors Award.

This paper was published in the Journal of IEST, volume 50, no. 1, in April 2007 and was the product of a collaboration between CALCE, BD Systems, and NASA. Robin Ferebee from NASA Marshall Space Flight Center and Joseph Clayton from BD Systems are co-authors. The paper presents a physics-of-failure based virtual remaining life assessment method for assessing the remaining life of an electronic circuit card. The approach is then demonstrated through a case study of a circuit card assembly in the Space Shuttle Solid Rocket Booster. To obtain this paper visit www.prognostics.umd.edu in the What's New section.

CALCE Paper Wins MFPT Best Paper Award

"Prognostics of Electronics under Vibration Using Acceleration Sensors," authored by Jie Gu, Donald Barker, and Michael Pecht, won the Best Paper Award at the 62nd Meeting of the Society for Machinery Failure Prevention Technology.

The paper was published in the Proceedings for the 62nd Meeting of the Society for Machinery Failure Prevention Technology (MFPT), pp. 253-263, May 2008. The paper discusses a prognostics methodology for assessing the remaining life of electronic components mounted on a circuit board using a single accelerometer to monitor the life-cycle vibration loads. A case study is presented for an electronic circuit board that is subject to random vibration. The paper compares the failure prognostic results to experiments. Visit www.prognostics.umd.edu in the What's New section to obtain this paper.

NASA Project Awarded to CALCE PHM

The CALCE Prognostics Group has been awarded a three-year NASA project titled "Reliable Diagnostics and Prognostics for Critical Avionics Systems." The CALCE PHM Lab will develop and validate system and component-level (LRU) diagnostic and prognostic methods for increasing the safety of avionic systems.

This research aims to improve the accuracy of avionics fault detection capability, boost in-flight performance, reduce maintenance costs, and improve overall aircraft reliability. Additionally, the project will provide algorithms for offline data analysis to detect soft faults and find the patterns of soft faults in relation to other relevant system events.

Prognostic algorithms will be developed to track degradation and predict the remaining useful life for avionics systems. These algorithms will be validated against simulated and experimental data, and the requirements will be tested based on scenarios that emulate avionics type data. This will include the investigation of several potential mathematical techniques and/or the combination of these techniques to design diagnostic and prognostic algorithms. Visit www.prognostics.umd.edu to learn more about the CALCE PHM.

CALCE Test Service and Failure Analysis Laboratory

The CALCE Test Services and Failure Analysis (TSFA) Laboratory provides support to the electronics industry to help improve product quality and reliability. The services provided include reliability testing, physics-of-failure based reliability modeling, supplier benchmarking, design reviews, and failure analysis. The TSFA Laboratory's philosophy is that failure analysis is most effective when it allows identification of the possible root causes of failure (the most basic factor or factors that lead to failure, and whose elimination will prevent its recurrence). This information can then be used to improve product reliability. The TSFA Laboratory has extensive experience in conducting failure analysis and identifying failure mechanisms for a broad spectrum of parts and products (such as active and passive components, printed wiring boards, optoelectronic devices, plastic-encapsulated microcircuits, solder interconnects, connectors, and flip-chips). Failure analysis is a systematic examination of failed devices designed to

- identify the failure modes (the way the product failed);
- identify the failure site (where in the product failure occurred);
- identify the failure mechanism (the specific physical process that caused the failure); and
- recommend failure prevention methods.

For further information on CALCE TSFA Laboratory capabilities contact Bhanu Sood at bpsood@calce.umd.edu.

CALCE Provides Printed Circuit Board Inspection

Applications with high-input/output designs for specific integrated circuits are pushing printed circuit board (PCB) manufacturing technology to feature smaller sizes, higher layer counts, and more complex boards. Today, a typical multi-layered PCB has thousands of high-aspect-ratio plated-through-holes, closely spaced line traces, and power/ground planes. Substantial concerns have arisen over the quality of PCBs, given their increasing density and complexity.

CALCE has been supporting clients by providing upfront evaluation of PCBs. Some common defects observed in PCBs by CALCE are nicks on the board edges, surface plating defects, blisters or wrinkles in the solder mask, nodules and burrs in plated-through-holes, and filled through-holes. For further information, contact Bhanu Sood at bpsood@calce.umd.edu.

Tin Whisker Issues Challenge Equipment Manufacturers

Tin whiskers continue to present a reliability risk for electronic equipment manufacturers. Tin whiskers are growths of conductive tin that form needle-like structures that can grow to lengths greater than 200 microns, with the longest reported whisker reaching 25 mm. While whisker lengths are generally lower than a few hundred microns, these growths present a shorting risk for modern electronic equipment. CALCE has recently observed whiskers on tin-finished terminals of flexible ribbon cables, which are becoming common in electronic assemblies. Currently, tin whisker tests standards by JEDEC (JESD22A121 and JESD201), as well as IEC standard IEC 60068-2-82, are not particularly formulated for tin and lead-free tin surfaces that experience contact pressure. CALCE is providing tin whisker testing services to assist industry. For more information contact Dr. Michael Osterman at osterman@calce.umd.edu.

CALCE Enhances Vibration Test Capabilities

In our continuing effort to expand and improve our test capability, CALCE has installed two vibration test systems. These systems will be used to support CALCE research on test methods and studies of high cyclic reliability of electronic hardware. In particular, lead-free materials that have shown a lower durability than tin-lead materials under elevated vibration exposure will be the subject of extensive studies. Research on vibration durability at load levels that more closely resemble field conditions is being pursued to help quantify field life expectancy and provide data to validate simulation techniques.

The first vibration system is a single-axis shaker produced by Data Physics. The system is capable of 1000 lbf sine and 580 lbf random output. CALCE intends to use this system for testing printed board assemblies and small systems.

The second vibration system is a unique multi-axis, electrodynamic shaker with six independently controlled degrees of freedom (three translational and three rotational). This is the second of two such shakers developed by TEAM Corporation, and is a relatively small shaker, intended for research purposes. This shaker has a 200 mm square table, capable of 900 N force on each translational axis and over 57 N-m torque on each rotational axis. Measured on the bare table, the max linear acceleration is 30Gs and the max angular acceleration is over 4340 rads/s^2. The max payload is 3 Kg per axis. The max displacement is 12.5 mm, and the max velocity is 1.5 m/s. CALCE intends to use this shaker to study the possible synergies between multiple axes when conducting accelerated vibration testing of electronic hardware.

CALCE and Buehler to Offer Four-day Course on Failure Analysis of Electronics

On September 16-19, 2008, CALCE and Buehler will conduct an intensive four-day course on Failure Analysis of Electronics in the CALCE Failure Analysis Laboratory at the University of Maryland. The four-day course will cover specimen preparation and materials analysis techniques applicable to electronic assemblies, components, and devices. The course consists of a combination of classroom instruction, demonstrations, and hands-on laboratory training. Lecture topics include physics-of-failure root-cause analysis, guidelines for selecting analytical tools, and practical instruction on laboratory techniques. The laboratory portion of the course includes demonstrations and step-by-step hands-on sample preparation using metallographic techniques on the latest failure analysis equipment from Buehler. In addition, a number of important non-destructive and destructive analysis techniques will be demonstrated.

Each course attendee is invited to submit one sample to CALCE at least three weeks before the course starts. Several of the submitted samples, along with course samples, will be prepared and analyzed in advance for use during course demonstrations.

For more information or to register for the course contact Bhanu Sood at bpsood@calce.umd.edu.

Discovery of New High-Rate Failure Mechanism for Multilayer Ceramic Chip Capacitors (MLCC)

Passive components play a key role in electronic assemblies. MLCC components in particular are prevalent in today's designs, appearing in consumer grade, professional grade, and military products. The behavior of MLCC devices when subjected to low- to medium-rate bending (PWB strain rate 10^{-1}/s) has been well documented in the literature. However, many of these components have the potential to experience some degree of high rate loading during their life cycle. Examples of this include the dropping of a portable consumer electronic device by the end user and the launch cycle of smart munitions for military applications. Thus, an understanding of the behavior of MLCC devices when subjected to high rate loading is required.

The parts selected for this study include standard termination MLCC capacitors of size 1206, 0603, and 0402, as well as flexible termination capacitors of size 1206 and 0603.

A round test board was designed with the intention of clamping the edges of the board to produce a diaphragm-type motion. This configuration was chosen due to the ability to obtain a radial strain distribution on the board, thus having capacitors subjected to a variety of maximum strains for a single experimental trial. The test board was double-sided and contained 148 parts per side (296 total).

The experimental method used to obtain high rate failures was a drop test. Strain measurements were taken from three locations on the test board, along with accelerometer data. A high speed video camera was also used to capture the drop event. The capacitors being evaluated were probe-tested prior to and after the test to determine failure, which was defined as a ± 10% change in capacitance. The peak acceleration for the drop experiments was selected as 5 kG. The resulting PWB strain rate was calculated to be 10^{0}/s.

Size 0603 and 0402 parts clearly outperformed size 1206 standard termination parts. Size 1206 flexible termination parts outperformed their standard termination equivalents. The performance of size 0603 flexible termination parts was roughly equivalent to that of the size 0603 standard termination parts; both had survival rates of roughly one hundred percent. Again, failure occurred at a maximum strain value much lower than expected and via the new failure mechanism.

Upon reviewing the high speed videos of the drop events, it was determined that component failure occurred within the first three board oscillations in all cases of failure. These first few cycles of board motion represent the transient response, which damped out after three to four full cycles of board oscillation. Thus, the possible fatigue influence due to the steady-state damped sinusoidal response of the test board after impact can be negated. This effect would have been minimal in any case, since the cracking occurred in the ceramic portion of the MLCC and ceramics are not susceptible to fatigue due to their brittle nature.

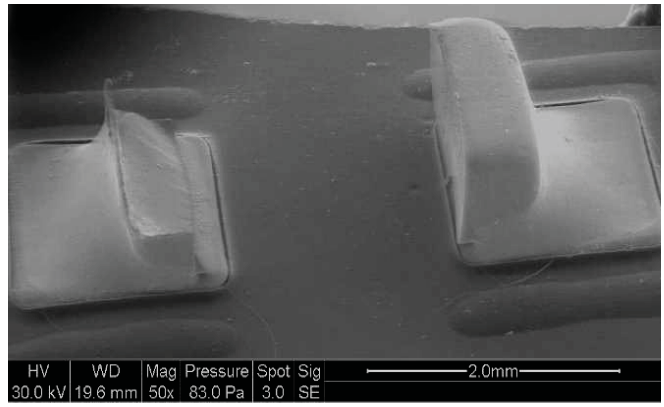

Figure 1: MLCC failure site induced by high strain rate failure mechanism.

Failure analysis was conducted for all documented failures. In all cases, failure occurred via a new failure mechanism unique to high-rate loading. Figure 1 shows an example of this failure mechanism. The defining characteristic of this new mechanism is the vertical fracture surface that occurs near the solder attach. The fracture surface at the opposite attach exhibits the same 45-degree shape as the MLCC low-rate failure mechanism documented in many prior studies. It is clear based on experimental evidence that the vertical fracture surface is the first damage to occur on the part, followed by the 45-degree crack at the opposite solder attach. The new failure mechanism was observed in all MLCC sizes evaluated in this study, as well as in both standard and flexible termination components.

This new failure mechanism, which only appears at higher loading rates (determined to be 100/s PWB strain rate in this study), also occurs at a much lower maximum strain value than the well-documented medium to low-rate failure mechanism. A literature review, in addition to bending experiments conducted by the authors at PWB strain rates 10^{-1}/s, confirms the occurrence failure in size 1206 MLCC devices at strain levels on the order of 3000 μ. However, the new failure mechanism that has been documented here occurs at strain levels as low as 500 μ.

MLCC devices have been shown to fail at lower than expected strain levels when subjected to high-rate loads. These results raise concerns about the use of MLCC devices in applications that will experience high-rate loading, due to their unexpected early failure in high strain environments.

For further information contact Prof. Donald Barker at dbarker@calce.umd.edu.

Determining the Dynamic Fracture Strength of Single-Crystal Silicon in MEMS

Single-crystal silicon (SCSi) is a primary building block for many microelectromechanical systems (MEMS) devices. Therefore, identification of the dynamic fracture strength of SCSi can tremendously aid in virtual qualification of new MEMS devices used in dynamic loading applications. Since silicon is a brittle material, crystal plane orientation and surface flaws play a major role in influencing the fracture strength. Surface flaws, which are functions of processing techniques and device feature size, significantly influence the fracture strength of SCSi. CALCE is assessing the influence of deep reactive ion etching (DRIE) technology on the dynamic fracture strength of SCSi. Currently, the primary focus has been to develop test methodologies that can be used for identifying the dynamic fracture strength of SCSi.

The test methodologies that have been recently developed were applied to simple MEMS shock test structures. These test structures consist of proof-masses supported by cantilever beams of various lengths on a single die fabricated by DRIE. Figure 2 shows an ESEM image of one type of the shock test structures that were investigated. The shock test structures were fabricated on p-type (100) SCSi SOI substrates. The MEMS shock test structures in a die were mounted on specimen fixtures with EPO-TEK® ND353 epoxy and were subjected to 3000 g (small drop table) and 5000 g (large drop table) acceleration pulses along critical loading directions.

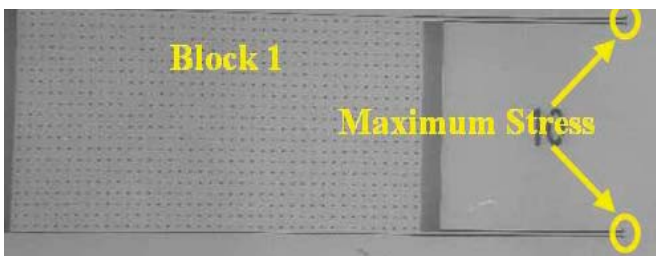

Figure 2: A Block 1 shock test structure

Figure 3 shows an ESEM image of a cantilever beam from the shock test structure shown in Figure 1 that was subjected to out-of-plane bending with a 3000 g acceleration pulse. The structure failed near the wall support, and the failure propagated from the bottom surface of the beam to the top surface of the beam, as expected for out-of-plane bending of cantilever beams attached to the proof mass. Figure 2 also indicates that the failure occurred along a {111} plane. An ESEM image of the bottom face of a Block 1 proof-mass and cantilever beam is illustrated in Figure 4, showing various etching anomalies.

Based on the analytical stress calculations and experiments performed thus far, the dynamic fracture strength of DRIE processed (100) SCSi is >1.10 GPa and <1.37 GPa for bending around <100> and <110> directions, respectively. As expected, it appears that failure starts at/or near the surface anomalies generated by the etching process.

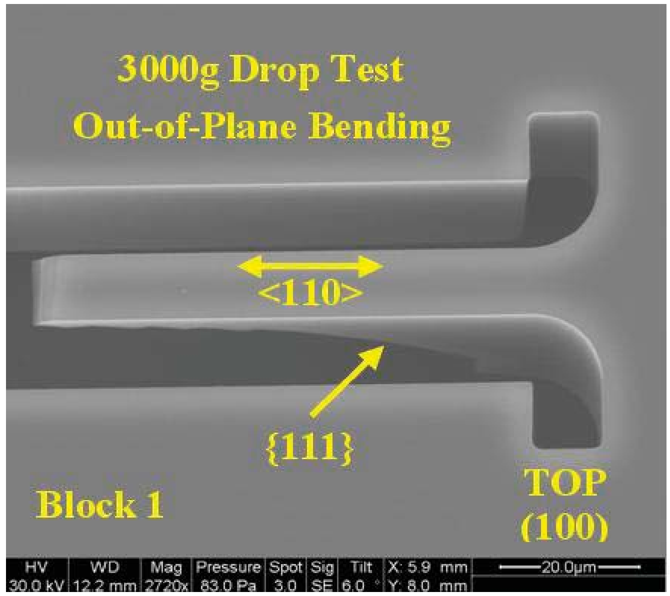

Figure 3: A Block 1 cantilever beam

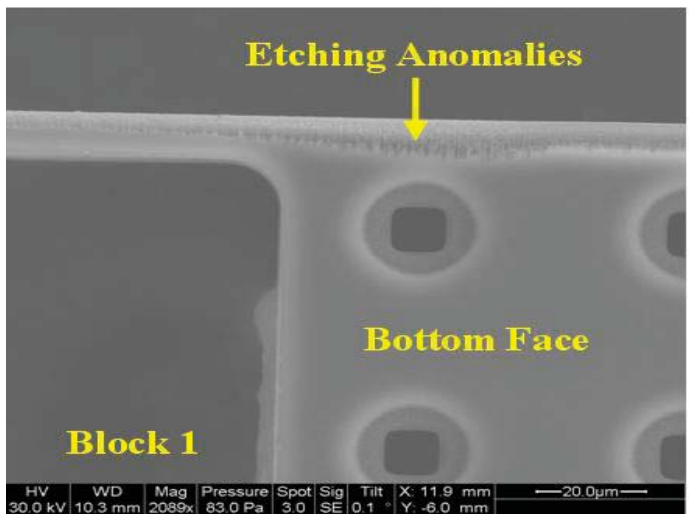

Figure 4: Bottom face of a Block 1 structure

A statistically significant number of experiments will be performed in the near future to identify the dynamic fracture strength and to quantify the uncertainties in the strength value of SCSi subjected to a particular DRIE process. In future experiments, we hope to understand the differences in strength values as a function of different DRIE processes.

For more information contact Prof. Donald Barker at dbarker@calce.umd.edu.

Second Symposium on Avoiding, Detecting, and Preventing Counterfeit Electronic Parts

On September 9-10, 2008, CALCE will hold the Second Symposium on Avoiding, Detecting, and Preventing Counterfeit Electronic Part Infiltration at the University of Maryland in collaboration with SMTA. A counterfeit electronic part is one whose identity (e.g., manufacturer, part number, date code, lot code) has been deliberately misrepresented. Counterfeit electronics have been reported in a wide range of products, including computers, telecommunications equipment, automobiles, avionics, and military systems. Counterfeit electronics include everything from very inexpensive capacitors and resistors to costly microprocessors, completed assemblies, and even systems. Going beyond anecdotes and examples of counterfeit parts, this symposium focuses on the solutions that are available and are under development by all sectors of the industry. Topics of presentation will include:

- Electronic parts supply chain
- Sources of counterfeit parts
- Preven methodologies for reducing chances of being victims of counterfeit parts
- Supply chain management tools to mitigate counterfeit part risks
- Inspections tools and techniques for detecting counterfeit parts
- Authentication techniques for securing electronic part supply chain
- Trade and business issues adopted by industry
- Law enforcement and international cooperation

This symposium will be valuable to supply chain managers, component engineers, brand protection specialists, marketing and procurement policy makers, contracts management, security specialists, and other interested engineers. Our focus is to provide relevant information to professionals that can be used for solving problems today while planning for a different business and technology environment in the future. Contact Dr. Diganta Das at digudas@calce.umd.edu for more information.

Symposium on Part Reprocessing, Tin Whisker Mitigation, and Assembly Rework and Repair

On November 11-12, 2008, CALCE will hold the second Symposium on Part Reprocessing, Tin Whisker Mitigation, and Assembly Rework and Repair at the University of Maryland. The symposium will provide a forum to learn about and discuss issue mitigation strategies, and the impact of rework and repair as it pertains to lead-free materials. Topics to be discussed include:

- Part reprocessing techniques
- Reliability of reprocessed parts
- Tin whisker testing and mitigation techniques
- Effectiveness of tin whisker mitigation techniques
- Assembly rework techniques
- Reliability of reworked/repair assemblies

If you are interested in participating or would like further information contact Dr. Michael Osterman at osterman@calce.umd.edu.

Professor Pecht Receives IEEE Reliability Society Lifetime Achievement Award

Prof. Michael Pecht was awarded the IEEE Reliability Society's Lifetime Achievement Award, the highest reliability honor, at the RAMS Conference in Las Vegas, 2008. The award was given to Prof. Pecht for his major contributions to the Reliability Society, Reliability Research, and Reliability Education, all benefiting the Reliability Community.

Selected Publications

1. P. Sandborn, "Trapped on Technology's Trailing Edge," IEEE Spectrum, Vol. 45, No. 4, pp. 42-45, 54, 56-58, April 2008.
2. A. Kleyner and P. Sandborn, "Minimizing Life Cycle Cost by Managing Product Dependability via Validation Plan and Warranty Return Cost," International Journal of Production Economics, Vol. 112, No. 2, pp. 796-807, April 2008.
3. P. Sandborn and P.A. Sandborn, "A Random Trimming Approach for Obtaining High-Precision Embedded Resistors," IEEE Trans. on Advanced Packaging, Vol. 31, No. 1, pp. 76-81, February 2008.
4. P.A. Sandborn and C. Wilkinson, "A Maintenance Planning and Business Case Development Model for the Application of Prognostics and Health Management (PHM) to Electronic Systems," Microelectronics Reliability, Vol. 47, No. 12, pp. 1889-1901, December 2007.
5. E. Scanff, K.L. Feldman, S. Ghelam, P. Sandborn, M. Glade, and B. Foucher, "Life Cycle Cost Estimation of Using Prognostic Health Management (PHM) for Helicopter Avionics," Microelectronics Reliability, Vol. 47, No. 12, pp. 1857-1864, December 2007.
6. Z. Wang and B. Han, "Advanced Iterative Algorithm for Randomly Phase-Shifted Interferograms with Intra- and Inter-Frame Intensity Variations," Optics and Lasers in Engineering, Vol. 45, pp. 274–280, 2007.
7. C. Han and B. Han, "Phase-shifting in Achromatic Moiré Interferometry System," Optics Express, Vol. 15, pp. 9970-9976, 2007.
8. K. J. Kim, A. Bar-Cohen, and B. Han, "Thermo-Optical Modeling of Intrinsically Heated Polymer Fiber Bragg Grating," Applied Optics, Vol. 46, No. 20 , pp. 4437-4370, 2007.
9. S. Yoon, B. Han, and Z. Wang, "On Moisture Diffusion Modeling Using Thermal-Moisture Analogy," Journal of Electronic Packaging, Vol. 129, pp. 421-426, 2007.
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12. A. Goswami and B. Han, "On Ultra-Fine Leak Detection of Hermetic Wafer Level Packages," IEEE Transactions on Advanced Packaging, Vol. 31, No. 1, pp. 14-21, 2008.
13. C. Jang, S. Park, B. Han, and S. Yoon, "Advanced Thermal-Moisture Analogy Scheme for Anisothermal Moisture Diffusion Problem, Journal of Electronic Packaging, Vol. 130, 2008.

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