SARDAR PATEL UNIVERSITY
VALLABH VIDYANAGAR
M.Sc. Semiconductor Science and Technology (Semester – III)
Effective from June-2026

Course Code	Course Title	Course Type	T/P	Credits	Number of Hours per Week
PS03CSST01	Nano-Fabrication and Device Testing	Disciplinary Major	T	4	4

Course Objectives	- To provide comprehensive knowledge of semiconductor fabrication processes used in integrated circuit manufacturing. - To develop understanding of thin film formation techniques such as oxidation, chemical vapor deposition and metallization processes. - To familiarize students with modern lithography and etching methods used for micro/nano-scale pattern transfer. - To introduce principles of impurity doping, diffusion, ion implantation and annealing processes for semiconductor device fabrication. - To explain the concepts of device reliability and failure mechanisms in semiconductor technologies. - To train students in identifying process limitations and selecting suitable fabrication techniques for advanced devices. - To expose students to analytical tools and characterization methods used in semiconductor manufacturing and failure analysis.

Course Content	
Description	**Weightage (%)**
Unit-I: Film Formation Thermal Oxidation, Thin Oxide Growth, Chemical Vapor Deposition of Dielectrics: Silicon Dioxide, Deposition Methods, Properties of Silicon Dioxide, Step Coverage, P-Glass Flow, Silicon Nitride, Low and High Dielectric Constant Materials and Materials Options, Chemical Vapor Deposition of Polysilicon and Metallization.	25
Unit-II: Lithography and Etching Optical Lithography: The clean Room, Exposure Equipment, Masks, Photoresist, Spin Coating, Pattern Transfer, Wet Photoresist Striping, Dry Photoresist Stripping, Resolution Enhancement techniques, Advanced Lithography: Electron Beam Lithography: Electron Resist, The Proximity Effect, Ion beam lithography, Extreme-Ultraviolet Lithography, Wet Chemical Etching, Dry Chemical Etching.	25
UNIT III: Impurity Doping Impurity Doping: Basic Diffusion Process, Extrinsic Diffusion, Diffusion Related Processes, Ion-Implantation: Range of Implanted Ions, Implant Damage and Annealing, Rapid Thermal Annealing, Millisecond Annealing, Implantation Related Processes: Multiple Implantation and Masking, Tilt Angle Ion-Implantation, High-Energy High-Current Implantation, Doping profile extraction from C-V Measurements.	25
UNIT IV: Reliability and Failure Analysis: Introduction, Failure Times and Acceleration Factors, Distribution Functions, Reliability Concerns, Electromigration (EM), Hot Carriers, Gate Oxide Integrity (GOI), Negative Bias Temperature Instability (NBTI), Stress Induced Leakage Current (SILC), Electrostatic	25

Discharge (ESD), Failure Analysis Characterization Techniques: Quiescent Drain Current, Mechanical Probes, Emission Microscopy (EMMI), Fluorescent Microthermography (FMT), Infrared Thermography (IRT), Voltage Contrast, Laser Voltage Probe (LVP), Liquid Crystals (LC), Optical Beam Induced Resistance Change (OBIRCH), Focused Ion Beam (FIB). Reliability Testing, Test Methodology		
Course Outcomes	- Explain the fundamentals of thin film growth, oxidation, dielectric deposition, polysilicon deposition and metallization processes. - Analyze the properties and selection criteria of materials used in semiconductor device fabrication. - Describe and compare optical lithography, electron beam lithography, ion beam lithography, EUV lithography and related patterning techniques. - Understand and evaluate wet and dry etching processes for semiconductor microfabrication. - Apply knowledge of diffusion, ion implantation, masking, annealing and doping profile extraction in device processing. - Analyze semiconductor device reliability issues such as electromigration, hot carrier effects and gate oxide integrity. - Apply fabrication and reliability concepts to modern semiconductor technologies, research, and industrial manufacturing environments.	

❖ **Recommended Textbooks and References:**

1. Semiconductor Devices: Physics and Technology, S. M. Sze and M. K. Lee, John Wiley and Sons Inc. Third Edition, 2012.
2. VLSI Technology, Edited by S. M. Sze, McGraw-Hill Book Company.
3. Fabrication Engineering at the Micro and Nano Scale, Stephen A. Campbell, Oxford University Press, Third Edition, 2008.
4. The Science and Engineering of Microelectronic Fabrication, Stephen A. Campbell, Oxford University Press, Second Edition, 2001.
5. VLSI Fabrication Principles: Silicon and Gallium Arsenide, Sorab K. Gandhi, John Wiley and Sons Inc. Second Edition, 1994.
6. Silicon VLSI Technology: Fundamentals, Practice and Modeling, James D. Plummer, Michael D. Deal, Peter B. Griffin, Printice Hall Inc.
7. Semiconductor Material and Device Characterization, Dieter K. Schroder

❖ **Online Resources:**

1. https://sites.google.com/view/advancedsemiconductors
2. https://www.youtube.com/watch?v=jnnXZa_hWq4
3. https://www.youtube.com/playlist?list=PLgMDNELGJ1CbHti4HN0BuagtoD06H78YT
4. https://www.youtube.com/playlist?list=PLPYBrn3UjhUMKBPqheDQsBopQrKrW6zR_
5. https://www.youtube.com/watch?v=nFb8ZVt8ahE

***

SARDAR PATEL UNIVERSITY
VALLABH VIDYANAGAR
M.Sc. Semiconductor Science and Technology (Semester – III)
Effective from June-2026

Course Code	Course Title	Course Type	T/P	Credits	Number of Hours per Week
PS03CSST02	VLSI Design and Device Simulation	Disciplinary Major	T	4	4

Course Objectives	
	- To introduce students to the fundamentals of Verilog HDL and its role in modern digital system design and VLSI development. - To develop understanding of different modeling styles in Verilog such as gate-level, dataflow, behavioral and structural modeling. - To familiarize students with design hierarchy, modular design concepts, syntax, operators, procedural blocks and simulation techniques in Verilog HDL. - To provide knowledge of Technology Computer Aided Design (TCAD) and its significance in semiconductor device research and industrial applications. - To train students in the use of TCAD tools for semiconductor device modeling, process simulation and performance analysis. - To enable students to analyze device characteristics under varying material, geometry, and environmental conditions for advanced semiconductor applications. - To expose students to current developments and research trends in VLSI design and semiconductor device simulation.

Course Content	
Description	**Weightage (%)**
UNIT 1: Fundamentals of Verilog HDL and Modelling Overview of Digital Design with Verilog HDL, Evolution of Digital Design, Emergence of HDLs, Typical VLSI Design Flow, Importance and Advantages of Verilog HDL, Hierarchical Modelling Concepts, Top-Down and Bottom-Up Design Methodologies, Module and Module Instantiation, Design Hierarchy, Levels of Abstraction in Modelling, Components of Simulation (Design Block And Stimulus Block), Basic Concepts, Lexical Conventions, Data Types, System Tasks and Compiler Directives, Modules, Ports , Hierarchical Names.	25
UNIT 2: Verilog Modelling Techniques Gate-Level Modelling, Logic Gate Types, Gate Delays, Dataflow Modelling, Delays, Expressions and Operators, Operator Types, Behavioural Modelling, Structured Procedures, Procedural Assignments, Timing Control, Conditional Statements, Multiway Branching, Loops, Sequential and Parallel Blocks, Tasks and Functions, Differences Between Tasks and Functions, Declaration and Syntax, Examples.	25
UNIT III: Fundamentals of Technology Computer Aided Design (TCAD) Introduction to device simulation and its role in semiconductor device research and industry. Introduction to Technology Computer-Aided Design (TCAD). Overview of TCAD tools (Silvaco, Synopsys Sentaurus and others). Fundamentals of device simulation methodology, Process simulation and device simulation concepts, Physical models used in TCAD simulations, Faculty selected recent topic from current science and latest discovery	25

UNIT IV: Semiconductor Device Simulation using TCAD Programming to design advanced semiconductor devices, Extraction and analysis of device characteristics, Device performance under different geometry and environment, Device scalability, parameter variation and performance optimization, Faculty selected recent topic from current science and latest discovery		25
Course Outcomes	- Explain the concepts of digital design flow, Verilog HDL evolution and hierarchical design methodologies. - Write and simulate Verilog programs using modules, ports, data types, operators, tasks, functions and procedural statements. - Perform simulation and debugging of combinational and sequential logic circuits using Verilog HDL tools. - Understand the principles of TCAD-based semiconductor device simulation, including physical models and process-device interactions. - Use TCAD tools such as Silvaco, Synopsys Sentaurus and similar platforms for device structure creation, simulation and result interpretation. - Evaluate semiconductor device performance by analyzing characteristics such as I-V behavior, scalability, geometry dependence, and optimization strategies.	

❖ **Recommended Textbooks and Refences:**

1. Verilog HDL: A Guide to Digital Design and Synthesis by Samir Palnitkar, SunSoft Press, 1996.
2. Verilog Digital System Design by Zainalabedin Navabi, McGraw-Hill
3. The Verilog Hardware Description Language by Thomas & Moorby, Springer
4. A Verilog HDL Primer by J. Bhasker, BSP Books
5. Advanced Digital Design with Verilog HDL by Michael D. Ciletti, Pearson
6. Computer Aided Design of Micro and Nanoelectronic Devices, Chinmay Kumar Maiti, World Scientific Publishing
7. Introducing Technology Computer-Aided Design (TCAD): Fundamentals, Simulations, and Applications, Chinmay Kumar Maiti, Pan Stanford publishing
8. 3D TCAD simulation for Semiconductor process, Devices and Optoelectronics, Simon Li and Yue Fu, Springer New York, NY

❖ **Online Resources:**

1. https://sites.google.com/view/advancedsemiconductors
2. https://silvaco.com
3. NPTEL course: Semiconductor device modeling and Simulation: https://nptel.ac.in/courses/108105188
4. NPTEL course: Modeling and TCAD Simulation of Solar PV Cell: https://nptel.ac.in/courses/108105713
5. Digital Design with Verilog: https://onlinecourses.nptel.ac.in/noc26_cs24/preview
6. NPTEL course: Hardware Modeling using Verilog: https://nptel.ac.in/courses/106105165

***

SARDAR PATEL UNIVERSITY
VALLABH VIDYANAGAR
M.Sc. Semiconductor Science and Technology (Semester – III)
Effective from June-2026

Course Code	Course Title	Course Type	T/P	Credits	Number of Hours per Week
PS03CSST03	High Frequency Semiconductor Devices and their Packaging for RF, Space and Defence	Disciplinary Major	T	4	4

Course Objectives	
	- To introduce the fundamentals of RF, space, and radar systems along with their application areas and basic operating principles. - To understand high-frequency semiconductor devices and the role of key RF circuit elements such as amplifiers, mixers, and oscillators. - To study the design considerations and realization of high-frequency circuits using MIC and MMIC technologies. - To gain knowledge of fabrication processes and elements involved in MMIC technology. - To understand packaging techniques used for high-frequency circuits and their importance in performance and protection. - To learn the concepts of reliability, failure mechanisms, and qualification methods used in RF and microwave systems.

Course Content	
Description	**Weightage (%)**
Unit I: Introduction to basic RF, Space and Radar Systems Electromagnetic Spectrum, Frequency Band Nomenclature, Application Areas, Introduction to RF Transceiver, Communication Satellite, RADAR, High Frequency Semiconductor/Device Technologies- GaAs HEMTs, pHEMTS, mHEMTS, GaAs HBTs, GaAs Pin Diodes, GaN HEMTs, SiGe BiCMOS, InP HBTs, Circuit Elements and Their Functions- Power Amplifier, Low Noise Amplifier, Mixer, Oscillator, Small Signal Amplifier, Phase Shifter	25
Unit II: High Frequency Circuit Realization Salient Considerations for High Frequency Circuit Realization, Hybrid Microwave Integrated Circuits (MMIC)- Introduction, Advantages, Disadvantages, Monolithic Microwave Integrated Circuits (MMIC)- Introduction, Advantages, Disadvantages, MMIC Elements- Transistors, Diodes, Resistors, Capacitors, Inductors, Transmission Lines, Vias, Pads, MMIC Wafer Growth and Fabrication Flow	25
Unit III: Packaging of High Frequency Circuits Basic functions of packaging, Wire bonded packaging- Metal, Ceramic, Plastic, Die attachment techniques, Flip Chip packaging, Multi-Chip-Module (MCM) packaging- Thin film Microwave Integrated Circuit (MIC), Low Temperature Co-fired Ceramic (LTCC), High Temperature Co-fired Ceramic (HTCC), Hermetic Sealing- Sealing and leak testing methods	25
Unit IV: Reliability and Qualification Overview of Reliability- Definition of Reliability, Introduction to Failures, Quantification of Reliability, Different failure modes and mechanisms, Radiation effects on MMICs, Qualification methods- Process Qualification, Product Qualification, Product Acceptance	25

Course Outcomes	- Explain the basic concepts of RF systems, electromagnetic spectrum, and radar and satellite communication. - Identify and describe high-frequency semiconductor devices and their applications in RF circuits. - Analyze the working of RF circuit components such as amplifiers, mixers, and oscillators. - Understand and compare MIC and MMIC technologies along with their fabrication processes. - Describe different packaging methods and evaluate their impact on circuit performance and reliability. - Evaluate reliability issues, failure mechanisms, and qualification techniques in high-frequency systems.

❖ **Recommended Textbooks and References:**

1) Microwave Engineering, David M. Pozar, 2012
2) RFIC and MMIC Design and Technology, I. D. Robertson, S. D. Lucyszyn, 2001
3) RF Microelectronics, Behzad Razavi, 2012
4) Microwave Circuit Design Using Linear and Nonlinear Techniques, George D. Vendelin, Anthony M. Pavio, Ulrich L. Rohde, Matthias Rudolph, 2021
5) Fundamentals Of Device & Systems Packaging, 2nd Edition, Rao Tummala, 2021
6) GaAs MMIC Reliability Assurance Guideline for Space Applications, Sammy Kayali, George Ponchak, Roland Shaw, 1996

❖ **Online Resources:**

1) https://nptel.ac.in/courses/108107379
2) nptel.ac.in/courses/108105154
3) https://onlinecourses.nptel.ac.in/noc26_ee86/preview
4) https://onlinecourses.nptel.ac.in/noc20_ee25/preview
5) https://www.microwaves101.com/encyclopedias/mmic-design
6) https://onlinecourses.nptel.ac.in/noc22_me61/preview
7) https://nptel.ac.in/courses/108108031
8) https://www.ti.com/quality-reliability/reliability/testing.html#temperature-cycle
9) https://onlinecourses.nptel.ac.in/noc23_ge20/preview

***

SARDAR PATEL UNIVERSITY
VALLABH VIDYANAGAR
M.Sc. Semiconductor Science and Technology (Semester – III)
Effective from June-2026

Course Code	Course Title	Course Type	T/P	Credits	Number of Hours per Week
PS03CSST04	Fundamentals of Semiconductor Packaging Technology	Disciplinary Major	T	4	4

Course Objective	- To understand the role and significance of semiconductor packaging in electronic systems. - To study the structural and electrical design aspects of semiconductor packages. - To analyse heat dissipation and thermal design solutions across various system levels. - To assess mechanical reliability challenges and interconnect technologies in packaging. - To introduce packaging solutions for modern applications such as electric vehicles.

Course Content	
Description	**Weightage (%)**
Unit I: Introduction to Device and Systems Packaging Technologies Anatomy of an Electronic Packaged System from a Packaging Point of View, Fundamentals of Packaging, Systems Packaging Involves Electrical, Mechanical, and Materials Technologies, Nomenclature, Devices and Moore's Law, On-Chip Interconnections, Interconnect Materials, The Resistance and Capacitance Delays (RC Delays) of On-Chip Interconnects, Future of Device Scaling. Electronic Technology Waves: Microelectronics, RF/Wireless, Photonics, MEMS, and Quantum Devices. Packaging and Moore's Law for Packaging: Moore's Law or SOC Era (1960–2010), Moore's Law for Packaging Era from 2010 to 2025, Moore's Law for Systems Era from 2025. Core Packaging Technologies, Packaging Technologies and Their Trends, Emerging 3D Systems Packaging	25
UNIT II: Fundamentals of Electrical Design for Signals, Power, and Electromagnetic Interference Electrical Anatomy of a Package, Fundamentals of Electrical Package Design, Signal Distribution, Devices and Interconnections, Kirchhoff's Laws and Transit Time Delay, Transmission Line Behaviour of Interconnections, Characteristic Impedance, Typical Transmission Line Structures Used as Package Interconnections, Transmission Line Losses, Crosstalk. Power Distribution: Power Supply Noise, Inductive Effects, Effective Inductance, Effect of Package Design on Inductance, Decoupling Capacitors, Electromagnetic Interference.	25
UNIT III: Fundamentals of Thermal Technologies Introduction, Anatomy of a Thermal Package System, Fundamentals of Heat Transfer, Chip	25

Level Thermal Technologies, Thermal Interface Materials (TIMs),Thermal Vias. Module Level Thermal Technologies: Heat Sinks, Heat Pipes and Vapor Chambers, Closed-Loop Liquid Cooling, Cold Plates, Immersion Cooling, Jet Impingement Cooling, Spray Cooling. System Level Thermal Technologies: Air Cooling, Hybrid Cooling, Immersion Cooling. Power and Cooling Technologies for Electric Vehicles.	
UNIT IV: Fundamentals of Chip-to-Package Interconnections and Assembly Introduction, Anatomy of an Interconnection and Assembly, Fundamentals of Interconnections and Assembly: Electrical, Thermal, Mechanical, Reliability, Interconnection and Assembly Pitch. Fundamentals of Assembly and Bonding: Metallurgical Bonding and Adhesive Bonding. Interconnections and Assembly Technologies; Evolution, Wire-Bonding, Tape Automated Bonding (TAB), Flip-Chip Interconnection and Assembly Technology, Copper Pillar with Solder Cap Technology, SLID Interconnection and Assembly Technology, Future Trends in Interconnection and Assembly Technologies. Introduction to 2D, 2.1D, 2.3D, 2.5D, and 3D IC integration.	25

Course Outcomes	- Students will develop understanding of the critical role of semiconductor packaging in system performance. - Students will learn the fundamentals of electrical signal and power distribution in package design. - Students will be able to analyse thermal challenges in devices, modules, and systems. - Students will gain the skill to evaluate the failure mechanisms and design for mechanical reliability. - Student will have insight into various interconnection and assembly technologies used in advanced packaging.

Recommended Textbooks and References:

1. **Rao R. Tummala**, *Fundamentals of Device and Systems Packaging: Technologies and Applications*, 2nd Edition, McGraw Hill, 2020.
2. Chen, Andrea. *Semiconductor Packaging: Materials Interaction and Reliability.* McGraw-Hill Education, 2016. ISBN: 9780071828396.
3. John H. Lau, *Semiconductor Advanced Packaging,* 1st Edition, Springer, 2021

Online Resources:

1. https://archive.nptel.ac.in/courses/108/108/108108031/
2. https://archive.nptel.ac.in/courses/112/105/112105267/
3. https://www.youtube.com/playlist?list=PLD50A0FB75B98EDA3

***