City University of Hong Kong
Course Syllabus

offered by Department of Materials Science and Engineering
with effect from Semester A 2024/25

Part I Course Overview

Course Title:	**Quantum Theory of Semiconductors**
Course Code:	**MSE6265**
Course Duration:	**One Semester**
Credit Units:	**3**
Level:	**P6**
Medium of Instruction:	**English**
Medium of Assessment:	**English**
Prerequisites: *(Course Code and Title)*	**Nil**
Precursors: *(Course Code and Title)*	**Nil**
Equivalent Courses: *(Course Code and Title)*	**AP6265 Emerging Semiconductor Devices in 21st Century (From the old curriculum)**
Exclusive Courses: *(Course Code and Title)*	**AP5265 Semiconductor Physics and Devices (From the old curriculum)** **AP8265 Emerging Semiconductor Devices in 21st Century (From the old curriculum)**

Part II Course Details

1. Abstract

(A 150-word description about the course)

This course introduces the quantum mechanics (QM) of semiconductors from theory to applications. It aims to facilitate students to develop a stronger fundamental background of semiconducting materials, and to provide guided examples on applying QM theories to understand materials properties.

The course covers the basic principles of QM, including wave-particles duality, energy quantization, uncertainty principle, postulations in QM, the Schrodinger wave equation, and hydrogen atom model. It is then followed by the discussion on particle-in-a-box problem to density-of-state in semiconductors, the crystal structure of semiconductors, the periodic structure to the origin of energy gap in semiconductors. The course also covers the carrier density and the carrier transport theory in semiconductors. Finally, we will discuss the application of QM on semiconductor devices such as p-n junction and Schottky junction and connect the theories with the fabrication of semiconductor materials and devices.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting* (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Master the fundamental principles and postulates of quantum mechanics, Schrodinger wave equation, and atomic orbitals of elements.	30%		√	
2.	Solve the particle-in-a-box problem to understand the quantum mechanical approximation.	10%		√	
3.	Explain the molecular orbital theory, the periodic crystal structure of semiconductors, and the origin of energy gap in semiconductors.	20%		√	
4	Explain the intrinsic and extrinsic semiconductors and their transport property.	20%		√	√
5	Develop theoretical connections between electronic device functionalities and fundamental properties of semiconductors as well as their fabrication processes.	20%	√	√	√
	** If weighting is assigned to CILOs, they should add up to 100%.*	100%			

A1: *Attitude*
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: *Ability*
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: *Accomplishments*
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

3. Learning and Teaching Activities (LTAs)

(LTAs designed to facilitate students' achievement of the CILOs.)

LTA	Brief Description	CILO No.					Hours/week (if applicable)
		1	2	3	4	5	
1. Lecture	Students will gain a conceptual overview of the basic principles of quantum mechanics and comprehensive understanding of their utilization in understanding semiconductor materials and devices.	√	√	√	√	√	26 hrs / 13 wks
2. Tutorials	Students will gain a deeper understanding on how to apply quantum mechanics to describe semiconducting behaviour and device properties.	√	√	√	√	√	13 hrs / 13 wks

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.					Weighting*	Remarks
	1	2	3	4	5		
Midterm	√	√	√			40%	
Examination (duration: 2 hours)	√	√	√	√	√	60%	
** The weightings should add up to 100%.*						100%	

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Midterm	Individual ability of problem solving; able to apply knowledge on differentiating different requirements and judging various technical issues of semiconductor devices.	High	Significant	Moderate	Basic	Not reaching marginal level
2. Examination	Having an in-depth understanding on the selected semiconductor property, device working principle, limitations, and future development.	High	Significant	Moderate	Basic	Not reaching marginal level

Applicable to students admitted from Semester A 2022/23 to Summer Term 2024

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Midterm	Individual ability of problem solving; able to apply knowledge on differentiating different requirements and judging various technical issues of semiconductor devices.	High	Moderate	Basic	Not reaching marginal level
2. Examination	Having an in-depth understanding on the selected semiconductor property, device working principle, limitations, and future development.	High	Moderate	Basic	Not reaching marginal level

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

(An indication of the key topics of the course.)

- The fundamentals of quantum mechanics.
- Particle-in-a-box problem
- Schrodinger equation and atomic orbitals.
- Molecular orbital theory and band theory of solid.
- Intrinsic and extrinsic semiconductors.
- Carrier transport in semiconductors.
- Fabrication of semiconductors and devices.

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

1.	S. M. Sze and Kwok K. Ng, “Physics of Semiconductor Physics (3rd)”, Wiley, 2007
2.	Serway, Moses, and Moyer, “Modern Physics”, Sounders College Publishing

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

1.	Charles Kittel, “Introduction to Solid State Physics”, Wiley