ECE/MSE/ME 6776: Microelectronics Systems Packaging
Spring 2024

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Office Hours: Thursday 3:30-4:30 PM
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Class time: TH 2-3:15 PM
Class Location: Klaus 1447

Text Book:

- Fundamentals of Device and Systems Packaging: Technologies and Applications, 2nd Edition, Rao Tummala; (Available online through GT Library [AccessEngineering Database])
- Will supplement the course with journals and conference proceedings

Course Overview:
Course overview: Monolithic silicon integrated circuits (ICs) have progressed at an unprecedented rate of innovation in the past 60 years through Moore's Law. During much of these 60-years, electronic packaging played a 'secondary-role' – the package was there to enable simple space transformation and routing of interconnects off-chip. This, however, has changed. Today, advanced packaging and heterogeneous integration have evolved to be critical enablers to the next phase of Moore's Law. It is widely accepted that classical monolithic integration can no longer simultaneously meet performance, power, and cost needs of future electronics, and thus, giving rise to the ever more critical fields of "advanced packaging" and "heterogeneous integration." In this class, we explore traditional packaging technologies and emerging new heterogeneous integration architectures based on 2.5D and 3D integrated circuits. This class will explore these important new integration technologies along with understanding some of the electrical, thermal, and thermo-mechanical design considerations. The course material is both very timely and exciting given the revolutionary changes happening today in IC design and technology.

Grading:
Homework: 10% (graded based on effort)
Exams: Two in class exams each 22.5% (45% total)
Project: Written proposal: 30%
Proposal class presentation: 15%

Exams: There will be two exams during the semester. All exams are closed book and closed notes. You may bring one US letter page (8.5 by 11 inches, one side) of **handwritten** notes and formulas to each of the two exams (along with a scientific calculator).

Project: ***Written Proposal***

The course project is designed to educational, useful, and fun; the objective is to write a research proposal! The goal of the proposal is for you to pick a topic that most interests you in the field of packaging and to write a mock NSF research proposal on it (instead of NSF 15-page limit, we will do 5-page proposals – excluding executive summary; references not included in page limit). Think of this as your opportunity to propose a topic of research for your MS/PhD degree to a potential thesis advisor and/or funding agency (including fellowship applications). We will strictly follow NSF proposal writing guidelines. The written proposal grading will be split into three parts:

Part 1: (5% of written proposal grade)

- Topic selection: Short paragraph on the topic of choice and why

Part 2: (25% of written proposal grade):

- 1-Page executive summary of **intellectual merit** and **broader impact** of your proposed research

Part 3: (70% of written proposal grade)**:**

- The **relevant prior work** in your chosen area (2-pages)
- The **broader impact of your research** (1 page)
- The **intellectual merit of the proposed research** (2 pages)

Proposal Class Presentation

You will make an in-class presentation addressing **intellectual merit** and **broader impact** of your proposed research. The presentation length will be based on class size. This will be determined during the semester.

Course Topics Include:

- Traditional interconnection approaches: wirebonds and flip-chip
  - Traditional packaging
  - Discuss technology and pros/cons
  - Electrical and thermal design considerations
  - Material attributes
  - Fabrication and processes
- Package substrates
  - Organic
  - Ceramic
  - Glass
  - Silicon
  - Polymer (flexible electronics)
- Emerging 2.5D and 3D IC Technologies

    - Discussion of technology options
    - State of the art (products and research)
    - Fabrication and technology considerations
        - TSVs
        - Polymer bonding
        - Oxide bonding
        - Cu-Cu
        - Hybrid bonding
    - Fan-out wafer-level packaging
    - Electrical modeling
        - Parasitics
        - S-parameters; [RLCG] extraction
        - HFSS overview and modeling
        - Various interconnect technology modeling and benchmarking
        - High bandwidth density digital signaling design considerations
        - Power delivery design considerations
- Thermal challenges and opportunities
    - Thermal modeling
    - Impact of temperature on electronics
    - Overview of cooling technologies (conductive and convective) and benchmarking
    - State of the art demonstrations/products (Google TPUs, Microsoft immersion cooling, etc)
- RF/mm-wave and photonic packaging
    - Unique challenges
    - Design considerations
    - Material properties
    - Examples of state of the art
- Thermomechanical design considerations
    - Materials, stresses, warpage in 2.5D and 3D IC technologies

Projected course schedule is shown below.

Week	Topic	Notes
8-Jan	Welcome and Introduction to Field	
15-Jan	Packaging Technology Evolution: Wirebonds, Surface-mount, flip-chip	
22-Jan	PCBs, Packages, and Interposers: Technologies and Design Considerations [HFSS Demo]	
29-Jan	PCBs, Packages, and Interposerss: Technologies and Design Considerations [HFSS Demo]	**Project: Topic Selection [Thursday]**
5-Feb	PCBs, Packages, and Interposers: Technologies and Design Considerations	**Project: Proposal 1-Page executive summary due [Thursday]**
12-Feb	3D ICs: Technologies, processes, design considerations	
19-Feb	**EXAM 1 on Tuesday** 3D ICs: Technologies, processes, design considerations	**Exam 1 on Tuesday Feb 20th**
26-Feb	3D ICs: Technologies, processes, design considerations Thermal design and cooling technologies for electronics	
4-Mar	Thermal design and cooling technologies for electronics	
11-Mar	Design for Thermomechanical Reliability	**March 13 Withdraw deadline**
18-Mar	[No classes]	Spring Break
25-Mar	Fan-Out Wafer Level Packaging	
1-Apr	**Exam 2 on Tuesday** Co-Packaged Photonics and Emerging Trends	**Exam 2 on Tuesday April 2nd**
8-Apr	Class presentations	
15-Apr	Class presentations	
22-Apr	Class presentations	Final Instructional Class Days April 22 23
25-Apr	[No Final Exam; project due latest by final exam day]	**Written proposal latest due date by 5:30 PM on Thu Apr 25**