Harsh-Environment Node of NextFlex at Auburn University
Message from the Director

I am glad to report that Auburn University has been selected to lead a national manufacturing effort on harsh environment electronics as part of a U.S. Department of Defense led flexible hybrid electronics institute.

On Friday, Aug. 28, at NASA's Ames Research Center, Department of Defense Secretary Ashton Carter announced a cooperative agreement to the research consortium FlexTech Alliance to establish and manage a Manufacturing Innovation Institute for Flexible Hybrid Electronics, or FHE MII. FlexTech Alliance, based in San Jose, California, will coordinate the FHE MII, which comprises 96 companies, 11 laboratories and non-profits, 43 universities and 15 state and regional organizations. Auburn University will head the only node in the state of Alabama.

The harsh environment focus of Auburn's node aligns well with the core strengths of Auburn's NSF Center for Advanced Vehicle and Extreme Environment Electronics (CAVE). In the center, we have been working on electronics performance, reliability and survivability in extreme environments for the automotive, military and defense companies and federal agencies. Establishment of a national harsh environment node for FHE MII will provide engineers with the integrated skills and theoretical background for the manufacture of flexible hybrid electronics for extreme environment applications, as well as create intellectual property, expenditures on research, education and related activities leading to a measurable economic impact by generating jobs and catalyzing development of technologies which can be manufactured in Alabama.

We have developed strategic partnerships with industry and research labs not only in Alabama, but across the nation for development and demonstration of technologies for harsh environment operation. Alabama is home to more than 200 aerospace and defense companies including Lockheed Martin, Northrop Grumman, Raytheon and Boeing. Redstone Arsenal is home to government agencies including the U.S. Army, NASA and MDA. In addition, Alabama is home to several automotive manufacturers and their electronics suppliers.

Flexible Electronics Harsh Environment Node will focus on the manufacturing challenges related to raw materials, materials handling, fabrication and assembly of flexible electronics for harsh environments, as well as TRL4 technologies for use in automotive, military and defense environments. The focus of flexible electronics fabrication will be on processes which meet the demands of soft, pliant and often easily damaged surfaces capable of low temperature processing. We will partner with industries to create demonstrators for new technologies such as printed flexible roll-to-roll electronics to mitigate the risk associated with the use of the new technologies in end-applications, as well as creating device designs for stretchable electronics.

Auburn University's prior expertise uniquely positions the Flexible Electronics Harsh Environment Node to make a positive impact on the creation of manufacturing jobs related to the manufacture of flexible electronics.

- Pradeep Lall, John and Anne MacFarlane Endowed Professor and Director, Harsh-Node of NextFlex
AGENDA

8:00-8:30  Check in

8:30-8:55  Overview of the FlexTech Team and FHEMII  
         Paul Semenza, Director of Commercialization, FlexTech

8:55-9:20  AU Harsh Environment Node  
         Pradeep Lall, Ph.D., Endowed Professor, Auburn University

9:20-9:45  Flexible Electronics Applications in Aerospace Environments  
         Benjamin Leever, Gooi CTO NextFlex, Air Force Research Laboratories

9:45 – 10:10  Challenges and opportunities in the flexible electronics manufacturing  
         Amanda Schrand, Additive Manufacturing for Fuze Electronics and Design Fuzes, Eglin AFB

10:10-10:35  Importance of Flexible Electronics in Army Applications  
         Mike Bieri, AMRDEC

10:35-10:45  Break

10:45-11:10  Flexible Electronics – A Parts and Packaging Perspective  
         Bruce Hughes and David Locker, AMRDEC

11:10-11:35  Flexible Electronics in Commercial and Military Application  
         Erick Seltmann, Boeing

11:35-12:00  Survivability Testing of Flexible Electronics – Pop Shock  
         Ryan Lowe, ARA Associates

12:00-1:15  Working Lunch – Importance of Manufacturing to the Alabama Economy  
         John M. Mason, Jr., Vice President for Research and Economic Development, Auburn University  
         Christopher B. Roberts, Dean, Samuel Ginn College of Engineering, Auburn University

1:15-1:40  LM priorities and Objectives for FHEMII  
         Jeff Stuart and Jim Libous, Lockheed Martin

1:40-2:05  Additive Manufacturing of Flexible Electronics  
         Mike O’Reilly, Director, Optomec, Inc.

2:05-2:30  Ultra-thin Chips for Flexible Electronics  
         Val Marinov, Uniqarta, Inc.

2:30-2:55  Inkjet and Aerosol Jet for Digital Deposition  
         Tim Luong, Ceradrop MGI

2:55-3:05  Break

3:05-5:00  Break-Out Sessions  
         This section of the program will be a working session on project road-mapping, teaming and proposal development for the 1st year.
Economic Impact

*In Alabama:*

There is a strong presence of aerospace, defense and automotive companies in Alabama, all of which rely on harsh environment flexible electronics. With this addition, we are poised to increase the workforce needed throughout the state because of the new technologies created. In addition, manufacturing will be expanded with a base for higher-paying job opportunities. In addition, the state’s economic development plan “Accelerate Alabama” focuses specifically on these product categories. Auburn has formed relationships with several companies in these industries through past work in the area of harsh environment electronics and looks to continue and strengthen these relations.

*In the nation:*

The institute’s activities will benefit a wide range of markets including defense, automotive, communications, consumer electronics, medical devices, health care, transportation and logistics and agriculture. The impact on the trade deficit will also be positively felt through creation of a domestic supply-chain in flexible electronics. Currently, the largest portion of the trade deficit is driven by elevated imports of manufactured electronic goods. We can assist in driving that deficit down through the creation of electronic manufacturing within the state and country.

**Overall Positive Effects**

Eleven targeted business sectors, along with areas of focus for each, have been identified for the state of Alabama to focus its recruitment, retention and renewal efforts over the next three years. The determination of these targets involved the review of the current business/industry base in Alabama, current targeted sectors of state, regional and local economic development organizations in Alabama, as well as the various power provider, recent project activity, and other emerging sectors that have shown growth at the national, state, and possibly local level. The strengths of Alabama
related to each sector were also considered. The targeted sectors and areas of focus are outlined below and further defined in this section.
Work with Us

What Do Companies Hope to Gain from the Institute?

Companies engaging in partnership with the institute can do the following:

1. Become part of teams that bid on project calls on the topic of flexible electronics
2. Align focus of the proposed project with their next-generation product needs
3. Ability to task project teams with development of product technology demonstrator in pre-competitive format
4. Realize the benefits of 1:1 cost-share provided by the federal grant to the institute.

Project Calls

- We anticipate targeted project calls each year based on consensus roadmaps prepared by the Technical Council and endorsed by the Governing Council.
- The first project call is tentatively expected to be released in November 2015. To receive notice of the project calls, ensure you are on our interest list by registering at www.FHEMII.com.
- If you were on the proposal team, you will automatically be placed on the interest list and receive all communications from the MII.

Introducing Technology to Nextflex

There are multiple ways to participate in, or introduce your technology, products or needs, to the FHE MII, including:

1. Join the FHE MII and represent your interests at program reviews, meetings and workshops.
2. Submit proposals to the project calls.
4. Email a summary of your technology and market applications at info@fhemii.com. These will be cataloged for staff and members to access as needed.
About the Institute

Auburn University and the Samuel Ginn College of Engineering have a rich history in harsh environment electronics research. In 1999, the National Science Foundation Center for Advanced Vehicle and Extreme Environment Electronics (CAVE3) was established at Auburn as a national center of excellence in harsh environment electronics. The harsh environment node, which represents Auburn University and Stanford University and a number of companies and government laboratories. Since its inception CAVE3 has formed a number of long-term partnerships among industry, government and academic agencies.

The center has benefited from a strong nexus in the area of harsh environment electronics because of a strong presence, in Alabama, of major automotive and transportation companies, including Honda, Kia, Hyundai, Toyota, Mercedes, ThyssenKrup and International Diesel. In addition, the Huntsville area is home to the Redstone Arsenal and more than 238 aerospace and defense companies. Approximately 17 faculty and 53 students are engaged in research projects in various area related to extreme environment electronics.

Primary focus of the research is on extreme environments which includes wide temperature extremes, high humidity, exposure to vibration loads and high-g shock loads. The center has extensive capabilities for board and component fabrication and assembly. Accelerated test capabilities are performed for thermal cycling and humidity exposure capable of addressing wide
temperature extremes from geothermal applications to space environments. Mechanical shock capabilities include shock towers capable of 100,000g of acceleration. Notable non-destructive inspection capabilities include X-ray MicroCT system with 3D rendering capabilities.

Facilities

The National Science Foundation Center for Advanced Vehicle and Extreme Environment Electronics (CAVE3) has a demonstrated focus on electronics reliability in extreme environments and its research capabilities include several laboratories. The Center is in Phase-III of the NSF IUCRC grant award. Research in the center is supported by 29 members.

CAVE3 Facts

- Founded in 1999
- Located at Auburn University
- Phase three NSF center
- Supported by 29 members
- Research focus on harsh environments
- 17 faculty (engineering and sciences)
- 53 students
- 15 laboratories

Modeling and Simulations Tools

The laboratory has a full suite of computer-aided design, and high-end simulation tools. Computer-aided design tools include pro-engineer and solid edge. Simulation tools include, ANSYS, LS-DYNA, ABAQUS, ABAQUS/Explicit, NASTRAN and MATLAB. The laboratory is well equipped with dual processor pentium-class workstations, and Unix multi-processor compute server.

Transient Dynamics Laboratory

The laboratory houses state-of-art tools used for measurement of high-speed, high strain rate transient dynamic events such as shock and vibration. Equipment includes high speed data acquisition systems, Vision Research Phantom-Series high-speed camera capable of 275,000 fps, SAI 3D image tracking software for high-speed image analysis and measurement, oscilloscopes, HP Spectrum Analyzers, vishay instruments 2311 high-speed wide-band strain-gage amplifier, motion-control drop tower, LDS v700 Series vibration system. Full-field strain measurement capabilities using digital image correlation.

CT Scan

The laboratory has a CT scan capability which allows the examination of defects and failure modes including voids, cracks, delamination with a micron-level resolution. Reconstruction tools such as volume graphics are also available in the laboratory.
μCT system

3D-Printers

Surface Mount Assembly
This laboratory includes a state-of-the-art high volume surface mount assembly line capable of flip chip assembly, as well as other equipment for advanced electronics packaging including manual and automated wire bonders, encapsulant dispense systems, facilities for thick/thin film hybrid circuit fabrication on ceramic substrates, and a vacuum solder sealing system for MEMS and SiC packaging. The surface mount assembly line can be used for prototype creation, fabrication of test structures, development of manufacturing processes or new product launch platform. In addition, in-line inspection capabilities enable x-ray, acoustic and laser profilometry based inspections. In addition, the laboratory has semi-automatic placement machines and rework stations. Specific equipment includes MPM AP solder paste printer with vision system, Agilent SP1 solder paste inspection system, Asymtek Flux jetting system, Siemens SIPLACE 80F5 Pick and Place machine, VISCOM VPS 6053 automated optical inspection system, Heller 1800 solder reflow conveyor oven with nitrogen capability, Slim-KIC 2000 thermal profiling system, CAM/ALOT 3700 encapsulant dispense system

Electronic Packaging

Our facilities and laboratories include the most cutting-edge electronic packaging equipment such as the Air Vac DRS24 solder rework station, Semiconductor Equipment Corporation 4150 Split Optics Alignment System for die placement, Karl Suss thermocompression flip chip bonder, Yield Engineering YES-R3 plasma etch System, Palomar products Model 2460-V automatic thermosonic wire bonder, K&S Model 2071 VFP automatic wedge bonder, Asymtek Model 402 dispensing system, Fisher Scientific programmable cure oven, ATV Model PEO 601 programmable brazing furnace, SST 3150 vacuum sealing furnace. The assembly and packaging resources are supported by inspection and failure analysis equipment including a Phoenix micro-focus x-ray system, Sonix C-mode scanning acoustic microscopy (CSAM) system, WYCO wafer inspection system, Tencor surface profilometer, Brookfield viscometer, Dage PC2400 pull and shear tester, and optical and scanning electron microscopes.

Accelerated Testing Laboratory

This laboratory includes capabilities for imposing various steady-state and cyclic temperature and humidity stresses. Chambers includes 3 Blue-M thermal cycling ovens, two liquid-to-liquid thermal shock systems, a Ransco air-to-air thermal shock system, two humidity chambers, and an express test HAST chamber.
Material Characterization

Major equipment includes Instron 3367 with several load cells, LVDTs, Blue-Hill software, micro-scale mechanical testing system, facilities for calibration and application of stress and thermal test chips, and an environmental vibration system, an infrared thermal imaging system, and several custom-built apparatuses for characterizing thermal resistance of materials and assemblies.

Surface Analysis Laboratory

The Surface Science laboratory includes several Scanning Electronic Microscopes (SEMs) with heating capabilities, and a Transmission Electron Microscope (TEM). Method capabilities include Energy Dispersive X-Ray Spectroscopy (EDS), X-Ray Photoelectron Spectroscopy (XPS), Scanning Auger Spectroscopy (SAS), and Rutherford Backscattering Spectroscopy (RBS).

Micro-Fabrication Laboratory

CHA Mark 50 dual E-beam/sputter/ion gun deposition system, plasma reactive ion etcher, applied materials 8130 metal etcher, applied materials 8110 oxide etcher, applied materials 8110 oxide etcher, Matrix 103 asher, Matrix 303 etcher, Karl Suss MA/BA 6 frontside/backside mask aligner, wet benches, thermco oxidation and diffusion furnaces, Tempress LPCVD system, nickel and gold plating, STS ASE 100 DRIE, STS AOE 100 DRIE, CO2 critical point dryer, room temperature ion deposition/milling system.

Stanford Partnership

We have access to world-class facilities including the Stanford Nanofabrication Facility (SNF), the Stanford Nanocharacterization Lab (SNL) and the Stanford Nano Center (SNC). These campus-wide shared facilities are part of the National Nanotechnology Infrastructure Network (NNIN) funded by the National Science Foundation (NSF) with management support from Stanford University. In addition, we have access to unique characterization equipments for performing wide range of experiments to study the electrical and thermal properties of devices. All of these will support the proposed research.

Manufacturing and Development Goals

A primary institute goal is to accelerate technology adoption into advanced products by developing and commercializing advanced manufacturing technologies. The institute will leverage the electronics industry and the high performance printing industry, both well-established US industrial and academic areas of strength. The five FHE core manufacturing focus areas are included below:
1. Device integration and packaging
2. Materials
3. Printed flexible components and microfluidics
4. Modeling and design
5. Standards, tests and reliability

It is envisioned that the potential for adoption of the flexible electronics technologies for high volume consumer products will be greatly increased through reduction in the risk-related to the use of the flexible architectures. The reduction in the risk will be achieved through the efforts on enablement of infrastructure technologies and populating the NextFlex harsh node’s technology shelf. The infrastructure technologies are foundational technologies that impact a number of different technology demonstrators including - Human performance and medical devices, IoT, wearable electronics, vehicle structural sensors, information devices and RF, communication components and DOD unique applications. The technology demonstrators will populate the technology shelf as well. It is envisioned that the NextFlex harsh node’s efforts in the area of infrastructure technologies will result in the creation of proprietary technologies and result in reduction of risk related to the broader use of flexible technologies through better understanding of – scalability for high volume production, characterization of process windows, potential defects and solutions, process controls, expected defect rates in ppm or ppb. The NextFlex harsh node on flexible hybrid electronics will focus on the transitioning TRL4 infrastructure technologies and cross the chasm between laboratory research and high volume product implementation. In this program, the technology diffusion time will be greatly reduced through IMI’s ecosystem in partnership with industry and academia for the creation of a technology shelf and technology demonstrators.
Auburn Location

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