SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. Semiconductor Science and Technology Semester-II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCSST01	Technologically Important Materials: Growth, Processing and Wafer Analysis	4-0-0	120	04

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO1: Assess the preparation, purification, and crystal growth techniques of silicon and their importance in semiconductor device fabrication.

CLO2: Analyze the material properties, growth mechanisms, and defect control in SiC.

CLO3: Analyze growth techniques and material characteristics of compound semiconductors such as GaN and GaAs for advanced electronic applications.

CLO4: Evaluate wafer processing techniques, resistivity measurement methods, and mapping strategies used in semiconductor manufacturing.

CLO5: Apply knowledge of wafer defect analysis, inspection techniques, and yield optimization in semiconductor fabrication processes.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	**Silicon** History of Crystal Growth in India and Contributions of Indian Scientists, Naikund furnace for Iron Smelting, Silicon: The Key Material for Integrated Circuit Fabrication Technology, Introduction, Preparation of Raw Silicon Material, Metallurgical-Grade Silicon, Purification of Metallurgical-Grade Silicon, Polycrystalline Silicon Feed for Crystal Growth, Single Crystal Growth Technique of Silicon: Introduction, Bridgman Crystal Growth Technique, Czochralski Crystal Growth/Pulling Technique: Distribution of Dopant, Effective Segregation Coefficient, Crucible Choice for Molten Silicon, Chamber Temperature Profile, Seed Selection for Crystal Pulling, Environmental and Ambient Control in the Crystal Chamber, Crystal Pull Rate and Seed/Crucible Rotation, Dopant Addition for Growing Doped Crystals, Post-Growth Thermal Gradient and Crystal Cooling after Pull-Out, Silicon Float-Zone Process, From Silicon Ingots to Silicon Wafers overview, Doping methods.	CL, SM, PBL, ROL, SDL	CLO1
II	**Silicon Carbide (SiC)** Physical Properties of Silicon Carbide: Crystal Structure, Electrical properties: Impurity Doping and Carrier Density, Mobility, Drift Velocity, Breakdown Electric Field Strength, Bulk Growth of Silicon	CL, SM, CBL, COL, ICT	CLO2

	Carbide: Sublimation Growth, Phase Diagram of Si-C, Physical Vapor Transport Method. Defect Evolution and Reduction in Sublimation Growth: Stacking Faults, Micropipe Defects, Threading Screw Dislocation, Threading Edge Dislocation and Basal Plane Dislocation, Defect Reduction, Doping Control in Sublimation Growth: Impurity Incorporation, n-Type Doping, p-Type Doping, Semi-Insulating, High-Temperature Chemical Vapor Deposition (CVD), Solution Growth, Wafering and Polishing, Ion Implantation.		
III	**Gallium Nitride (GaN):** Hydride Vapor Phase Epitaxy of GaN: Introduction, Thermodynamic Analysis on HVPE Growth of GaN, Cubic GaN Epitaxial Growth on (100) GaAs Substrate, Growth of Bulk GaN Crystals by HVPE on Single Crystalline GaN Seeds: Introduction, Experimental: Seed Crystals, HVPE Reactor and Growth Conditions, Solution Growth Technology: Ammonothermal Growth of GaN Under Ammono-Basic Conditions, Acidic Ammonothermal Growth Technology for GaN, Flux Growth Technology: High Pressure Solution Growth of Gallium Nitride: Introduction, Growth Method: Thermodynamic and Kinetic Aspects of HPS Growth, Experimental. **Gallium Arsenide (GaAs):** Crystal-Growth Techniques: Starting Materials, Bulk Growth of GaAs, Doping Considerations, Horizontal Bridgman, Liquid-Encapsulated Czochralski (LEC) and Vertical Gradient Freeze (VGF) Technique, Epitaxial Growth of GaAs, Diffusion, Ion Implantation and Crystalline Defects in GaAs.	CL, SM, PBL, ROL, ICT	CLO3
IV	**Semiconductor Crystalline Wafer Technology: Mapping, Defects and Yield** Electrical Techniques: Wafer Resistivity: Introduction, Four Point Probe, Hall effect, Correction factor, Measurement circuits, Errors and Precautions, Wafer Mapping. Resistivity Profiling: Anodic Oxidation-Four Point Probe, Spreading Resistance, Contactless Methods: Eddy current, Conductivity Type Identification, Strength and Weaknesses Types of Wafer Defects: Random Defects, Systematic Defects, Surface Defects, Pattern Defects, Wafer Edge Defects, Lattice Defects, Wafer Inspection Methods: Optical Inspection, Electron Beam Inspection (EBI), Infrared Inspection, Laser Scattering, Referential Inspection, Mix Observation, Impact of Wafer Defects: Reduced Yield, Reduced Device Performance, Increased Cost, Importance of Wafer Inspection: Quality Control, Process Optimization, Cost Reduction.	CL, SM, MPR, EL, RP	CLO4, CLO5

(*) Learning Pedagogies/Methods

(a) CL: Classroom Lecture
(b) SM: Seminars (Student-led and Faculty-moderated)
(c) CBL: Case-Based Learning
(d) MPR: Micro-Projects/Mini Research Tasks
(e) Visit: Industrial Visit/Field Visit/Institutional Visit
(f) PBL: Problem-Based Learning
(g) ROL: Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
(h) COL: Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)

(i) EL: Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
(j) SRP: Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
(k) ICT: ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
(l) RP: Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
(m) IBL: Inquiry-Based Learning
(n) SDL: Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

- **Assessment Methodologies**

(A) Internal Assessment

a. Internal Formative assessment

(a) Assignment
(b) Seminars
(c) Class Regularity

b. Internal Summative Assessment

(a) Quizzes
(b) Mid-term tests

(B) Weightage of Learning Efforts for External Assessment [Total: 50 Marks]

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
I	**CLO1**	30	3	4	5	12
II	**CLO2**	30	2	5	5	12
III	**CLO3**	30	2	5	6	13
IV	**CLO4, CLO5**	30	2	6	5	13
		120	**09**	**20**	**21**	**50**

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Mid-term tests, Seminars, Assignments, Quizzes, Class Regularity	50
2	End-Semester Examination	Written Exam Project Evaluation (Report, Presentation, Viva)	50

(C) CLOs – PLOs Matrix

CLO	PLO									
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	2	1	1	-	2	3	1	-	-
CLO2	3	3	2	-	2	2	2	1	-	1
CLO3	3	2	2	1	2	2	3	1	1	2
CLO4	3	2	2	2	3	1	2	1	1	2
CLO5	3	2	2	2	3	1	2	1	2	2

Values to **CLO-PLO** matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- **Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Crystal Growth and Evaluation of Silicon for VLSI and ULSI	G. Eranna	2015	CRC Press (Taylor & Francis Group), USA
2	Fundamentals of Silicon Carbide Technology: Growth, Characterization, Devices, and Applications	T. Kimoto, J. A. Cooper	2014	John Wiley & Sons, Singapore
3	Wide Bandgap Semiconductors for Power Electronics: Materials, Devices, Applications	P. Wellmann, N. Ohtani, R. Rupp (Eds.)	2022	Wiley-VCH GmbH, Germany
4	Technology of Gallium Nitride Crystal Growth	Dirk Ehrentraut, Elke Meissner, Michal Bockowski	2010	Springer, Germany
6	Semiconductor Devices: Physics and Technology	S. M. Sze, M. K. Lee	3rd Ed. (2012)	John Wiley & Sons
7	Semiconductor Material and Device Characterization	Dieter K. Schroder	3rd Ed. (2006)	IEEE Press, John Wiley & Sons
8	Introduction to Dislocation	D. Hull, D.J. Bacon	5th Ed. (2011)	Pergamon Press
9	Concise history of Science in India	D. M. Bose, S. N. Sen, B. V. Subbarayappa	2nd Ed. (2009)	Universities Press
10	Research Methodology for Natural Sciences	Prof. Soumitro Banerjee	2022	IISC Press

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	Google Sites resource on advanced semiconductor and thin film technology	https://sites.google.com/view/advancedsemiconductors
2	Bridgman crystal growth technique	https://youtu.be/P5GMX9Cr22g
3	Czochralski crystal growth method	https://youtu.be/RdVTBIyf6kg
4	Verneuil method	https://youtu.be/Qp0u0Vp2jQU
5	Floating zone process	https://youtu.be/K4X9WsfgEPQ
6	Silicon and Processing of Silicon - I	https://www.youtube.com/watch?v=2KlSYmgdWQ0
7	Power Electronics with WBG Devices (NPTEL Course)	https://onlinecourses.nptel.ac.in/noc24_ee126/preview
8	Basic Overview of Semiconductor Device Processing and IC Fabrication (NPTEL Course)	https://onlinecourses.nptel.ac.in/noc26_ee04/preview
9	Crystal Structures in GaAs	https://www.youtube.com/watch?v=s3Z8OF9Giqs
10	An NPTEL course on Research Methodology for Natural Sciences	https://nptel.ac.in/courses/127106227

SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. Semiconductor Science and Technology Semester-II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCSST02	Vacuum and Thin Film Technology	4-0-0	120	04

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO1: Analyze the fundamentals of vacuum science, pressure measurement techniques, and the working principles of various pumps and gauges used in semiconductor processing.

CLO2: Asses the kinetic theory of gases and analyze the mechanisms involved in thin film formation, nucleation, and different growth modes.

CLO3: Evaluate the role of substrate properties, cleaning techniques, and adhesion in determining the quality and performance of thin films.

CLO4: Analyze various thin film deposition techniques and compare their suitability for different materials and applications.

CLO5: Apply knowledge of characterization techniques to interpret structural, compositional, and functional properties of thin films.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	**Pumps and Gauges** History of Pump and Gauge Manufacturing in India, Fundamentals of Vacuum Science and Pressure Ranges, Vacuum Unit Conversion, Vacuum Pumps, Classification of Vacuum Pumps: Rotary Pump, Diffusion Pump, Molecular Drag Pump, Gettering and Ion Pumping, Sputter Ion Pump, Measurement of Pumping Speed: Constant Pressure Method, Constant Volume Method. Classification of Gauges: Mcleod Gauge, Thermal Conductivity Gauge, Thermocouple Gauge, Hot Cathode Ionization Gauge, Bayard-Alpert Gauge, Cold Cathode Ionization Gauge, Penning Gauge, Magnetron Gauge. Vacuum Leak: Leak Detection Introduction, Direct and Indirect Methods of Leak Detection, Helium Leak Detection in Semiconductor Processing, Controlling and Preventing Leaks in Semiconductor Process Systems.	CL, SM, PBL, ROL, SDL	CLO1
II	**Kinematics of Thin Film Science** Kinetic Theory of Gases, Equilibrium Vapor Pressure of Materials, Atomistic Concept of Gas Pressure and Temperature, Clausius-Clapeyron Equation, Impingement Rate of Molecules on a Surface, Free Path of Gas Molecules, Introduction of Thin	CL, SM, CBL, COL, ICT	CLO2

	Film Deposition, Thermal Evaporation Physics, Evaporation Rate, Vapour Pressure of Elements, Evaporation of Compounds and Alloys, Condensation and Nucleation in Thin Film and Growth of Continuous Thin Films, Impingement, Adsorption and Thermal Accommodation, The Capillarity Model, Atomistic Model, Four Stages of Thin Film Growth, Three Growth Modes of Thin Film: Volmer-Weber (Island Growth), Frank-Van Der Merwe (Layer-By-Layer Growth), Stranski-Krastanov (Layer + Island Growth).		
III	**Substrate and Properties of Thin Films** Substrate, Substrate Function and Its Importance, Distance and Angle Importance Between Substrate and Source, Substrate Materials and Selection, Importance of Substrate Structure, Substrate Cleaning and Its Importance, Wet Cleaning, Dry Cleaning, Mechanical Cleaning, Thermal Cleaning, Thin Film Adhesion and Its Importance, Adhesion Measurement Techniques, Film Thickness Measurement Technique Practiced in Semiconductor Industry: Ellipsometry, Quartz Crystal Oscillators. Mechanical, Electrical and Magnetic Properties of Thin Film.	CL, SM, MPR, PBL, RP	CLO3
IV	**Thin Film Deposition Techniques** Coatings in Ancient India and their Applications, Spin Coating for Photoresist Deposition, Physical Vapour Deposition (PVD): Thermal Evaporation, Flash Evaporation, Sputtering: DC, Radio Frequency and Magnetron Sputtering, E-Beam Deposition Method, Pulsed Laser Deposition (PLD), Chemical Vapour Deposition (CVD), Atomic Layer Deposition (ALD), Epitaxial Method: Liquid Phase, Vapour Phase and Molecular Beam Epitaxy (MBE). **Characterization Techniques:** Life and Work of Sir C. V. Raman, Electron Microscopy: SEM, TEM, HRTEM, EDAX and EBIC, Atomic Force Microscopy, Low Energy Electron Diffraction-LEED, Reflection High Energy Electron Diffraction-RHEED, Auger Electron Spectroscopy-AES, X-Ray Photoelectron Spectroscopy-XPS, Raman Spectroscopy, Rutherford Back Scattering-RBS, Secondary Ion Mass Spectrometry-SIMS.	CL, SM, ROL, ICT, EL	CLO4, CLO5

(*) Learning Pedagogies/Methods

(o) CL: Classroom Lecture
(p) SM: Seminars (Student-led and Faculty-moderated)
(q) CBL: Case-Based Learning
(r) MPR: Micro-Projects/Mini Research Tasks
(s) Visit: Industrial Visit/Field Visit/Institutional Visit
(t) PBL: Problem-Based Learning

(u) ROL: Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
(v) COL: Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
(w) EL: Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
(x) SRP: Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
(y) ICT: ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
(z) RP: Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
(aa) IBL: Inquiry-Based Learning
(bb) SDL: Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

- **Assessment Methodologies**

(D) Internal Assessment

a. Internal Formative assessment

(d) Assignment
(e) Seminars
(f) Class Regularity

b. Internal Summative Assessment

(c) Quizzes
(d) Mid-term tests

(E) Weightage of Learning Efforts for External Assessment

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
I	**CLO1**	30	2	4	6	12
II	**CLO2**	30	2	4	7	13
III	**CLO3**	30	2	5	5	12
IV	**CLO4, CLO5**	30	2	5	6	13
		120	**08**	**18**	**24**	**50**

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Mid-term tests, Seminars, Assignments, Quizzes, Class Regularity	50
2	End-Semester Examination	Written Exam	50

(F) CLOs – PLOs Matrix

CLO	PLO									
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	1	1	-	1	2	2	-	-
CLO2	3	3	2	-	1	-	2	2	-	-
CLO3	3	2	2	2	2	1	2	2	-	-
CLO4	3	2	2	1	2	1	3	2	1	2
CLO5	3	2	2	1	3	1	2	2	2	2

Values to **CLO-PLO** matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- **Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Vacuum Science and Technology	V. V. Rao, T. B. Ghosh, K. L. Chopra	2001	Allied Publishers
2	Vacuum Technology and Applications	D. J. Hucknall	1991	Butterworth-Heinemann
3	Introduction to Nanotechnology	C. P. Poole, F. J. Owens	2003	Wiley India
4	Handbook of Thin Film Technology	L. I. Maissel, R. Glang (Eds.)	1970	McGraw-Hill
5	Thin-Film Deposition: Principles and Practice	D. L. Smith	1995	McGraw-Hill
6	The Materials Science of Thin Films	M. Ohring	2nd Ed. (2002)	Academic Press
7	Thin Film Phenomena	K. L. Chopra	1969	McGraw-Hill
8	Thin Film Processes	J. L. Vossen, W. Kern (Eds.)	1991	Academic Press
9	Handbook of Semiconductor Wafer Cleaning Technology	W. Kern (Ed.)	1993	Noyes Publications
10	Concise history of Science in India	D. M. Bose, S. N. Sen, B. V. Subbarayappa	2nd Ed. (2009)	Universities Press
11	Research Methodology for Natural Sciences	Prof. Soumitro Banerjee	2022	IISC Press

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	Google Sites resource on advanced semiconductor and thin film technology	https://sites.google.com/view/advancedsemiconductors
2	Video lecture on vacuum systems and thin film basics	https://youtu.be/nLohZYiiHuc
3	Lecture on thin film deposition and growth mechanisms	https://youtu.be/PPRHOdMRzbg
4	Lecture on characterization techniques and applications	https://youtu.be/7hRiTvgClTQ
5	An NPTEL course on Research Methodology for Natural Sciences	https://nptel.ac.in/courses/127106227

M.Sc. Semiconductor Science and Technology Semester-II

Course Type	Course Code	Course Title	Teaching-Learning Scheme L-P-T	Total Notional Hours	Course credits
DSC	P2S02NCSST03	Advanced Semiconductor Devices	4-0-0	120	04

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO1: Analyze the fundamental concepts of heterojunction devices, bandgap engineering, and their role in improving the performance of modern semiconductor devices.

CLO2: Analyze the operation and characteristics of field-effect devices such as JFET, MESFET, and MODFET, including their current–voltage behaviour under different biasing conditions.

CLO3: Interpret the structure and working of MOS-based devices, including MOSCAP and MOSFET, and evaluate their behaviour under various operating regions and scaling conditions.

CLO4: Compare different semiconductor devices and technologies including BJTs, FETs and power devices, in terms of performance, efficiency and application suitability.

CLO5: Apply conceptual understanding of advanced semiconductor materials and devices to emerging technologies such as high-speed electronics, power systems, and recent developments in the field.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	**Heterojunction Bipolar Transistors** Limitations of BJT Design, Necessity of Bandgap Engineering, Various Band Tailoring Techniques. Overview of Heterojunction Bipolar Transistors Including Si-based HBTs, GaAs/AlGaAs HBTs, InGaAs/InAlAs, and InGaAs/InP HBTs. Methods for Channel Isolation in Field-Effect Devices, JFET, Difference Between Working of BJT and JFET, Fundamentals of JFET and MESFET and Their I-V Characteristics, JFET Biasing, Approximations in Deriving I-V Equations, Active and Saturation Region, Effect in Real Devices: Velocity-field Dependence and Channel Length Modulation.	CL, SM, PBL, ROL, SDL	CLO1
II	**Advanced Field Effect Devices** Motivation Behind Heterojunction FETs, Charge Control Model for MODFET, Current Control in MODFET Across Active and Saturation Regions, High-Frequency, High-Speed Issues: Small Signal Characteristics, Equivalent Circuit, Large Signal Analog Applications with Semiconductor Parameter Requirements, Charge-Coupled Devices (CCD), Advanced MOS Technologies:	CL, SM, CBL, ICT, COL	CLO2

	HMOS and SIMOX.		
III	**MOSFET** Structure and Operation of Metal-Oxide-Semiconductor Capacitors (MOSCAP): Accumulation, Depletion and Inversion Regions, Capacitance-Voltage Characteristics of MOSCAP Structures and Their Equivalent Circuit Representation, Overview of MOSFET: Structural Aspects and Analysis of I-V Characteristics, Depletion-Mode and Enhancement-Mode MOSFET, Complementary MOSFET Configurations, Key Effects in Long-Channel and Short-Channel MOSFETs, Introduction to FINFET and VMOS, High-Frequency Issues, MOSFET Biasing, Some Selected Numerical Examples.	CL, SM, PBL, ICT, EL	CLO3
IV	**Power Semiconductor Devices and Technologies** Natural Resources of Energy as Visualized in Ancient India, Power Semiconductor Devices: Introduction, Scope and Application, Classification of Power Converters, Construction and Characteristics of Thyristors, Power MOSFET, IGBT, IGCT and GTO, Comparison of Controllable Switches. Properties and Advantages of Wide Bandgap Semiconductors (SiC and GaN) and Ultra-wide Bandgap materials (Ga1O1 and diamond), Applications of Power Electronic Devices: Electric Vehicles (EVs), Renewable Energy Systems (Solar and Wind Inverters), Industrial Motor Drives.	CL, SM, MPR, Visit, EL	CLO4, CLO5

(*) Learning Pedagogies/Methods

(cc) CL: Classroom Lecture
(dd) SM: Seminars (Student-led and Faculty-moderated)
(ee) CBL: Case-Based Learning
(ff) MPR: Micro-Projects/Mini Research Tasks
(gg) Visit: Industrial Visit/Field Visit/Institutional Visit
(hh) PBL: Problem-Based Learning
(ii) ROL: Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
(jj) COL: Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
(kk) EL: Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
(ll) SRP: Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
(mm) ICT: ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
(nn) RP: Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
(oo) IBL: Inquiry-Based Learning
(pp) SDL: Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

]

- **Assessment Methodologies**

(G) Internal Assessment [Total: 50 Marks]

a. Internal Formative assessment

(g) Assignment
(h) Seminars
(i) Class Regularity

b. Internal Summative Assessment

(e) Quizzes
(f) Mid-term tests

(H)Weightage of Learning Efforts for External Assessment [Total: 50 Marks]

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
I	**CLO1**	30	3	4	5	12
II	**CLO2**	30	2	5	5	12
III	**CLO3**	30	2	5	6	13
IV	**CLO4, CLO5**	30	2	6	5	13
		120	**09**	**20**	**21**	**50**

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Mid-term tests, Seminars, Assignments, Quizzes, Class Regularity	50
2	End-Semester Examination	Written Exam	50

(I) CLOs – PLOs Matrix

CLO	PLO									
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	1	1	-	-	3	-	-	1
CLO2	3	3	2	-	1	-	2	-	-	2
CLO3	3	2	2	1	2	-	2	1	-	2
CLO4	3	2	1	1	3	-	2	-	1	2
CLO5	3	2	2	-	3	1	3	1	2	2

Values to **CLO-PLO** matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- **Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Semiconductor Devices: Basic Principles	Jasprit Singh	1st Ed. (2001)	John Wiley & Sons
2	Semiconductor Devices - An Introduction	Jasprit Singh	1994	McGraw-Hill Inc.
3	Physics of Semiconductors and their Heterostructures	Jasprit Singh	1993	McGraw-Hill Inc.
4	Electronic Devices and Components	J. Seymore	1989	Longman Scientific & Technical
5	Power Electronics: Devices, Circuits, and Applications	Muhammad H. Rashid	4th Ed. (2013)	Pearson / Prentice Hall
6	Power Electronics: Converters, Applications, and Design	Ned Mohan, Tore M. Undeland	2nd Ed. (2003)	Wiley
7	Fundamentals of Power Semiconductor Devices	B. Jayant Baliga	2019	Springer
8	Power Electronics Semiconductor Devices	Robert Perret	2009	Wiley
9	Principles of Electronics	V. K. Mehta, Rohit Mehta	12th Ed. (2020)	S. Chand Publication
10	Wide Bandgap Semiconductors for Power Electronics: Materials, Devices, Applications	Peter Wellmann, Noboru Ohtani, Roland Rupp	2021	Wiley
11	Wide Bandgap Semiconductors: Fundamental Properties and Modern Photonic and Electronic Devices	Kiyoshi Takahashi, Akihiko Yoshikawa, Adarsh Sandhu	1st Ed. (2007)	Springer
12	Concise history of Science in India	D. M. Bose, S. N. Sen, B. V. Subbarayappa	2nd Ed. (2009)	Universities Press

13	Research Methodology for Natural Sciences	Prof. Soumitro Banerjee	2022	IISC Press

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	A Google Sites page with resources on advanced semiconductor technology	https://sites.google.com/view/advancedsemiconductors
2	NPTEL course on High-Speed Devices and Circuits with focus on heterojunctions	https://archive.nptel.ac.in/courses/117/106/117106089/
3	NPTEL lectures on MESFETs: I–V characteristics and velocity-field relation	https://archive.nptel.ac.in/courses/117/106/117106089/
4	Video lecture explaining MODFET (HEMT) fundamentals and operation	https://www.youtube.com/watch?v=FHGopzr64XY
5	Video lecture on MOSFET operation and characteristics	~~http://www.youtube.com/watch?v=MuBiC9yz2fc~~
6	NPTEL course covering MOSCAP concepts and C–V characteristics	~~https://archive.nptel.ac.in/courses/108/106/108106181/~~
7	NPTEL courses on Power Electronics covering devices, converters and applications	https://archive.nptel.ac.in/courses/108/101/108101126/ https://archive.nptel.ac.in/courses/108/105/108105066/
8	An NPTEL course on Research Methodology for Natural Sciences	https://nptel.ac.in/courses/127106227

M.Sc. Semiconductor Science and Technology Semester-II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCSST04	Practical-1	0-8-0	120	04

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO1: Analyze the characteristics of nanomaterials using image processing software.

CLO2: Evaluate the electrical and switching characteristics of fundamental semiconductor devices and power electronic components.

CLO3: Determine the fundamental charge carrier properties and electrical resistivity of semiconductors using advanced analytical techniques such as the Hall Effect and Four-Probe method.

CLO4: Analyze the optoelectronic performance and spectral response of photovoltaic devices by writing and executing data visualization scripts in Python.

CLO5: Calibrate and evaluate the sensitivity, linearity, and response characteristics of both resistance-based and voltage-output temperature sensors.

Unit	Course Content	Learning Pedagogies*	CLO(s)
1	SEM Image Analysis of Nanostructures	ROL, EL, ICT	CLO1
2	MOSFET characteristics	ROL, COL, EL	CLO2
3	Characteristics of Power Electronics Devices	ROL, COL, EL, IBL	CLO2
4	Hall Effect in Semiconductors	ROL, COL, EL, IBL	CLO3
5	Electrical Resistivity by Four-Probe Method	ROL, SRP, ICT, IBL	CLO3
6	Spectral Response Analysis of a Solar Cell Using Python	ROL, COL, EL, SDL	CLO4
7	Resistance-Based Temperature Sensors	ROL, COL, EL, IBL	CLO5
8	Voltage-Output Temperature Sensors	ROL, COL, EL, IBL	CLO5

(*) Learning Pedagogies/Methods

(qq) CL: Classroom Lecture

(rr) SM: Seminars (Student-led and Faculty-moderated)

(ss) CBL: Case-Based Learning

(tt) MPR: Micro-Projects/Mini Research Tasks
(uu) Visit: Industrial Visit/Field Visit/Institutional Visit
(vv) PBL: Problem-Based Learning
(ww) ROL: Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
(xx) COL: Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
(yy) EL: Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
(zz) SRP: Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
(aaa) ICT: ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
(bbb) RP: Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
(ccc) IBL: Inquiry-Based Learning
(ddd) SDL: Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

- **Assessment Methodologies**

(J) Internal Assessment [Total: 50 Marks]

a. Internal Formative assessment

(j) Preparation of Journal
(k) Practical Viva
(l) Laboratory Regularity

b. Internal Summative Assessment

(g) Mid-term Practical Examination
(h) Laboratory Performance

(K)Weightage of Learning Efforts for External Assessment [Total: 50 Marks]

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
Practical	**CLO1, CLO2, CLO3, CLO4, CLO5**	**120**	**10**	**20**	**20**	**50**

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Mid-Term Practical Exam, Lab Performance, Record/Journal, Internal Practical Viva, Attendance	50

2	End-Semester Examination	End-Term Practical Exam with Viva.	50

(L) CLOs – PLOs Matrix

CLO	PLO									
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	2	3	1	3	2	1	1	-
CLO2	3	1	1	2	3	-	3	-	-	1
CLO3	3	2	2	3	1	2	1	1	1	-
CLO4	3	3	2	1	2	-	1	-	2	-
CLO5	3	1	1	3	1	-	1	-	3	1

Values to **CLO-PLO** matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- **Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Scanning Electron Microscopy and X-Ray Microanalysis	Joseph Goldstein	3rd Ed. (2003)	Springer
2	Power Electronics: Circuits, Devices, and Applications	Muhammad H. Rashid	4th Ed. (2013)	Pearson
3	Semiconductor Material and Device Characterization	Dieter K. Schroder	3rd Ed. (2006)	Wiley
4	Python Programming and Numerical Methods: A Guide for Engineers and Scientists	Qingkai Kong	1st Ed. (2020)	Academic Press
5	Sensors and Transducers	D. Patranabis	2nd Ed. (2003)	PHI Learning

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	NIH ImageJ Documentation: documentation for nanoparticle image analysis and processing.	https://imagej.net/ij/docs/pdfs/ImageJ.pdf
2	Virtual Labs (IIT Bombay): Power Electronics	https://pe-iitr.vlabs.ac.in/
3	Virtual setups for both the Hall Effect and the Four-Probe resistivity measurements.	https://vlab.amrita.edu/?sub=1&brch=282

M.Sc. Semiconductor Science and Technology Semester-II

4	SciPy / Matplotlib Tutorials	https://matplotlib.org/stable/tutorials/index.html
5	NPTEL: Sensors and Transducers:	https://nptel.ac.in/courses/108105064

Course Type	Course Code	Course Title	Teaching-Learning Scheme L-P-T	Total Notional Hours	Course credits
DSC	P2S02NCSST05	Practical-2	0-8-0	120	04

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO1: Analyze the temperature-dependent, optical, and high-frequency characteristics of fundamental semiconductor devices to evaluate their operational metrics.

CLO2: Investigate the thermal and structural properties of solid-state materials by measuring temperature-dependent resistivity, analyzing lattice dynamics.

CLO3: Determine the velocity of acoustic waves and the compressibility of liquids using an ultrasonic interferometer.

CLO4: Design, program, and interface microcontroller-based systems using Arduino.

CLO5: Design and verify circuits using Hardware Description Language (HDL) and simulating ion-implantation processes.

Unit	Course Content	Learning Pedagogies*	CLO(s)
1	Characteristics of a Light Dependent Resistor (LDR)	ROL, COL, EL	CLO 1
2	I-V-T Characteristics of Diode	ROL, COL, EL, IBL	CLO 1, CLO 2
3	Gunn Diode characteristics	ROL, COL, EL	CLO 1
4	Lattice Dynamics	ROL, COL, EL, SRP	CLO 2
5	Ultrasonic Interferometer	ROL, COL, EL, IBL	CLO 3
6	Arduino Interfacing and Programming	PBL, COL, EL, ICT	CLO 4
7	Verilog	SRP, ICT, SDL	CLO 5
8	Ion-implantation simulation	ROL, COL, EL, IBL	CLO 5

(*) Learning Pedagogies/Methods

(eee) CL: Classroom Lecture
(fff) SM: Seminars (Student-led and Faculty-moderated)
(ggg) CBL: Case-Based Learning
(hhh) MPR: Micro-Projects/Mini Research Tasks
(iii)Visit: Industrial Visit/Field Visit/Institutional Visit
(jjj)PBL: Problem-Based Learning

(kkk) ROL: Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
(lll) COL: Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
(mmm) EL: Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
(nnn) SRP: Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
(ooo) ICT: ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
(ppp) RP: Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
(qqq) IBL: Inquiry-Based Learning
(rrr) SDL: Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

- **Assessment Methodologies**

(A) Internal Assessment [Total: 50 Marks]

a. Internal Formative assessment

(a) Preparation of Journal
(b) Practical Viva
(c) Laboratory Regularity

b. Internal Summative Assessment

(a) Mid-term Practical Examination
(b) Laboratory Performance

(B) Weightage of Learning Efforts for External Assessment [Total: 50 Marks]

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
Practical	CLO1, CLO2, CLO3, CLO4, CLO5	120	10	20	20	50

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Mid-Term Practical Exam, Lab Performance, Record/Journal, Internal Practical Viva, Attendance	50
2	End-Semester Examination	End-Term Practical Exam with Viva.	50

(C) CLOs – PLOs Matrix

CLO	PLO									
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	1	3	1	1	2	-	2	3

CLO2	3	3	1	3	1	2	1	-	1	1
CLO3	3	2	1	3	-	1	-	-	1	-
CLO4	3	1	1	2	1	-	3	-	3	1
CLO5	3	2	1	1	1	-	3	-	1	1

Values to **CLO-PLO** matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- **Suggested Learning Materials Books:**

Sr.No.	Title	Author(s)	Edition/Year	Publisher
1	Solid State Electronic Devices	Ben G. Streetman, Sanjay Kumar Banerjee	7th Ed. (2014)	Pearson
2	Microwave Devices and Circuits	Samuel Y. Liao	3rd Ed. (1990)	Pearson
3	Introduction to Solid State Physics	Charles Kittel	8th Ed. (2004)	Wiley
4	Fundamentals of Acoustics	Lawrence E. Kinsler, et al.	4th Ed. (1999)	Wiley
5	Arduino Cookbook	Michael Margolis	3rd Ed. (2020)	O'Reilly Media
6	Verilog HDL: A Guide to Digital Design and Synthesis	Samir Palnitkar	2nd Ed. (2003)	Pearson

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	Virtual Labs (IIT Roorkee): Microwave Engineering: Interactive virtual lab to test and plot Gunn diode V-I characteristics.	http://vlabs.iitkgp.ernet.in/mr/
2	NPTEL: Solid State Physics: Comprehensive lectures covering Lattice Dynamics, phonons, and temperature-dependent resistivity.	https://nptel.ac.in/courses/115105099
3	Virtual Labs (Amrita University): Advanced Physics: Virtual setup for the Ultrasonic Interferometer experiment.	https://vlab.amrita.edu/?sub=1&brch=201
4	Arduino Official Reference: Open-source language reference, tutorials, and circuit schematics for microcontroller programming.	https://www.arduino.cc/en/Tutorial/HomePage
5	EDA Playground: A free, web-based IDE to write, simulate, and view waveforms for Verilog HDL code.	https://www.edaplayground.com/

M.Sc. Semiconductor Science and Technology Semester-II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCSST06	Research Project	0-2-0	60	02

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO1: Identify and define a relevant problem in semiconductor science and technology through literature survey.

CLO2: Apply appropriate experimental, simulation, or analytical techniques to address the selected problem.

CLO3: Analyze and interpret the obtained results using scientific reasoning and data analysis tools.

CLO4: Develop technical documentation and present the findings effectively through written reports and oral presentations.

CLO5: Demonstrate independent learning, problem-solving ability, and research-oriented thinking.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	Research Project	SM, ROL, IBL, SDL, PBL, COL, EL, ICT, RP	CLO1, CLO2, CLO3, CLO4, CLO5

(*) Learning Pedagogies/Methods

(sss) CL: Classroom Lecture
(ttt)SM: Seminars (Student-led and Faculty-moderated)
(uuu) CBL: Case-Based Learning
(vvv) MPR: Micro-Projects/Mini Research Tasks
(www) Visit: Industrial Visit/Field Visit/Institutional Visit
(xxx) PBL: Problem-Based Learning
(yyy) ROL: Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
(zzz) COL: Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)

(aaaa) EL: Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
(bbbb) SRP: Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
(cccc) ICT: ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
(dddd) RP: Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
(eeee) IBL: Inquiry-Based Learning
(ffff) SDL: Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

- **Assessment Methodologies**

(D) Internal Assessment [Total: 25 Marks]

a. Internal Formative assessment
(a) Continuous Progress Monitoring
(b) Performance and Regularity

b. Internal Summative Assessment
(a) Internal Presentation
(b) Project Report

(E) Weightage of Learning Efforts for External Assessment [Total: 25 Marks]

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
I	CLO1, CLO2, CLO3, CLO4, CLO5	60	04	07	14	25

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Continuous Progress Monitoring, Performance and Regularity, Internal Presentation, Project Report	50
2	End-Semester Examination	Project Evaluation: Final Report, Presentation and Viva Voce	50

(F) CLOs – PLOs Matrix

CLO	PLO									
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10

CLO1	2	-	3	2	-	1	2	1	-	1
CLO2	3	3	2	1	2	-	3	-	-	2
CLO3	3	2	2	2	2	-	2	-	3	-
CLO4	2	2	2	-	2	2	2	-	3	1
CLO5	2	2	2	-	1	2	2	-	2	2

Values to **CLO-PLO** matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- **Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Introduction to Semiconductor Manufacturing Technology	Stephen A. Campbell	2nd Ed. (2008)	McGraw-Hill Education
2	Research Methodology: Methods and Techniques	C.R. Kothari	2nd Ed. (2004)	New Age International
3	Electronic Instrumentation and Measurements	David A. Bell	2nd Ed. (2007)	Oxford University Press / PHI
11	Research Methodology for Natural Sciences	Prof. Soumitro Banerjee	2022	IISC Press

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	A Google Sites page with resources on advanced semiconductor technology	https://sites.google.com/view/advancedsemiconductors
2	Complete Guide to Semiconductor Devices by Kwok K. Ng: A comprehensive handbook.	https://ieeexplore.ieee.org/book/5271197
4	NPTEL course on Semiconductor Physics and Devices by IISc	https://archive.nptel.ac.in/courses/108/108/108108122/