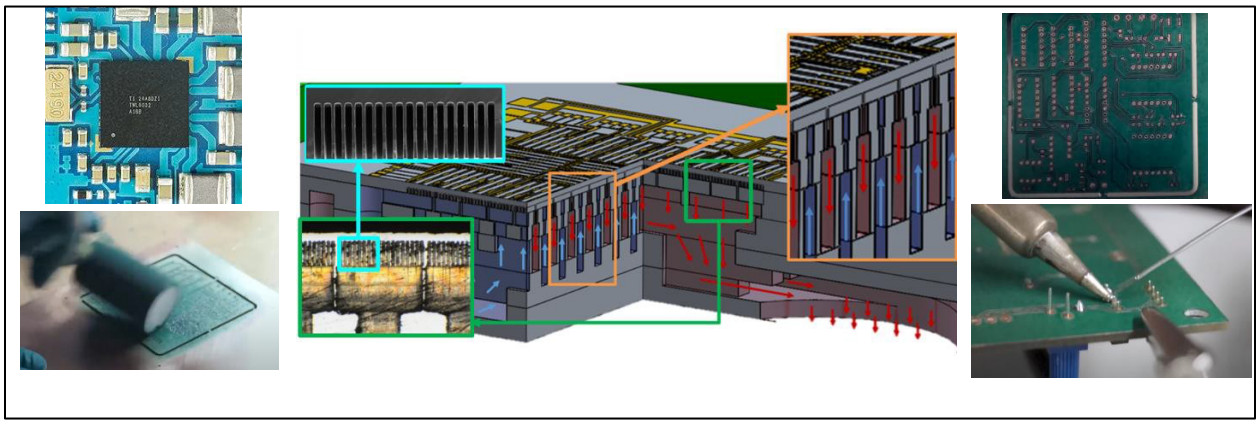
ECE 3893: Introduction to Heterogeneous Integration and Electronics Packaging

Spring 2024

Tentative Syllabus (11/2023)

Course Overview: This Undergraduate-Level Engineering course leverages both theoretical and hands-on instruction methods for an introductory understanding of modern Heterogeneous Integrated electronic packaging systems and underlying cross-disciplinary knowledge for characterization and design. Knowledge and experience gained from this course will have direct applicability to multiple industries, some of which include Defense, Aerospace, Automotive, Consumer Electronics, as well as many other rapidly growing industries.



Instructors: Prof. Muhannad Bakir (mbakir@ece.gatech.edu)
Office: Marcus 4135; Office Hours: TBD

Laboratory TA: TBD

Topics Covered:

1. Overview of HI and Electronics Packaging
2. Material Selection and Characterization
3. Electrical Design and Characterization
4. Package Fabrication
5. Thermal Design and Characterization
6. Mechanical Design and Characterization

Format

- 2 hours Lecture per week
- 3 hours laboratory per week (Unsupervised Laboratory)
  The laboratory will consist of a short virtual tutorial (1 hour or less) followed by two hours of laboratory assignments/exercises.

Prerequisites

Junior-Level standing in an ABET Accredited Undergraduate Engineering Program. Restricted to all COE students who are not freshmen or sophomore.

Reference Textbook: Fundamentals of Device and Systems Packaging: Technologies and Applications, Second Edition edited by Rao. R. Tummala, McGraw Hill, 2019. *This book can be downloaded from the library. Go to Databases – Access Engineering and search for the book title*.

Grading

Quizzes (online)	20%
Laboratory Assignments Weekly	65%
Final Exam	15%

Note: This course was jointly developed by several universities shown below. Specific acknowledgment goes to the following instructors:

Georgia Tech: Muhannad Bakr, Email: mbakir@ece.gatech.edu
Georgia Tech: Mohan Kathaperumal, Email: kmohan@ece.gatech.edu
Georgia Tech: Ethan Shackelford, Email: eshackelford3@gatech.edu
Purdue University: Ganesh Subbarayan, Email: gss@purdue.edu
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Pre-recorded tutorials for the laboratory sections and pre-recorded lectures from these instructors will be used in addition to the in-person classroom instruction.

Course Outcome

1. Explain the role of electronic packaging, and describe the reasons for heterogeneous integration.
2. Understand and analyze electrical, thermal, and mechanical behavior of electronic packages.
3. Understand and characterize material behavior.
4. Understand electronic package manufacturing process.
5. Describe processes and failure using statistical models.

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/.Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Student-Faculty Expectations Agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See

http://www.catalog.gatech.edu/rules/22/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

This (below) was a tentative outline from SPRING 2022; we will follow a similar list of topics in spring 2024. The list will be updated before the start of the Spring term

Tentative Outline

1/10	Course Introduction; Introduction & Microsystems Integration
1/12	Fundamentals of Packaging & Emerging Applications
1/17	Holiday
Fundamentals of Package Fabrication	
1/19	Chip and Substrate Fabrication
1/24	Assembly
	Lab: Package Fabrication (PCB Milling & Soldering)
Electrical Design & Characterization	
1/26	Resistance, Capacitance & RC Behavior I
1/31	Resistance, Capacitance & RC Behavior II
	Lab: Interconnect, Capacitance & RC Behavior
Material Selection & Characterization	
2/2	Atomic Structure & Bonding in Solids
2/7	Phase Diagrams
	Lab: Microstructural Characterization and Mechanical Properties of Interconnects
2/9	Characterization: Scanning Electron Microscopy (SEM) and Energy Dispersive Microscopy (EDS)
2/14	Characterization: X-ray Microtomography
	Lab: Pb-Sn Optical and SEM
2/16	Nanoindentation 1
2/21	Nanoindentation 2
	Lab: Nanoindentation of Solder Joint
Electrical Design & Characterization	
2/23	Delay, Latency & Transmission Lines I
2/28	Delay, Latency & Transmission Lines II
	Lab: Interconnect Delay, Latency & Transmission Lines
3/2	Density, Energy, Data Rate & Bandwidth
3/7	Power Delivery
	Lab: Eye Diagrams and Power Delivery
Thermal Design & Characterization	
3/9	Introduction to Heat Transfer
3/14	Introduction to Heat Transfer (cont.)
	Lab: Spreading Resistance and Thermal Interface Resistance
3/16	Basics of Electronic Cooling
3/21	Spring Break
3/23	Spring Break
3/28	Basics of Electronic Cooling (cont.)
	Lab: Air-Cooled Heat Sinks and Water-Cooled Cold Plates

4/4	Basics of Electronic Cooling (cont.)
4/6	Basics of Electronic Cooling (cont.)
	Lab: Immersion Cooling and Heat Pipes

Mechanical Design & Characterization

4/11	Motivation for Mechanical Design
4/13	Fundamentals of Mechanical Design
	Lab: Strain Measurement
4/18	Bars and Beams
4/20	Thermoelasticity
	Lab: Modulus Measurement
4/25	Accelerated Testing and Acceleration Factor
	Lab: Mechanical Characterization of Solder (if time permits)
5/4	Final Exam