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Mission Statement
CAVE is dedicated to working with industry in developing and implementing new technologies for the packaging and manufacturing of electronics, with special emphasis on the cost, harsh environment, and reliability requirements of the automotive, aerospace, military, computing, portable and other industries.

Message from Director
The field of electric lighting is undergoing major revolution. We are in the process of transition to solid state lighting from the incandescent lighting that we have so grown used to and fond of. Energy is one of the major grand challenges facing us in the 21st century. Lighting accounts for 17% of the worldwide electricity consumption. Energy consumption is on the rise, with non-OECD countries presently accounting for 82% of the increase in global energy usage. One possible way to address the growing demand for energy is to reduce the energy consumption on lighting. In 2012, the incandescent bulb is banned in a number of countries including South Korea, and Japan. Australia, Argentina, Philippines and Cuba have earlier bans in place. The United Kingdom and European Union are expected to enforce bans in 2013 and 2014 respectively. LEDs have seen a 200% growth in supply and a 90% growth in demand between 2009 and 2011. The transition to LEDs is by no-means limited to home or commercial lighting. The lighting revolution has touched televisions to automobiles. LEDs are the dominant form of backlight in LCD televisions and monitors in 2011. It is expected that over a 100 billion dies will be incorporated into LCDs by the end of 2014. The Lexus 600h is the first car to use daytime running headlights producing a savings of 1mpg. Today we can easily recognize an Audi very readily by the LED headlights.

The transition to solid state lighting brings along various challenges including the lumen depreciation, luminous flux and color shift, flicker, dimmability, sensitivity to power transients, driver reliability and lifetime. The driver power supply, control unit, and the LED package are major contributors to the reliability of solid state lighting. The CAVE3 Electronics Research Center along with RTI lead team of SAS and White Optics is one of the winning teams for the DOE research award to develop reliability models for solid state luminaires. The three-year grant will target the development of fundamental understanding of failure mechanisms and the physics-of-failure in solid state lighting systems. Researchers from CAVE3 and RTI attended the DOE research and development conference in Atlanta on January 31, 2012 and presented a poster on their research effort. CAVE3 extensive capabilities in reliability modeling, accelerated testing and surface science analysis will be used to gain fundamental insights into progression of damage mechanisms in luminaires used for various applications from down lights to automotive applications.

- Pradeep Lall, T. Walter Professor and Director

Professor Lall Named 2012 IEEE Fellow
Professor Pradeep Lall has been named an IEEE Fellow. He is being recognized for contributions to reliability prediction for electronic packaging. Dr. Lall’s contributions to reliability prediction methods which encompass failure mechanism models and prognostication health management techniques, have had a profound impact on electronics operation in harsh environments which often needs high-reliability for extended period of time. Leading indicators of failure identified by Lall for electronic equipment have enabled the early identification of impending failure – thus enabling safe repair and replacement of damaged modules. The IEEE Grade of Fellow is the highest grade of membership conferred by the IEEE Board of Directors upon a person with an outstanding record of accomplishments in any of the IEEE fields of interest. The total number selected in any one year cannot exceed one-tenth of one percent of the total voting membership.
CAVE³ Review

CAVE³ Consortium Spring Technical Review Meeting

The Center for Advanced Vehicle and Extreme Environment Electronics (CAVE³) will hold its Spring Technical Review and Project Planning Meeting on March 7-8, 2012 in Auburn University Hotel & Conference Center. All current members of the Consortium are invited to attend. The agenda for this event is available at cave.auburn.edu under CAVE³ Reviews. The following projects will be presented at the meeting:

- Acceleration Factors and Life Prediction Models for on-chip and off-chip Failure Mechanisms
- Advanced Interconnect Systems and 3D-Packaging Architectures in Harsh Environments
- Prognostic Health Monitoring Methodologies for Damage Estimation in Leaded and Lead-Free Solder Alloys
- PHM for Field-Deployed Electronics Subjected to Multiple Thermal Environments
- Leadfree Part Reliability, Crack Propagation and Life Prediction under Extreme Environments
- The Effects of Environmental Exposure on Underfill Behavior and Flip Chip Reliability
- Models for Underfill Stress-Strain and Failure Behavior with Aging Effects
- Insitu Die Stress Measurements in Flip Chip Packaging
- Modeling and Material Characterization for Flip Chip Packaging
- Theoretical and Experimental Investigation on Fretting Corrosion and Thermal Degradation for Hybrid and Electric Vehicles
- Complaint Pin/Press Fit Technology
- Model Simulation and Validation for Vibration-Induced Fretting Corrosion
- Vibration Based Interfaces for Information Transmission
- Microstructural and Mechanical Studies of SAC/Sn-37Pb Mixed Solders
- Aging Behavior of Next Generation Pb-Free Alloys
- Extreme Low Temperature Behavior of Solders
- Composition, Microstructure, and Reliability of Mixed Formulation Solder Joints
- QFP Reliability on Powered and Non-powered Thermal Cycle Environment
- Harsh Environment Substrate Performance
- Module Overmolding for Harsh Environments
- Systems Reliability of Lead Free for Harsh Environment Electronics

A block of rooms has been reserved for Review attendees at the preferred group rate. Room block will expire on February 27, 2012.

Contact Information:
Auburn University Hotel & Conference Center
241 South College Street
Call: (334) 821-8200

SPECIAL EVENTS

2012 IEEE International Conference on Prognostics and Health Management
June 18-21, 2012
Omni Interlocken Resort, Denver, Colorado

The IEEE Reliability Society is proud to sponsor its third annual International Conference on Prognostics and Health Management (IEEE PHM2012). CAVE³ is a technical sponsor for the conference. The 2012 IEEE PHM Conference is bringing together the expertise of relevant technical and management communities to facilitate cross-fertilization in this broad interdisciplinary technical area. This conference provides a sociable, professional environment to network with other practitioners and experts, forge new relationships, and deepen existing ones. The conference will cover a broad range of research and application topics covering the full scope of PHM development, from systems engineering and design to processes, methodology, and barriers to PHM application and implementation. World-renowned speakers will provide presentations, and participate in panel discussions, with a full day of tutorials free to all registrants. Details of the IEEE PHM can be found at www.phmconf.org

Call for Abstracts: 10th Annual AIMS Harsh Environment Electronics Symposium

October 15, 2012
The Swan & Dolphin Resort & Convention Center, Orlando, FL
In conjunction with SMTA International

The SMTA and CAVE³ at Auburn University are pleased to announce the 2012 AIMS (Automotive, Industrial, Military and Space) Harsh Environment Electronics Symposium. Dr. Pradeep Lall and Dr. John Evans, Conference Chairs and the SMTA International technical committee invite you to submit an abstract to participate in this timely program. The symposium will once again focus on harsh environments with an emphasis on military and space. We are soliciting abstracts that will provide NEW and TIMELY INFORMATION to attendees on the LATEST DEVELOPMENTS in these areas. Specific subject areas include, but are not limited to, those listed below: Alternative Energy (including, wind, water transportation, battery), Substrate Advancements, Components and Component Reliability, Connectors and Interconnect Technology, Corrosion, Extreme Environmental Applications, Lead-Free Issues Related to Harsh Environments, Latest Developments in Thermal Cycle Testing for Extreme Environment Electronics, Substrate Surface Finishes for Harsh Environment Applications, Tin Whiskers

DEADLINE FOR ABSTRACTS: March 12, 2012

Abstracts should be submitted on-line at http://www.smta.org/smtai/call_for_papers.cfm
Extended Kalman Filter Models and Resistance Spectroscopy for Prognostication and Health Monitoring of Lead-Free Electronics under Vibration

A technique has been developed for monitoring the structural damage accrued in BGA interconnects during operation in vibration environments. The technique uses resistance spectroscopy based state space vectors, rate of change of the state variable, and acceleration of the state variable in conjunction with Extended Kalman Filter and is intended for the pre-failure time-history of the component. Condition monitoring using the presented technique can provide knowledge of impending failure in high reliability applications where the risks associated with loss-of-functionality are too high to bear. The methodology has been demonstrated on SAC305 lead-free area-array electronic assemblies subjected to vibration. Future state of the system has been estimated based on a second order Extended Kalman Filter model and a Bayesian Framework. The measured state variable has been related to the underlying interconnect damage using plastic strain. Performance of the prognostication health management algorithm during the vibration test has been quantified using performance evaluation metrics. Model predictions have been correlated with experimental data. The presented approach enables the estimation of residual life based on level of risk averseness.

Figure 1: Comparison of Actual RUL versus Predicted RUL

Decorrelated Feature Space and Neural Nets Based Framework for Failure Modes Clustering in Electronics Subjected to Mechanical-Shock

Electronic systems under extreme shock and vibration environments including shock and vibration may sustain several failure modes simultaneously. Previous experience of the authors indicates that the dominant failure modes experienced by packages in a drop and shock frame work are in the solder interconnects including cracks at the package and the board interface, pad cratering, copper trace fatigue, and bulk-failure in the solder joint. In this paper, a method has been presented for failure mode classification using a combination of Karhunen Loéve transform with parity-based stepwise supervised training of a perceptron. Early classification of multiple failure modes in the pre-failure space using supervised neural networks in conjunction with Karhunen Loéve transform is new. Feature space has been formed by joint time frequency analysis. Since the cumulative damage may be accrued under repetitive loading with exposure to multiple shock events, the area array assemblies have been exposed to shock and feature vectors constructed to track damage initiation and progression. Error Back propagation learning algorithm has been used for stepwise parity of each particular failure mode. The classified failure modes and failure regions belonging to each particular failure modes in the feature space are also validated by simulation of the designed neural network used for parity of feature space. Statistical similarity and validation of different classified dominant failure modes is performed by multivariate analysis of variance and Hotelling’s T-square. The results of different classified dominant failure modes are also correlated with the experimental cross sections of the failed test assemblies. The methodology adopted in this paper can perform real-time fault monitoring with identification of specific dominant failure mode and is scalable to system level reliability.

Figure 2: Designed Feed-forward Neural Network for Fault isolation (Test Vehicle-A).

Whisker Growth under Controlled Humidity Exposure

Studies of Sn whiskers under controlled, calibrated humidity conditions shows that the highest whisker densities occur for approximately 85% RH. The whisker specimens were 1500 Å Sn films sputtered under compressive stress conditions on silicon and electrochemically polished brass. Subsequently, the samples were exposed to a series of saturated aqueous salt solutions (which generated calibrated relative humidity values of 33, 43, 70, 76, 85, 98% RH) for ~140 days at room temperature. The Sn on
brass case at 85% RH produced 6X greater whisker densities than Sn on brass exposed to pure O2, which in turn produced 9X greater whisker densities than Sn on brass exposed to ambient room temperature/humidity. The longest average whisker lengths (6.1 μm for Sn on brass and 9.3 μm for Sn on Si) occurred for 70% RH on both substrates. Corrosion features were observed on all samples, but the 98% RH samples experienced excessive corrosion. Generally, we find a dramatic increase in whisker density at > 60% RH and especially around 85% RH, in agreement with batch processed whisker experiments involving humidity.

Figure 3: Whisker Growth from Corrosion Regions Due to Humidity Exposure (a) 33% RH on Brass, (b) 76% RH on Brass, (c) 98% RH on Brass and (d) 98% RH on Si.

Correlation of Intrinsic Thin Film Stress Evolution and IMC Growth with Whisker Growth

This paper explores the notion that the nucleation and growth of Sn whiskers is motivated by net compressive intrinsic thin film stress. In this view, a threshold level of stress should exist at which Sn whiskers nucleate; furthermore, whiskering will relieve the compressive stress by a measurable amount. We examine the threshold stress for whisker nucleation and measure the amount of stress relieved during Sn whisker growth on brass substrates. The stress evolution has been evaluated by traditional bent beam analysis via novel machine vision techniques. Whisker nucleation and growth of the Cu-Sn intermetallic layer was observed by FIB sectioning, EDX mapping, and electron microscopy. Results show that the measured stress evolution shows little correlation to whisker nucleation and intermetallic growth. Further, we observe whisker population densities under both compressive and near neutral thin film stress conditions.

Reliability Studies for Package-On-Package Components in Drop and Shock Environments

The consumer electronics industry stands at a critical juncture where manufacturers strive to incorporate more functionality in smaller packages. In the highly competitive consumer electronics market, a continued demand for products with smallest possible form-factor yet high functionality has led to the proliferation of 3D packaging technologies. Package-on-Package (PoP) architectures, in particular have attracted a lot of interest, especially in portable electronics industry. The advantages of these stacked 3D architectures include simplified and compact design, savings of board space allowing for more package landings, reduced pin counts and optimized production costs. While a lot of recent research, in the field of PoP architectures has been focused on development of optimum process flows and warpage control during reflow, the effects of reflow parameters on the quality of PoP build and the associated reflow defects including warpage have not been extensively researched. Additionally, studies on reliability issues associated with PoP assemblies in drop and shock environments are scarce. Since PoP architectures find their applications mainly in portable electronics, which are susceptible to frequent drops and careless handling at the hand of the consumer, the reliability of PoP architectures in environments representative of the real world is critical to their success in the industry. In this study, single component PoP test vehicles have been fabricated as per JEDEC standards for quantifying the reliability of PoP packages in drop and shock. Daisy chained double-stack PoP components have been used to identify failure for subsequent drop/shock performance analysis. Experimental strain data acquired using Digital Image Correlation and high speed continuity data for identifying failure has been used in conjunction with validated FE simulations of drop test events; for development of life prediction models for PoP architectures. Validated node based global-local FE simulations are used to predict strains in critical solder balls in both layers of the PoP stack. The
drop/shock reliability studies and life prediction models presented in this work, present an insight into PoP failures and eliminate the need for exhaustive testing procedures.

**Figure 5:** A schematic of Package-On-Package stack showing both the constituent packages viz. the bottom (PSvBGA) and the top (CSP) packages.

**Ridge Regression Based Development of Norris-Landzberg Acceleration Factors and Goldmann Constants for Lead Free Electronics**

Goldmann Constants and Norris-Landzberg acceleration factors for lead-free solders have been developed based on ridge regression models (RR) for reliability prediction and part selection of area-array packaging architectures under thermo-mechanical loads. Ridge regression adds a small positive bias to the diagonal of the covariance matrix to prevent high sensitivity to variables that are correlated. The proposed procedure proves to be a better tool for prediction than multiple-linear regression models. Models have been developed in conjunction with Stepwise Regression Methods for identification of the main effects. Package architectures studied include, BGA packages mounted on copper-core and no-core printed circuit assemblies in harsh environments. The models have been developed based on thermo-mechanical reliability data acquired on copper-core and no-core assemblies in four different thermal cycling conditions. Packages with Sn3Ag0.5Cu solder alloy interconnects have been examined. The models have been developed based on perturbation of accelerated test thermo-mechanical failure data. Data has been gathered on nine different thermal cycle conditions with SAC305 alloys. The thermal cycle conditions differ in temperature range, dwell times, maximum temperature and minimum temperature to enable development of constants needed for the life prediction and assessment of acceleration factors. Norris-Landzberg acceleration factors have been benchmarked against previously published values. In addition, model predictions have been validated against validation data-sets which have not been used for model development. Convergence of statistical models with experimental data has also been computed and correlated. Good correlations have been achieved for parameters examined.

**Figure 6:** Ridge Plot of VIF of Various Variables in the Input Data-Set versus Ridge Estimator for Assessing the Influence of Silver Content on Thermo-Mechanical Reliability.

**Interrogation of Accrued Damage and Remaining Life in Field-Deployed Electronics Subjected to Multiple Thermal Environments of Thermal Aging and Thermal Cycling**

Field deployed electronics may accrue damage due to environmental exposure and usage after a finite period of service but may not often have any macro-indicators of failure such as cracks or delamination. A method to interrogate the damage state of field deployed electronics in the pre-failure space may allow insight into the damage initiation, progression, and remaining useful life of the deployed system.

Aging has been previously shown to affect the reliability and constitutive behavior of second-level lead free interconnects. Prognostication of accrued damage and assessment of residual life can provide valuable insight into impending failure. In this paper, field deployed parts have been extracted and prognosticated for accrued damage and remaining useful life in an anticipated future deployment environment. A subset of the field deployed parts has been tested to failure in the anticipated field deployed environment to validate the assessment of remaining useful life. In addition, some parts have been subjected to additional known thermo-mechanical stresses and the incremental damage accrued validated with respect to the amount of additional damage imposed on the assemblies. The presented methodology uses leading indicators of failure based micro-structural evolution of damage to identify
accrued damage in electronic systems subjected to sequential stresses of thermal aging and thermal cycling. Damage equivalency methodologies have been developed to map damage accrued in thermal aging to the reduction in thermo-mechanical cyclic life based on damage proxies. The expected error with interrogation of system state and assessment of residual life has been quantified. Prognostic metrics including $\alpha$-$\lambda$ metric, sample standard deviation, mean square error, mean absolute percentage error, average bias, relative accuracy, and cumulative relative accuracy have been used to compare the performance of the damage proxies.

Figure 7: Combined $\alpha$-$\lambda$ Curve for Prognostication.

Failure Mode Clustering in Electronic Assemblies Using Sammon’s mapping with Supervised Training of Perceptrons

An anomaly detection and failure mode classification method has been developed for electronic assemblies with multiple failure modes. The presented prognostic health management method targets the pre-failure space of the electronic assembly life to trigger repair or replacement of impending failures. Presently, health monitoring systems focus on reactive diagnostic detection of failure modes. Examples of diagnostic detection include the built in self-test and on-board diagnostics. In this paper, damage pre-cursors from time-spectral measurements of the electronic assemblies have been measured under applied vibration and shock stimulus. The time evolution of spectral content of the damage pre-cursors has been studied using joint time frequency analysis in a full-field manner on the printed circuit assembly. Frequency moments have been used to build a feature vector. Evolution of the feature vector with damage initiation and progression has been studied under shock and vibration. The feature vector from multiple locations in the board assemblies has been mapped into a de-correlated feature space using Sammon’s mapping. Several chip-scale packages have been studied, with SAC305 and SAC405 lead-free second-level interconnects. Transient strain has been measured during the drop-event using digital image correlation and high-speed cameras operating at 100,000 fps. Continuity has been monitored simultaneously for failure identification. In addition, explicit finite element models have been developed and various kinds of failure modes have been simulated such as solder ball cracking, trace fracture, package falloff and solder ball failure. The neural net has been trained using simulated data-sets created from error-seeded models with specific failure modes. The neural net has then been used to identify and classify the failure modes in board assemblies experimentally. Supervised learning of multilayer neural net in conjunction with parity has been used to identify the hard-separation boundaries between failure mode clusters in the decorrelated feature space. The assemblies have been cross sectioned to verify the identified failure modes. Cross-sections indicate that the experimentally measured failures modes correlate well with the position of the cluster in the decorrelated feature space.

Figure 8: Experimental Cross Sections with Inter Connect Fracture.

Life Assessment of Pb-Free SAC305 Alloy Under Simultaneous Temperature and Vibration Loading

Electronics installed in automotive systems are subjected simultaneously to mechanical vibrations and thermal loads in under the hood applications. Typical failure modes include solder joint failure, pad cratering, chip-cracking, copper trace fracture, and under-fill fillet failures. The solder interconnects accrue damage much faster when vibrated at elevated temperatures. Industry migration to lead-free solders has resulted in a proliferation of a wide variety of solder alloy compositions. Presently, the literature on mechanical behavior of lead free alloys under simultaneous harsh environment of high-temperature vibration is sparse. In this study, a test vehicle with a variety of lead-free SAC305 daisy chain components including BGA, QFP, SOP, and TSOP has been tested to failure by subjecting it to two elevated temperatures and harmonic vibrations at its first natural frequency. The first natural frequency is obtained by simulation as well as modal analysis. The global FE model is correlated...
Research Highlights

using system characteristics such as mode shapes and natural frequencies. The test matrix includes variation in the amplitude of vibration from 10G to 14G as well as variation in temperature. Full field strain on the PCB has been extracted using high speed cameras operating at 100,000 fps in conjunction with digital image correlation. A node based sub-modeling technique is used in FEA to obtain solder interconnect stress. High cycle fatigue constants are obtained by curve fitting into failure data points plotted on the S-N curve. The reduction in number of cycles to failure with temperature is evaluated.

Figure 9: Cycles until Failure versus Temperature.

SIF Evaluation Using XFEM and Line Spring Models under High Strain Rate Environment for Lead Free Alloys

In this work, fracture properties of Sn3Ag0.5Cu lead-free high strain-rate solder-copper interface have been evaluated and validated with those from experimental methods. Bi-material Copper-Solder specimens have been tested at strain rates typical of shock and vibration with an impact-hammer tensile testing machine. Models for crack initiation and propagation have been developed using the line spring method and the extended finite element method (XFEM). The critical stress intensity factor for the Sn3Ag0.5Cu solder-copper interface have been extracted from line spring models. Displacements and derivatives of displacements have been measured at the crack tip and near the interface of the bi-material specimen using high speed imaging in conjunction with digital image correlation. Specimens have been tested at strain rates of 20s⁻¹ and 55s⁻¹ and the event was monitored using a high speed data acquisition system, as well as, high speed cameras with frame rates in the neighborhood of 300,000 fps. Previously, the authors have applied the technique of XFEM and DIC for predicting failure location and to develop constitutive models in leaded and few lead-free solder alloys. The measured fracture properties have been applied to the prediction of failure in ball-grid arrays subjected to high-g shock loading in the neighborhood of 12500g in a JEDEC configuration. Prediction of fracture in board assemblies using explicit finite element full-field models of board assemblies under transient-shock is new. The stress intensity factor at the Copper pad and bulk solder interface is also evaluated in the ball grid array packages.

PHM of Lead-Free Electronic Assemblies Using Resistance Spectroscopy with Sequential Importance Resampling

Electronic assemblies have been monitored using state-space vectors from resistance spectroscopy, phase-sensitive detection and particle filtering (PF) to quantify damage initiation, progression and remaining useful life of the electronic assembly. A prognostication health management (PHM) methodology has been presented for electronic components subjected to mechanical shock and vibration. The presented methodology is an advancement of the state-of-art, which presently focuses on reactive failure detection and provides limited or no insight into the system reliability and residual life. Previously damage initiation, damage progression, and residual life in the pre-failure space has been correlated with microstructural damage based proxies, feature vectors based on time, spectral and joint time-frequency characteristics of electronics. Precise resistance measurements based on the resistance spectroscopy method have been used to monitor interconnects for damage and prognosticate failure. In this paper, the effectiveness of the proposed particle filter and resistance spectroscopy based approach in a prognostic health management (PHM) framework has been demonstrated for electronics. The measured state variable has been related to the underlying damage state using non-linear finite element analysis. The particle filter has been used to estimate the state variable, rate of change of the state variable, acceleration of the state variable and...
construct a feature vector. The estimated state-space parameters have been used to extrapolate the feature vector into the future and predict the time-to-failure at which the feature vector will cross the failure threshold. Remaining useful life has been calculated based on the evolution of the state space feature vector. Standard prognostic health management metrics were used to quantify the performance of the algorithm against the actual remaining useful life. Application to part replacement decisions for ultrahigh reliability system has been demonstrated. Using the technique described in the paper the appropriate time to reorder a replacement part could be monitored, and defended statistically. Robustness of the prognostication algorithm has been quantified using standard performance evaluation metrics.

FIGURE 11: RESULTS OF PARTICLE FILTERING APPLIED TO FEATURE VECTOR.

Stress-Strain Behavior of Sn-Ag-Cu Lead-Free Alloys at High Strain Rates Typical Of Mechanical Shock

Electronic products are subjected to high G-levels during mechanical shock and vibration. Failure-modes include solder-joint failures, pad cratering, chip-cracking, copper trace fracture, and underfill fillet failures. The second-level interconnects may be experience high-strain rates and accrue damage during repetitive exposure to mechanical shock. Industry migration to lead-free solders has resulted in proliferation of a wide variety of solder alloy compositions. Few of the popular tin-silver-copper alloys include Sn1Ag0.5Cu and Sn3Ag0.5Cu. The high strain rate properties of lead-free solder alloys are scarce. Typical material tests systems are not well suited for measurement of high strain rates typical of mechanical shock. Previously, high strain rates techniques such as the Split Hopkinson Pressure Bar (SHPB) can be used for strain rates of 1000 per sec. High speed cameras operating at 300,000 fps have been used in conjunction with digital image correlation for the measurement of full-field strain during the test. Constancy of cross-head velocity has been demonstrated during the test from the unloaded state to the specimen failure. Solder alloy constitutive behavior has been measured for SAC105, and SAC305 solders. Constitutive model has been fit to the material data. Samples have been tested at various times under thermal aging at 25°C and 125°C. The constitutive model has been embedded into an explicit finite element framework for the purpose of life-prediction of lead-free interconnects. Test assemblies has been fabricated and tested under JEDEC JESD22-B111 specified condition for mechanical shock. Model predictions have been correlated with experimental data.

FIGURE 12: SPECIMEN CONFIGURATION WITH A SLIP-JOINT.
CAVE3 Researchers Win Best-of-Conference Paper Award at SMTAI Conference


The award winning paper developed a PHM technique based on nonlinear least-squares method called Levenberg-Marquardt (LM) algorithm which has been developed for two different damage proxies. Prognostic model performance based on standard prognostic metrics has also been evaluated for both the damage proxies to determine which leading indicator of failure can be employed for accurate life prediction. Results of interrogation of system state have been compared with a second set of experimental-matrix to validate the proposed methodology. The award was conferred at the SMTAI 2011 held in Ft. Worth Texas from October 17-21, 2011. SMTAI is a premier electronic packaging conference focusing on materials and processing, assembly, design, system level engineering, and supply chain management.

CAVE3 Student Wins 2011 IEEE Holm Conference Young Investigator Award

Erika Crandall, one of our CAVE3 physics students working on tin whiskers, has won the first Paul and Dee-Dee Slade Young Investigator Award, presented in September 2011 at the IEEE Holm Conference on Electrical Contacts in Minneapolis, MN. The Slade Award recognizes outstanding achievements by young investigators in the field of electrical contacts. To be eligible, the candidate must be under the age of 35 and present a paper at the Conference in which he or she is either the sole or first author. Award selection is based on the quality of the written paper, oral presentation, and the knowledge and enthusiasm shown by the candidate during an interview by the awards committee. We congratulate Erika on her achievement, which came with a plaque and cash award of $500. Her paper was entitled “Whisker Growth under Controlled Humidity Exposure” E. R. Crandall, G. T. Flowers, P. Lall, M. J. Bozack.

CAVE and SMTA once again hosted the AIMS/Harsh Environments Workshop at the SMTAI 2011

CAVE Electronics Research Center hosted the AIMS/Harsh Environments Workshop at the SMTAI 2011 in Ft. Worth Texas on October 16th and 17th 2011. The workshop, which was co-founded by CAVE and SMTA and annually chaired by Dr. John L. Evans (CAVE Associate Director), is now in its eighth year. The best paper in the workshop was awarded to Dr. Lall for his work in thermal mechanical prognostics. There were 12 outstanding papers submitted for the 4 session workshop and the quality of technical material was outstanding. The 9th AIMS/Harsh Environments Workshop will be held Monday October 14th 2012 in Orlando Florida (Walt Disney World Dolphin Hotel). The deadline for abstracts to SMTA is March 12th 2012.

CAVE3 ISE Faculty Starts New Course on Manufacturing

On January 19, 2012, the department of Industrial and Systems Engineering began teaching a new “hands on” manufacturing course using the new 4,000 sq. ft. facility in the Shelby Transportation Center.

This facility is designed to put students in a real manufacturing facility and includes: materials handling, robotics, PLCs, optical inspection, and manual work cells.

In addition, the facility is teaching the student facility planning and management by integrating best practices of lean manufacturing, six sigma, and visual management (SQDCM) Safety, Quality, Delivery, Cost, Morale.
Approximately 100 students are in the inaugural class taught by John Evans (ISE faculty and Associate Director of CAVE3). The lab will also serve as a component for other manufacturing classes, including lean manufacturing (taught by Tom Devall – Director, Automotive Manufacturing Initiatives). ISE plans to integrate the lab into many aspects of education (quality, ergonomics and safety, data analysis), research, outreach and extension.

Lall Presents Invited Lecture at the WIAS 2012 in Bangalore
Prof. Lall gave an invited talk at the Workshop on Integrated Vehicle Health Management and Aviation Safety in Bangalore, India on January 9-10, 2012. The workshop jointly organized by NASA and NAL was attended by over 200 people and featured speakers from various leading Universities, Companies, and Government Organizations from both US and India. The workshop was focused on various aspects of IVHM including Special sensors for Health Management, IVHM Architecture, Diagnostics & prognostics algorithms, Data Mining, Modeling & Simulation, Software, Prognostics of systems, and Vehicle level reasoning. Lall’s lecture focused on the leading indicators developed by CAVE3 for prognostication of multiple failure mechanisms in electrical systems subjected to shock loads.

Lall receives SRC Contract on Inverse Model for PoP Warpage
Many state of the art electronic devices including some of the most recognizable touch screen cell phones are now being built with circuit boards that incorporate an electronics architecture known as package on package (PoP). In this configuration integrated circuits are literally stacked on top of each other in an effort to make devices lighter and smaller. The new PoP architectures require very tight manufacturing tolerances to function correctly. Auburn was recently awarded a grant to develop new methods to measure the Micron level warping that cause failures in PoP assemblies and recommend process improvements to increase throughput for manufactures using the PoP architecture.

CAVE3 Rolls out the New Website
The new website for the CAVE3 Electronics Research Center has been rolled out in February 2012. The website uses the new content management system designed to provide ready and more streamlined access to research results and online software tools.

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Selected Recent Publications


10. Lall, P., Gupta, P., Goebel, K., Decorrelated Feature Space and Neural Nets Based Framework For Failure Modes Clustering in Electronics Subjected to Mechanical-Shock, IEEE International Conference on Prognostics and Health Management (PHM), 2011.


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