OFFICE OF THE REGISTRAR :: DIBRUGARH UNIVERSITY :: DIBRUGARH

Ref. No. DU/DR-A/131st AC/Curriculum-Semiconductor Course/2024/1280 Date: 03.07.2024

NOTIFICATION

As recommended by the Committee constituted vide No. DU/RG/G.01.01/2024/6748, dated 09.04.2024 and Joint Meeting (Special) of the Under Graduate Board (128th) and Post Graduate Board (155th), Dibrugarh University held on 06.06.2024, the 131st Meeting (Special) of the Academic Council, Dibrugarh University held on 13.06.2024 vide ***Resolution No. 09*** has approved the Course Curriculum of Post Graduate Diploma Programme on Semiconductor: Theory and Applications with effect from the academic session 2024-2025.

The syllabus is attached herewith.

Issued with due approval.

Alaganka 03/07/2024

Deputy Registrar (Academic)
Dibrugarh University

Copy for kind information and necessary action to:

1. The Hon'ble Vice-Chancellor, Dibrugarh University.
2. The Deans, Dibrugarh University.
3. The Registrar, Dibrugarh University.
4. All the Heads / Chairpersons of the Teaching Departments / Centres of Studies, Dibrugarh University.
5. The Chairperson, Committee of the Semi Conductor Course, Dibrugarh University.
6. The Controller of Examinations i/c, Dibrugarh University.
7. The Joint / Deputy Controller of Examinations – 'B', 'C' & 'A', Dibrugarh University.
8. The Programmer, Dibrugarh University with a request to upload the notification in the Dibrugarh University Website.
9. File.

Alaganka 03/07/2024

Deputy Registrar (Academic)
Dibrugarh University

SYLLABUS

SEMICONDUCTOR: THEORY & APPLICATION

1 YEAR

(POST GRADUATE DIPLOMA)

DIBRUGARH UNIVERSITY

[2024-25 Batch Onwards]

Semester-wise structure of curriculum

[L= Lecture, T = Tutorials, P = Practicals & C = Credits]

Branch/Course SEMICONDUCTOR THEORY & APPLICATION

Semester I (First year)

SL. No	Course Code	Course Title	Hours per week			Credit
			L	T	P	
1	STA-C-100	Industry Awareness and Soft Skills	2	0	0	2
2	STA-C-101	Fundamentals of material science and semiconductor technology	4	0	0	4
3	STA-C-102	Fundamentals of Electrical Circuit	3	0	0	3
4	STA-C-103	Fundamentals of Digital Systems	4	0	0	4
5	STA-C-104	Electronic Devices and Circuits	4	0	0	4
6	STA-C-111	Basic Electronics Laboratory	0	0	8	4
	Total Credits					21

Semester II (First year)

SL. No	Course Code	Course Title	Hours per week			Credit
1	STA-C-200	Computer Skills	2	0	0	2
2	STA-C-201	Instrumentation and Equipment Maintenance	3	0	0	3
3	STA-C-202	Clean Room and Vacuum Technology	4	0	0	4
4	STA-C-203	Semiconductor Packaging and Testing	4	0	0	4
5	STA-C-204	Fundamentals of VLSI Fabrication	4	0	0	4
6	STA-C-211	Advanced Semiconductor Laboratory	0	0	8	4
	Total Credits					21

SEMESTER-1

STA-C-100	Industry Awareness and Soft Skills	2L:0T:0P	2 Credit

Course Outcome:

At the end of this course, students will demonstrate the ability to

CO1: Understand the basic role of industry in the country's development.

CO2: Develop awareness of the technology needs.

CO3: Learn innovative ways of learning and personal development

CO4: Understand different communication methods

CO5: Learn to resolve conflict and build interpersonal skills

Module-I: (12 Hours, 20 Marks)

Introduction: A new approach to life, role of citizens, how a country relies on different socio-economic factors, the role of industry, agriculture, human development, etc. What is technology, how technology helps, using technology for human needs, being innovative, developing a perspective of personal role and goal achieving collective and personal milestones

Module-I: (18 Hours, 30 Marks)

Human Perceptions, Understanding different types of People, Communication: Significance Of Listening, Interpersonal Transactions, Nonverbal Communication: Introduction and importance, Body Language, Interpreting Non-Verbal Cues, Conflict Resolution Skills: Seeking Win-Win Solution, Regulating Stress: Making The Best Out Of Stress,

Communication: Basic Writing/Telephone Skills, E-Mail Principles Advanced Skills, Presentation Skills, Out of box thinking, and thinking habits

STA-C-101	Fundamentals of semiconductor physics and devices	4L:0T:0P	4 Credit

Course Outcome:

At the end of this course, students will demonstrate the ability to

CO1: Understand the basics of semiconducting materials.

CO2: To develop knowledge about semiconductor devices.

CO3: Learn the workings of FET and MOSFET devices.

Detailed Syllabus

Module-I Introduction to material science and semiconductors: (15 Hours, 30 Marks)

Semiconductor Materials; Crystal Lattices: Periodic Structures, Cubic Lattices, Planes and Directions, Diamond Lattice; Bulk Crystal Growth: Growth of Single-Crystal Ingots, Wafers, Doping;

Bonding Forces and Energy Bands in Solids: Bonding Forces in Solids, Energy Bands, Metals, Semiconductors, and Insulators, Direct and Indirect bandgap Semiconductors, Variation of Energy Bands with Alloy Composition; Charge Carriers in Semiconductors: Electrons and Holes, Effective Mass, Intrinsic Material, Extrinsic Material; Carrier Concentrations: The Fermi Level, Electron and Hole Concentrations at Equilibrium, Temperature Dependence of Carrier Concentrations; Drift of Carriers in Electric and Magnetic Fields: Conductivity and Mobility, Drift and Resistance, Effects of Temperature and Doping on Mobility; Diffusion of Carriers, Diffusion Processes, Diffusion and Drift of Carriers.

Module-II Junctions (9 Hours, 20 Marks)

Equilibrium Conditions: The Contact Potential, Equilibrium Fermi Levels, Space Charge at a junction; Forward- and Reverse-Biased Junctions: Qualitative Description of Current Flow at a Junction, Carrier Injection, Reverse Bias, Reverse-Bias Breakdown, Zener Breakdown, Avalanche Breakdown, Rectifiers, Time Variation of Stored Charge, Switching Diodes, Capacitance of p-n Junctions, The Varactor Diode, Ohmic Losses, Graded Junctions, Metal–Semiconductor Junctions, Schottky Barriers, Rectifying Contacts, Ohmic Contacts, Typical Schottky Barrier.

Module-III Field-Effect Transistors (12 Hours, 25 Marks)

The Junction FET, Pinch-off and Saturation, Gate Control, Current-Voltage Characteristics, The Metal–Semiconductor FET, The GaAs MESFET, The High Electron Mobility Transistor (HEMT), Short Channel Effects, The Metal–Insulator–Semiconductor FET, The Ideal MOS Capacitor, Effects of Real Surfaces, Threshold Voltage, MOS Capacitance–Voltage Analysis, Current-Voltage Characteristics of MOS Gate Oxides, The MOS Field-Effect Transistor, Output Characteristics Transfer Characteristics, Short Channel MOSFET *I–V* Characteristics, Control of Threshold Voltage, Substrate Bias Effects-the “body” effect, Short Channel Effect and Narrow Width Effect, FinFet

Module-IV Bipolar Junction Transistor (12 Hours, 25 Marks)

Fundamentals of BJT Operation, Amplification with BJTs, Minority Carrier Distributions and Terminal Currents, Solution of the Diffusion Equation in the Base Region Evaluation of the Terminal Currents, Current Transfer Ratio, Generalized Biasing, Charge Control Analysis, Switching, Cutoff, Saturation, The Switching Cycle, Specifications for Switching Transistors, Drift in the Base Region, Base Narrowing, Injection Level; Thermal Effects,Base Resistance and Emitter Crowding, Frequency Limitations of Transistors, Capacitance and Charging Times, Transit Time Effects.

REFERENCE BOOKS:

1. Solid State Electronic Devices; Ben G. Streetman and S K Banerjee; Pearson
2. Semiconductor Physics and Devices: Basic Principles; Donald A. Neamen; McGraw Hill
3. Introduction to Solid State Physics; C. Kittel, Wiley
4. Solid State Physics; A. J. Dekker, Macmillan and Co. Ltd

STA-C-102	Fundamentals of Electrical Circuit	3L:0T:0P	3 Credit

Course Outcome:

At the end of this course, students will demonstrate the ability to

CO1: Understand different theorems and apply them on DC circuits.

CO2: Comprehend magnetic circuits with its laws and parameters

CO3: Understand Electromagnetic Induction.

CO4: Comprehend the principles of AC fundamentals and Understand vector algebra

CO5: Understand various single-phase AC parameters in R, L, C, R-L, R-C, R-LC series and parallel circuits

CO6: Understand Poly-phase AC circuits.

Module I: Introduction: (12 Hours, 25 Marks)

Types of circuits: open, closed and short circuits, Linear, non linear circuits, passive active circuits and components, node, unilateral, bilateral circuits. D.C circuits : Kirchhoff's laws, Ideal Voltage, Ideal Current source & conversion Star - delta Transformation. Network theorems: Thevenin's Theorem, Reciprocity Theorem, Superposition Theorem Maximum power transfer Theorem. Problems on KVL,KCL, star-Delta transformation and Network theorems.

Module II: Magnetism and Magnetic circuits: (12 Hours, 25 Marks)

Magnetic circuit, MMF, reluctance and mention their units, Absolute permeability and Relative permeability and mention their units, relationship between Flux, MMF and Reluctance, Compare Electric circuit with magnetic circuit.
Magnetic field around a current carrying conductor, Cork Screw Rule and Right Hand Thumb Rule, Faraday's laws of Electromagnetic Induction, EMF induced in a coil, Types of induced emfs and their application, Fleming's Right Hand Rule, Lenz's law, Self induced emf and Mutually induced emf and their application, Self inductance and Coefficient of Self inductance, Mutual inductance and Coefficient of Mutual inductance

Module III: A.C. Principles : (12 Hours, 25 Marks)

Generation of Single phase AC voltage, Frequency, Amplitude, Cycle, Time period and their units, Maximum value, RMS value, Average value, Form factor and Peak factor of a sinusoidal wave, Instantaneous value of Voltage and Current, phase and phase difference, Vectorial representation of AC quantities, Power and Power factor in AC circuits, Vector Algebra: Represent vectors in Rectangular, Trigonometric and Polar forms, Convert Rectangular form into Polar form and vice-versa.

Module IV: Single Phase AC Circuits : (12 Hours, 25 Marks)

Current and Power in a pure resistive, pure inductive and pure capacitive circuit, Capacitive reactance, Inductive reactance, Impedance, Current, Power and Power factor of R-L, R-C, R-L-C series and parallel circuits, Poly-phase AC Circuits.

REFERENCE BOOKS:

1. B.L. Theraja, " A Textbook of Electrical Technology (Volume-IV)", S. Chand Pub., 2014.
2. Hughes, "Electrical and Electronic Technology", Pearson Pub., 2010

3. V.K. Mehta &Rohit Mehta, "Principles Of Electrical Engineering", S. Chand Pub., 2005

STA-C-103	Fundamentals of Digital Systems	4L:0T:0P	4 Credit

Course Outcome:

At the end of this course, students will demonstrate the ability to

CO1: Understand the basic logic operations and combinational logic elements.

CO2: Design and analyze combinational circuits.

CO3: Design and analyze synchronous sequential logic circuits.

CO4: Understand the architecture of microprocessors and microcontrollers.

CO5: Develop programs for various microcontrollers.

Module-I: (12 Hours, 20 Marks)

Logic Simplification and Codes: Review of Boolean Algebra and De Morgan’s Theorem, SOP & POS forms, Canonical forms, Karnaugh maps up to 6 variables, different codes, Code Conversion.

Module-II: (12 Hours, 20 Marks)

Combinational Logic Design: MSI devices like Comparators, Multiplexers, Encoder, Decoder, Driver & Multiplexed Display, Half and Full Adders, Subtractors, Serial and Parallel Adders, BCD Adder, Barrel shifter and ALU.

Module-III: (12 Hours, 20 Marks)

Sequential Logic Design: Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF, Ripple and Synchronous counters, Shift registers, Finite state machines, Design of synchronous FSM, Algorithmic State Machines charts. Designing synchronous circuits like Pulse train generator, Pseudo Random Binary Sequence generator, Clock generation.

Module-IV: (12 Hours, 20 Marks)

Logic Families and Semiconductor Memories: TTL NAND gate, Specifications, Noise margin, Propagation delay, fan-in, fan-out, Tri-state TTL, ECL, CMOS families and their interfacing, open drain/collector devises, pull-up resistor, lMemory elements: RAM/ROM, DRAM ICs, Concept of Programmable logic devices like FPGA. Logic implementation using Programmable Devices.

Module-V: (12 Hours, 20 Marks)

Overview of microcomputer systems and their building blocks, instruction sets of microprocessors (with examples of 8085 and 8086), memory interfacing, concepts of interrupts and Direct Memory Access, UART, introduction to advanced microprocessors and microcontroller.

REFERENCE BOOKS:

1. R.P. Jain, "Modern digital Electronics", Tata McGraw Hill.
2. R. Anand, Digital Electronics, Khanna Book Publishing Company.
3. Gothman, "Digital Electronics-An introduction to theory and practice", Pearson Education.
4. Douglas-Hall, "Digital Circuits and Systems", Tata McGraw Hill.
5. Charles Roth, "Digital System Design using VHDL", Tata McGraw Hill.
6. R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085/8080A, Penram International Publishing, 1996.

STA-C-104	Electronic Devices and Circuits	4L:0T:0P	4 Credit

Course Outcome:

At the end of this course students will demonstrate the ability to

CO1: Understand the characteristics of diodes and transistors.

CO2: Design and analyze various rectifier and amplifier circuits.

CO3: Design sinusoidal and non-sinusoidal oscillators.

CO4: Understand the functioning of OP-AMP and design OP-AMP based circuits.

Module-I: (12 Hours, 20 Marks)

Diode Circuits, Amplifier models: Voltage amplifier, current amplifier, trans-conductance amplifier and trans-resistance amplifier. Biasing schemes for BJT and FET amplifiers, bias stability, various configurations (such as CE/CS, CB/CG, CC/CD) and their features, small signal analysis, low frequency transistor models, estimation of voltage gain, input resistance, output resistance etc., design procedure for particular specifications, low frequency analysis of multistage amplifiers.

Module-II: (12 Hours, 20 Marks)

High-frequency transistor models, frequency response of single-stage and multistage amplifiers, cascode amplifiers. Feedback topologies: Voltage series, current series, voltage shunt, current shunt, the effect of feedback on gain, bandwidth, etc., calculation with practical circuits, the concept of stability, gain margin and phase margin.

Module-III: (12 Hours, 20 Marks)

Oscillators and regulators: Review of the basic concept, Barkhausen criterion, RC oscillators (phase shift, Wien bridge etc.), non-sinusoidal oscillators.

Voltage regulators and power considerations: regulator like 723, high current regulators, three-terminal regulators, high voltage and low noise regulators,

Module-IV: (12 Hours, 20 Marks)

Current mirror: Basic topology and its variants, V-I characteristics, output resistance and minimum sustainable voltage (VON), maximum usable load. Differential amplifier: Basic structure and principle of operation, calculation of differential gain, common mode gain, CMRR and ICMR. OP-AMP design: design of differential amplifier for a given specification, design of gain stages and output stages, compensation.

Module-V: (12 Hours, 20 Marks)

OP-AMP applications: review of inverting and non-inverting amplifiers, integrator and differentiator, summing amplifier, precision rectifier, Schmitt trigger, and its applications. Active filters, regulators, different types of ICs, PLL

REFERENCE BOOKS:

1. A.V.N. Tilak, Design of Analog Circuits, Khanna Publishing House, 2022.
2. J.V. Wait, L.P. Huelsman and GA Korn, Introduction to Operational Amplifier theory and applications, McGraw Hill, 1992.
3. P. Horowitz and W. Hill, The Art of Electronics, 2nd edition, Cambridge University Press, 1989.
4. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Saunder's College Publishing, Edition IV.
5. Paul R.Gray & Robert G. Meyer, Analysis and Design of Analog Integrated Circuits, John Wiley, 3rd Edition.

STA-C-105	Basic Electronics Laboratory	0L:0T:4P	4 Credit

Course Outcome:

At the end of this course, students will demonstrate the ability to

CO1: Identify different electronic components

CO2: Analyze electronic circuits

CO3: Identify the various digital ICs and understand their operation.

CO4: Apply the fundamentals of assembly-level programming of microprocessors and microcontrollers

Experiments:

1. Familiarization of electronics components and handling instruments.
2. Studying I-V characteristics of transistors in different configurations.
3. Biasing transistors (BJT, FET, and UJT).
4. Studying OP-AMP application circuits.
5. Studying combinational circuits and ICs.
6. Studying different sequential circuits like counters and registers.
7. Programming of 8085/8086
8. Programming of 8051
9. LoRa Arduino kit familiarization and applications

SEMESTER-2

STA-C-200	Computer Skills	2L:0T:0P	2 Credit

Course Outcome:

At the end of this course, students will demonstrate the ability to

CO1: Understand the role of computer systems in industry.

CO2: Learn the basic functionalities of a computerized industrial system.

CO3: Learn basic programming skills.

Module-I: (12 Hours, 20 Marks)

Introduction to a computer system, different components, philosophy of the computer architecture, Von Neumann and Harvard Architecture, hardware, firmware, software, memory, I/O Processor, role of OS, Interfacing, ports, data acquisition systems, integration of sensors, open and proprietary systems, Computer Integrated Manufacturing (CIM)

Module-I: (18 Hours, 30 Marks)

Importance of software, application and system level software, high-level language, Integrated development environments, problem-solving: algorithms, programming language ideas like C, object-oriented and interpreted languages, open source codes, programming basic interfacing with some language like Python or R.

STA-C-201	Instrumentation and Equipment Maintenance	3L:0T:0P	3 Credit

<u>Course Outcome:</u>

CO1: Understand the principles and operation of electrical machines.

CO2: Apply AC bridge networks and measurement techniques.

CO3: Utilize measuring instruments and calibration methods.

CO4: Apply troubleshooting procedures and electronic component testing.

CO5: Perform rework and repair of surface mount assemblies.

Module I: (12 Hours, 20 Marks)

D.C. Machine, Principle of D.C. motor, A.C. Machine, Basic Principle of operation, Construction, Phasor diagram, equivalent circuit, Efficiency & Regulation of- Single phase transformer, Three phase induction motor, Synchronous Machine

Module II: (12 Hours, 20 Marks)

Instrument Transformers, Galvanometers, A.C. Bridges, Transducers, Wave Analysers, Different types of Sensors and their use in measurement and instrumentation.

Module III: (12 Hours, 20 Marks)

Measuring Instruments: Classification of measuring instruments, General consideration of torques employed in indicating type instrument (deflection torque, control torque, damping torque), Construction and working of voltmeter and ammeter, Significance of range extension, Use of series and shunt multipliers, Instrument transformer for range extension, Working principle of potentiometer, Calibration method of ammeter and voltmeter (D.C.) by potentiometer, Multirange ammeter and voltmeter, Simple problems on these topics.

Module IV: (12 Hours, 20 Marks)

Instrument construction, handling and cooling, cabinets, Fundamental Troubleshooting Procedures Inside An Electronic Equipment: Reading Drawings And Diagrams – Block Diagram, Circuit Diagram, Wiring Diagram, Fault finding aids – Service and maintenance manuals and instruction manuals, Passive Components and Their Testing Passive Components, Logic IC families, Packages in Digital ICs, IC identification, IC pin-outs, Handling ICs, Digital troubleshooting methods.

Module V: (12 Hours, 20 Marks)

Rework and Repair of Surface Mount Assemblies Surface Mount Technology and surface mount devices Surface Mount Semiconductor packages – SOIC, SOT, LCCC, LGA, BGA, COB, Flatpacks and Quad Packs, Cylindrical Diode Packages, Packaging of Passive Components as SMDs Repairing Surface Mount PCBs, Rework Stations.

Reference Books:

1. A.K. Sawhrey , "A Course in Electrical & Electronics Measurements & Measuring Instruments", Dhanpad Rai Pub., 2015.
2. Khandpur," Modern Electronic Equipment: Trouble- shooting, Repair and Maintenance", TMH, 2006.
3. R. G. Gupta," Electronic Instruments and Systems: Prin- ciples, Maintenance and Troubleshooting", Tata McGraw Hill Edition, 2001.
4. G. C. Loveday, A. H," Electronic Testing and Fault Diagnosis", Wheeler Publishing, 1995.
5. J.G. Joshi ,"Electronic Measurement and Instrumentation" Khanna Publishing House, 2019.

STA-C-202	Clean Room and Vacuum Technology	4L:0T:0P	4 Credit

Course Outcome:

CO1: Understand cleanroom technology fundamentals, including HVAC systems and safety measures, at a comprehension level.

CO2: Analyze particle technology's role in cleanrooms, evaluating filtration mechanisms and methods to reduce particle contamination.

CO3: Apply vacuum technology principles to design and optimize vacuum systems for various applications.

CO4: Evaluate vacuum system design concepts and applications in fields like microfabrication and space simulation, integrating knowledge at a synthesis level.

Detailed Syllabus

Module 1: (12 Hours, 25 Marks)

Fundamentals of Cleanroom Technology: Introduction to Cleanroom Technology; Cleanroom Construction: Design and Layout, Heating, Ventilation, and Air Conditioning Systems for Cleanrooms; Cleanroom Components: Safety Cabinets, Air Locks, Air Showers; Cleanroom Garments: Performance Requirements, Materials; Basics of Hygiene: Cleaning, Disinfection, Sterilization.

Module 2: (12 Hours, 25 Marks)

Particle Technology and Filtration: Introduction to Particle Technology and its Importance in Cleanrooms; Defects Caused by Particles: Probability of Defect Formation, Yield Effects; Particle Characterization: Size Distributions, Properties of Aerosols and Particle Statics/Dynamics; Fundamentals of Sedimentation and Filtration Technology: Filtration Mechanisms, Filter Properties, Pressure Drop, Particle Collection, Types of Filters and Applications, Measurement and Minimization of Particles in Process Gases and Liquids.

Module 3: (12 Hours, 25 Marks)

Fundamentals of Vacuum Technology: Gas kinetic theory, pressure, conductance, gas flow regimes, vapor pressure, pumping speed, throughput; Gas surface interactions: physisorption, chemisorption, condensation; General working principles and operating regimes of vacuum Pumps: Mechanical, diffusion, molecular drag, turbo molecular, cryopumps, ion pumps; Vacuum Instrumentation: Vacuum gauges, gas regulators, flow meters, residual gas analyzers, interpretation of data.

Module 4: (12 Hours, 25 Marks)

Vacuum System Design and Applications: Design Concepts: Materials, chambers, components, joins, seals, valve; Overall system design and integration. Problem Solving: Leak detection and detectors, gas signatures. Vacuum Applications: Idea of microfabrication, Thin film technology, Implantation, packaging, cryogenic insulation.

Reference Books:

1. R. P. Donovan, *Particle Control for Semiconductor Manufacturing*. CRC Press.
2. W. Whyte, *Cleanroom Design*. John Wiley.
3. M. Ramstorp, *Introduction to Contamination Control and Cleanroom Technology*. Wiley
4. M. H. Hablanian and H. H. Hablanian, *High-vacuum Technology: A Practical Guide*, 2nd ed. CRC Press, 1997.
5. A. D. Tripathi and A. Gupta, *Ultra High Vacuum Techniques*. Allied Publishers Private Limited, 2002.
6. A. Roth, *Vacuum Technology*, 3rd ed. Elsevier Science
7. High Vacuum Technology, J. Yarwood Chapman and Hall Ltd
8. Handbook of Vacuum Science and Technology, Dorothy M. Hoffman, John H. Thomas, Bawa Singh, Elsevier Science and technology Books

STA-C-203	Semiconductor Packaging and Testing	4L:0T:0P	4 Credit

Course Outcomes:

At the end of the course learners will be able to

CO1: Discuss the various packaging types

CO2: Design of packages which can withstand higher temperatures, vibrations and shock

CO3: Design of PCBs that minimize the EMI and operate at higher frequency

CO4: Analyze the concepts of testing methods.

CO5: Discuss the various packaging types

Module I: (12 Hours, 20 Marks)

Overview of Electronic Systems Packaging: Functions of Electronic Packaging, Packaging Hierarchy, IC packaging: MEMS packaging, consumer electronics packaging, medical electronics packaging, Trends and Challenges, Driving Forces on Packaging Technology, Materials for Microelectronic packaging, Packaging Material Properties, Ceramics, Polymers, and Metals in Packaging, Material for high density interconnect substrates

Module II: (12 Hours, 20 Marks)

Electrical Issues in Packaging: Electrical Issues of Systems Packaging, Signal Distribution, Power Distribution, Electromagnetic Interference, Transmission Lines, Clock Distribution, Noise Sources, Digital and RF Issues.

Design Process Electrical Design: Interconnect Capacitance, Resistance and Inductance fundamentals; Packaging roadmaps - Hybrid circuits - Resistive, Capacitive and Inductive parasitics.

Module III: (12 Hours, 20 Marks)

Chip Level Packaging: IC Assembly - Purpose, Requirements, Technologies, Wire bonding, Tape Automated Bonding, Flip Chip, Wafer Level Packaging, reliability, wafer level burn – in and test. Single chip packaging: functions, types, materials processes, properties, characteristics, trends.

Multi chip packaging: types, design, comparison, trends. System – in - package (SIP); Passives: discrete, integrated, and embedded.

Module IV: (12 Hours, 20 Marks)

PCB, Surface Mount Technology and Thermal Considerations: Printed Circuit Board: Anatomy, CAD tools for PCB design, Standard fabrication, Micro via Boards. Board Assembly: Surface Mount Technology, Through Hole Technology, Process Control and Design Challenges. Thermal Management, Heat transfer fundamentals, Thermal conductivity and resistance, Conduction, convection and radiation–cooling requirements

Module V: (12 Hours, 20 Marks)

Testing: Reliability, Basic concepts, Environmental interactions. Thermal mismatch and fatigue – failures – thermomechanically induced –electrically induced – chemically induced. Electrical Testing: System-level electrical testing, Interconnection tests, Active Circuit Testing, Design for Testability.

Textbook/Reference books:

1. Tummala, Rao R., Fundamentals of Microsystems Packaging, McGraw Hill, 2001.
2. Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000.
3. Tummala, Rao R, Microelectronics packaging handbook, McGraw Hill, 2008.
4. Bosshart, Printed Circuit Boards Design and Technology, TataMcGraw Hill, 1988.
5. R.G. Kaduskar and V.B.Baru, Electronic Product design, Wiley India, 2011.
6. R.S.Khandpur, Printed Circuit Board, Tata McGraw Hill, 2005.
7. Recent literature in Electronic Packaging.
8. Michael L. Bushnell &Vishwani D. Agrawal," Essentials of Electronic Testing for Digital, memory & Mixed signal VLSI Circuits", Kluwer Academic Publishers.2000.
9. M. Abramovici, M. A. Breuer, and A.D. Friedman, "Digital System Testing and Testable Design", Computer Science Press,1990

STA-C-204	Fundamentals of VLSI Fabrication	4L:0T:0P	4 Credit

Course Outcomes:

At the end of the course learners will be able to

CO1: Identify the different methods involved in VLSI fabrication.

CO2: Implement the Silicon wafer cleaning process for device fabrication.

CO3: Design and simulate the fabrication processes required for IC fabrication.

CO4: Explain process integration flow for different IC fabrication technologies.

Module I: (12 Hours, 20 Marks)

Introduction: History of IC's; Operation & Models for Devices of Interest: CMOS and MEMS. **Electronic Materials:** Crystal Structures, Defects in Crystals, Si, Poly Si, Si Crystal Growth. **Clean room and Wafer Cleaning:** Definition, Need of Clean Room, RCA cleaning of Si.

Module II: (12 Hours, 20 Marks)

Oxidation: Dry and Wet Oxidation, Kinetics of Oxidation, Oxidation Rate Constants, Dopant Redistribution, Oxide Charges, Device Isolation, LOCOS, Oxidation System, **Lithography:** Overview of Lithography, Radiation Sources, Masks, Photoresist, Components of Photoresist Optical Aligners, Resolution, Depth of Focus, Advanced Lithography: E-beam Lithography, X-ray Lithography, Ion Beam Lithography

Module III: (12 Hours, 20 Marks)

Diffusion: Pre-Deposition and Drive-in Diffusion Modeling, Dose, 2-Step Diffusions, Successive Diffusion, Lateral Diffusion, Series Resistance, Junction Depth, Irvin's Curves, Diffusion System. **Ion Implantation:** Problems in Thermal Diffusion, Advantages of Ion Implantation, Applications in ICs, Ion Implantation System, Mask, Energy Loss Mechanisms, Depth Profile, Range & Straggle, Lateral Straggle, Dose, Junction Depth, Ion Implantation Damage, Post Implantation Annealing, Ion Channeling, Multi Energy Implantation

Module IV: (12 Hours, 20 Marks)

Thin Film Deposition: Physical Vapor Deposition: Thermal evaporation, Resistive Evaporation, Electron beam evaporation, Laser ablation, Sputtering **Chemical Vapor Deposition:** Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types, Boundaries and Flow, Different kinds of CVD techniques: APCVD, LPCVD, Metalorganic CVD (MOCVD), Plasma Enhanced CVD etc.

Module V: (12 Hours, 20 Marks)

Etching: Anisotropy, Selectivity, Wet Etching, Plasma Etching, Reactive Ion Etching. Overview of Interconnects, Contacts, Metal gate/Poly Gate, Metallization, Problems in Aluminium Metal contacts, Al spike, Electromigration, Metal Silicide, Multi-Level Metallization, Planarization, Inter Metal Dielectric

Reference books:

1. Plummer, Deal and Griffin, "Silicon VLSI Technology" 1st Edition, Pearson Education, 2009.
2. S. M. Sze, "Semiconductor Devices", 2nd Edition, John Wiley & Sons, 2002.
3. S K Gandhi, "Silicon Technology", Wiley India , 2nd edition , 2009
4. Wayne wolf," Modern VLSI design", 2nd Edition, Pearson Education, 2008.

STA-C-211	Advanced Semiconductor Laboratory	0L:0T:4P	4 Credit

Course Outcome:

CO1: Evaluate performance characteristics of different types of sensors

CO2: Familiarization of the fabrication processes required for IC fabrication

CO3: Design and fabrication of PCB for simple electronic circuits

CO4: Design and implementation of various applications using Raspberry Pi

Experiments:

1. Study of different sensors characteristics (temperature, humidity, pressure)
2. Studies on pressure-time characteristics curve of different types of vacuum pumps
3. Fabrication of semiconductor thin films by physical vapor deposition.
4. Electrical characterization of thin films
5. Fabrication of PCB for simple electronic circuits
6. Sample Analysis using Spectrum/Impedance/Vector Network Analyzer.
7. Design experiment on interfacing UART with sensors
8. Design experiments in FPGA, Xilinx
9. Design and implementation of digital circuits using CMOS 130nm technology with industry-standard software (e.g.).
10. Various applications using Raspberry Pi.