MSE6266: SEMICONDUCTOR MATERIALS AND DEVICES

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Semiconductor Materials and Devices

Subject Code
MSE - Materials Science and Engineering
Course Number
6266

Academic Unit
Materials Science and Engineering (MSE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

This course provides both fundamental and practical knowledge on the properties, design, and applications of semiconductor materials and devices. Designed for students in Materials Science and Engineering, this course addresses the essential areas of semiconductor physics, material properties, device fabrication, and system applications. Emphasis will be placed on understanding the semiconducting properties of both traditional materials such as silicon (Si) and gallium nitride (GaN), as well as emerging materials including zero-dimensional (0D), one-dimensional (1D), two-dimensional (2D) materials, and organic/polymeric materials. In an era where integrated circuits power the economy, drive the development of AI, and are integral to national security, this course also dedicates substantial coverage to the important area of electronic chips.

The course is structured to cover firstly the fundamental theories of semiconductors, such as junction theory, carrier transport, and recombination mechanisms. Then, students will delve into the design and fabrication of various semiconductor devices, including diodes, field-effect transistors (FETs), photodetectors, photovoltaics. Practical aspects of device fabrication, including lithography, doping, and etching techniques, will be thoroughly explored.

Upon completion of the course, students will have acquired a good command of both the theoretical and practical aspects of semiconductor materials and devices. The knowledge gained will be especially applicable to industries such as integrated circuits, optoelectronics, and nanotechnology.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe and explain the concepts, preparation, and characterization of semiconductor materials, devices, and circuits used in modern chips.	20%	x		
2	Describe the working principles and applications of various types of semiconductor materials and devices.	20%	x		
3	Apply the relevant methodologies to evaluate and demonstrate the semiconducting properties of currently used or researched semiconductor materials, devices, and circuits used in modern chips.	20%		x	
4	Innovatively apply knowledge of materials science and engineering to design or propose new semiconductor materials, devices, and circuits used in modern chips.	20%			x
5	Discuss state-of-the-art development in the relevant areas and to form opinions on specific issues.	20%	x		

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.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Lectures	1, 2, 3, 4, 5	2 hrs
2	Tutorial	Tutorial	1, 2, 3, 4, 5	1 hr

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Assignments	2, 3, 4, 5	20	-	No
2	Midterm Tests	1, 2, 3	30	-	No

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Assessment Rubrics (AR)

Assessment Task

Assignment(s) (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

UNDERSTANDING concepts of semiconductor materials and devices, their working principles, characterization techniques, and applications.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Midterm (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

CAPACITY to solve an engineering problem related to semiconductor materials and device design.

Excellent

(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
ABILITY to ANALYSE problems and EXPLAIN engineering concepts related to semiconductor materials and devices.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Assignment(s) (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
UNDERSTANDING concepts of semiconductor materials and devices, their working principles, characterization techniques, and applications.

Excellent
(A+, A, A-) High

Good
(B+, B) Moderate

Marginal
(B-, C+, C) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Midterm (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
CAPACITY to solve an engineering problem related to semiconductor materials and device design.

Excellent
(A+, A, A-) High

Good
(B+, B) Moderate

Marginal
(B-, C+, C) Basic

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(F) Not even reaching marginal levels

Assessment Task
Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
ABILITY to ANALYSE problems and EXPLAIN engineering concepts related to semiconductor materials and devices.

Excellent
(A+, A, A-) High

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(B+, B) Moderate

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(B-, C+, C) Basic

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(F) Not even reaching marginal levels

Part III Other Information

Keyword Syllabus

Part A: Semiconductor Materials

a. Introduction to Semiconductor Materials
b. Fundamental Theories
c. Carrier Transport in P/N Junctions
d. Traditional Semiconductor Materials
e. Emerging Semiconductor Materials

Part B: Semiconductor Devices

a. Diodes
b. Field-Effect Transistors (FETs)

c. Advanced Semiconductor Devices
d. Integrated Circuits Fabrication Techniques
e. Device Characterization Techniques

Part C: Systems Applications of Semiconductor Devices

a. Device and System Applications
b. Emerging Trends and Future Directions

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	Sze, Simon M., and Kwok K. Ng. Physics of Semiconductor Devices. 3rd ed., Wiley-Interscience, 2006. ISBN: 978-0471143239.
2	Neamen, Donald A. Semiconductor Physics and Devices. 4th ed., McGraw-Hill Education, 2011. ISBN: 978-0073529585.
3	Streetman, Ben G., and Sanjay Banerjee. Solid State Electronic Devices. 7th ed., Pearson, 2015. ISBN: 978-0133356038.
4	Pierret, Robert F. Advanced Semiconductor Fundamentals. 2nd ed., Pearson, 2002. ISBN: 978-0130617927.
5	Pierret, Robert F. Semiconductor Device Fundamentals. 2nd ed., Pearson, 1996. ISBN: 978-0201543933.
6	Pierret, Robert F. Advanced Semiconductor Fundamentals. 2nd ed., Pearson, 2002. ISBN: 978-0130617927.
7	Taur, Yuan, and Tak H. Ning. Fundamentals of Modern VLSI Devices. 2nd ed., Cambridge University Press, 2009. ISBN: 978-0521832946.