AUBURN UNIVERSITY
SAMUEL GINN
COLLEGE OF ENGINEERING

Spring 2018

cave³ 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

Over the last six-months, I had a number of opportunities to present our work in additive manufacturing of flexible electronics. In September 2017, CAVE3 had a booth at the NextFlex Innovation Day. I had the opportunity to present the AU Biometric Band to a number of attendees, which included federal agencies and the companies from the flexible electronics ecosystem. The AU Biometric Band is a wearable watchdog, which monitors the vitals of the wearer, and when paired with a smartphone with installed LifeSaver APP is autonomously able to call emergency medical services if needed. The band has a number of uses for remote personnel monitoring and geriatric patients. The complete system including the band and the accompanying APP was design, fabricated and implemented in the CAVE3 Labs.

On December 7, 2017, I had an opportunity to present our work in development of test protocols for flexible electronics at the Defense Manufacturing Conference in Tampa, Florida. The presentation was part of a special session chaired by the Government CTO of the NextFlex Institute, Dr. Ben Leever to highlight the Institute's efforts on the test protocols related to flexible electronics. Most of the present-day standards are geared towards rigid electronics and wider adoption of flexible form-factors needs new methods to understand the reliability and survivability aspects.

In February-2018, I had the opportunity to teach a short course at 2018FLEX on the topic of Flexible Device Integration and Packaging co-taught with Doug Hackler (President and CEO, American Semiconductor) and Kurt Christensen (Senior Research Scientist, Optomec). The conference was held in Monterrey, CA and many of the session were concurrent with the NextFlex Technical Working Group meetings. I also presented two-technical papers at the conference. On February 15, 2018, I attended the NextFlex Governing Council Meeting, which was concurrently being held at the 2018FLEX. I was appointed to the Governing Council in June 2017 and presently serve as the representative for the Tier-1 Academic Members. On February 16, 2018, I presented at a special session of NextFlex on the topic of High Performance Flexible Printed Electronics. While, significant progress has been made in making simple circuits flexible with FHE, there are technical challenges that need to be surmounted to increase the flexibility of highly complex circuits. This special session was intended to draw input from wider-constituents of the ecosystems to help chart the course for high performance applications. Applications included thin silicon for more advanced devices than 8-bit microcontrollers including FPGAs, advanced node devices, interconnects for the high layer count and high routing density structures, and integration techniques for these devices, and, flexible batteries. During the course of the week FLEX conference, I also attended a number of technical working groups including materials, power and energy, and device integration and packaging. Speakers in the TWGs spoke on various aspects of relevance to the flexible electronics ecosystem. The very interactive meeting was used to engage various constituents of the supply-chain in a dialogue in order to identify the technology gaps and set priorities.

On February 23, 2018, Auburn University hosted the E-day to provide an opportunity to seventh-to-twelfth graders aspiring for a career in engineering to experience the excitement of working in the research labs. CAVE3 research labs were on the tour. I had an opportunity to show our flexible additive printed electronics lab to students from Auburn High School and Auburn Junior High School.

I want to extend a welcome to the new members of the CAVE3 consortium including U.S. Army Armament Research, Development and Engineering Center, Missile Defense Agency, and SubZero.

Pradeep Lall,
John and Anne MacFarlane Professor and Director

CAVE3 Consortium Spring-2018 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 March 7-8, 2018 in Auburn University Wiggins Hall. All current members of the Consortium are invited to attend. The following projects will be presented at the meeting:

- Effect of Shallow Cycling on Flexible Power-Source Survivability under Bending Loads and Operating Temperatures Representative of Stresses of Daily Motion
- Reliability of Flexible Substrates Under Stresses of Daily Motion
- Measurement of Interfacial Fracture Toughness and Cohesive-Zone Models of Potting Compounds with FR4 PCBs
- High-G Shock Reliability of Micro-Coil Springs and Polymer Core Ball Interconnects
- Reliability of SAC 305 Solder Interconnects on Double-Sided Flexible Printed Circuit Board Using X-Ray Micro-CT
- Design of Biometric Band and LifeSaver APP in Wear-and-Forget Format
- Reliability of a Fuze Assembly Using Micro-CT data based FE and Digital Volume Correlation
- Characterization of Electrical and Mechanical material properties using Aerosol Jet Printing based Additive Manufacturing Process
- Prognostication of Electronic Assemblies Subjected to Temperature-Vibration Loads
- Sub-Modeling of SJ Reliability in High-Temperature Vibration
- High Strain Rate Properties of SACQ Solder after Prolonged Thermal Aging up to 6-Months
- Damage evolution in MEMS Pressure Sensors during High Temperature Operating Life and Prolonged Storage at Sub-Zero Temperature
- Effect of High Temperature on Reliability of Cu, Au, Ag, PCC WB
- Moving Boundary Model based on the electrochemical measurements of Cu and Cu-Al IMCs
- Effect of Mean Temperature on The Evolution of Strain Amplitude in SAC Ball Grid Arrays During Operation under Thermal Aging and Temperature Excursions
- Mechanical Characterization of Solder Mask Materials
- Characterization of Die Stresses in Plastic Ball Grid Array Packages Subjected to Various Moisture Conditions
- Improved Finite Element Simulation Strategy with Submodeling for BGA Packages Subjected to Thermal Cycling
- The Effects of Temperature, Strain Rate, and Aging on The Poisson's Ratio of SAC Lead Free Solders
- Reliability of Aged Lead Free Doped Solders For Temperature Accelerated Life Testing
- Reliability Analysis of Super Ball Grid Array Packages
- Effect of Surface Finish on the Shear and Fatigue of Lead-Free Doped Solder Joints
- Evolution of the Cyclic Stress-Strain Behavior of Doped SAC Solder Materials Subjected to Isothermal Aging
- Evolution of the Cyclic Stress-Strain and Constitutive Behaviors of Doped Lead Free Solder During Fatigue Testing
- Effects of Mechanical Cycling on the Microstructure of Lead Free Solders
- Mechanical Characterization of SAC Solder Joints at High Temperature Using Nanoindentation

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

SPECIAL EVENTS

2018 IEEE International Conference on Prognostics and Health Management

June 11-13, 2018
Hilton Seattle Airport and Conference Center, Seattle, WA, USA.

The IEEE Reliability Society will sponsor its ninth annual International Conference on Prognostics and Health Management (IEEE PHM2018) . 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 2018

Conference: Oct. 14—Oct. 18, 2018
Exhibition: Oct. 16—Oct. 17, 2018
Donald Stephens Convention Center, Rosemont, IL

Annual SMTA International Conference will be held at the Donald Stephens Convention Center in Rosemont, Illinois from Oct. 14—Oct. 18, 2018. Abstract submission is presently open till March 16th, 2018. submission for half day course proposal is open till March 16th 2018. Full technical papers and course handouts are due by 27th July 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

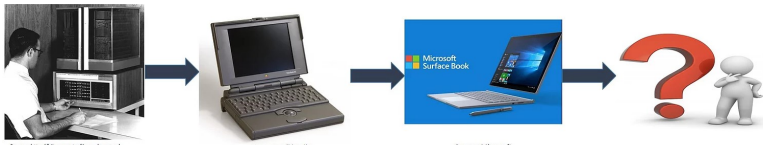
Flexible and Wearable – A New Frontier!!

By Shantanu Deshpande
GRA, NSF-CAVE3 Research Center, Auburn University.

Electronics!! It's everywhere. It's impossible to image our everyday life without them. It's really cool to see these things evolve so fast, and are still continuing to develop at breathtaking pace. It's not that long time back in the history, in 1893 concept of electric current was introduced. That was the beginning of electronic era. First transistor was demonstrated in 1947. In 1958, first concept of Integrated Circuit (IC) was presented, which enabled fabricating multiple transistors on a single chip. In the 1970's concept of very large scale integrated circuits (VLSI) changed the way we looked at electronics completely. This enabled development of computers, controllers, communication, medical field etc. and shaped the electronics that we see today.

First commercially available computer was developed by Digital Equipment Corporation in 1964. (Guess what was the cost ~ $18000). In 1971 Intel developed first microprocessor with 2250 transistors, which can do 90,000 operations per second. (Current Intel I7 have nearly 1,900,000,000 transistors, and rated for few million MIPS). One of the most famous laptop series "PowerBook" was introduced in 1991. It had trackpad, keyboard, internal floppy reader and palm rest. Now we have hybrid, extremely light weight laptops like Surface pro series, with touch and pressure sensitive HD screen, few gig's of RAM with powerful processors that can do multitasking. One thing that stands out is that over the period of time we have traveled from large form factor to small form factor, high performance, highly efficient electronics systems. This is true not only for the computers, but also for every day electronics such as televisions, cell phones, calculators, tablets, electronic sensors, data storage methods etc. Undoubtedly this trend will continue. Question is where to..?

Current electronics system a rigid system. Main reason being the Silicon chip, and printed circuit boards are solid, rigid and are not flexible. The new electronics systems does not have that rigidity anymore. Imagine ultra-thin 7" tablet that can be bent in a way we want, is flexible in all the direction. Sounds too good to be true

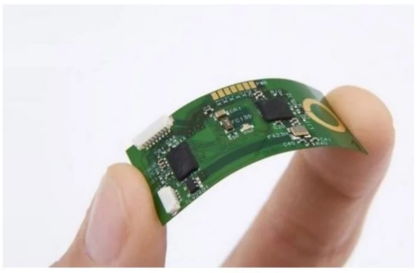


right? But it is happening. Another aspect of the latest trend is wearables. This is a vast area which includes fancy consumer applications like virtual watches, electronics that can track and monitor athletes activity and performance without causing them any discomfort, different sensors that can take readings from very complex and fragile body parts such as brain, heart etc. when patient continues day to day routine. This will not only make our life comfortable but also safer.

Next Stop: Flexible, wearable and stretchable:

Wearable technology will be the leading node of a shift towards better connected world. These devices can be on the human body for most of the times. Current thrust in this field include few hundreds of companies and university level research labs exploring this new world in terms of developing new materials, processes, and devices for the wearable electronics. Wearables and flexibles are supposed to me more human friendly with agronomical design. We shouldn't have to worry about the electronics we are carrying (Remember smartphone bending cases!!) during our daily activities. Even though these devices don't perfectly fit definition of flexible electronics, they provide descent start and a sneak peek into the future.

Source: Wikipedia
Flexible screen



Source: Android Authority
Flexible PCB Assembly

Materials and Process:

In order to use silicon in flexible applications, ultra-thin sheets of silicon are required. The behavior of these sheets then needs to be altered in order to make them flexible. This includes lots and lots of processing on silicon structure. Certain application still use this method to build flexible circuits, but one way to get around it is use of complex polymer chains of hydrocarbons.

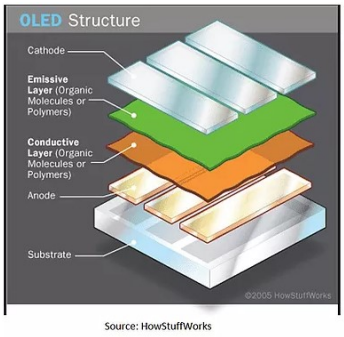
Idea of conductive polymers was first introduced in 1977 by A. Heeger. He demonstrated that by adding certain doping agents, polymers can become conductive (Nobel Prize in Chemistry in 200 for development of conductive polymers). First polymer LED was introduced in 1990, showing potential of this application. Very long polymers chains can be used for this purpose. These new electronic system requires new fabrication techniques. These techniques include printing or spraying electronic assemblies on flexible substrates (which could be 3D printed or mass fabricated). The fabricated assemblies can be used solar cells, electronics displays, LED's and in some cases as electronic skin!! Researchers also have successfully reported fabrication of organic field effect transistors, which can also be used as light emitting OFETs. The flexible and stretchable electronics has special interest from defense industry. Flexible electronics assemblies can sustain major mechanical shocks without damaging parts. However special materials and technique need to be developed for flexible electronics to pass through stringent reliability criterions of the harsh environment industry.

Any electronics requires a power source. Shift to flexibles have also triggered series of advances in battery technologies, in order to make them bendable, at the same time leak proof, safe and yet maintain high capacity. Recent developments in Li-ion polymer batteries are promising. In 2015 InterBattery event held at Seoul, Samsung and LG presented extremely thin, flexible long lasting band batteries that are highly reliable. Another important aspect is bendable and flexible displays. In order to make touch display responsive, and pressure sensitive, resistors or transistors must be printed on the flexible sheets. These displays are then supposed to work for thousands of hours without showing sign of degradation. Real challenge in this is ensuring stable response of the printed assemblies. Companies are investing heavily to seek the reliability related problem and troubleshoot it.

Applications:

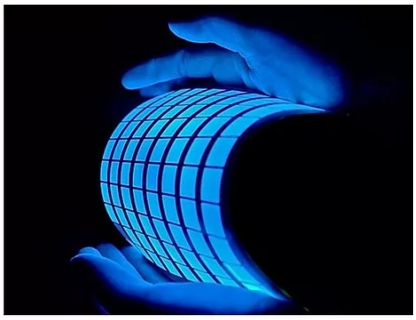
One of the cool and really useful application is electronic tattoos. These are just like normal tattoos on the skin but they do much more than that!! In recent consumer electronic showcase (CES 2016) tattoo was introduced to track the live monitoring of UV radiation. A startup company MC10 is using idea of electronic tattoos into the healthcare system. It is used to monitor real-time ECG data, heart rate, activity levels changes in body temperatures etc. Researches from University of Illinois at Urbana-Champaign published the work (Feb 2016) related to dissolvable temperature and pressure sensors, which can be implanted into brain or heart after the surgery and provide accurate data for up to 3 week before dissolving into the body.

Samsung recently announced their new product, smart shoes. These shoes can provide real-time data about pressure on each section



Source: HowStuffWorks

Organic Light Emitting Diode(OLED)



Organic Light Emitting Diode(OLED) in action

of feet, posture, balancing etc. Another such application is introduced by Athos. These are smart fitness cloths, which monitor individual muscle activity, stress levels in muscle, heart rate etc. this feature can provide athletes train better and avoid error in exercise that can yield into injuries. Researchers have developed wearable sweat sensors to provide physiological condition of the trainee. These sensors analyze chemicals from sweat in real time and provide idea about glucose, electrolytes levels. These give idea about fatigue levels, hydration levels of body.

BiostampMD by MC10 (From MC10 website)

These are just few of the numerous applications that are currently being introduced. There are many more challenges to be overcome in order to make these applications more perfect, reliable and economical. But hey, a lot can happen in upcoming days..

Assessment of Reliability of Missile Fuze Using Micro-CT Data based Finite Element with Digital Volume Correlation

Densely packed field extracted electrical assemblies like fuze, subjected to harsh environments may often undergo degradation in terms of material properties and physical structure (geometry), but no signs of damage may be visible from the physical appearance. Quantification of accrued damage may require cross-sectioning and thus sacrificing the sample which may be undesirable as it may not allow for any further investigation. Use of conventional finite element techniques for modeling such assemblies may be prohibitively time consuming. It has been shown earlier that the large number of components and geometric details in such assemblies make the modeling process, time consuming and results may not be accurate because of not modeling the accrued physical damage. In the past, researchers have studied the reliability of such assemblies using failure rates and mean time to failure approach.

Lall et. al. have used Digital Volume Correlation and micro-CT (Computed Tomography) data based finite element mesh to study remaining useful life of small sized packages like ball grid arrays No literature is found on studying reliability of large, densely packed electronics using micro-CT based non-contact type, full field deformation measurement techniques and finite element models that capture the real ‘as is’ geometry. In this paper, micro-CT data of the fuze has been used to perform Digital Volume Correlation, to measure deformations when the device is subjected to a thermal load. Young's modulus of the sub-components have been measured using nano-indentation, thus accounting for degradation in the material properties. Micro-CT data of a fuze has been used to create a finite element mesh which has been further used to perform a thermo-mechanical analysis of implicit type. Usage of micro-CT data has ensured the modeling of ‘as is’ geometry of the components of the fuze assembly, thus accounting for the prior accrued physical damage. The results of the finite element model are compared with the deformations measured using Digital Volume Correlation to analyze the accuracy of the FE method used for modeling fuze device.

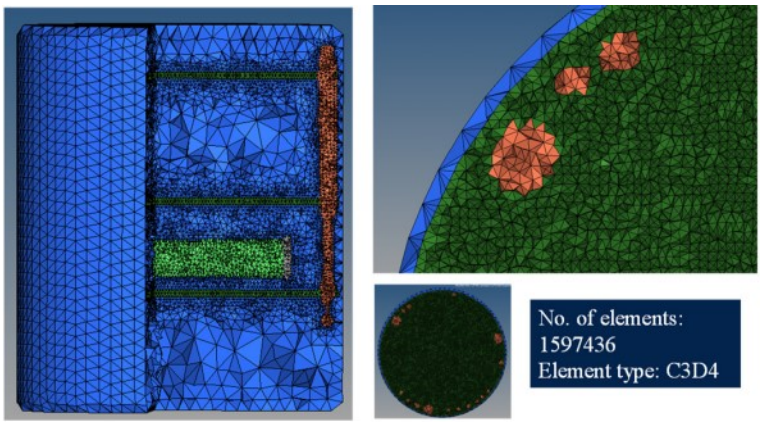
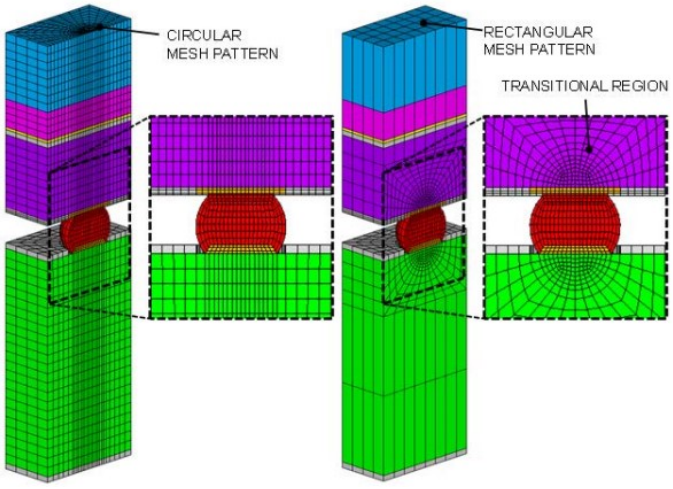


Figure 3— 3D Model of the FUZE assembly from CT Database

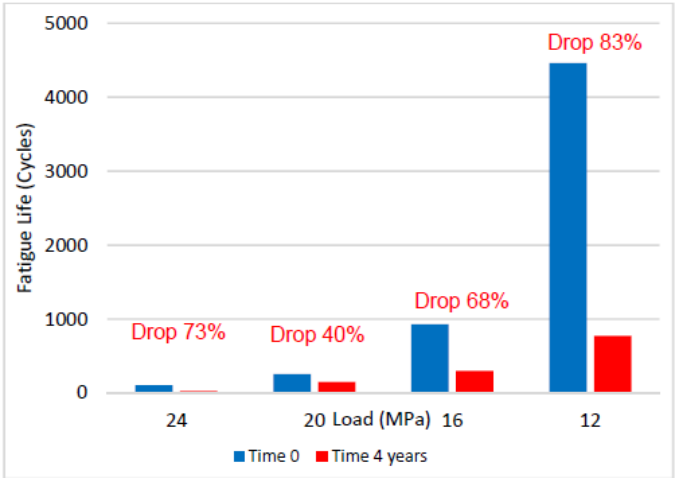
Improved FE Modeling Strategies with Multipoint Constraints for BGA Packages Subjected to Thermal Cycling

Finite Element simulations are often used to study the reliability of solder joints subjected to thermal cycling. Packaging configurations are becoming more complex to accommodate better functionality and performance. Increased complexity leads to several challenges for FE models including difficulties modeling thin layers and interfaces, as well as keeping the total numbers of nodes and elements to reasonable levels so that computation times can be practical. To reduce the use of high-density meshes and to relax the restrictions of nodal connections, the technique of Multi-Point Constraints (MPC) is often used in finite element analysis. In the MPC method, constraints are enacted between different degrees of freedom of the model to simply transition between finely and coarsely meshed regions. MPC algorithms require additional DOF constraints on a FE model; and extra contact nodes/ elements are deployed between the interfaces of contacting elements. MPC methods can be implemented with materials having linear or nonlinear mechanical behavior. The accuracy and efficiency of MPC-based finite element simulations for electronic packages have not been evaluated completely in the literature. In this work, an improved MPC based FE modeling strategy was developed for BGA packages to reduce the total number of elements (including both conventional and MPC elements), and thus reduce the simulation time. In addition, the new method can improve the simulation accuracy relative to models prepared using conventional meshing strategies. The proposed technique allows for different types of mesh patterns (circular pattern from solder joint and rectangular patterns from other component) to be connected in a package assembly while reducing the overall number of elements in the model. The proposed approach works with both symmetric and non-symmetric solder ball arrays, and achieves a good balance between simulation cost and simulation accuracy.



Effects of Long-Term Aging on SnAgCu Solder Joints Reliability in Mechanical Cycling Fatigue

For the past decade, the electronics industry has been switching to lead-free solders in the integrated circuit packages. Alloys with tin (Sn), silver (Ag) and copper (Cu) have been the most popular candidate in replacing the leaded solder joints. However, the reliability of SnAgCubased solder joints is a major challenge, especially in long-term applications. Many studies have been conducted to address the reliability issues of lead-free solder joints but without considering the effect of aging. Isothermal aging alters the structural and mechanical properties of the solder joints, which has a detrimental effect on their strength and fatigue life. This paper discusses (1) the effect of long-term isothermal aging at high temperature on SnAgCu Ball Grid Array components in high cycling fatigue (vibration), and (2) the effect of extended long-term isothermal aging at room temperature on individual SnAgCu solder joints in low cycling fatigue. The fatigue life of solder joints before and after aging was studied in both experiments. The results showed a significant impact of aging on the fatigue life of SnAgCu solder joints (i.e. the fatigue life dropped to 30% in long-term aging). In addition, only bulk solder joint failure was observed in all experiments.



Characteristic life degradation in SAC 105 alloy after 4 years of aging

Reliability Study of Doped Lead Free Solder Paste Alloys By Thermal Cycling Testing

This study was carried out to investigate the reliability performance of different electronic assemblies during thermal cycling testing. Various doped low creep lead-free solder alloys designed for high-temperature reliability have been used. The test boards used are 0.200" thick power computing printed circuit boards with MEGTRON6 as substrate material and OSP coating. Single-sided assemblies were built separately for the Top-side and Bottom-side of the boards. JEDEC JESD22-A104-B test standard was followed, the test boards were subjected to thermal cycling between the temperatures -40°C and +125°C respectively and 120-minute cycle profile with 45-minute transitions and 15-minute dwells at peak temperatures. The test assemblies include surface mount resistors, 5mm, 6mm, 13mm, 15mm, 17mm, 31mm, 35mm and 45mm ball grid array packages respectively. The failure data of 15mm CABGA208 and 17mm CABGA256 are used in this study to understand the effect of solder paste composition on the solder joint reliability during thermal cycling testing.

Announcements

Professor Lall Presents the AU Biometric Band at the NextFlex Innovation Day on Sept 20-21, 2017

CAVE3 had a booth at the NextFlex Innovation Day held in San Jose on Sept 20-21, 2017. Professor Pradeep Lall presented the Biometric Band and LifeSaver APP developed at Auburn University's NSF-CAVE3 Electronics Research Center. The biometric band is capable of acquiring vitals of the wearer and transmit them wirelessly to a paired smartphone. The band was designed, and fabricated in the NSF-CAVE3 Electronics Research Center labs.

The intended application for the technology product demonstrator (TPD) is for operators working on the inspection and maintenance on aircraft fuel tanks. The fuel tanks are small confined spaces in the aircraft, which reside in the fuselage and inside the wings of the aircraft. Inspection and maintenance operations require the operators to climb inside the confined space of the fuel tanks. Oxygen levels in a confined space may become depleted due to oxidation or depletion by another gas. The typical concentration of oxygen in the environment is 20.9-percent. When oxygen levels drop to 19.5-percent to 12-percent, judgment is impaired, and personnel may experience an increased pulse and fatigue. If levels drop further, from 12% to 6%, fatigue will worsen and nausea and vomiting will occur. A dual-use aspect of the technology may include the following applications - (1) monitoring of vitals of workers in high-heat environments to determine when workers need to come out of the heat before the effects of heat stress become a physical risk factor (2) monitoring of lone worker in a hazardous environment.

The band has been designed in wear-and-forget format with multiple bio-medical sensors including GPS, pulse-ox, pulse-rate, and electromyography sensor integrated with a microcontroller and Bluetooth communications link on a flexible high-density substrate. The smartphone app has been designed with the required logic for processing the vital signals of the operator with capability of autonomous decision making for contacting emergency services with the location of the operator if the operator well-being has deteriorated. The approach involved the design of flexible substrate for the assembly and integration of sensors with a microcontroller for the acquisition of signals and a Bluetooth module for the transmission of vital data to the paired smartphone. The multi-sensor biomedical band will be worn by the operator working in a confined space. The band will have multiple sensors including – GPS, pulse-ox, pulse-rate, and electromyography sensor for measurement of the loss of blood oxygenation resulting from depletion of oxygen in the environment in the fuel tank, abrupt changes in the pulse rate resulting from anxiety or claustrophobia, loss of consciousness, myocardial infarction, stroke, bradycardia or aneurysm. Additional sensors can be added if needed to address a broader range of medical conditions. The raw data from the sensors is gathered by the embedded microcontroller on the wearable band through the GPIO and transmitted via the Bluetooth sensor on the USART port of the microcontroller to the paired smartphone. The LifeSaver App is installed on the smartphone receives the transmitted data via the Bluetooth module and processes the data checking for imminent danger to the operator. If the status is OK, the app continues to monitor silently. However, if the operator is in imminent danger or in need of medical attention, the app autonomously contacts emergency medical services with the GPS location of the operator and details on the condition of the operator and the nature of the medical condition. Emergency medical personnel can be dispatched to the location of the operator immediately without any action needed on the part of the operator.

Auburn High School and Auburn Junior High students visit Flexible Additive Manufacturing Laboratory on E-Day

On Feb 23rd, we had the pleasure of hosting the Auburn High School and the Auburn Junior High School on E-day. Students considering a career in engineering joined us to get a sense of the look and feel of excitement of studying engineering at Auburn University. It is a chance to learn about the research programs, laboratory facilities, and research opportunities. Seventh through twelfth graders had an opportunity to chat one-on-one with students and faculty experience the interactive exhibits, including the new additive flexible electronics laboratory with capabilities of the vertically integrated manufacturing activities from design, fabrication, assembly, and test of flexible electronics. The students had a chance to see additive technology in action printing electronic circuits and sensors on non-planar and flexible surfaces. In addition, they had a chance to view methods used to study reliability of the assembled structures in operational environments.

Announcements

Professor Lall teaches Short-Course on Flexible Device Integration and Packaging at the 2018 FLEX Conference

Professor Lall co-taught a course on Flexible Device Integration and Packaging at the 2018 FLEX Conference with Doug Hackler (President and CEO of American Semiconductor) and Kurt Christensen (Senior Research Scientist at Optomec). The course which was well attended covered a number of topics including the manufacturing processes for the fabrication of printed electronics, die-thinning processes, assembly processes needed to assembly of ultra-thin chips on low temperature substrates, and the interconnection materials and technologies for first and second-level interconnects. In addition, Professor Lall also presented two papers and spoke at the High Performance Flexible Printed Electronics Special Session:

Lall, P., Hackler, D. Christensen, K., Short-Course: Flexible Device Integration and Packaging, 2018 FLEX Conference, Monterrey, CA, Feb 12-15, 2018

Lall, P., Zhang, H., Lall, R., Development of Flexible Biometric Sensor Band with LifeSaver APP, Session-7: Health Monitoring Systems, 2018 FLEX Conference, Monterrey, CA, Feb 12-15, 2018

Lall, P., Narangaparambil, J., Abrol, A., Test Protocols for Flexible Substrates in Wearable Applications, Session-14: Standards and Reliability, 2018 FLEX Conference, Monterrey, CA, Feb 12-15, 2018

Lall, P., High Performance Flexible Printed Circuits, NextFlex Special Session: High Performance Flexible Systems Roadmapping and Strategy, 8am-11am, Feb 16th, Held concurrently with the 2018 FLEX Conference, Monterrey, CA, Feb 12-15, 2018.

Shantanu Deshpande Wins ASME 2017 Electronic and Photonic Packaging Division Student Member of the Year Award

Shantanu Deshpande, doctoral candidate in mechanical engineering, won the American Society of Mechanical Engineers' 2017 Electronic and Photonic Packaging Division student member of the year award. The award recognizes a current student who has excelled in research and has shown promise to be a strong contributor in the field of electronic and photonic packaging. Only one student is selected every year for this national award. After earning his bachelor's degree in mechanical engineering from Pune University, Deshpande came to Auburn for his doctoral studies in 2012. He is working on reliability of copper wirebonding in harsh environments in the Center for Advanced Vehicle and Extreme Environment Electronics under the direction of Pradeep Lall, the John and Anne MacFarlane Professor of mechanical engineering.

Selected Recent Publications

1. Lall, P., Hackler, D. Christensen, K., Short-Course: Flexible Device Integration and Packaging, 2018 FLEX Conference, Monterrey, CA, Feb 12-15, 2018
2. Lall, P., Zhang, H., Lall, R., Development of Flexible Biometric Sensor Band with LifeSaver APP, Session-7: Health Monitoring Systems, 2018 FLEX Conference, Monterrey, CA, Feb 12-15, 2018
3. Lall, P., Narangaparambil, J., Abrol, A., Test Protocols for Flexible Substrates in Wearable Applications, Session-14: Standards and Reliability, 2018 FLEX Conference, Monterrey, CA, Feb 12-15, 2018
4. Lall, P., High Performance Flexible Printed Circuits, NextFlex Special Session: High Performance Flexible Systems Roadmapping and Strategy, 8am-11am, Feb 16th, Held concurrently with the 2018 FLEX Conference, Monterrey, CA, Feb 12 -15, 2018.
5. Akkara,F., Su, S., Thirugnanasambandang, S., Dawahdeh, A., Qasaimeh, A., Evans, J., Hamasha, S., Effects of Long-Term Aging on SnAgCu Solder Joints Reliability in Mechanical Cycling Fatigue, Proceedings of SMTA International, Rosemont, IL, pp. 419-425, Sep. 17-21, 2017.
6. Sridhar, S., Raj, A. Evans, J., Bozack, M., Johnson, W., Hamasha, S., Reliability Study of Doped Lead Free Solder Paste Alloys By Thermal Cycling Testing, Proceedings of SMTA International, Rosemont, IL, pp. 562-567, Sep. 17-21, 2017
7. Gordon, S., Thirugnansambandam, S., Sanders, T., Raj, A., Sridhar, S., Evans, J., Johnson, W., Hamasha, S., Reliability of Doped Ball Grid Array Components in Thermal Cycling After Long-Term Isothermal Aging, Proceeding of SMTA International, Rosemont, IL, pp. 438-442, Sep. 17-21, 2017
8. Lall, P., Kothari, N., Deep, J., Foley, J., Lowe, R., X-ray Micro Computed Tomography Based FE Models For Potted Fuze Electronics Assemblies, Proceedings of SMTA International, Rosemont, IL, pp. 253-263, Sep. 17-21, 2017
9. P. Lall, Y. Luo and L. Nguyen, "Package-level Multiphysics Simulation of Cu-Al WB Corrosion under High Temperature/ humidity Enviornmental Conditions," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1176-1184, May 30 - June 2, 2017 .
10. P. Lall, N. Kothari, J. Deep and R. Lowe, "Assessment of Reliability of Missile Fuze using Micro-CT Data Based Finite Element Technique and Digital Volume Correlation," in *Proceedings of the 16th ITherm*, Orlando, FL,pp. 1131-1138, May 30 - June 2, 2017.
11. P. Lall, H. Zhang and L. Davis, "Color Shift Analysis and Modeling of High Power pc-LED under High Temperature and High Humidity Enviornment," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1161-1177, May 30 - June 2, 2017.
12. P. Chowdhury, J. Suhling and P. Lall, "Experimental Characterization of Underfill Materials Exposed to Different Moisture," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1197-1208, May 30 - June 2, 2017.
13. P. Lall, A. S. Abrol, J. Suhling, L. Simpson, J. Glover and D. Locker, "Effect of Simultaneous High Temperature and Vibration on MEMS based Vibratory," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1214-1228, May 30 - June 2, 2017.
14. M. Alam, J. Suhling and P. Lall, "High Temperature Tensile and Creep Behavior of Lead Free Solders," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1229-1237, May 30 - June 2, 2017.
15. P. Lall and J. Wei, "X-ray Micro-CT and DVC Based Analysis of Strains in Metallization of Flexible Electronics," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1253-1261, May 30 - June 2, 2017.
16. P. Lall, K. Dornala, J. Deep and R. Lowe, "Effectiveness of Potting Methods and Underfills on the Enhancement of Survivability of Fine Pitch Electronics at 25000g Shock Loads," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1262-1274, May 30 - June 2, 2017
17. P. Lall, S. Deshpande and L. Nguyen, "Study of Electromigration in Cu and Ag Wirebonds Operating at High Current in Extreme Environments," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1275-1284, May 30 - June 2, 2017.
18. P. Lall, D. Zhang, J. Suhling and D. Locker, "Evolution of High Strain Rate and High Temperature Mechanical Properties of SAC305 with Long Term Storage up to 1-Year," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1285-1297, May 30 - June 2, 2017.
19. P. Lall and K. Goyal, "Study on the Effect of Fixtures on Deformation and Warpage of the Double-Sided Flexible Printed Circuit Board through Reflow Using DIC," in *Proceedings of the 16th ITherm*, Orlando, Fl, pp. 1306-1314, May 30 - June 2, 2017.
20. P. Lall, S. Deshpande and L. Nguyen, "Effect of EMCs on the High Current Reliability of Cu Wirebonds Operating in Harsh Environments," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1315-1324, May 30 - June 2, 2017.
21. N. Fu, J. Suhling, S. Hamasha and P. Lall, "Long Term Isothermal Aging Effects on the Cyclic Stress-Strain Behavior of Sn-Ag-Cu Solders," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1337-1345, May 30 - June 2, 2017.
22. N. Fu, J. Suhling, S. Hamasha and P. Lall, "Evolution of the Cyclic Stress-Strain and Constitutive Behaviors of SAC305 Lead Free Solder during Fatigue Testing," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1353-1360, May 30 - June 2, 2017.
23. M. Chowdhury, N. Fu, J. Suhling and P. Lall, "Evolution of the Cyclic Stress-Strain Behavior of Doped SAC Solder Materials Subjected to Isothermal Aging," in *Proceedings of the 16th ITherm*, Orlando, FL,pp. 1369-1379, May 30 - June 2, 2017.
24. A. Fahim, S. Ahmed, J. Suhling and P. Lall, "Nanomechanical Characterization of IMCs Formed in SAC Solder Joints Subjected to Isothermal Aging," in *Proceedings of the 16th ITherm*, Orlando, Fl, May 30 - June 2, pp. 1398-1408, 2017.
25. S. Ahmed, J. Suhling and P. Lall, "The Anand Parameters of Aging Resistant Doped Solder Alloys," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1416-1424, May 30 - June 2, 2017.
26. P. Lall, V. Yadav, J. Suhling and D. Locker, "Effect of Storage on High Strain Rate Mechanical Properties of SAC105 at Operating Temperature up to 200°C," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1433-1446, May 30 - June 2, 2017.
27. P. Lall, V. Yadav, J. Suhling and D. Locker, "High Strain Rate Mechanical Behavior of SAC-Q Solder," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1447-1455, May 30 - June 2, 2017.
20. C. Chen, J. Suhling and P. Lall, "Improved Finite Element Modeling Strategies with Multipoint Constraints for BGA Packages Subjected to Thermal Cycling," in *Proceedings of the 16th ITherm*, Orlando, FL, pp. 1456-1465, May 30 - June 2, 2017
21. N. Fu, S. Ahmed, J. C. Suhling and P. Lall, "Visualization of Microstructural Evolution in Lead Free Solders," in *Proceedings of the 67th ECTC*, Florida, pp. 429-440, May 30 - June 2, 2017.
22. S. Ahmed, M. Hasine, J. C. Suhling and P. Lall, "Mechanical Characterization of SAC Solder Joints at High Temperature Using Nanoindentation," in *Proceedings of the 67th ECTC*, Florida, pp. 1128-1135, May 30 - June 2, 2017.
23. P. Lall, D. Zhang, V. Yadav, J. Suhling and D. Locker, "Effect of Prolonged Storage up to 1-Year on the High Strain Rate Properties of SAC Leadfree Alloys at Operating Temperatures up to 200 °C," in *Proceedings of the 67th ECTC*, Florida, pp. 1219-1230, May 30 - June 2, 2017.

Selected Recent Publications

24. P. Lall, K. Mirza, J. Suhling and D. Locker, "Effect of Mean Temperature on the Evolution of Strain-Amplitude in SAC Ball -Grid Arrays during Operation under Thermal Aging and Temperature Excursions," in *Proceedings of the 67th ECTC*, Florida, pp. 1027-1038, May 30 - June 2, 2017.
25. P. Lall, S. Deshpande, Y. Luo and L. Nguyen, "Model for Interaction of EMC Formulation with Operating Current and Reliability of Cu-Al Wirebonds Operating in Harsh Enviorments," in *Proceedings of the 67th ECTC*, Florida, pp. 815-826, May 30 - June 2, 2017.
26. P. Lall, N. Kothari, J. Deep, J. Foley and R. Lowe, "Development of FE Models and Measurement of Internal Deformations of Fuze Electronics Using X-Ray MicroCT Data with Digital Volume Correlation," in *Proceedings of the 67th ECTC*, Florida, pp. 497-596, May 30 - June 2, 2017.
27. P. Lall and H. Zhang, "Test Protocol for Assessment of Flexible Power Sources in Foldable Wearable Electronics under Stresses of Daily Motion during Operation," in *Proceedings of the 67th ECTC*, Florida, pp. 804-814, May 30 - June 2, 2017.

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

Auburn University is an Equal Opportunity
Educational Institution/Employer.

Mechanical Engineering-CAVE3-3/2018

cave³ News

Spring 2018

cave.auburn.edu

www.auburn.edu

If you have recently changed your address or have colleagues who would be interested in receiving the CAVE³ 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.
- ☐ Please remove me from the CAVE News mailing list.
- ☐ My address has changed, please update it.
- ☐ Please add me to the CAVE email mailing list.

Name: _____ Country: _____

Title: _____ Phone #: _____

Company: _____ Fax #: _____

Address: _____ E-mail: _____

Comments and suggestions: _____

City: _____ State: _____ Zip: _____ _____