SEMESTER S4

COMPOUND SEMICONDUCTORS

Course Code	PEEVT413	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. Develop fundamental knowledge of compound semiconductor materials and its applications
2. Develop a strong theoretical background to understand, design and analyse devices made of compound semiconductors
3. Learn the basics of VLSI fabrication technology for compound semiconductor devices.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Compound Semiconductors: Classification of compound semiconductors- Binary, Ternary, Quaternary compound semiconductors (an overview) Material properties of compound semiconductors- Properties of III-V Compound semiconductors (GaAs, GaN, InP, AlGaAs, AlGaN, InGaAs, InAlGaN), IV Compounds: SiC, SiGe; Effect of mole fraction on bandgap and lattice constant Gallium Arsenide: Energy band structure, Crystal structure of GaAs, Velocity Field relationship III-Nitride semiconductors: Crystal structure of nitrides, Electrical and optical properties AlGaN alloy, InGaN alloy, InAlGaN quaternary alloy, Polarization Effects in nitrides: Spontaneous polarization, Piezoelectric polarization Metal semiconductor junctions: Schottky contacts, I-V characteristics of Schottky barrier junctions, Ohmic contacts Heterojunctions: Type I and Type II and Type III band alignments,	9

	Electrostatic characteristics of p-n hetero junctions: Band diagrams	
2	High Speed Devices: High speed performance parameters of devices - Transit time of charge carriers, junction capacitances, ON-resistances and their dependence on the device geometry and size, carrier mobility, doping concentration and temperature Heterojunction Bipolar Transistors- Principle of operation, Energy band diagrams, Types of HBTs- III-V semiconductor, SiGe HBT- Structure, Band gap engineering Metal Semiconductor Field Effect Transistor (MESFET) - Structure of GaAs MESFET, Pinch off and threshold voltage, MESFET Operation and I-V characteristics, Schokley's model, Effects of velocity saturation and velocity field effects High Electron Mobility Transistors (HEMT)- GaAs HEMT- Structure of GaAs HEMT, Principle of operation, Energy band diagrams, Off voltage, I-V characteristics	9
3	Optoelectronics Devices Optical Detectors: Photodetectors- Basic principle of operation, Photodetector structures, Photodetector materials, Photodetector parameters- Responsivity and efficiency, photodetector gain; Photodiodes: p-n photodiodes- Device structure, Operation, Analysis; p-i-n photodiodes: Device Structure, Principle of operation; Avalanche photodiodes: Device Structure, Operation Principle Optical Sources: LEDs: Principle of operation of homojunction and heterojunction LEDs, LED materials; LASER: Physics of LASER, LASER materials, Fabry Perot cavity LASER	9
4	Fabrication Technology: Crystal growth, Epitaxy - Vapour phase epitaxy, Oxidation- Dry and wet oxidation, Kinetics of oxidation, Diffusion and Ion implantation, Lithographic techniques- Photolithography, Etching- Dry etching, Wet etching, Deposition techniques- Chemical vapour deposition (CVD), Metallization techniques- Evaporation and sputtering	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Summarize the various compound semiconductors and acquire knowledge of different types of junctions involved in compound semiconductor based devices	K2
CO2	Identify the important performance parameters of high speed electronic devices and in depth understanding of various high speed compound semiconductor devices	K4
CO3	Understand the physics of important optoelectronic devices made of compound semiconductors and their performance parameters	K3
CO4	Identify the important fabrication and processing technologies of compound semiconductor materials and related devices	K2

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**											
CO2	**3**			**2**	**2**							
CO3	**3**			**2**	**2**							**2**
CO4	**3**			**2**	**2**							**2**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Compound Semiconductor Device Physics,	Sandip Tiwari	Academic Press	(1991), ISBN 0-12-691740-X.
2	High Speed Semiconductor Devices	S.M. Sze	Wiley	(1990) ISBN 0-471-62307-5
3	VLSI fabrication principles: silicon and gallium arsenide.	Ghandhi, Sorab K	John Wiley & Sons, 1994.	1994.
4	Fundamentals of semiconductor devices.	Achuthan, M. K., and MK Achuthan KN Bhat	Tata McGraw-Hill,	2006.
5	Semiconductor devices for high-speed optoelectronics. Vol. 116. Cambridge:	Ghione, Giovanni	Cambridge University Press	2009.
6	Physics of Semiconductor Devices	S. M. Sze, Kwok K. Ng.	John Wiley& Sons	Third Edition
7	Lectures on "High speed devices and circuits"	K. N. Bhat	NPTEL Course.	
8	Nitride Semiconductor Devices" Fundamentals and Applications	Hadis MorkoSc	Wiley VCH Verlag GMBH & Co. KGaA.	
9	Power GaN Devices" (pp. 299-300).	Meneghini, M., Meneghesso, G. & Zanoni, E.	Berlin: Springer.	(2017).
10	Lectures on "VLSI Technology" by, NPTEL Course.	Dr. Nanditha Das Gupta	NPTEL Course.	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Solid State Electronic Devices	Ben G. Streetman and Sanjay Kumar Banerjee	Pearson	6/e, 2010
2	Semiconductor Physics and Devices; Basic Principles,	Donald E Neamen	McGraw-Hill	Third Edition, 2003