12. Additive Flexible Hybrid Electronics – Manufacturing and Reliability

Course Leader: Pradeep Lall – Auburn University

Course Description:

In this course, manufacture, design, assembly, and accelerated testing of additively-printed flexible hybrid electronics for applications in some of the emerging areas will be covered. Manufacturing processes for additive-fabrication of flexible hybrid electronics will be discussed. Flexible hybrid electronics opens the possibilities for the development of stretchable, bendable, foldable form-factors in electronics applications, which have not been possible with the use of rigid electronics technologies. Flexible electronics may be subjected to strain magnitudes in the neighborhood of 50-150 percent during normal operation. The integration processes and semiconductor packaging architectures for flexible hybrid electronics may differ immensely in comparison with those used for rigid electronics. The manufacture of thin electronic architectures requires the integration of thin-chips, flexible encapsulation, compliant interconnects, and stretchable inks for metallization traces. A number of additive manufacturing processes for the fabrication and assembly of flexible hybrid electronics have become tractable. Processes for handling, pick-and-place operations of thin silicon and compliant interposers through interconnection processes such as reflow requires an understanding of the deformation and warpage processes for development of robust process parameters which will allow for acceptable levels of yields in high-volume manufacture. Modeling of operational stresses in flexible electronics requires the material behavior under loads including constant exposure to human body temperature, saliva, sweat, ambient temperature, humidity, dust, wear and abrasion. The strains imposed on flexible stretchable electronics may far exceed those experienced in rigid electronics requiring the consideration of finite-strain formulation in development of predictive models. The failure mechanisms, failure modes, acceleration factors in flexible electronics under operational loads of stretch, bend, fold and loads resulting from human body proximity are significantly different than rigid electronics. The testing, qualification and quality assurance protocols to meaningfully inform manufacturing processes and ensure reliability and survivability under exposure to sustained harsh environmental operating conditions, may differ in flexible electronics as well. A number of product areas for the application of flexible electronics are tractable in the near-term including Internet-of-Things (IoT), medical wearable electronics, textile woven electronics, robotics, communications, asset monitoring and automotive electronics.

Course Outline:

1. Additive Technologies in Flexible Electronics
2. Laser-direct Sintering
3. In-Mold Labeling
4. Aerosol-Jet Printing
5. Ink-Jet Printing
6. Screen-Printing and Gravure Printing
7. Ultra-Thin Chips
8. Die-Attach Materials for Flexible Semiconductor Packaging
9. Compliant Interconnects
10. Flexible Encapsulation Materials
11. Dielectric Materials for Large-Area Flexible Electronics
12. Flexible Substrates
13. Stretchable Inks for Printed Traces

14. Pick-and-Place and Material Handling Processes for Thin Chips
15. Reflow and Printing Processes
16. Accelerated Testing Protocols

Who Should Attend:
The targeted audience includes scientists, engineers and managers considering the use of additively-printed flexible electronics or considering moving from rigid electronics to flexible electronics, as well as reliability, product or applications engineers who need a deeper understanding of additively-printed flexible electronics: the advantages; limitations; and, failure mechanisms.

Bio:
Pradeep Lall is the John and Anne MacFarlane Endowed Distinguished Professor in the Department of Mechanical Engineering with a courtesy joint appointment in both the Department of Electrical and Computer Engineering and in the Department of Finance. He serves on the technical council and governing council of NextFlex Manufacturing Institute. He is the Director of the NSF Center for Advanced Vehicle and Extreme Environment Electronics at Auburn University. He is author and co-author of 2-books, 14 book chapters, and over 600 journal and conference papers in the field of electronics reliability, safety, energy efficiency, and survivability. Dr. Lall is a fellow of the ASME, fellow of the IEEE, a Fellow of NextFlex Manufacturing Institute, and a Fellow of the Alabama Academy of Science. He is recipient of the Auburn Research and Economic Development Advisory Board Award for Advancement of Research and Scholarship Achievement, IEEE Sustained Outstanding Technical Contributions Award, National Science Foundation's Alex Schwarzkopf Prize for Technology Innovation, Alabama Academy of Science's Wright A. Gardner Award, IEEE Exceptional Technical Achievement Award, ASME-EPPD Applied Mechanics Award, SMTA's Member of Technical Distinction Award, Auburn University's Creative Research and Scholarship Award, SEC Faculty Achievement Award, Samuel Ginn College of Engineering Senior Faculty Research Award, 3 - Motorola Outstanding Innovation Awards, 5 - Motorola Engineering Awards, and over 30 Best-Paper Awards at national and international conferences. Dr. Lall has served in several distinguished roles at national and international levels including serving as member of National Academies Committee on Electronic Vehicle Controls, Member of the IEEE Reliability Society AdCom, IEEE Reliability Society Representative on the IEEE-USA Government Relations Council for R&D Policy, Chair of Congress Steering Committee for the ASME Congress, Member of the technical committee of the European Simulation Conference EuroSIME, Associate Editor for the IEEE Access Journal, and Associate Editor for the IEEE Transactions on Components and Packaging Technologies. Dr. Lall is the founding faculty advisor for the SMTA student chapter at Auburn University and member of the editorial advisory board for SMTA Journal. He received the M.S. and Ph.D. degrees in Mechanical Engineering from the University of Maryland and the M.B.A. from the Kellogg School of Management at Northwestern University.