Indian Institute of Technology, Kanpur

Proposal for a New Course

1. Course No: MSE6XX

2. Course Title: Design and Reliability Aspects of Semiconductor Packaging

3. Per Week Lectures: (L), Tutorial: 3 (T), Laboratory: 0 (P), Additional Hours [0-2]: 0 (A), Credits (3*L+2*T+P+A): 9 Duration of Course: Full Semester

4. Proposing Department/IDP: MSE

5. Other Departments/IDPs which may be interested in the proposed course: EE, ME, CHE

6. Other faculty members interested in teaching the proposed course:

7. Proposing Instructor(s): Nilesh Badwe

8. Course Description:

A) Objectives: Upon successful completion of the course, students will be able to:

- Explain semiconductor packaging hierarchies, package architectures, materials, and emerging technology trends.
- Identify the electrical, thermal, and mechanical factors governing semiconductor package performance.
- Analyze the effects of material properties, thermal expansion mismatch, and thermomechanical stresses on package reliability.
- Understand finite element-based modeling approaches for evaluating package stresses and predicting solder joint fatigue life.
- Apply statistical methods, including Weibull analysis and lifetime distributions, to interpret reliability data and estimate component lifetime.
- Evaluate design challenges and reliability considerations in advanced packaging technologies, including 2.5D/3D integration, chiplets, and hybrid bonding.

B) Contents (preferably in the form of 5 to 10 broad titles):

S. No	Broad Title	Topics	No. of Lectures

1	Introduction to Semiconductor Packaging	Packaging hierarchy, package architectures, Moore's law for packaging, heterogeneous integration, industry trends	4
2	Anatomy of a Package	Passives, Die-prep processing, IC Assembly, Substrates, Encapsulants and Sealants, PCB assembly/SMT, Test	10
3	Electrical Design Aspects of Packaging	Signal and power integrity, parasitic resistance and inductance, high-speed interconnects, crosstalk and electromagnetic interference, electrical testing and characterization techniques, Substrate and PCB design	3
4	Thermal Design Aspects of Packaging	Heat transfer fundamentals, thermal resistance and junction temperature, package thermal design, thermal interface materials and heat sinks, cooling techniques, thermal modeling and simulation, thermal characterization	3
5	Mechanical Design Aspects of Packaging	Coefficient of thermal expansion mismatch, package warpage, residual stresses, mechanical reliability of interconnects, solder joint fatigue, creep, interface delamination and cracking, reliability techniques	5
6	Reliability modeling	Mechanical modeling using finite element analysis techniques to identify stresses generated in a solder joint, material properties critical to mechanical modeling, different models to estimate strain energy density generated during thermomechanical simulations, solder joint fatigue life prediction	6
7	Reliability Statistics	Probability distributions for failure analysis, Weibull analysis, failure rate and MTBF, reliability and hazard functions, statistical life data analysis, confidence intervals, Bayesian methods, accelerated life test data analysis	4
8	Advanced Packaging Case Studies	2.5D/3D integration, chiplets, hybrid bonding, power packages, package-level design challenges	5
		Total	40

C) Pre-requisites, if any: None

D) Short summary for including in the Courses of Study Booklet: This course provides an overview of semiconductor packaging architectures, materials, and design principles, with emphasis on electrical, thermal, and mechanical performance. It introduces package-level reliability mechanisms, finite element-based reliability modeling, statistical life data analysis, and emerging advanced packaging technologies. Through engineering concepts and case studies, students will develop an understanding of the relationship between package design, material properties, performance, and long-term reliability.

E) Recommended books:

- Rao R. Tummala, Eugene J. Rymaszewski, and Alan G. Klopfenstein (Editors), Microelectronics Packaging Handbook
- Rao R. Tummala, Fundamentals of Microsystems Packaging
- John H. Lau, Solder Joint Reliability of BGA, CSP, Flip Chip, and Fine Pitch SMT Assemblies
- John H. Lau, Thermal Stress and Strain in Microelectronics Packaging
- William Q. Meeker and Luis A. Escobar, Statistical Methods for Reliability Data
- Mohammad Modarres, Mark Kaminskiy, and Vasiliy Krivtsov, Reliability Engineering and Risk Analysis: A Practical Guide

9. Any other remarks:

Dated: Proposer:

Dated: DUGC/DPGC Convener:

The course is approved / not approved

Chairman, SUGC/SPGC

Dated: