AUBURN UNIVERSITY
SAMUEL GINN
COLLEGE OF ENGINEERING

Spring 2016

cave^3 News

NSF-CAVE3 Electronics Research Center
cave.auburn.edu; PH: (334) 844-3424

INSIDE

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

I am glad to report that we have successfully established the Harsh-Node of the NextFlex Manufacturing Institute at Auburn University. NextFlex is the 7th national manufacturing institute focusing on the topic of flexible hybrid electronics. Auburn University is now the founding member of NextFlex Institute. AU has significant infrastructure for design and development of harsh environment electronics under CAVE3 Electronics Center established in 1999 – which will be leveraged for flexible hybrid electronics manufacture. The five FHE core manufacturing focus areas including - Device Integration and Packaging, Materials, Printed Flexible Components and Microfluidics, Modeling & Design, Standards, Test & Reliability. The harsh node will focus on technologies which are at TRL4 or MRL4 and developing them for scale-up for high-volume manufacturing implementation and maturation to TRL7 and MRL7. Presently, a majority of the electronics supply-chain resides outside the United States. The institute is intended to help catalyze a manufacturing ecosystem for flexible hybrid electronics which would translate to a domestic manufacturing capability and the growth of manufacturing jobs in the United States. One of the major impediments with the implementation of new technologies is the risk averseness related to fear of using relatively unproven manufacturing methods and the resulting impact on the product development schedules. Volumes in consumer electronics are often high and small mistakes or changes in the manufacturing process may be amplified resulting in major ramifications on the product introduction. Examples include Apple's experiment with the use of Sapphire Screens in the iPhone, which did not work out. It is this risk averseness with the use of new technologies and methods which the institute is intended to address by a number of methods including but not limited to – putting the infrastructure technologies on the technology shelf, documentation of the process recipes, development of six-sigma process windows for new manufacturing technologies to allow their implementation in high volume manufacturing. Some of the aspects of consumer electronics have dual-use applications in the harsh-environment electronics including automotive, aerospace, defense and military applications. High-rel applications have an increased focus on mission preparedness and design for survivability under extreme environmental loads. Parts in high-rel applications are often replaced based on the fear of failure. In order to address the needs of the high-rel community, the flexible hybrid electronics solutions developed by the institute must have modeling tools and analysis methods which can be used for assessment of mission preparedness and survivability to fill the void that is often occupied with decades of test data under accelerated tests or past operational systems.

The first-round of pre-proposals was released in November-2015. On December 8, 2015, CAVE3 held the AU Harsh-Node Industry Day in Huntsville, to discuss the focus of the Harsh Node and the project ideas for the pre-proposals invited by the institute. The industry day was a major success featuring speakers from NextFlex, AFRL, AFOSR, Boeing, Lockheed Martin, Optomec, Ceradrop, Uniqarta, and Auburn University. Dr. Chris Roberts, Dean of the Samuel Ginn College of Engineering, and Dr. John Mason, Vice-President of Research at Auburn University were lunch speakers providing insights into immense focus on manufacturing at Auburn University. In response to the Project Call 1.0, CAVE3 responded in collaboration with several of the industry stakeholders which are part of the CAVE3 consortium. Two of the pre-proposals which have been submitted selected for the 2nd stage of the process. CAVE3 has been actively participating in various technical working groups to identify the technical impediments related to the implementation of flexible hybrid electronics. I am the University lead for the Asset Situational Awareness working group. Some of the other topical areas of the technical working groups include – human monitoring, modeling and simulation, standards and test methods. I also want to take this opportunity to welcome the Missile Defense Agency to the NSF-CAVE3 Electronics Research Center.

- Pradeep Lall, MacFarlane Professor & Director

CAVE^3 Consortium Spring-2016 Technical Review Meeting

The Center for Advanced Vehicle and Extreme Environment Electronics (CAVE^3) will hold its Spring Technical Review and Project Planning Meeting on September 7-8, 2016 in Auburn University Wiggins Hall. All current members of the Consortium are invited to attend. The agenda for this event is available at cave.auburn.edu under CAVE^3 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

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

SPECIAL EVENTS

2016 IEEE International Conference on Prognostics and Health Management

June 20-22, 2016
Carleton University,
Ottawa, ON, Canada

Professor Pradeep Lall is serving as the General Chair of the 6th Annual IEEE Reliability Society PHM conference will be held June 20-22 at Carleton University, Ottawa, ON, Canada. The conference will bring together persons from Industry and Academia, including engineers, scientists and managers from around the world to share and discuss the state of the art, state of practice, and future of Prognostics and Health Management. The conference includes Tutorials, Panel Sessions, and Papers that address the wide-ranging, interdisciplinary topics related to PHM technology and application. There will be a special working session on the in-process development of a PHM Standard. There will be a special session with presentations from the most successful entries in the conference PHM Challenge. Although the deadline for abstracts is past, the conference is accepting submission of full papers through the end of January. Papers will be reviewed, and those meeting the publication criteria, selected and presented at the conference will be published by the IEEE. Additional information about the conference, the challenge, and submitting papers is available on the conference web site at: phmconf.org.

SMTA International 2016

Conference: Sep. 26—Sep. 30, 2016
Exhibition: Sep. 29—Sep. 30, 2016
Donald Stephens Convention Center
Rosemont, IL

Annual SMTA International Conference will be held at the Donald Stephens Convention Center in Rosemont, Illinois from Sept 27-Sept 30, 2016. Abstract submission is open till Feb 29th, 2016. submission for half day course proposal is open till Feb 12th 2016. CAVE3 will be holding the Harsh Environment Symposium as part of the conference. The HE symposium will be held on the first two-days of the conference. Full technical papers and course handouts are due by 15th June 2016. The papers will focus on environments including thermal, thermo-mechanical, vibration, mechanical shock, corrosion, and contamination. Papers on variety of topics such as advanced packaging, assembly process and materials, MEMS, harsh environment, flexible electronics etc. will be presented during this conference. SMTAI has been recognized as a truly different type of industry event because of the high quality technical information and the networking opportunities that cannot be found anywhere else in the industry. Abstract Submission can be accessed at http://www.smta.org/smtai/call_for_papers.cfm

Research Highlights

Exploration of Aging Induced Evolution of Solder Joints Using Nanoindentation and Microdiffraction

Due to aging phenomena, the microstructure, mechanical response, and failure behavior of lead free solder joints in electronic assemblies are constantly evolving when exposed to isothermal and/or thermal cycling environments. In our ongoing studies, we are exploring aging phenomena by nano-mechanical testing of SAC lead free solder joints extracted from PBGA assemblies. Using nanoindentation techniques, the stress-strain and creep behavior of the SAC solder materials are being explored at the joint scale for various aging conditions. Mechanical properties characterized as a function of aging include the elastic modulus, hardness, and yield stress. Using a constant force at max indentation, the creep response of the aged and non-aged solder joint materials is also being measured as a function of the applied stress level. With these approaches, aging effects in actual solder joints are being quantified and correlated to the magnitudes of those observed in testing of miniature bulk specimens.

In our initial work (ECTC 2013), we explored aging effects in single grain SAC305 solder joints. In the current investigation, we have extended our previous work on nanoindentation of joints to examine a full test matrix of SAC solder alloys. The effects of silver content on SAC solder aging has been evaluated by testing joints from SACN05 (SAC105, SAC205, SAC305, and SAC405) test boards assembled with the same reflow profile. In all cases, the tested joints were extracted from 14 x 14 mm PBGA assemblies (0.8 mm ball pitch, 0.46 mm ball diameter) that are part of the iNEMI Characterization of Pb-Free Alloy Alternatives Project (16 different solder joint alloys available). After extraction, the joints were subjected to various aging conditions (0 to 12 months of aging at T = 125 C), and then tested via nanoindentation techniques to evaluate the stress-strain and creep behavior of the four aged SAC solder alloy materials at the joint scale.

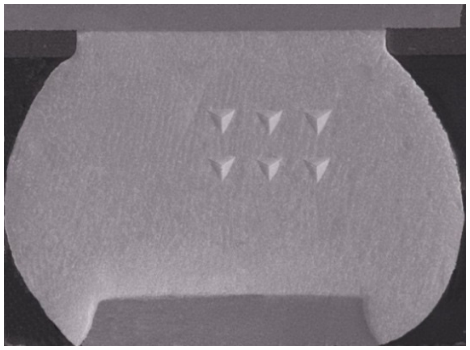

Figure 1 - Solder Ball after Nanoindentation Testing

The observed aging effects in the SACN05 solder joints have been quantified and correlated with the magnitudes observed in tensile testing of miniature bulk specimens performed in prior studies. The results show that the aging induced degradations of the mechanical properties (modulus, hardness) in the SAC joints were of similar order (30-40%) as those seen previously in the testing of larger "bulk" uniaxial solder specimens. The creep rates of the various tested SACN05 joints were found to increase by 8-50X due to aging. These degradations, while significant, were much less than those observed in larger bulk solder uniaxial tensile specimens with several hundred grains, where the increases ranged from 200X to 10000X for the various SACN05 alloys. Additional testing has been performed on very small tensile specimens with approximately 10 grains, and the aging-induced creep rate degradations found in these specimens were on the same order of magnitude as those observed in the single grain joints. Thus, the lack of the grain boundary sliding creep mechanism in the single grain joints is an important factor in avoiding the extremely large creep rate degradations (up to 10,000X) occurring in larger bulk SAC samples. All of the aging effects observed in the SACN05 joints were found to be exacerbated as the silver content in the alloy was reduced. In addition, the test results for all of the alloys show that the elastic, plastic, and creep properties of the solder joints and their sensitivities to aging are highly dependent on the crystal orientation.

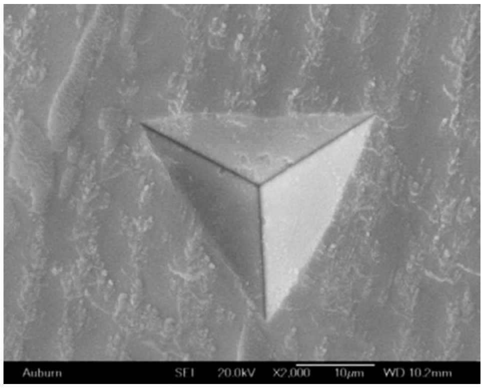

Figure 2 - Permanent Indentation after Testing

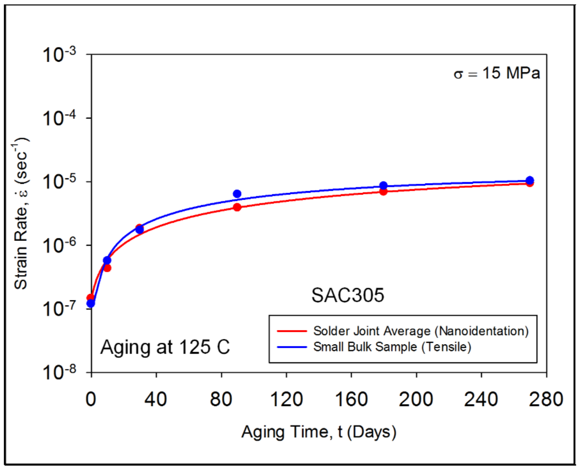

Figure 3- Creep Strain Rate Degradations with Aging (SAC305, Aging at T = 125 C) (NI and SAC305 Small Tensile Specimens)

The observed mechanical behavior changes in joints are due to evolution in the microstructure and residual strains/stresses in the solder material, and measurements of these evolutions are critical to developing a fundamental understanding of solder joint aging phenomena. As another part of this work, we have performed an initial study of these effects in the same SAC305 solder joints that were tested using nanoindentation. The enhanced x-ray microdiffraction technique at the Advanced Light Source (Synchrotron) at the Lawrence Berkeley National Laboratory was employed to characterize several joints after various aging exposures (0, 1, and 7 days of aging at T = 125 C). For each joint, microdiffraction was used to examine grain growth, grain rotation, sub-grain formation, and residual strain and stress evolution as a function of the aging exposure.

The entire joints were scanned using a 10 micron step size, and the results were correlated with changes in the mechanical response of the joint specimens measured by nanoindentation.

Prognostication of Solder-Joint Reliability of 0.4mm and 0.5mm Pitch BGAs Subjected to Mechanical Shocks up to 10,000g

Due to the reduced size and geometry constraints imposed on electronics in various applications there has been tremendous need for use of very fine pitch surface mount electronics. Fine pitch BGAs of 0.4mm and 0.5mm pitch are finding applications in military and defense applications. Fine pitch BGA electronics in aerospace applications they may be subjected to high-g levels in the neighborhood of 10,000g of mechanical shock during normal operation. Survivability and design envelope of fine pitch semiconductor packages under high g mechanical shock is unknown. In addition, the efficacy of the traditional supplemental restraint mechanisms such as underfills in mitigating the risk of interconnect failure under 10,000g mechanical shock, is not available. A circular board with an annular ring typical of projectile applications has been designed with fine pitch daisy chained packages. Packages studied have package interconnects in the range of 84-360 I/O. Two configurations of the test board have been studied including non underfilled, and underfilled assemblies. Full-field strain on the board assembly has been measured and the strain histories at the corner of the component locations extracted. The change in the resistance of the second-level interconnects has been monitored during the shock event using high speed data acquisition system. Resistance spectroscopy in conjunction with Kalman Filter has been used to identify the onset of failure and prognosticate remaining useful life.

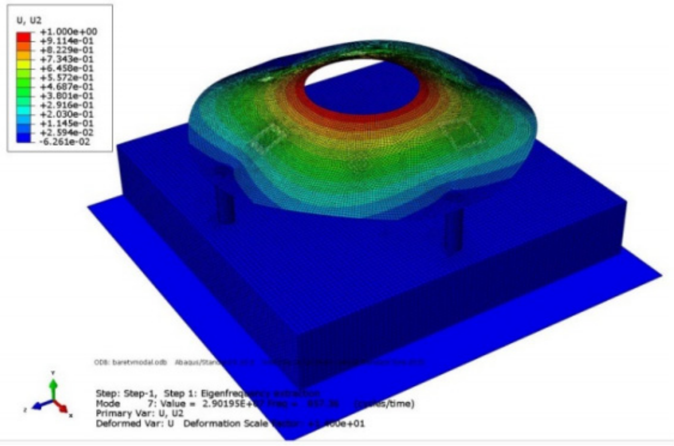

Figure 3 - Mode I for bare test board

High speed 3D-DIC measurements along with explicit finite element modeling has been used to study the transient dynamic behavior and characterize the in plane strain and out of plane deflection. From the modeling results solder joint strains were extracted for both 5,000g and 10,000g bare TV shocks. At 10,000g shock the peak strains in the corner interconnects of the packages averaged about 2300μ and in case of 5,000g it is 1750μ. The out of plane deflection contours from the modeling results were also extracted and a good correlation with respect to the 3D-DIC contours was observed. The PCB-X and PCB-Y Strains near the corner interconnects of the packages were extracted from 3D-DIC measurements. An average peak strain increase about 2000μ was observed in both PCB-X and PCB-Y strains when the boards were tested at 10000g compared to 5000g shock. Underfill reinforcing the packages shows a slight decrease in the peak strains near corner interconnects compared to the non underfilled boards. Resistance spectroscopy in conjuction with Kalman filter has been used to predict the onset of failure and prognosticate the remaining useful life.

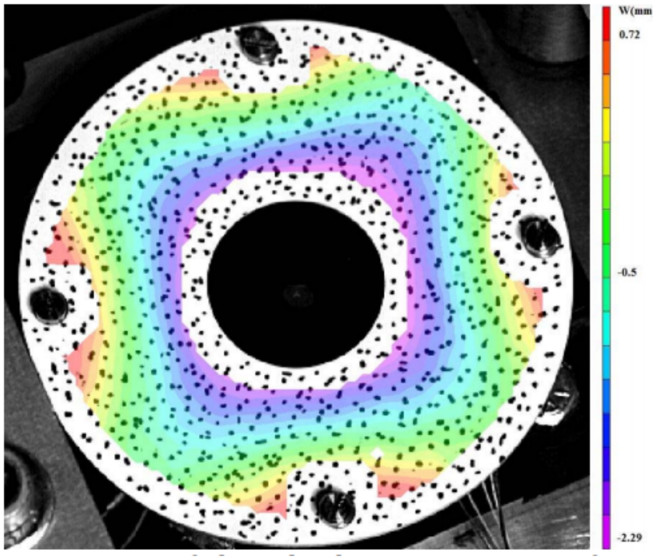

Figure 4 - Out of plane displacement contour of ME531 underfill reinforced TV at 10000g

Prognostication of LED Remaining Useful Life and Color Stability in the Presence of Contamination

The reliability of LED products may be affected by both luminous flux drop and color shift. Previous research on the topic focuses on either luminous maintenance or color shift. However, luminous flux degradation usually takes very long time to observe in LEDs under normal operating conditions. In this paper, the impact of a VOC (volatile organic compound) contaminated luminous flux and color stability are examined. As a result, both luminous degradation and color shift had been recorded in a short time. Test samples are white, phosphor converted, high-power LED packages. Absolute radiant flux is measured with integrating sphere system to calculate the luminous flux. Luminous flux degradation and color shift distance were plotted versus aging time to show the degradation pattern. A prognostic health management (PHM) method based on the state variables and state estimator have been proposed in this paper. In this PHM framework, unscented kalman filter (UKF) was deployed as the carrier of all states. During the estimation process, third order dynamic transfer function was used to implement the PHM framework. Both of the luminous flux and color shift distance have been used as the state variable with the same PHM framework to exam the robustness of the method. Predicted remaining useful life is calculated at every measurement point to compare with the tested remaining useful life. The result shows that state estimator can be used as the method for the PHM of LED degradation with respect to both luminous flux and color shift distance. The prediction of remaining useful life of LED package, made by the states estimator and data driven approach, falls in the acceptable error-bounds (20%) after a short training of the estimator.

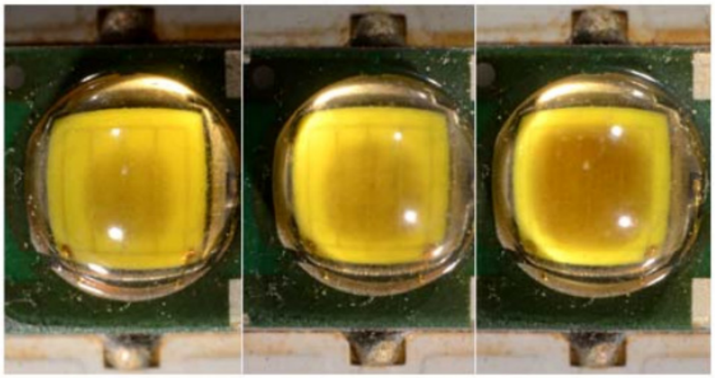

Figure 6 - Appearance of Contaminated LED Package

A PHM approach has been developed based on the state vector of measurement and the estimator. Even the physics based failure model has not established, the measured luminous flux and color shift distance can be used to train the state estimator and predict the state in the future. During the prediction part, the estimated state vector is projected forward based on the dynamic function to predict the remaining useful life based on the picked threshold. According to the simulated result, in order to make the PHM framework work, at least 38% percent experimental data should be measured to train the estimator algorithm. After the training process, the algorithm can work independently to project the state forward and predict the remaining useful life. The result shows that all prediction result can fall into the 20% boundary of the goal. In conclusion, the UKF based PHM framework can be used to predict the remaining useful life of LED products under harsh and contaminated environment based on the measurement of luminous flux or color shift distance.

Component Level Reliability for High Temperature Power Computing With SAC305 and Alternative High Reliability Solders

This experiment considers the reliability of a variety of different electronic components and evaluates them on 0.200" power computing printed circuit boards with OSP. Single-sided assemblies were built separately for the Top-side and Bottom-side of the boards. This data is for boards on the FR4-06 substrate. Isothermal storage at high temperature was used to accelerate the aging of the assemblies. Aging Temperatures are 25°C, 50°C, and 75°C. Select data from aging times of 0-Months (No Aging, baseline), 6-Months, and 12-Months will be presented.

The assemblies were subjected thermal cycles of -40°C to +125°C on a 120 minute thermal profile. The test was subject to JEDEC JESD22-A104-B standard high and low temperature test in a single-zone environmental chamber to assess the solder joint performance.

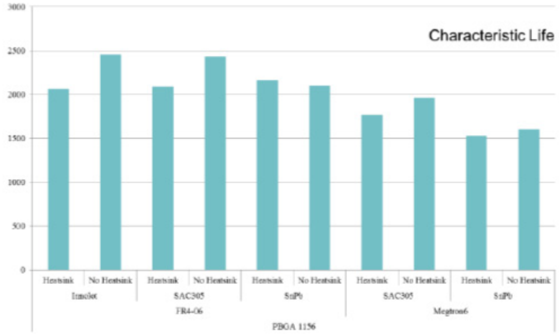

Figure 7 - Characteristic Life: PBGA1156 – FR4-06 – No Aging

The principal test components are 5 mm, 6mm, 13mm, 15mm, 17mm, 31mm, 35mm and 45 mm ball grid array (BGA) packages with solder ball pitch varying from 0.4 mm to 1.27 mm. Most of the BGA packages are plastic over-molded, while the 31mm and 45mm packages are Super-BGAs (SBGAs). Several surface mount resistors (SMRs) are also considered in order to understand the effect of solder paste composition on paste-only packages. The primary solder for package attachment in this experiment is standard SAC305. Two solders designed for high-temperature reliability are also considered.

A very clear trend also exists regarding the substrate effect: smaller plastic BGA components assembled on the FR4-06 substrate are universally more reliable than identical components assembled on the Megtron6 substrate, when controlling for all other factors. A larger plastic BGA component, the PBGA 1156, shows similar failure trends in terms of most particulars. However, one key difference exists. The PBGA does not show a significant improvement in joint reliability during Innolot paste doping. Two Super-BGA components, the SBGA 304 and SBGA 600, also show differences in failure data trends to the smaller plastic ball grid arrays. These are cavity-down, metal-capped components, and so are structurally quite different from the previously discussed packages. Like the PBGA 1156, these packages do not show an improvement in reliability via Innolot paste doping (in fact, reliability is lower in the doped case). Moreover, both of the Super-BGA components show a reversal of the substrate-effect seen in the plastic packages and display higher reliability on the Megtron6 substrate than on the FR4-06 substrate.

Thermal Shock Reliability Test on Multiple Doped Low Creep Lead Free Solder Paste and Solder Ball Grid Array Packages

In this experiment, the thermal shock performance of various doped solder paste alloys on leaded and leadless lead free packages on laminate assemblies were observed in order to determine their reliability. This investigation is based on determining the potential solution to replace the SAC 305 packages which has the deleterious effects in long term isothermal aging conditions. The results discuss the most optimal doping element of ball grid array, doping quantity and package structures that could be used upon by industries as a replacement for the standard SAC305 structure. The test vehicle consists of 35 mm, 31mm, 15 mm and 6mm ball grid array packages with perimeter solder balls on a 1.0 mm, 1.27mm and 0.8mm pitch respectively. The BGA packages include the PBGA 1156, CABGA 208, CABGA 36 and SBGA 304's. The passive 5mm QFN packages with 0.65mm pitch and 2512 resistors are added in order to understand the effect of doped solder paste on conventional packages. The test boards are built with three different reflow profiles on 6 mil stencil thickness and one reflow profile on a 4 mil stencil thickness, to study the differences in doping volume effects of the new doped alloys. The test vehicles were subjected to high temperature accelerated life test of 3000 thermal cycles with -40°C to +125°C on a 15-minute thermal profile (5 minutes dwell time and 2.5 minutes transition time). The test was subjected to standard high and low temperature test in a thermal liquid shock environmental chamber with perfluorocarbon liquid to assess the solder joint performance. Reliability of the test packages were determined from the ability of the components and solder interconnects to withstand the thermal stresses induced by alternating high and low temperature extremes. The lead free alloy micro structures of the components were studied in a scanning electron microscope to determine the impact of the intermetallic components on the solder joint reliability. The results showed that the main crack initiation position was at the top left corner of the solder joints near the chip side.

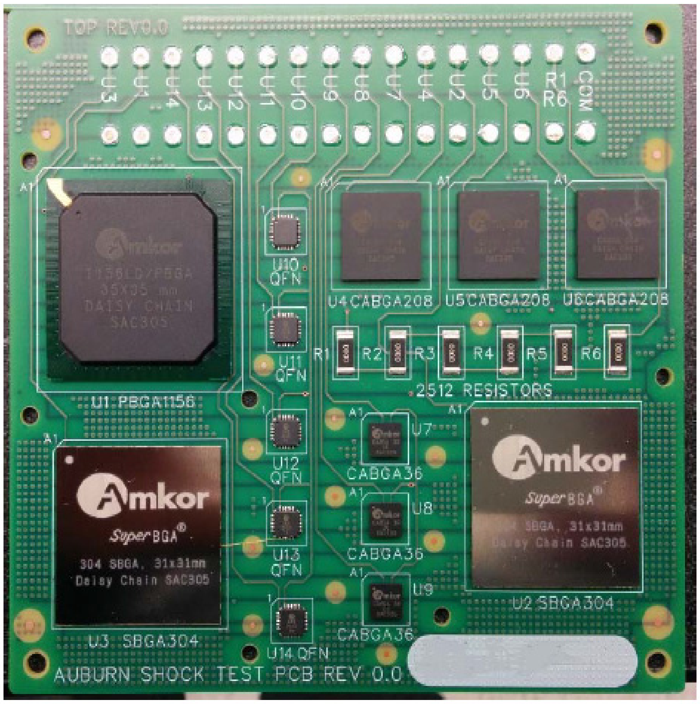

Figure 8 – SAC 5 mix component board

Deformation and Strain Measurements in Operational Electronics Using X-Ray Micro-Ct and Digital Volume Correlation

Electronic components may be subjected to significant deformation under the action of thermal and mechanical loads during operation and storage. The use of thin material layers in addition to fine embedded interconnects limits the possibilities for the integration of sensors to measure deformation and strain. Previously, deformations in electronic components and assemblies have been measured using optical methods including moiré interferometry and digital image correlation – both of which require the cross sectioning of the solder joint to gain access to the joint of interest for the purpose of strain and deformation measurement. Cross-sectioning is an invasive technique which requires discarding a portion of the package. In addition, the measurements are often limited to line of sight allowing measurement of only the optically visible cut section. In this paper, a new method has been presented for Measurement of displacements in solder joints noninvasively using a combination of x-ray computed tomography and digital volume correlation. The new method does not require cross-sectioning of the part for the purpose of deformation and strain measurement. In addition, the measurements are not limited to the joints in the line of sight. The three-dimensional measurements of deformation and strain have been visualized on the geometry of the solder joints in the package. It is envisioned that the method will allow the validation of the deformation and strain field in interconnects of the electronic package. Measurements of deformation and strain on light-emitting diodes and ball-grid array packages have been made using the combination of digital volume correlation and x-ray computed tomography. a new technique for measurement of in-situ deformation in operational parts has been presented based on digital image correlation of X-ray MicroCT data. The inherent grayscale of the x-ray data has been used to track the deformation.

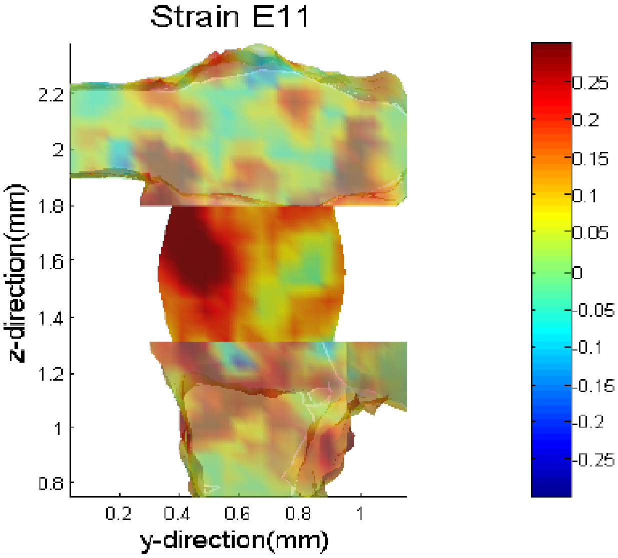

Figure 9 – E11 Strain Contours in the Solder Joint.

THEMATIC NODE ON HARSH ENVIRONMENTS ON FLEXTECH TEAM FOR FHE-MII

Manufacturing plays a key role in spurring innovation and economic development. The recent call for proposals for the formation of a National Network for Manufacturing Innovation focuses on the topic of Flexible Hybrid Electronics. Auburn University is leading a thematic node on harsh environments on the FlexTech Team in response to the FOA for an IMI on the topic of Flexible Hybrid Electronics.

The thematic node team in addition to AU consists of key players from categories of material suppliers, equipment makers and system integrators. Flexible electronics has been identified as one of the frontier goals by the National Academies of Engineering Reports on Leading Edge Engineering in 2013. In order to make flexible electronics possible, processes must meet the demands of soft, pliant and often easily damaged surfaces. Compatibility with delicate surface often requires low temperature processing. There are no large flexible electronics manufacturing firms in the US engaged in large scale commercial manufacturing of products that integrate flexible and printed electronics technologies. Thirty years ago when large corporate laboratories were prevalent, applied research and practical application of science used to be an area of strength in the United States. However, pricing pressures, commoditization of products, and the migration of manufacturing to the Far East has resulted in the downsizing and many cases elimination of the corporate research laboratories. There is a chasm between the laboratory research and the realization of commercialized products. The global flexible electronics industry is in its infancy as scaled up production for commercial applications exists in only a few niche areas including e-paper, RFID tags and organic light emitting diode screens

An IMI in the area of flexible electronics will fill in the void between lab research and commercial products. The semiconductor manufacturing is highly automated, utilizing complex processes developed by multiple vendors which cannot be readily integrated without coordination between players. The manufacturing challenges exist at multiple levels including raw materials, material handling, fabrication and assembly. Processing at low temperatures on conformal bendable, stretchable and foldable substrates is needed or device assembly integration. Adequate survivability in harsh applications will require development of flexible encapsulation approaches in addition to physical packaging and common interconnects and interfaces. Stretchable electronics will need device designs for mitigating the interconnect failures due to fracture and delamination under large deformation and strain. Innovative thermal management schemes are needed to ensure thermal and thermo-mechanical survivability in the presence of multi-material thin-film interfaces. In parallel with the development of manufacturing protocols, it is envisioned that the development of modeling tools and prediction methods is needed to assess the device design, layout, and fabrication parameters. Accelerated test methods and test conditions which have been developed for rigid electronics will need to be scaled to flexible hybrid electronics. The existence of the prior research expertise in the area of harsh environment electronics for automotive and military environments uniquely positions the AU led thematic node to put together a successful IMI-node in the area of flexible hybrid electronics.

CAVE STUDENT WINS 2015 STEVE ADAMSON AWARD

Cong Zhao has been awarded the 2015 Steve Adamson Award. The IMAPS Foundation's Steve Adamson Student Recognition Award honors an active student member's participation in IMAPS events, chapters, and programs. Significant technical research and/or service contributions to IMAPS and the microelectronics industry were considered during the judge's review. The award winner receives a check for $3000 and student membership dues will be waived until graduation.

L to R : Cong Zhao (AU), Mr. Voya Markovich

BEST-OF-CONFERENCE PAPER OF ECTC 2014

The following CAVE3 paper from ECTC 2014 was recognized with the Best-of-Conference Session Paper Award at the ECTC 2015 on May 27, 2015 in San Diego. Paper was entitled Exploration of Aging Induced Evolution of Solder Joints Using Nanoindentation and Microdiffraction, by Mohammad Hasnine, Jeffrey C. Suhling, Barton C. Prorok, Michael J. Bozack, and Pradeep Lall.

CAVE STUDENT SELECTED AS ONE OF FIVE FINALISTS FOR THE 2015 IEEE PAUL AND DEE-DEE SLADE YOUNG INVESTIGATOR AWARD

Erika Snipes was selected as one of the finalist for 2015 IEEE Paul and Dee-Dee Slade young investigator award for her paper "Influence of Sn Whiskering of Controlled Bismuth Additions to Sputtered Sn Films," The paper was presented by her at the 2015 IEEE Holm Conference on Electrical Contacts on October 12, 2015. The objective of the Paul and Dee-Dee Slade Young Investigator Award is to recognize outstanding achievement of young investigators in the field of Electrical Contacts and to encourage young scientists and engineers to enter this field. In order to be eligible for the Award, the candidate must be under the age of 35 and be selected from the pool of authors for that year's IEEE Holm Conference on Electrical Contacts.

Erika Snipes (AU)

CAVE3 PAPER WINS 2014/2015 ASME JOURNAL OF ELECTRONIC PACKAGING BEST PAPER AWARD

The following paper has been selected as the **2014/2015 ASME Journal of Electronic Packaging Best Paper Award winner.** Lall, P., Lowe, R., Comparison of Prognostic Health Management Algorithms for Assessment of Electronic Reliability Under Vibration, ASME Journal of Electronic Packaging, Volume 136, No. 4, doi:10.1115/1.4028163, pp. 041013-1-to 041013-8, December 2014.The award was conferred at the ASME IMECE 2015 Conference in Houston, TX on Nov 17th, 2015.

LALL RECEIVES THE 2016 WRIGHT A. GARDNER AWARD OF THE ALABAMA ACADEMY OF SCIENCES

Pradeep Lall is the 2016 recipient of the Wright A. Gardner Award of the Alabama Academy of Sciences. The Wright Gardner Award was established, by the Alabama Academy of Science in 1984 to honor individuals whose work during residence in Alabama had been outstanding. Past recipients nominated for this award have included researchers, teachers, industrialists, clinicians, scholars and active members and office bearers of the Alabama Academy of Science. Dr. Lall is the MacFarlane Endowed Professor in the Department of Mechanical Engineering, Director of the Harsh-Node of NextFlex Manufacturing Institute, and Director of the NSF-CAVE3 Electronics Research Center at Auburn University. He holds a courtesy joint appointment in the Department of Finance at Auburn University. Lall, who is also a Fellow of the Alabama Academy of Sciences received this honor at the 93rd Annual Meeting of the Academy held in Florence, Alabama, Feb 17-19, 2016. Lall joined Auburn University in 2002 as an Associate Professor after a successful career at Motorola where he worked on development and manufacture of wireless products including cellular phones and two-way radios. “I am honored to receive this award and want to thank the Academy for this recognition. The award is a testament to the strong research environment at Auburn University which has provided me the opportunity to make a meaningful impact. ”, Lall said

Dr. Lall is best known for his seminal contributions to the fields of reliability and prognostics for electronic systems operating in harsh environments. His landmark contributions to development of methodologies for prognostication of electronics based on leading indicators of failure have been adopted by the automotive industry for development of next generation on-board diagnostic systems. Lall says that his prior experience in development of manufacturing processes in high-volume environment has enabled him to bring the electronics manufacturing related industry aspects into the classroom and his research at Auburn University. In the role of the Director of the NSF-CAVE3 Electronics Research Center, Lall works with Industry and Federal Agencies which focus on products intended for operation in harsh environments. The center works at the cross-roads of engineering-research and pre-competitive product development while accelerating research into practice for making an impact on new products and technologies. “It is exciting to see research make a societal impact through products”, says Lall. “That is what keeps me motivated to work on hard-problems”.

Lall has been responsible for spearheading the establishment of the Harsh Environments Node of the NextFlex Manufacturing Institute at Auburn University. Lall says, “The AU Harsh Environment Node of the NextFlex will catalyze the establishment of a flexible electronics ecosystem in Alabama through the development of technology product demonstrators, and workforce training programs to have a measurable impact on manufacturing economy in Alabama.” NextFlex is the 7th national manufacturing institute focusing on the topic of flexible hybrid electronics. Auburn University is now the founding member of NextFlex Institute. The focus of the institute is flexible hybrid electronics (FHE) manufacturing with the goal of re-establishing manufacturing in the US and developing the workforce. Manufacturing is taking an ever increasing role in the State of Alabama’s economy with the growth of automotive companies in the region. The establishment of the Flexible Hybrid Electronics in the region will provide a nexus to develop products, retrain the workforce for growth of manufacturing jobs, and the development of products for commercialization in various sectors of the economy ranging from wearable electronics, automotive, aerospace and consumer products. This is the 7th national manufacturing institute and one of the first ones with a sizeable footprint in the State of Alabama.

Lall has served as the adviser for more than 45 doctoral and post-doctoral graduates and master’s degree students and has taught numerous courses at Auburn, as well as short courses throughout the U.S. and Europe. He is the author and co-author of two books, 14 book chapters and more than 430 journal and conference papers. In addition, he has earned 24 Best Paper Awards at national and international conferences. He is a fellow of the Institute of Electrical and Electronics Engineers (IEEE) and a fellow of the American Society of Mechanical Engineers (ASME). In addition, Lall serves as an elected member of the IEEE Reliability Society’s AdCom and IEEE Reliability Society Representative on the IEEE-USA Government Relations Council for R&D Policy.

Selected Recent Publications

1. Lall, P., Zhang, D., Suhling, J., Locker, D., Anand Viscoplasticity Model for the Effect of Aging on Mechanical Behavior of SAC305 Operating at High Strain Rate and High Temperature, Proceedings of the ASME 2015 International Mechanical Engineering Congress & Exposition (IMECE2015,) Houston, TX, Paper # 53751, pp. 1- 11, November 13-19, 2015
2. Lall, P., Mirza, K., A Study on the Effect of Mean Cyclic Temperature on the Thermal Fatigue Reliability of SAC Solder Joints Using Digital Image Correlation, Proceedings of the ASME 2015 International Mechanical Engineering Congress & Exposition (IMECE2015,) Houston, TX, Paper # 53476, pp. 1-11, November 13-19, 2015
3. Lall, P., Luo, Y., Nguyen, L., Multiphysics Model for Chlorine-Ion Related Corrosion in Cu-Al Wirebond Microelectronic Packages, Proceedings of the ASME 2015 International Mechanical Engineering Congress & Exposition (IMECE2015,) Houston, TX, Paper # 53742, pp. 1- 12, November 13- 19, 2015
4. Zhang, H., Lall, P., A Comparison of Temperature and Humidity Effects on Phosphor Converted LED Package and the Prediction of Remaining Useful Life with State Estimation, Proceedings from LED A.R.T. Symposium, Atlanta, GA, November 17-19, 2015
5. Zhang, H., Lall, P., Phosphor Converted LED Failure Mechanisms Related to Phosphor Layer, Proceedings from LED A.R.T. Symposium, Atlanta, GA, November 17- 19, 2015
6. Lall, P., Kothari, N., Foley, J., Lowe, R., A Novel Micro-CT Data Based Finite Element Modeling Technique to Study Reliability of Densely Packed Fuze Assemblies, Proceedings of 86th Shock and Vibration Symposium (SAVE '15,) Orlando, FL, October 5- 8, 2015
7. Zhao, C., Shen, C., Hai, Z., Zhang, J., Bozack, M., Evans, J., Long Term Aging Effects on the Reliability of Lead Free Solder Joints In Ball Grid Array Packages With Various Pitch Sizes and Ball Alignments, Proceedings of the SMTAI, Rosemont, IL, pp. 199- 206, September 27- October 1, 2015
8. Raj. A., Thirugnanasambandam, S., Sanders, T., Sridhar, S., Evans, J., Bozack, M., Johnson, W., Thermal Shock Reliability Test on Multiple Doped Low Creep Lead Free Solder Paste and Solder Ball Grid Array Packages, Proceeding of the SMTAI, Rosemont, IL, pp. 354- 361, September 27- October 1, 2015
9. Lall, P., Luo, Y., Nguyen, L., Corrosion and Contaminant Diffusion Multi-Physics Model for Copper-Aluminum Wirebonds in High Temperature High Humidity Environments, Proceedings of the SMTAI, Rosemont, IL, pp. 14-27, September 27-October 1, 2015
10. Sanders, T., Thirugnanasambandam, S., Evans, J., Bozack, M., Suhling, J., Johnson, W., Component Level Reliability for High Temperature Power Computing With SAC305 and Alternative High Reliability Solders, Proceeding of the SMTAI, Rosemont, IL, pp. 144- 150, September 27- October 1, 2015
11. Lall, P., Wei, J., Deformation and Strain Measurements in Operational Electronics Using X-Ray Micro-CT and Digital Volume Correlation, Proceeding of the SMTAI, Rosemont, IL, pp. 515-526, September 27- October 1, 2015
12. Lall, P., Zhang, D., Locker, D., Damage Prediction in SAC305 Lead Free Electronics Subjected to Mechanical Shock After Long-Term Storage, Proceeding of the SMTAI, Rosemont, IL, pp. 904- 914, September 27- October 1, 2015
13. Lall, P., Deshpande, S., Nguyen, L., Fuming Acid Based De-Capsulation Process for Copper-Aluminum Wirebond System Molded with Different EMC's, Paper IPACKICNMM2015-48638; Session 14-2-1, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-13, July 6-9, 2015
14. Lall, P., Sakalaukus, P., Davis, L., An Investigation of Catastrophic Failure in Solid-State Lamps Exposed to Harsh Environment Operational Conditions, Paper IPACKICNMM2015-48257; Session 1-5-1, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp.1- 7, July 6-9, 2015
15. Lall, P., Luo, Y., Nguyen, L., Chlorine Ion Related Corrosion in Cu-Al Wirebond Microelectronic Packages, Paper IPACKICNMM2015-48639; Session 1-3-2, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-12, July 6-9, 2015
16. Lall, P., Zhang, H., Davis, L., Prognostics Health Management Model For LED Package Failure Under Contaminated Environment, Paper IPACKICNMM2015-48724; Session 1-5-1, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-9, July 6-9, 2015
17. Lall, P., Wei, J., LED Chip Deformation Measurement During the Operation Using the X-ray CT Digital Volume Correlation, Paper IPACKICNMM2015-48785; Session 14-5-1, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-6, July 6-9, 2015
18. Lall, P., Abrol, A., Simpson, L., Glover, J., Survivability of MEMS Accelerometer Under Sequential Thermal and High-G Shock Environments, Paper IPACKICNMM2015-48790; Session 3-1-1, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-11, July 6-9, 2015
19. Lall, P., Yadav, V., Suhling, J., A Study on the Evolution of the High Strain Rate Mechanical Properties of SAC105 Lead-free Alloy at High Operating Temperatures, Paper IPACKICNMM2015-48389; Session 14-2-1, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-17, July 6-9, 2015
20. Lall, P., Kothari, N., Glover, J., Mechanical Shock Reliability Analysis and Multiphysics Modeling of MEMS Accelerometers in Harsh Environments, Paper IPACKICNMM2015-48457; Session 3-3-2, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-9, July 6-9, 2015
21. Lall, P., Mirza, K., Suhling, J., DIC Based Investigation into the Effect of Mean Temperature of Thermal Cycle on the Strain State in SnAgCu Solder Joint, Paper IPACKICNMM2015-48727, Session 14-5-1, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-13, July 6-9, 2015

Selected Recent Publications

22. Basit, M., Motalab, M., Suhling, J., Lall, P., Viscoplastic Constitutive Model For Lead-Free Solder Including Effects of Silver Content, Solidificaton Profile, and Severe Aging, Paper IPACKICNMM2015-48619, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-18, July 6-9, 2015
23. Basit, M., Motalab, M., Suhling, J., Evans, J., Lall, P., FEA Based Reliability Predictions for PBGA Packages Subjected to Isothermal Aging Prior to Thermal Cycling, Paper IPACKICNMM2015-48620, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-11, July 6-9, 2015
24. Chowdury, P., Chhanda, N., Suhling, J., Lall, P., Experimental Characterization of Underfill Materials Exposed to Moisture Including Preconditioning, Paper IPACKICNMM2015-48622, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-9, July 6-9, 2015
25. Hasnine, M., Suhling, J., Prorok, B., Bozack, M., Lall, P., Characterization of the Effects of Silver Content on the Aging Resistance of SAC Solder Joints, Paper IPACKICNMM2015-48623, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-15, July 6-9, 2015
26. Ahmed, S., Basit, M., Suhling, J., Lall, P., Characterization of Doped SAC Solder Materials and Determination of Anand Parameters, Paper IPACKICNMM2015-48624, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-14, July 6-9, 2015
27. Nguyen, Q., Roberts, J., Suhling, J., Jaeger, R., Lall, P., Measurement and Simulation of Moisture Induced Die Stresses in Flip Chip on Laminate Assemblies, Paper IPACKICNMM2015-48626, ASME International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), San Francisco, CA, pp. 1-13, July 6-9, 2015

All other published CAVE^3 articles are available at cave.auburn.edu under Publications

Auburn University
CAVE 3
Samuel Ginn College of Engineering
1418 Wiggins Hall
Auburn, AL 36849

Non-profit Org.
U.S. Postage
PAID
Permit No. 9
Auburn, AL
36849

Mechanical Engineering-CAVE3-3/2016

cave³ News

Spring 2016

cave.auburn.edu

www.auburn.edu

If you have recently changed your address or have colleagues who would be interested in receiving the CAVE^3 News, please fill out the following information and either return it to the above address, fax it to 334-844-1898, or email it to *cave@auburn.edu*.

☐ Please add me to the CAVE News mailing list.
☐ My address has changed, please update it.
☐ Please remove me from the CAVE News mailing list.
☐ Please add me to the CAVE email mailing list.

Name: ____________________
Title: ____________________
Company: ____________________
Address: ____________________
City:________ State:_____ Zip: ________

Country: ____________________
Phone #: ____________________
Fax #: ____________________
E-mail: ____________________
Comments and suggestions: ____________________
____