AUBURN UNIVERSITY

SAMUEL GINN
COLLEGE OF ENGINEERING

Fall 2020

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

We have lived through an interesting six-months with COVID-19 and the university transitioning to remote instruction. It has been a learning experience as the student teams and the faculty have had to adjust to an alternate model of operation for lab-access to allow safe-operations while allowing for the research programs to keep ticking. In spite of the restrictions, I am proud to say that the AU graduate research assistants have been very resilient in adjusting when needed to the rigors of remote working and offset-hours. We have a full slate of results to show this Fall-2020 review. The past 6-months has also been very eventful on a number of other fronts. The CAVE3 electronics research center has had a major augmentation of the research facilities in the area of additively-printed flexible electronics to add to an already formidable slate of facilities. The additions include 1) SUSS MicroTEC PixDro LP50 Inkjet Printer (2) nScrypt 3Dn-300 Direct Write Quad-Head Printer (3) Xenon X-1100 Photo-sintering System with Flatbed Capability (4) Lamination Encapsulation for FHE. The added facilities have been installed, are fully operational, and being used in a number of FHE programs.

National conferences at which CAVE3 students had a number of papers also transitioned to a virtual live format including the IEEE Electronic Components and Technology Conference (ECTC) and the IEEE ITHERM. I am glad to report that the CAVE3 students had a strong showing at the ITHERM conference, winning best-paper awards in a number of paper categories. Winning students included Tony Thomas, Deb Mondal, and Ved Soni for the following papers (1) Outstanding Paper of Conference Award: Lall, P., T. Thomas, and K. Blecker, RUL estimations of SAC305 solder PCBs under different conditions of temperature and vibration loads, Proceedings of the 19th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems, pp. 1340-1349, July 21-23, 2020. (2) Best Overall Poster Award: Mondal, D., A. Fahim, J. Suhling, P. Lall, Modeling Deformation Behavior of Multiple Grained SAC305 Solder Joints, Proceedings of the 19th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems, pp. 1221-1229, July 21-23, 2020. (3) Outstanding Poster Award, Emerging Technologies & Fundamentals: Lall, P., V. Soni, and S. Miller, Effect of Dynamic Folding with Varying Fold Orientations and C-rates on Flexible Power Source Capacity Degradation, Proceedings of the 19th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems, pp. 854-860, July 21-23, 2020.

We made some major advancements in the areas of flexible encapsulation solutions for FHE working with Flex International and a number of material vendors including ACI and Novagard on the development, modification and identification of material solutions which would stand the rigors of flexing, twisting and folding in the presence of sweat expected of wearable applications. We have also made major advancements in additive printed processes for multilayer circuits. In addition, we will report new results on process recipes for the additive aerosol-jet printing of multilayer circuits for upto 8-layers. We have developed and will report in this review on new process-property-performance relationships for additive printed traces.

We kicked off a new programs for NASA AstroSENSE module, a three-way collaboration between NASA Marshall Space Flight Center, Auburn University and NextFlex in which the AU team will work on developing a solution for reliable operation of the encapsulated wearable electronics modules intended for astronauts. of thin flexible batteries as part of the program. I am glad to report that Texas Instruments has joined the CAVE3 Electronics Research Center as a full member.

Pradeep Lall,
MacFarlane Distinguished Professor and Director

SAMUEL GINN COLLEGE OF ENGINEERING

CAVE3 Consortium Fall 2020 Semi-Annual Technical Review Meeting

The CAVE3 Fall Semiannual Fall-Review 2020 will be a virtual-live meeting owing to COVID-19 related travel concerns. The Center for Advanced Vehicle and Extreme Environment Electronics (CAVE^3) will hold its Fall 2020 Technical Review and Project Planning Meeting via MICROSOFT TEAMS on September 8-11, 2020. In order to accommodate the differing time zones of the membership - the review has been spread out over 4-days from 10am-2pm CT each day. In addition, the member causus will be held at the end of each day. All the member feedback will be done at the end of the review on Friday, Sept 11th. The meetings will be recorded and made available to the membership for asynchronous viewing. All current members of the Consortium are invited to attend. The following projects will be presented at the meeting:

- P19-302: Microstructural Evolution in Aging Lead Free Solders
- P17-302: High Temperature Tensile and Creep Behavior of Lead Free Solders
- P16-301: Aging Behavior of Solder Joints at Elevated Temperatures
- P20-103a: Effect of Shock Angle on Solder-joint Reliability of Potted Assemblies Under High-G Shock
- P20-103b: Effect of Thermal Aging on the Interface Fracture Toughness of the Substrate-UF Interface
- P20-104a: High Strain Rate Properties for SAC305 at Cold Operating Temperatures down to -65°C
- P20-102a: RUL Estimations of SAC305 Solder PCB's under Different Conditions of Temperature and Vibration Loads
- P20-105a: Process Consistency in Printed Layers in Multi-Layer Substrate Using Aerosol Jet Technology
- P20-105b: Process Development for Printing Z-Axis Interconnects in Multilayered Flexible Substrates
- P20-101a: Accelerated Factors for FHE with Human Body Measurements
- P20-106a: Effect of Dynamic Folding and Flex-to-Install with Varying Fold Orientations and C-rates on Flexible Power Source Capacity Degradation
- P20-104b: Low Temperature High Strain-Rate Material Properties for SAC-Q Leadfree Alloys
- P20-107a: Effect of Sustained High-Temperature Operation on Underfill Material Properties
- P20-104c: Evolution of High Strain Rate Mechanical Properties of SAC-R with High Temperature Storage at 50°C with High and Low Operating-Temperatures
- P20-107b: Degradation Mechanisms of Underfills Subjected to High Temperature Long Term Sustained High Temperature Operation from 150-200°C
- P20-105b: Effect of Sintering Process Conditions for Additive Printing of Multi-Layer Circuits using Aerosol-Jet Process with Blind-Vias
- P20-106b: Twist Reliability Assessment of Flexible Battery in Wearable Applications
- P20-102b: Feature Vectors for Flexible Electronics Under Mechanical Vibration
- P20-101c: Study on Folding-Reliability of Wearable Biometric Band
- P18-501: Thermal Cycling Reliability of Newly-Developed Solder Materials for Automotive and Harsh Applications
- P19-503: Effect of Combined Creep and Fatigue on Solder Joint Reliability
- P18-502: Electronic Interconnections under Varying Amplitude Cycling
- P18-301: Fatigue Properties of SAC-based Solder Joints with Aging
- P19-303: Effects of Aging on the Cyclic Fatigue Life of Pb-Free Alloys
- P19-304: Effects of Alloys Composition on the Performance of SAC+Bi Lead Free Solders
- P19-305: : Analysis of Solder Joint Behavior Including Grain Effects
- P17-601: Convective Cooling of High-Power Electronics
- P17-602Thermal Materials Testing

Contact Information:

1418 Wiggins Hall, Department of Mechanical Engineering
Auburn University, Auburn, AL
Call: (334) 844-3424

UPCOMING CONFERENCES WITH CAVE3 PAPERS

SMTA International 2020 (SMTAI 2020)

On-Demand Conference and Expo: September 28-October 23, 2020
Live Virtual Exposition: September 28-30, 2020

Dr. Lall, Dr. Hamasha and CAVE3 Graduate Research Assistants will present their papers on the 'Harsh Environment Applications', 'Advanced Packaging Technology', and 'Lead-Free and Low Temperature Soldering Techniques' tracks at the SMTAI 2020 Conference's Virtual Exposition. SMTA International provides its' members in the electronics industry with the best chance to reconnect with the global electronics manufacturing community and to stay competitive, identify challenges, innovate and exceed expectations. The papers to be presented will include:

- Lall, P., Design for Sustained High Temperature Operation of FCBGAs Based on Process-Performance Relationships, SMTA International, September 28-30, 2020.
- Lall, P., Material Behavior of Aged SAC Solder Alloys under Sustained Operation at Extreme Cold Temperatures at High-Strain Rates, SMTA International, September 28-30, 2020.
- Belhadi, M., Effect of New SAC-Bi Solder Pastes on Thermal Cycling Reliability Considering Aging, SMTA International, September 28-30, 2020.
- Abueed, M., Combined Creep and Fatigue Loadings on SAC305 Solder Joint, SMTA International, September 28-30, 2020.

SMTA Additive Electronics TechXchange

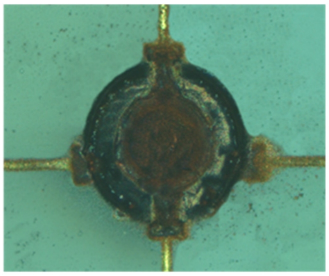
Dr. Lall will be featured as a speaker at the SMTA Additive Electronics TechXchange on October 15, 2020. The conference is designed not only to showcase options and processes intended to enable line width and space from .003" to 5 microns, but also to provide information on supporting materials and processes that are being developed to serve all market segments and expose attendees to other new advanced technologies intended to meet the ever increasing challenges of smaller, lighter and more powerful electronic devices. Dr. Lall received the SMTA Member of Technical Distinction Award in 2013.

Research Highlights

Process-Consistency in Printed Layers in Multi –Layer Substrate Using Aerosol Jet Technology

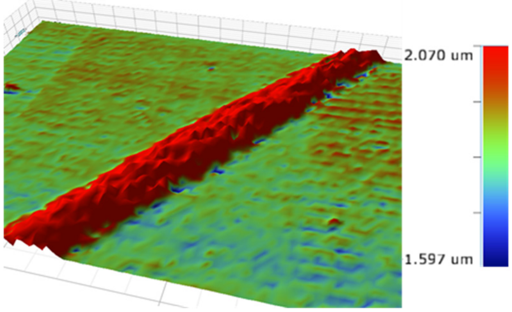
Growing interest can be seen in the field of additively printed electronics. Being able to directly print on any type of substrate, whether be rigid, flexible, or conformable, brings many advantages, which can easily triumph over traditional techniques used for electronics fabrication. Digital printing techniques such as Aerosol Jet, Inkjet, Gravure Offset, etc. are becoming more and more well known in the field of printed electronics, each having its own merit. In addition, given the fact that electronic systems are fundamentally multi-material, it is important to understand the material-material interaction including their compatibility, curing conditions, adhesion. Some of these concerns can be resolved by Aerosol Jet technology, which supports wide range of materials, viscosity ranging from 1cP – 1000cP. It involves use of two atomization processes: Ultrasonic Atomizer (UA) for materials with low range of viscosity (1-5cP); and Pneumatic Atomizer (PA) for higher range (1-1000cP). With its ability to print multi-material, additional problems need to be addressed such as the degradation in the printed base layer from curing while printing a multi-layer substrate. This project provides an insight into such problems, including the curing profile for all the layers. The materials chosen for the study are such that both the atomizers can be used simultaneously without having to remove after printing. With that in mind, a Silver Nanoparticle ink as a conducting material is used with low viscosity suitable for UA, and a dielectric as an insulating material with high viscosity suitable for PA. The dielectric will be used in the areas needed only. Process parameters will be developed for a multi-layer substrate, and the consistency of in the printed lines will be addressed. In the end, process capability using statistical measures will be performed. This study will help gain more understanding into the problems that are not clearly visible while manufacturing a printed multi-layer substrate with vias through Aerosol Jet.

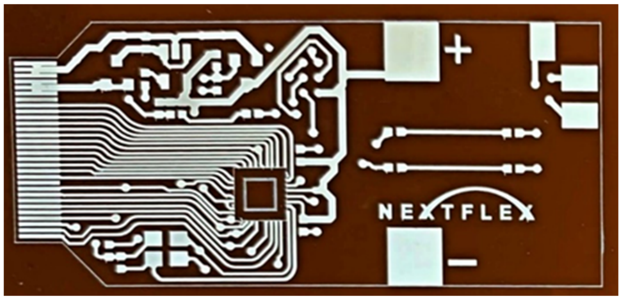
Aerosol Jet Printed Metal Line



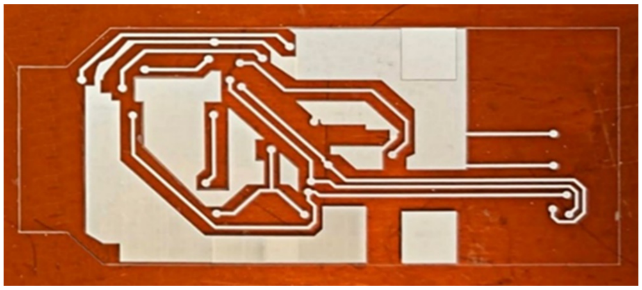
Via connecting 7th and 8th layer

Micro-Via Metal Line





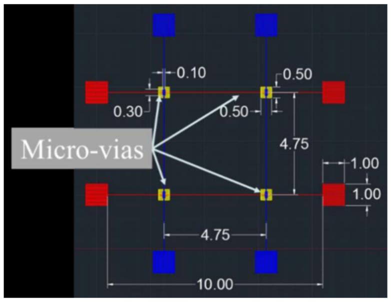
Aerosol Jet Printed Arduino Board at CAVE top layer (above)



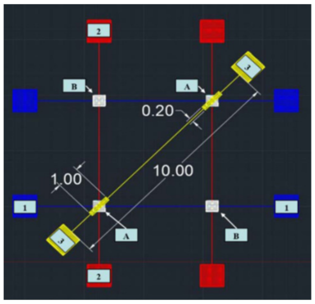
Aerosol Jet Printed Arduino Board at CAVE bottom layer (above)

Sintering Process Conditions for Additive Printing of Multi-Layer Circuitry Aerosol-Jet Process in Conjunction with Nanoparticle Ink

Flexible electronics has emerged as a new form-factor in the consumer and defense applications. Aerosol-Jet Printing technology has shown potential for additive printing of flexible electronics on both planar and non-planar surfaces. The width of the needed lines can varied through control of the process parameters allowing the printing of very narrow traces of the order of 5-10μm in width. Reported research till date primarily concentrates on the single-layer printing with consideration of various parameters like humidity, temperature and strain rate. However, conventional PCBs are multi-layered and for the flexible PCB to be used in real-world it is important to have multi-layer stacking of interconnects and establish z-axis interconnections through vias as currently in the conventional PCBs. Use of additive methods such as aerosol printing method provides a great amount of design freedom without the need for specialized masks to establish the interconnects for different inks available like silver, copper, and carbon. In this paper, the objective is to establish z-axis interconnections with the help of Aerosol printable silver ink and dielectric polyimide ink. The silver ink would be using the ultrasonic atomizer to print, and the pneumatic atomizer has to be used for the polyimide ink. The printed conductive lines have been subjected to different sintering conditions and then tested for the parameters like resistance across the interconnects and shear load to failure.

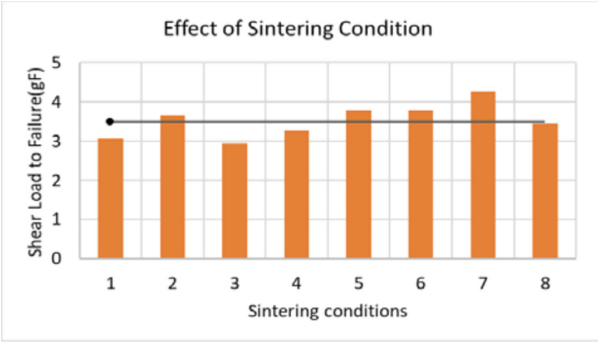


2-layer test with 4 vias in AutoCAD



3-layer test vehicle in AutoCAD

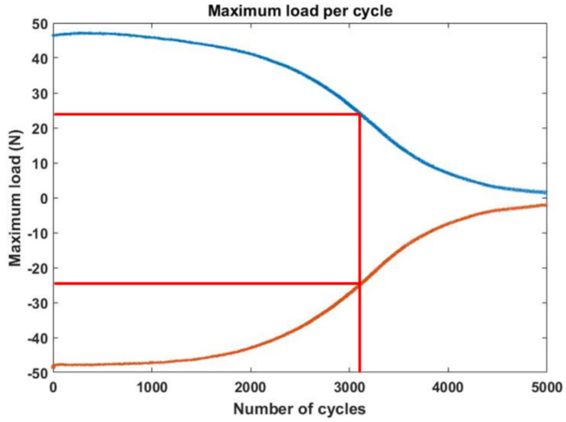
Effect of various sintering profile on resistance (above)



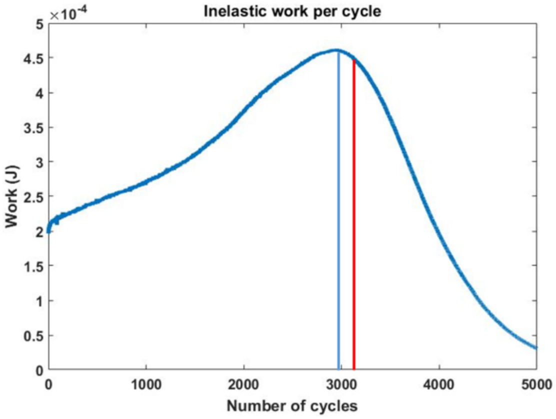
Effect of various sintering profile on shear load to failure

Fatigue Performance of Doped SAC Solder Joints in BGA Assemblies

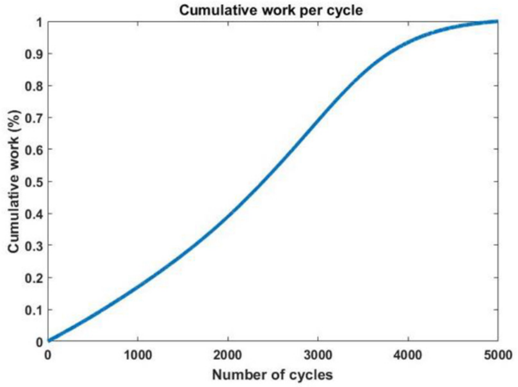
Fatigue failure of interconnected solder joints is a critical consideration for the reliability of an electronic product. Commonly, fatigue properties of solder materials are investigated using large bulk samples. However, limited studies considered the actual solder joints that are typically found in BGA components. This study includes customized sandwich BGA test vehicles with 3×3 solder joints connected between two substrates. Instron Micromechanical Tester is used to test the samples in both stress-controlled and strain-controlled experiments at room temperature. The testing was conducted at a constant strain rate. The tested solder materials are Sn-3Ag-0.5Cu (SAC305), Sn-3.5Ag-0.7Cu-3Bi-1.5Sb-0.125Ni (Innolot), Sn-3.41Ag-0.52Cu-3.3Bi (SAC-Q), and Sn-0.92Cu-2.46Bi (SAC-R). The displacement-load (hysteresis)loops for each sample were systematically recorded, and thus the work per cycling and plastic strain range are measured. The results showed that Innolot has better fatigue life than SAC305, SAC-Q and SAC-R in both stress-controlled test and strain-controlled test, while the fatigue performance of SAC305 in strain-controlled test is better than that in stress-controlled test.



Maximum load per cycle to number of cycles (SAC305) with displacement 0.015mm (above)



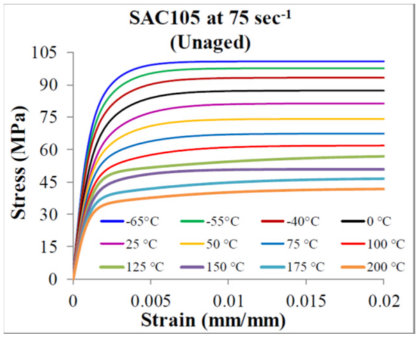
Work per cycle to number of cycles (SAC305) with displacement 0.015mm (above)



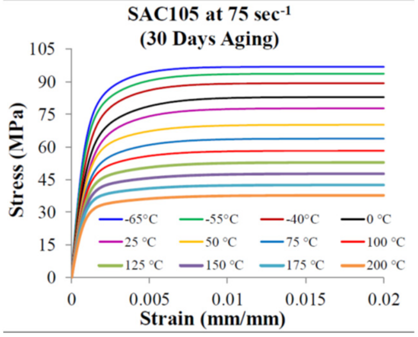
Cumulative work per cycle to number of cycles (SAC305) with displacement 0.015mm

Effect of Thermal Aging on the Evolution of Anand Parameters for SAC105 Leadfree Alloys Operating at Cold Temperatures down to -55°C

Automotive and defense electronic systems may be subjected to low and high temperatures (-55°C 150°C) and high strain rates (1-100 per sec) during storage, operation and handling which can contribute to the failures of electronics devices. Temperatures in these applications can varies between -55 to 200°C. The microstructure evolution due to change in operating temperature and thermal aging can cause degradation in mechanical properties of Leadfree solder alloys. So, we need more reliable lead-free solder alloys which can survive in these extreme harsh environments. Previously, effect of thermal aging on mechanical properties and Anand model parameters for SAC (SAC105, SAC305 and SAC-Q) solder materials have been studied at different high strain rates (10, 35, 50, 75 /sec) and elevated temperature (25°C-200°C) for pristine samples and aged samples up to 1 year have been studied and observed that SAC alloys are sensitive to strain rate, operating temperature and thermal aging. [Lall 2013-2019]. However, there are no data available in published literature for SAC105 solder alloy at high strain rate at low operating temperature. In this paper, pristine and thermally aged (up to 6 months) leadfree SAC105 solder alloy has been studied at low operating temperatures (-65°C-0°C) at high strain rates (10-75 per sec). Stress-Strain data have been measured using tensile tests. Microstructural Evolution for SAC105 solder alloys has been explored induced due to thermal aging. Experimental data has been fit to Anand Viscoplastic model. Evolution of Anand Model parameters for SAC105 solder has been investigated. To verify the accuracy of the model, the computed parameters from experimental data have been used to simulate the uniaxial tensile test. A good correlation was found between experimental data and model predicted data.



Pristine SAC105 stress-Strain curve at low operating temperature. (top left)

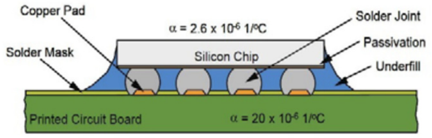


30 Days aged SAC105 stress-Strain curve at low operating temperature. (bottom left)

Effect of Long Term Isothermal Exposure on Underfill Material Properties

The flip chip packages when exposed to high temperature develop a bending of the structure (thus die) due to CTE (coefficient of thermal expansion) mismatch between the die and the substrate. The presence of underfill encapsulants reduces the solder joint strains and thus improves the fatigue life of the joints. Owing to the emergence of automotive electronics applications, many of which reside underhood, it has become important to study the properties of underfill materials when exposed to high temperature, specially at or above the Tg (glass transition temperature) of the material. In this work, the changes in material dynamic mechanical properties were studied for isothermal aging at three different temperatures which are above, near, and below the glass transition temperature of the material. Long term exposure of different underfill materials were investigated at three different isothermal aging temperatures, those are 100°C, 125°C, and 150°C. A simple method has been developed to prepare test specimens for DMA testing. The properties of underfill materials such as storage modulus, loss modulus, and Tg were investigated using DMA (Dynamic Mechanical Analyzer). DMA test was done in a three point bending mode with a frequency of 1 Hz and a heating rate of 3°C/min. The storage modulus, loss modulus, and tan δ were determined by the instrument software (PerkinElmer DMA 8000). The Tg of the samples can be found as the peak of the loss modulus plot, peak of the tan δ plot, and slop of the storage modulus plot at the transition phase.

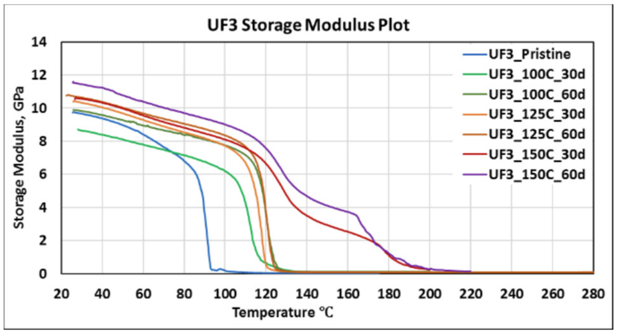
1. Typical Flip-Chip Assembly



2. Properties of Underfill Mater-ials

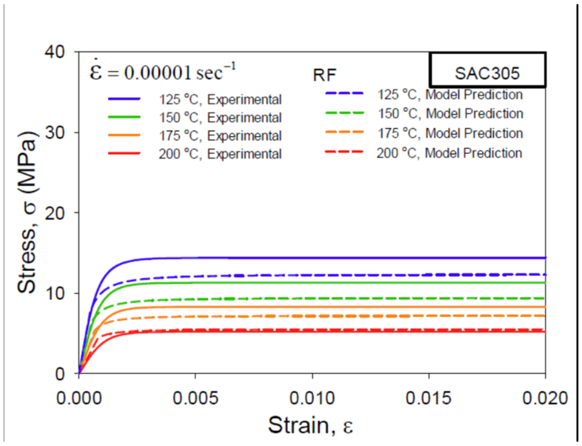
Underfill Material	T_g °C	CTE (ppm/°C)		Curing
		$<T_g$	$>T_g$	
UF3	108	29	102	165°C / 2 hrs.
UF4	107	27	95	150°C / 2 hrs.

3. Storage Modulus for UF3 Underfill

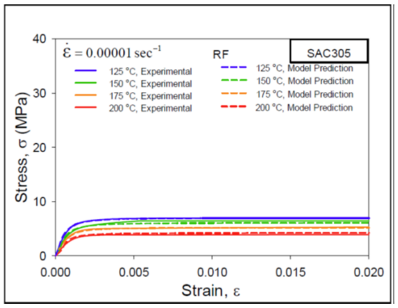


Isothermal Aging Dependent Anand Parameters of SAC305 Lead Free Solder at Extreme High Temperatures

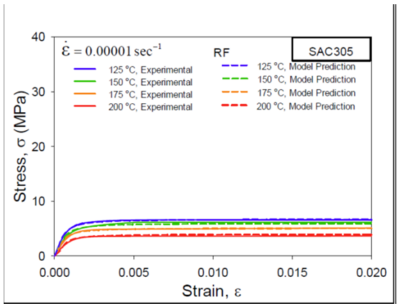
With the emergence of the modern electronic packaging technology over the last few decades, lead free solder alloys have been the primary interconnects material used in electronic packaging industry. Experimental testing has revealed that SAC solders exhibit mechanical properties that change significantly with isothermal aging. These changes are especially large in harsh environments, such as at extreme high temperatures where the effects of aging on solder joint behavior must be accounted for and included in constitutive models when predicting reliability. The nine parameter Anand viscoplastic constitutive model is a popular commercial finite element code built in to many commercial FEA packages like ANSYS and ABAQUS, which is widely used in the electronic packaging industry to predict reliability. Reliability prediction results are highly sensitive to the specified Anand parameters, and there are great variations in the available literature values. Electronic devices frequently experience harsh environment applications where solders are exposed to very high temperatures from 125-200 °C. We have studied the changes in mechanical properties and the Anand viscoplastic constitutive model for SAC305 (96.5Sn-3.0Ag-0.5Cu) lead free solder by considering the isothermal aging effect. The pre aging was done at 125 °C. Uniaxial tensile stress-strain tests were carried out on SAC305 specimens using a micro tension/torsion testing machine with three strain rates (0.001, 0.0001 and 0.00001 (1/sec)), four extreme high testing temperatures (T = 125, 150, 175, and 200°C), and four and four temperatures (T = 125, 150, 175, and 200°C), and four different preaging conditions (0, 1, 5, and 20 days at 125 °C). Our findings show that 2 of the 9 Anand parameters remain essentially constant during aging, while the other 7 show significant changes with aging. Once the Anand constants were determined, we used the constitutive model to predict the stress-strain curve at each particular temperature and strain rate used in each experimental testing to evaluate the goodness of fit of the constitutive model to the test data. Good correlation was observed between the experimental curves and the model predictions.



No Aging (RF), SR = 0.00001 sec-1 (above)



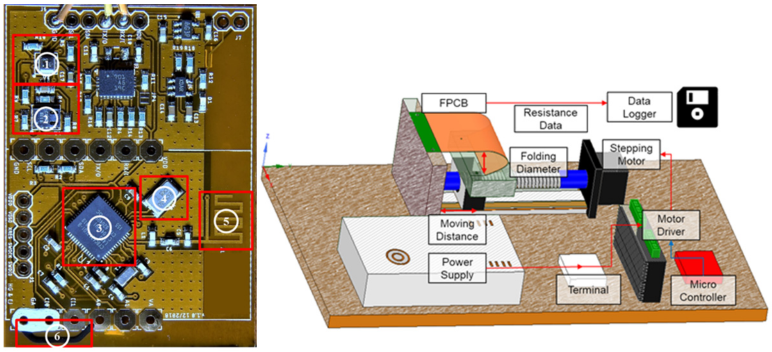
5 Days Aging at T = 125 °C, SR = 0.00001 sec-1 (top left)



20 Days Aging at T = 125 °C, SR = 0.00001 sec-1 (top right)

Study on Folding-Reliability of Wearable Biometric Band

The use of flexible electronics for wearable applications provides a number of advantages including compactness, nonplanar architectures, and light-weighting. There is increased interest in dealing with the process and reliability issues related to the use of flexible electronics in wearable applications under the stresses of daily motion. Stresses of daily motion have the potential to cause the premature failure of the electronics systems and sensors. Wearable electronics may be subjected to twisting, flexing and folding under normal operational use-life. In this study the effect of the stresses of daily motion have been studied through the development of test protocol for dynamic folding imposed on a flexible biometric band with printed sensor and surface mount components. This research study involved the calibration, characterization, and reliability study of wearable biometric bands subjected to dynamic folding. The wearable band used for the study combines a biometric sensor unit, a micro-controller unit with a wireless connection, and a printed thermistor unit. The sensors have been calibrated by actual temperature and biometric signals. Furthermore, the folding test was conducted utilizing multiple boards. Due to multiple components and printed lines of the PCB, optical images were taken in order to confirm which parts failed and the reasons for the failures. An FEM analysis was developed in order to understand the locations of stress concentration the PCB and which parts are stressed during the folding process. Fatigue failure analysis on folding reliability of the wearable biometric band was conducted using experimental analysis, microscopy analysis, and simulating analysis. A correlation of the stress change in the biometric band with the progression of dynamic folding was determined using the finite element model.



Functiontional wearable biometric sensor band (left) and Test Protocol (right)

Announcements

CAVE3 Graduate Research Assistants Win Best-Paper Awards at ITHERM 2020 Conference

Three CAVE3 Graduate Research Assistants received top awards at the ITHERM 2020 Virtual Conference, which was held from July 21-23, 2020.

Outstanding Paper of Conference Award: Lall, P., T. Thomas, and K. Blecker, RUL estimations of SAC305 solder PCBs under different conditions of temperature and vibration loads, Proceedings of the 19th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems, pp. 1340-1349, July 21-23, 2020.

Best Overall Poster Award: Mondal, D., A. Fahim, J. Suhling, P. Lall, Modeling Deformation Behavior of Multiple Grained SAC305 Solder Joints, Proceedings of the 19th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems, pp. 1221-1229, July 21-23, 2020.

Outstanding Poster Award, Emerging Technologies & Fundamentals: Lall, P., V. Soni, and S. Miller, Effect of Dynamic Folding with Varying Fold Orientations and C-rates on Flexible Power Source Capacity Degradation, Proceedings of the 19th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems, pp. 854-860, July 21-23, 2020.

Final Conference Program

The 19th Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems

ITherm VIRTUAL 2020

Live Virtual Events July 21 – 23, 2020

Thermal and Thermomechanical Phenomena in Electronic Systems

ITherm 2020

ITherm Virtual Conference July 21-23, 2020
(Originally scheduled for May 26 – 29, 2020)

Lall honored with IEEE Biedenbach Outstanding Engineering Educator Award

Pradeep Lall, the John and Anne MacFarlane Endowed Distinguished Professor of mechanical engineering, is the recipient of the IEEE Region 3 Biedenbach Outstanding Engineering Educator Award for 2020, which recognizes those who have made outstanding contributions to the electrotechnology profession through teaching in industry, government or in an institution of higher learning. Lall, director of the National Science Foundation Center for Advanced Vehicle and Extreme Environment Electronics (CAVE3), was recognized for his contributions to education in the field of additively printed electronics manufacturing and reliability for harsh environment operation.

"Dr. Lall is a world-renowned expert, researcher and teacher in the field of electronics," said Jeff Suhling, Quina Endowed Professor and chair of the Department of Mechanical Engineering. "I am delighted to see him recognized with the IEEE Biedenbach Award."

Lall says that one of his professional motivations is to demystify certain aspects of additively printed electronics and harsh environment electronics.

Pradeep Lall, MacFarlane Endowed Distinguished Professor

"Through my publications and courses, I try to make the subject more accessible to a wider audience, from high schoolers to practicing engineers," said Lall, who has been the principal investigator on a number of research initiatives focused on those topics. "The topic of harsh environment electronics has implications in a number of industries including automotive, downhole and defense. The use of additive technologies provides pathways for faster time-to-market and productization of ideas and intellectual property."

A significant portion of Lall's research includes partnerships for workforce development. Accordingly, Lall has engaged high school teachers in sponsored research programs that expose students to additive electronics manufacturing at the K-12 level. He has engaged undergraduate students in Research Experiences for Undergraduates programs and generally advises a number of undergraduate students working on research projects on a regular basis.

In his role as director of CAVE3, Lall leads research projects in harsh environment electronics while interfacing with companies and government agencies that fund the center's research. He leads a sizable team of graduate students in working on a wide range of programs with significant implications in the electronics sector of the nation's growing additive manufacturing industry.

Lall was part of the founding proposal team for the NextFlex National Manufacturing Institute, which aims to renew and maintain the national focus of flexible electronics manufacturing; Auburn University is a tier-1 academic member of NextFlex. Lall also sits on the Technical Council and Governing Council of the NextFlex National Manufacturing Institute, as well as serves as the academic co-lead for the Asset and Situational Awareness Technical Working Group in NextFlex.

He was named a NextFlex Fellow in 2019.

Announcements

"Dr. Lall has created a world-class research program in additively printed-electronics manufacturing at Auburn University," said Christopher B. Roberts, dean of engineering. "This award adds to the recognition of the impact that he has made at the national level."

Augmentation of Additive Printed Flexible Electronics Capabilities at CAVE3

A number of key-pieces of equipment have been procured by the CAVE3 Electronics Research Center to augment the already formidable set of tools. Additional tools include (1) SUSS MicroTEC PixDro LP50 Inkjet Printer (2) nScrypt 3Dn-300 Direct Write Quad-Head Printer (3) Xenon X-1100 Photo-sintering System with Flatbed Capability (4) Lamination Encapsulation for FHE.

SUSS MicroTEC PixDro LP50 Inkjet Printer

nScrypt 3Dn-300 Direct Write Quad-Head Printer

User: user Recipe: Test Status: Modified

On Time 65 (us) Energy 103 (J)

Off Time 1000 (us)

Pulse List

	On (us)	Off (us)	Energy (J)
1	55	1000	103
2	58	1000	103
3	61	1000	103
4	65	1000	103

Energy Available = 79%

Total Energy Used = 412(J)

Voltage: 2660 (V) HV Present Comms OK

Programming pulse profiles and sequencing is done on a single screen.

User: user Recipe: Test Status: Modified

Run Mode: Single Shot

I Max(A) 880

V Max(V) 2992

Energy(J) 980

us/Div 125

Voltage: 2660 (V) HV Present Comms OK

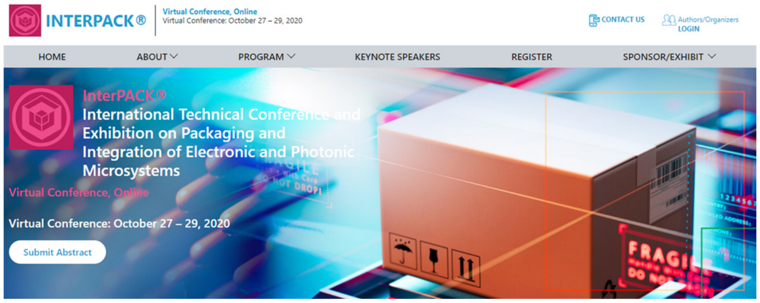
Lamp operating parameters (voltage and current) and pulse energy are monitored and displayed to confirm system operation.

Xenon X-1100 Photosintering System

Lamination Encapsulation for FHE

Lall Serves as Track-Chair of the Additive Printed Flexible Electronics Track at ASME INTERPACK 2020

Professor Lall will serves as the track-chair of the Additive Printed Flexible Electronics Track at ASME INTERPACK 2020. Dr. Ben Leever, US-AFRL and Dr. Janos Veres, NextFlex are track co-chairs. The conference will be held in a virtual live format and is scheduled for Oct 27-29, 2020.



Virtual Conference, Online
Virtual Conference: October 27 – 29, 2020

InterPACK®
International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems

Virtual Conference, Online

Virtual Conference: October 27 – 29, 2020

Selected Recent Publications

2020 CAVE3 Papers

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2. Wu, J., M.S. Alam, KM R. Hassan, J.C. Suhling, and P. Lall, Investigation and Comparison of Aging Effects in SAC+X Solders Exposed to High Temperatures, in Proceedings of the IEEE Electronic Components and Technology Conference, Orlando, FL, pp. 492-503, June 3-30, 2020.
3. Lall, P., V. Yadav, V. Mehta, J. Suhling, and K. Blecker, Extreme Cold-Temperature High-Strain Rate Properties of SAC Solder Alloys, in Proceedings of the IEEE Electronic Components and Technology Conference, Orlando, FL, pp. 782-792, June 3-30, 2020.
4. Lall, P., K. Goyal, and J. Narangaparambil, Accuracy, Hysteresis and Extended Time Stability of Additively Printed Temperature and Humidity Sensors, in Proceedings of the IEEE Electronic Components and Technology Conference, Orlando, FL, pp. 1070-1080, June 3-30, 2020.
5. Lall, P., K. Goyal, N. Kothari, and S. Miller, Process-Consistency-Performance Relationships for Additively Printed Z-axis Interconnects in Multilayer Circuits, in Proceedings of the IEEE Electronic Components and Technology Conference, Orlando, FL, pp. 1247-1258, June 3-30, 2020.
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Auburn University
CAVE3
Samuel Ginn College of Engineering
1418 Wiggins Hall
Auburn, AL 36849

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