Class Syllabus – Spring Semester, 114 Academic Year

Department of Mechanical Engineering, National Chung Cheng University

Course Name:： Micro-/nano-scaled mechanical behavior characterization and applications				Dept.		Master Program in Advanced Engineering
				Course Code		4465056
Instructors	**Pei-Chen Huang**	Credits	3	Compulsory /Elective	Grade	MS/PhD
EMI	■ Yes □ No					

Prerequisites: Engineering Materials, Mechanics of Materials

Class Description：This course integrates materials characterization and mechanical theory to explore the mechanical effects on semiconductor devices and packaging structures arising from the mechanical property mismatch between components, crystallographic defects, and residual stress sources such as thermal and lattice strain. The curriculum covers fundamental theories through to practical research applications, encompassing both experimental techniques and numerical analysis methods.

Class Objective：After completing this course, students will understand the physical and mechanical properties of typical semiconductor materials and be able to analyze structural reliability issues caused by thermal- and lattice-induced residual stresses in practical applications.

Textbooks	1. S. M. Sze, M. K. Lee, Semiconductor Devices: Physics and Technology 3/e, John Wiley, 2012. 2. J. H. Lau, C. P. Wong, J. L. Prince, Electronic Packaging: Design, Materials, Process, and Reliability, McGraw-Hill Professional, 1998. 3. S. Liu, Y. Liu, Modeling and Simulation for Microelectronic Packaging Assembly: Manufacturing, Reliability and Testing, John Wiley & Sons, 2011.

An overview of the main points of teaching

Teaching Materials	■ PPT □ Self-edited textbooks □ Self-made instructional videos	□ Course handouts □ Teaching Procedures □ Other
Teaching Methods	■ Lectures □ Oral presentation □ Case studies	□ Group discussion □ Problem-oriented learning □ Other
Evaluation Tools	■ Mid-term Exam □ In-class Quiz ■ Homework □ Final Report □ Other	■ Final Exam □ In-class homework □ Mid-term Report □ Special Report □ Scales
Teaching Resources	■ Course website ■ Electronic files of textbooks are available for download □ Internship website	

Instructor's Information	Prof. Pei-Chen Huang is a Joint-Appointed Assistant Professor in the AIM-HI and Department of Mechanical Engineering at National Chung Cheng University. His research focuses on semiconductor FEOL strain engineering, electronic packaging mechanics, and micro/nanoscale mechanical characterization of materials, with over 30 journal publications.

Course Outlines		Teaching Hours				Core Competence
Unit Title	Contents	Lectures	Demo	Practice	Other	
Introduction	1. Process flow of semiconductor from front-end to back-end (including packaging)	9				D1, D2, D3, D4
2D/3D Transistors Device	1. MOSFET 2. FinFET 3. GAAFET 4. Advanced FET	6				D1, D2, D3, D4
Small scale material behaviors	1. Concept of atomics, molecules, and lattices structures 2. Potential functions 3. Defects	9				D1, D2, D3, D4
Solid mechanics	1. Stress/strain tensors expression 2. Orientation-dependance stiffness matrix Mechanical constitutive models and those applications	9				D1, D2, D3, D4
Case studies in interposer system	1. Interposer and through vias material system 2. Thermo-mechanical and keep out zone issues	6				D1, D2, D3, D4
Material characterization	1. X-ray diffraction (XRD) 2. X-ray photoelectron spectroscopy (XPS) 3. Raman Spectroscopy 4. Nanoindentation	9				D1, D2, D3, D4

Achievable Core Competence		Achievable Objective
D1	Professional knowledge for understanding and analyzing issues in the field of semiconductor materials.	Ability to understand the fundamental operations, structures, and physical properties of semiconductors—from transistor devices to electronic packaging—and to acquire technical knowledge of micro/nanoscale materials mechanics.
D2	Ability to plan and conduct research projects in the fields of semiconductor materials and mechanical analysis.	Ability to learn from the curriculum the evolution of transistor and electronic packaging structures as well as process advancements, thereby gaining awareness of mechanical issues.
D3	Ability to write technical papers and deliver professional presentations.	Ability to acquire, through process technologies and practical case studies presented in the curriculum, the skills to compose professional papers grounded in theoretical principles and analytical results.

D4	Ability to think innovatively and independently solve mechanical problems in semiconductor manufacturing processes.	Ability to establish innovative thinking and practical problem-solving skills centered on analytical techniques for semiconductor material mechanical behavior at both micro- and macro-scales, laying a solid foundation for industry partners to develop new substrates/carriers and enhance their mechanical reliability and yield.

The core competence of the Institute

D1 has expertise in the field of mechanical and opto-mechanical integration engineering

D2 Ability to plan and execute special research projects in the field of mechanical and opto-mechanical integration engineering

D3 Ability to write scientific papers and presentations

D4 Ability to think creatively and solve mechanical and opto-mechanical integration engineering problems independently

D5 Ability to coordinate and integrate cross-disciplinary personnel

D6 Good international outlook

D7 has team spirit and the ability to lead, manage, plan and communicate

D8 Ability of lifelong self-learning and growth

D9 Understand the importance of engineering ethics, social responsibility and sustainable development

Weekly teaching plan				
Course Time	Course Location	Grading	Office hour	Teaching quality evaluation method
三 3-5	ME 214R	Mid-term exam: 40% Final exam: 40% Homework: 20%	Friday: AM 10:00-11:30 Room 432C	Questionnaire

Weeks	Teaching & Homework Progress	Note
1	Process flow of semiconductor front-end process	
2	Process flow of semiconductor back-end process	
3	Process flow of semiconductor electronic packaging	
4	MOSFET, FinFET	
5	GAAFET, Advanced FET	
6	Concept of atomics, molecules, and lattices structures	HW#1 Technical report about semiconductors and packaging, due in mid-term exam
7	Potential functions	
8	Defects	
9	Mid-term exam, stress/strain tensors expression	Hand in HW#1
10	Orientation-dependance stiffness matrix	
11	Mechanical constitutive models and those applications	
12	Interposer and through vias material system	
13	Thermo-mechanical and keep out zone issues	
14	X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS)	
15	Raman Spectroscopy	
16	Nanoindentation	
17	Final exam	

18	Final exam	