S. S. Jain Subodh P.G. College (Autonomous)
Jaipur

SYLLABUS

Post Graduate Diploma In Semiconductor Technology

(Semester Scheme)
Choice Based Credit System (CBCS)
(As Per The National Education Policy - 2020)

I & II Semester Examinations 2026-2027
[Onwards]

Postgraduate Diploma In Semiconductor Technology

Introduction To The Programme

India is racing towards Viksit Bharat-2047 and has taken a stride in semiconductor manufacturing as well. In this broader vision of Viksit Bharat-2047, S.S. Jain Subodh P.G. College, Jaipur is introducing a postgraduate diploma in semiconductor physics from the session 2026-2027. Semiconductor technology is the backbone of modern electronics encompassing nanoelectronics that enables innovations in computing, telecommunications, automotive systems, healthcare devices & industrial automation. This program teaches students the concepts and hands-on skills required to develop, build, and refine integrated circuits (ICs) and system-on-chip (SoC) solutions.

The syllabus includes semiconductor physics, circuit simulation, fabrication techniques, hardware description languages, testing and verification, and low-power design. It also focuses on industry-standard tools and practical training with Electronic Design Automation (EDA) software to prepare graduates for careers in semiconductor design and manufacturing.

Programme Objectives :

- To deliver both fundamental and advanced understanding of semiconductor devices, microelectronics, and chip fabrication techniques.
- To train professionals proficient in designing, simulating, and validating integrated circuits and SoCs using industry-standard tools.
- To give students practical experience via fabrication labs, simulation platforms, and real-world chip-design projects.
- On completing the program, students will be ready for careers across the semiconductor ecosystem, including IC/SoC design, verification and testing, wafer fabrication, and embedded hardware engineering.

Programme Learning Outcomes :

On successful completion of the programme, students should be able to :

- Use semiconductor physics, microelectronics concepts, and integrated-circuit design principles in practical applications.
- Implement and verify digital and mixed-signal designs using hardware description languages such as VHDL, Verilog, or System Verilog.
- Conduct chip-level simulations, execute testing, and optimize performance for various applications

- Understand fabrication processes, packaging, and reliability considerations in semiconductor manufacturing.

S. S. Jain Subodh P.G. College (Autonomous), Jaipur

Post Graduate Diploma In Semiconductor Technology

Syllabus & Exam Outline of Post Graduate Diploma In Semiconductor Technology

Paper	Nomenclature of Paper	Credits	Max. Marks (EoSE)
PAPER - I [PGD SPCD 101]	Fundamentals of Semiconductors	04	100 Marks
PAPER – II [PGD SPCD 102]	Semiconductor Devices	04	100 Marks
PAPER – III [PGD SPCD 103]	Introduction To Digital Electronics	04	100 Marks
PAPER – IV [PGD SPCD 104]	Semiconductor Devices for Energy Applications	04	100 Marks
PAPER – V [PGD SPCD 111]	Semiconductor Characterization Lab	06	150 Marks
INTERNSHIP [PGD SPCD 112]	Internship (Exposure To Semiconductor Facility)	04	100 Marks
TOTAL		**26**	**650 Marks**

Paper	Nomenclature of Paper	Credits	Max. Marks (EoSE)
PAPER - I [PGD SPCD 201]	Nanomaterial Synthesis & Characterization	04	100 Marks
PAPER – II [PGD SPCD 202]	IC Fabrication & Technology	04	100 Marks
PAPER – III [PGD SPCD 203]	Flexible Electronics & Sensors	04	100 Marks
PAPER – IV [PGD SPCD 204]	Semiconductor Packaging & Assembly	04	100 Marks
PRACTICAL [PGD SPCD 211]	Lab	06	150 Marks
DISSERTATION [PGD SPCD 212]	#Project Work/Dissertation	06	100 Marks
TOTAL		**26**	**500 Marks**

L = Lectures, T = Tutorials, P = Practical
 # Project work is mandatory and must be submitted to the department one week before the second-semester examinations. A faculty supervisor will be assigned to each student at the end of the first semester.

Lab Marks = 150 Marks = 90 (External) + 60 (Internal)

*** Students will select MOOCs from SWAYAM and other platforms based on course availability and the Department's recommendations.**

Name of College	**S.S. Jain Subodh P.G. College (Autonomous), Jaipur**
Name of Faculty	**Science**
Name of Programme	**Post Graduate Diploma (PGD)**
Name of Discipline	**Discipline – Semiconductor Technology**

PROGRAMME PREREQUISITES

Completed undergraduate degree in any stream with B.Sc. in Computer Science/Mathematics/Physics/Electronics or B.Tech. or B.Sc. in Chemistry/Biology/Biotechnology/Microbiology/BCA

PROGRAMME OUTCOMES (POs)

1. Proficiency in Semiconductor Physics Principles : Students will demonstrate a strong understanding of fundamental semiconductor physics principles. They will be able to apply these principles to analyze and solve complex problems.
2. Analytical and Critical Thinking : Students will develop analytical and critical thinking skills through the study of semiconductor physics. They will be able to evaluate and interpret data, formulate hypotheses, and draw logical conclusions based on evidence.
3. Quantitative and Computational Skills : Students will acquire proficiency in quantitative and computational methods. They will be able to perform calculations, manipulate mathematical expressions, and use computational tools to solve scientific problems.
4. Experimental and Laboratory Skills : Students will gain hands-on experience in conducting experiments in semiconductor physics & analysing experimental data. They will understand the importance of accurate measurement, data interpretation, and documentation.
5. Problem Solving and Modelling : Students will develop problem-solving skills and the ability to create mathematical models to represent real-world phenomena. They will apply mathematical and scientific concepts to formulate and solve problems in physics, chemistry, and related fields.
6. Effective Communication : Students will develop effective oral and written communication skills. They will be able to communicate scientific ideas, theories, and experimental results clearly and concisely to both technical and non-technical audiences.
7. Ethical and Professional Responsibility : Students will understand and adhere to ethical and professional standards in scientific research and practice. They will demonstrate integrity, responsible conduct, and respect for intellectual property.
8. Lifelong Learning : Students will recognize the importance of lifelong learning and professional development. They will be motivated to pursue further studies, engage in research, and keep up with advancements in physics, chemistry, and mathematics.
9. Teamwork and Collaboration : Students will develop teamwork and collaboration skills through group projects, laboratory work, and research activities. They will be able to work effectively in diverse teams and contribute to collective goals.

Credentials of The Postgraduate Diploma Programme -

1. Credit = 25 Marks For Examination/Evaluation
2. The minimum duration for completion of Postgraduate Diploma Programme (PGDP) is two semesters (one academic year).
3. Maximum duration of completion of programme is two years.
4. A student should have minimum 75% attendance in classes, seminars, practical/ lab in each course of study without which he/she will not be allowed for the end-Semester examination.
5. All theory courses in the programme shall have Continuous Internal Assessment (CIA) component of 40 marks and a Semester-end component of 60 marks. The minimum pass marks for a course is 50%.
6. The student has to appear 2 CIA tests of 15 marks each per semester in each course from which the best 2 performances shall be considered for the purpose of calculating the marks. A record of the continuous assessment is maintained by the department. The remaining 10 marks are awarded based on participation and performance in:
   Assignments
   Class presentations
   Seminars
   Quizzes
7. A student should pass separately in both CIA and the Semester-end Examination.
8. Semester-end examination shall consist of objective type questions, descriptive type questions, short answer questions and case studies or any others.
9. A student failing to secure the minimum pass marks in the CIA is not allowed to take the semester-end examination of that course. She/He has to redo the course by attending special classes for that course and get the pass percentage in the internal tests to become eligible to take the semester-end examination.
10. Students failing a course due to lack of attendance should redo the course.

Post Graduate Diploma In Semiconductor Technology

Semester - I

Paper (I) – Fundamentals of Semiconductors

(PGD SPCD 101, Credits Theory 04, Lectures 60)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
I	PGD SPCD 101	Fundamentals of Semiconductors	8	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Completed undergraduate degree in science stream with B.Sc. in Computer Science/Mathematics/Physics/Electronics or B.Tech. or B.Sc. in Chemistry/Biology/Biotechnology/Microbiology/BCA			
Objectives of The Course :	➢ Present the basic physics and key properties of semiconductor materials. ➢ Describe carrier transport, *pn*-junction electrostatics, and core device operating principles. ➢ Explanation of BJT & MOSFET device structures, their characteristics, and performance parameters. ➢ Covers the concept of advanced FETs, such as, Fin-FETs.			

Unit - I : Introduction To Semiconductors

Theory of Semiconductors : Intrinsic & extrinsic semiconductors, Band structure of semiconductors, Carrier concentration in intrinsic & extrinsic semiconductors, Electrical conductivity & conduction mechanism in semiconductors, Fermi level in intrinsic & extrinsic semiconductors, and its dependence on temperature and carrier concentration, Carrier generation – recombination, mobility, drift-diffusion current, Hall effect. **(15 Lectures)**

Unit - II : PN Junction

PN junction electrostatics, Fixed & free charge, Depletion approximation, Electric field at the junction, Built-in potential, Step junction vs linearly graded junction, Energy band diagram of a PN Junction & quasi-Fermi levels, PN junction under applied bias, Minority carrier injection & spatial variation in depletion and quasi-neutral regions, Band-bending under applied bias, Ideal diode equation, Diode non- idealities, Breakdown, Depletion & diffusion capacitance, *p-i-n* Diode, Metal-Semiconductor junctions. **(15 Lectures)**

Unit - III : Bipolar Junction Transistor (BJT) & MOSFET

Bipolar junction transistor (BJT), *p-n-p* and *n-p-n* transistors : Principle & modes of operation, Current relations, V-I characteristics, Fundamentals of MOSFET, Long Channel MOSFETs,

Energy band diagram & qualitative understanding of MOSFET operation, I_D-V_D and I_D-V_G relationships, Square law theory of MOSFET, Sub-threshold slope, Performance metrics of a MOSFET, JFET, Heterojunctions – quantum wells. **(15 Lectures)**

Unit - IV : Physics of Advanced FETs & Optical Devices

Moore's law & Technology scaling , Qualitative understanding of short channel effects – Velocity saturation, Channel length modulation, Drain induced barrier lowering (DIBL), Differences in I-V characteristics of long & short channel MOSFETs, Overview of modern FETs (FinFETs, Tunnel FETs & nanowire transistors) **(15 Lectures)**

References Books/Text Books :

1. Solid State Electronic Devices, by Ben Streetman and Sanjay Banerjee, Prentice Hall.
2. Introduction to Semiconductor Materials and Devices, by M. S. Tyagi, Wiley Publications.
3. Semiconductor Physics & Devices by Donal Neaman & Dhrubes Biswas, McGraw Hill.

Suggested E-Resources :

1. MIT OpenCourseWare : Semiconductors - This resource provides lecture notes, problem sets, and solutions for a complete course on semiconductor devices : https://ocw.mit.edu/courses/6-012-microelectronic-devices-and-circuits-fall-2009/
2. Fundamental of Semiconductor Devices : https://nptel.ac.in/courses/108108122
3. https://onlinecourses.nptel.ac.in/e-learning/preview/noc20_bt17

Course Learning Outcomes :

1. Explain the properties of semiconductor materials, energy bands, and carrier transport.
2. Examine pn-junction behavior under different bias conditions and the characteristics of diodes.
3. Describe BJT operation, MOSFET physics, and important performance metrics.
4. Understand the impact of technology scaling and short-channel effects in modern transistors.
5. Understanding of the operating principles of advanced Fin-FETs, tunnel FETs & nanowire transistors.

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Semester - I

Paper (II) – Semiconductor Devices

(PGD SPCD 102, Credits Theory 04, Lectures 60)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
I	PGD SPCD 102	Semiconductor Devices	8	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Completed undergraduate degree in science stream with B.Sc. in Computer Science/Mathematics/Physics/Electronics or B.Tech. or B.Sc. in Chemistry/Biology/Biotechnology/Microbiology/BCA			
Objectives of The Course :	➢ Explanation of semiconductor fundamentals ➢ Explanation of the carrier transport in semiconductors ➢ Explanation of the MOS device ➢ Explanation of the MOSFET device ➢ Explanation of optoelectronic devices ➢ Explanation of compound semiconductors ➢ Explanation of devices based on compound semiconductors			

Unit - I : Semiconductor Fundamentals & Carrier Transport

Introduction to solid state physics, Properties of semiconductor and crystal growth, Energy band formation, Effective mass of electrons, E-k diagram, Fermi level, Fermi-Dirac distribution, Density of states, Temperature dependence of Fermi level, Doping of semiconductor, Direct & indirect semiconductor, Equilibrium carrier concentration, Temperature dependence, Carrier scattering and mobility, Velocity saturation, Drift-diffusion transport, Excess carrier decay & recombination, Charge injection, Continuity equation, Quasi-Fermi level, Ambipolar transport **(15 Lectures)**

Unit - II : MOS Devices & Advanced Concepts

Ideal MOS capacitor operating regimes : Accumulation, depletion, inversion, Energy band structure in operating regimes, MOS Cap C-V characteristics, Structure & operation of MOSFET, I-V characteristics, Substrate bias effects, Sub-threshold current, Oxide breakdown, Short channel MOSFET, Short channel effect, CMOS technology, impact ionization, Band-to-band tunneling, Dielectric breakdown, Devices based on tunneling & impact ionization effects. **(15 Lectures)**

Unit - III : Optoelectronic Devices

Optoelectronic devices in daily life, III-V Semiconductors, Direct and indirect bandgaps, Optical absorption, PIN photodetectors, Solar cells, Open-circuit voltage & short-circuit

current, Light emitting devices – Heterostructures, LEDs & their luminescent efficiency, Double heterostructure & population inversion, Diode lasers, LI characteristics & threshold current. **(15 Lectures)**

Unit - IV : Compound Semiconductors & Devices

Compound semiconductors (GaAs, GaN, InP), Band diagram of Heterojunction, Basics of heterojunction FET & bipolar transistor, Optoelectronic devices : Optical absorption & band gap, Materials for optoelectronic devices, LED : Device structure & working principle, Semiconductor Photodiode : *p-n* diode, *p-i-n* diode, Avalanche photodiode, Operation, Figure of merit, Solar cell : Introduction to solar cell, efficiency. **(15 Lectures)**

References Books/Text Books :

1. Solid State Electronic Devices, by Ben Streetman and Sanjay Banerjee, Prentice Hall.
2. Introduction to Semiconductor Materials and Devices, by M. S. Tyagi, Wiley Publications.
3. Semiconductor Physics & Devices by Donal Neaman & Dhrubes Biswas, McGraw Hill.
4. Optoelectronic Devices and Systems (2nd Ed.) by S.C. Gupta, PHI Learning.
5. Optoelectronics: An Introduction by J. Wilson & J.F.B. Hawkes, Prentice Hall Europe.
6. Compound Semiconductors: Physics, Technology, and Device Concepts by Ferdinand Scholz, Taylor & Francis.
7. Handbook of Compound Semiconductors by Peter Holloway, Elsevier.
8. VLSI Fabrication Principles (Silicon & Gallium Arsenide) by S.K. Gandhi, John Wiley & Sons Inc.

Suggested E-Resources :

1. MIT Open Course Ware : Semiconductors - This resource provides lecture notes, problem sets, and solutions for a complete course on semiconductor devices : https://ocw.mit.edu/courses/6-012-microelectronic-devices-and-circuits-fall-2009/
2. Fundamental of Semiconductor Devices : https://nptel.ac.in/courses/108108122
3. https://onlinecourses.nptel.ac.in/e-learning/preview/noc20_bt17
4. Semiconductor Optoelectronics : Theory & Design : https://ocw.mit.edu/courses/6-977-semiconductor-optoelectronics-theory-and-design-fall-2002/
5. Semiconductor Optoelectronics : https://nptel.ac.in/courses/115102103
6. Compound Semiconductors : https://nptel.ac.in/courses/108108122
7. MIT Open Course Ware : https://ocw.mit.edu/courses/6-772-compound-semiconductor-devices-spring-2003/

Course Learning Outcomes :

1. Understanding of the fundamentals of semiconductors & solid state physics with basic reference to carrier transport as well.
2. Explain the operating principles and characteristics of MOS capacitor, MOSFETs & CMOS technology.
3. Understanding of optoelectronic devices.
4. Understanding of the light emitting devices (LEDs).
5. Understanding of the compound semiconductors.
6. Understanding of heterojunction devices.

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Semester - I

Paper (III) – Introduction To Digital Electronics

(PGD SPCD 103, Credits Theory 04, Lectures 60)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
I	PGD SPCD 103	Introduction To Digital Electronics	8	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Completed undergraduate degree in science stream with B.Sc. in Computer Science/Mathematics/Physics/Electronics or B.Tech. or B.Sc. in Chemistry/Biology/Biotechnology/Microbiology/BCA			
Objectives of The Course :	➢ Introduce number systems, binary arithmetic, and the basics of logic gates. ➢ Explain Boolean algebra and methods for simplifying logic expressions. ➢ Cover combinational and sequential circuits, including multiplexers, flip-flops, and counters. ➢ Provide an overview of data conversion methods and digital logic families.			

Unit - I : Number Systems

Number Systems, Binary Arithmetic, Binary Codes and Logic gates, Boolean Algebra and Standard representation of Logic functions, Number System : Weighted & Unweighted Codes, Binary, Octal, and Hexadecimal numbers; Fixed- and Floating-Point Number Representations, number base conversion, Complements. **(15 Lectures)**

Unit - II : Binary Arithmetic & Simplification of Logic Functions

Binary Arithmetic : Addition, Subtraction, Multiplication and Division, BCD Code. Introduction to Boolean algebra, Laws of Boolean algebra, logic gates (AND, OR, NOT, NAND, NOR, Exclusive OR & Exclusive NOR), Universal logic gates, MOS-Logic, POS and SOP notations, Canonical logic forms, Simplification of logic functions using reduction techniques. **(15 Lectures)**

Unit - III : Simplification of Boolean Functions & Combinatorial Circuits

Simplification of Boolean Functions: Laws of Boolean algebra and K-Maps, Tabulation Method, Combinational Circuits : Design Procedure of Combinational Circuits, Adders, Subtractors, Code Converters, Magnitude Comparator. Arithmetic Circuits Encoder and Decoders. **(15 Lectures)**

Unit - IV : Multiplexer, Demultiplexer, Flip Flops & Counters

Combinational Circuits : Encoder, Decoder, Multiplexer, Demultiplexer and its Applications. ROM, PLAs, PALs etc. and implementation of Boolean function through these ROM, PLAs & PAL, Flip Flop & Latches, Counters, Shift register, Digital to Analog converter and Analog to Digital converter, Logic Families, Excitation Tables; Registers, RAM. **(15 Lectures)**

Reference Books/Text Books :

1. Digital Electronics : Principles, Devices And Applications by Anil K. Maini, Wiley India, 1st Ed., 2007.
2. A Textbook of Digital Electronics by R. S. Sedha, S. Chand Publishing.
3. Digital Electronics by B. K. Jain, Khanna Publishing House.
4. Basics of Digital Electronics by Banani Ghosh, Routledge.

E-Resources :

1. MIT Open Courseware : https://ocw.mit.edu/courses/6-111-introductory-digital-systems-laboratory-spring-2006/
2. Introduction To Digital System Design : https://nptel.ac.in/courses/117105080
3. https://onlinecourses.nptel.ac.in/e-learning/preview/noc21_ee39

Course Learning Outcomes :

1. Perform binary arithmetic and use binary codes to represent data.
2. Apply Boolean algebra to simplify digital logic expressions.
3. Design and analyze arithmetic circuits, encoders, decoders, and comparators.
4. Understand and implement flip-flops, latches, counters, and shift registers.
5. Explain the operation of DACs, ADCs, and different logic families used in digital systems.

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Semester - I

Paper (IV) – Semiconductor Devices for Energy Applications

(PGD SPCD 104, Credits Theory 04, Lectures 60)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
I	PGD SPCD 104	Semiconductor Devices For Energy Applications	8	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Completed undergraduate degree in science stream with B.Sc. in Computer Science/Mathematics/Physics/Electronics or B.Tech. or B.Sc. in Chemistry/Biology/Biotechnology/Microbiology/BCA			
Objectives of The Course :	➢ To explain the concept of energy storage fundamentals & semiconductors in energy storage ➢ Explanation of advanced fuel & battery system ➢ Explanation of semiconductor quantum materials for optical applications ➢ Explanation of solar hydrogen generation ➢ Explanation & understanding of thermoelectric devices ➢ To explain the fundamental concepts of nanofabrication technology ➢ Explanation of the MEMS concepts			

Unit - I : Energy Storage Fundamentals

Basics of energy storage, Different types of energy storage, Electrochemical energy storage, Rechargeable batteries, Electrochemical capacitors, Semiconductor electrochemistry for clean energy conversion & storage, Semiconductors for rechargeable Li-ion, Li-S & Na-ion batteries. **(15 Lectures)**

Unit - II : Advanced Fuel & Battery Systems

Air-batteries, Batteries for electric vehicles, Semiconductors for fuel cells, Solid oxide fuel cells (SOFCs), Semiconductors for photo-electrochemical cells, Photovoltaic, Semiconductor solar cells, Perovskite solar cells. **(15 Lectures)**

Unit - III : Advanced Energy Technologies

Solar hydrogen generation, Solid-state lighting, Semiconductor Quantum Dots for energy conversion & storage, Semiconductor thermoelectrics, Thermoelectric devices, Applications in waste heat recovery & energy harvesting. **(15 Lectures)**

Unit - IV : Nanofabrication Technology

Introduction & Background of MEMS, Typical MEMS device & Microsystems, MEMS Applications, MEMS technology in sensors, Physical vapour deposition (PVD) & chemical vapor deposition techniques (CVD). **(15 Lectures)**

Reference Books/Text Books :

1. Energy Storage Devices - A Comprehensive Overview by Khairy Sayed, Mahmoud Aref, Ahmed G. Abokhalil, Mahmoud A. Mossa (eds.), IntechOpen.
2. Energy Storage Devices for Renewable Energy-Based Systems by R. Bhuvaneswari, S. A. Singh, S. P. Singh, Academic Press.
3. Energy Storage Systems by Dr. Satyendra Singh, Nova Science Publishers.
4. Semiconductor Physics And Devices by Donald Neamen, Wiley India, 2021.
5. Semiconductor Devices : Physics & Technology by S.M. Sze, Wiley, 2007.
6. Semiconductor Devices : Theory And Application by James. M. Fiore, Open Textbook.
7. VLSI Fabrication Technology by S.M. Sze, Wiley Sons Inc.

E-Resources :

1. MIT OpenCourseWare : https://ocw.mit.edu/courses/8-21-the-physics-of-energy-fall-2009/
2. MIT OpenCourseWare : https://ocw.mit.edu/courses/ec-s07-photovoltaic-solar-energy-systems-fall-2004/
3. MIT OpenCourseWare : https://ocw.mit.edu/courses/11-942-regional-energy-environmental-economic-modeling-spring-2007/
4. MIT OpenCourseWare : https://ocw.mit.edu/courses/10-626-electrochemical-energy-systems-spring-2014/
5. MIT OpenCourseWare : https://ocw.mit.edu/courses/6-777j-design-and-fabrication-of-microelectromechanical-devices-spring-2007/
6. Introduction To MEMS & Microsystems : https://nptel.ac.in/courses/117105082
7. Micro-Sensors : https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ee09

Course Learning Outcomes :

1. Understanding of the fundamentals of energy storage.
2. Understanding of different types of batteries.
3. Understanding of working methodology of fuel cells.
4. Understanding of solar cells & photovoltaic cells.
5. Understanding of solar hydrogen generation.
6. Understanding of semiconductor quantum dots.
7. Understanding of thermoelectric devices.
8. Understanding of MEMS technology.

Post Graduate Diploma In Semiconductor Technology

Semester - II

Paper (I) – Nanomaterial Synthesis & Characterization

(PGD SPCD 201, Credits Theory 04, Lectures 60)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
II	PGD SPCD 201	Nanomaterial Synthesis & Characterization	8	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Completed undergraduate degree in science stream with B.Sc. in Computer Science/Mathematics/Physics/Electronics or B.Tech. or B.Sc. in Chemistry/Biology/Biotechnology/Microbiology/BCA			
Objectives of The Course :	➢ Introduce the basics of nanoscale materials ➢ Explanation of different types of nanomaterials ➢ Explanation of characterization techniques & applications ➢ Explanation of synthesis methodologies of nanomaterials ➢ Explain methods of vacuum generation and the different types of vacuum pumps and components. ➢ Understand gas flow behavior at low pressure and determine conductance and pumping speed. ➢ Explore the applications of vacuum systems in industry and research, along with their design considerations.			

Unit-I: Introduction to Nanomaterials

General introduction to various nanomaterials, Inorganic, organic & polymer nanomaterials, Semiconductor nanomaterials, Nucleation & growth of nanosystems, Self-assembly, Hybrid, Functional nanomaterials & nanostructured thin films, Morphology & size of nanomaterials, Dimension of nanomaterials : 0D, 1D, 2D and 3D nanomaterials, Band gap dependence on particle size. **(15 Lectures)**

Unit - II : Types of Nanomaterials & Synthesis

Carbon nanomaterials, Graphene & related materials, Alloys, Intermetallic, Quantum dots, Spinel, Inverse spinel, Perovskites, Natural microporous & mesoporous solids, Zeolites, Coordination polymers & metal-organic frameworks, 'Top down' vs. 'Bottom up' approach of synthesis, Wet chemical methods : Sol-gel, Hydrothermal/solvothermal, Micro-emulsion/reverse micro-emulsion technique, Chemical reduction, Decomposition of organometallic precursors, CVD. **(15 Lectures)**

Unit - III : Characterization Techniques & Applications

Optical spectroscopy : Absorption & Fluorescence spectroscopy, Vibrational spectroscopy : Infrared & Raman spectroscopy, Structural by XRD, Microscopic techniques : Optical microscopy, SEM, TEM/HRTEM, Scanning probe microscopy (STM, AFM), Surface Spectroscopy : XPS, UPS, Applications in semiconductor technology, Energy & environmental applications. **(15 Lectures)**

Unit - IV : Introduction To Vacuum Technology

Introduction to Vacuum, Natural vacuum, Kinetic theory of gases, Physical Parameters of Vacuum and Regions of Vacuum, Vacuum Process Applications. Pumping Speed and Throughput Concepts, Rotary Vacuum Pump, Diffusion Pump, Molecular Vacuum Pumps. **(15 Lectures)**

References Books/Text Books :

1. Nanomaterials: Synthesis, Characterization & Applications — edited by Shashank S. Kawar (Indian editor; collection of chapters on synthesis and characterization).
2. Nanomaterials: Synthesis, Properties and Applications — Nitin K. Sharma (covers synthesis routes and characterization techniques).
3. Nanomaterials and Nanocomposites: Synthesis, Properties, Characterization Techniques, and Applications — Rajendra Kumar Goyal.
4. Vacuum Science & Technology- VV Rao, KL Chopra & TB Ghosh.
5. Vacuum Technology and Process Applications by V V Rao.
6. Modern Vacuum Physics by Austin Chambers.
7. High Vacuum Technology: A Practical Guide by M. H. Hablanian.

E-Resources :

1. Nanomaterials And Their Properties : https://nptel.ac.in/courses/113104102
2. MIT Open Courseware : https://ocw.mit.edu/courses/2-674-micro-nano-engineering-laboratory-spring-2016/resources/mit2_674s16_lec7nano/
3. Vacuum Technology & Process Application : https://onlinecourses.nptel.ac.in/e-learning/preview/noc22_ge30
4. NPTEL : https://nptel.ac.in/courses/127105231
5. https://www.classcentral.com/course/edx-vacuum-systems-and-technology-7885

Course Learning Outcomes :

1. Understanding of nanomaterials and characterization techniques.
2. Understanding of different types of nanomaterials.
3. Understanding of synthesis methodologies of different types of nanomaterials.
4. Explain the principles of vacuum physics and classify the different vacuum regions.
5. Describe the operation of various vacuum pumps and vacuum measurement systems.
6. Design basic vacuum systems and troubleshoot performance problems in practical setups.

Post Graduate Diploma In Semiconductor Technology

Semester - II

Paper (II) - IC Fabrication Technology

(PGD SPCD 202, Credits Theory 04, Lectures 60)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
I	PGD SPCD 202	IC Fabrication technology	8	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Completed undergraduate degree in science stream with B.Sc. in Computer Science/Mathematics/Physics/Electronics or B.Tech. or B.Sc. in Chemistry/Biology/Biotechnology/Microbiology/BCA			
Objectives of The Course :	➢ To explain the concepts of integrated circuitry (IC) ➢ To explain different types of ICs, such as, SSI, MSI, LSI, VLSI & ULSI ➢ To explain the concepts of oxidation & lithography ➢ To explain the concept of doping in semiconductor physics ➢ To explain the concept of diffusion & ion implantation ➢ To explain the concepts related to thin film deposition ➢ To explain the concept of physical vapour deposition (PVD) ➢ Explanation of the concept of wet & dry etching in device fabrication ➢ Explanation of formation of interconnects by metallization			

Unit - I : Introduction To ICs

Introduction to IC Technology : SSI, MSI, LSI, VLSI, and ULSI, Importance of scaling, Miniaturization and system integration, Basic VLSI/ULSI design flow from specification to fabrication and packaging. **(15 Lectures)**

Unit - II : Oxidation & Lithography

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, X-ray, Ion beam lithography. **(15 Lectures)**

Unit - III : Doping & Thin Film Deposition

Doping : Pre-deposition & Drive-in diffusion modeling, Dose, 2-Step Diffusions, Successive diffusion, lateral Diffusion, Junction depth, Diffusion system, Ion implantation : Problems in thermal diffusion, Advantages, Applications in ICs, Ion implantation system, Mask, Energy

loss mechanisms, Ion implantation damage, Post implantation annealing, Ion channeling, Multi-energy Implantation.

Physical vapor deposition (PVD) : Thermal evaporation, Electron beam evaporation, Laser ablation, Sputtering, PLD & ALD. **(15 Lectures)**

Unit - IV : Etching & Interconnects

Etching : Anisotropy, Selectivity, Wet etching, Plasma etching, Reactive ion etching.

Interconnects : Overview of interconnects, Contacts, Metal gate/Poly Gate, Metallization, Problems in Aluminum metal contacts, Al spike, Electromigration, Metal silicides, Multi-level metallization, Planarization, Inter-metal dielectric. **(15 Lectures)**

Reference Books/Text Books :

1. Integrated Circuit Fabrication : Science & Technology by James D. Plummer & P.B. Griffin
2. Integrated Circuit Fabrication by Shubham Kumar & Ankaj Gupta, Manakin Press.
3. Integrated Circuit Fabrication Technology by David Elliott, McGraw-Hill International Edition.
4. VLSI Fabrication Technology by S. M. Sze, McGraw Hill.
5. Handbook of Thin Film Deposition by Krishna Seshan, Noyes Publications, USA.
6. Introduction To Thin Film Deposition Techniques by Robert B. Mason, Jr., ASM International Books.
7. VLSI Fabrication Principles by S.K. Gandhi, Wiley & Sons Inc.

E-Resources :

1. Nanoscale Transport Phenomena : https://ocw.mit.edu/courses/2-57-nano-to-macro-transport-processes-spring-2012/resources/lecture-1-intro-to-nanotechnology-nanoscale-transport-phenomena/
2. Fundamentals of Micro And Nanofabrication : https://nptel.ac.in/courses/102108078
3. https://onlinecourses.nptel.ac.in/e-learning/preview/noc19_bt29

Course Learning Outcomes :

1. To understand the concept of VLSI.
2. Understanding of different types of integration rules of SSI, MSI, LSI, VLSI & ULSI.
3. To understand the concept of oxidation.
4. Understanding of the lithographic process.
5. Understanding of thin films & their deposition methodologies.
6. Understanding of the concept of etching.
7. Understanding of the concept of formation of metal interconnects.

Post Graduate Diploma In Semiconductor Technology

Semester - II

Paper (III) – Flexible Electronics & Sensors

(PGD SPCD 203, Credits Theory 04, Lectures 60)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
I	PGD SPCD 203	Flexible Electronics & Sensors	8	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Completed undergraduate degree in science stream with B.Sc. in Computer Science/Mathematics/Physics/Electronics or B.Tech. or B.Sc. in Chemistry/Biology/Biotechnology/Microbiology/BCA			
Objectives of The Course :	➢ To introduce flexible & stretchable electronics ➢ To make understand the concept of metal oxide nanostructures ➢ To make understand the concept of nanostructured materials ➢ To make understand the integration strategies of substrates, transfer & bonding ➢ To introduce flexible PCBs & printed electronics ➢ To introduce additive manufacturing ➢ To explain flexible displays, thin film transistors & wearable electronics ➢ To explain the concepts of sensors & transducers			

Unit - I : Introduction To Flexible Electronics & Materials

Introduction To Flexible Electronics : Introduction & Historical Background of flexible & stretchable electronics, Scaling Effects, Physics and mechanics of flexible electronics, Charge transport in polymers.

Materials For Flexible Electronics : Flexible Silicon, Organic and polymer electronic materials, Metal oxide semiconductors, Gr. III-V semiconductors, Nanostructured materials.

(15 Lectures)

Unit - II : Integration Strategies & Fabrication

Integration Strategies : Substrates, transfer and bonding, Flexible printed circuit boards, Printed electronics, Roll-to-roll, Transfer printing, Inkjet printing, Additive manufacturing, 3D printing approach, Low temperature processing technique on flexible substrates.

(15 Lectures)

Unit - III : Flexible Electronics - Applications & Advanced Systems

Flexible Electronics - Applications : Thin film transistor, Flexible display, Polymer, paper & textile-based application of electronic devices, Sensor & actuators, OLEDs, Wearable electronics, Electronic skin, Implantable flexible device, Wearable device packaging & evaluation, Microfluidics for flexible electronics. **(15 Lectures)**

Unit - IV : Sensors & Transducers

Sensors & Transducers : Sensor classification, Performance and Types : Classification of Active & Passive transducer, Static & dynamic characteristics of sensor/transducer, Modelling of the sensor & its electrical equivalent analysis, Flexible & wearable sensors, Nanomaterials & sensors, Chemical sensors : Metal oxide, CHEMFET, ISFET, Electrochemical, Amperometric, Conductometric, Biosensors, Biomedical sensors, Environmental Sensors, Piezoelectric sensors : SAW, BAW, Gravimetric, ultrasonic, Magnetic sensors like eddy current sensors, radioactive sensors. **(15 Lectures)**

Reference Books/Text Books :

1. Introduction to Flexible Electronics - Aftab M. Hussain, Routledge.
2. Flexible Electronics: Materials and Applications – Ed. William S. Wong and Alberto Salleo.
3. Flexible Electronics by S. Rackauskas (Ed.), IntechOpen.
4. Flexible Electronics (Vol. 1 & Vol. 2) by V. K. Khanna, IOP Publishing.
5. Innovative Processes And Materials In Additive Manufacturing by Sunpreet Singh, CRC Press, Taylor & Francis.
6. Sensors & Transducers by D. Patranbis, PHI Learning.
7. Transducer Engineering by Nagraj.
8. Sensor & Instrumentation by Mayur Srivastava, Jaspreet Srivastava, Monica Mehrotra, S. K. Kataria & Sons.
9. https://www.sciencedirect.com/topics/engineering/magnetic-sensor

E-Resources :

1. https://www.sciencedirect.com/topics/physics-and-astronomy/flexible-electronics
2. https://www.youtube.com/watch?v=tRel4WbQNdU
3. https://onlinecourses.swayam2.ac.in/e-learning/preview/ntr24_ed17
4. Fundamentals of Additive Manufacturing : https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_me151
5. https://www.open.edu/openlearn/science-maths-technology/additive-manufacturing/content-section-0?active-tab=description-tab
6. MIT OpenCourseWare : https://ocw.mit.edu/courses/mas-836-sensor-technologies-for-interactive-environments-spring-2011/pages/lecture-notes/
7. Sensor Technologies : https://nptel.ac.in/courses/108106193
8. https://www.youtube.com/watch?v=SCwpE16qZ60
9. https://www.youtube.com/watch?v=5HnH5IqvW90
10. https://www.youtube.com/watch?v=cnMUpVBsoeo

Course Learning Outcomes :

1. Basic understanding of flexible & stretchable electronics.
2. Understanding of the materials for flexible electronics.
3. Understanding of the integration strategies for substrates, transfer & bonding.
4. Understanding of flexible printed circuit boards.
5. Understanding of printed electronics.
6. Understanding of additive manufacturing.
7. Understanding of 3D printing.
8. To understand the advanced applications of flexible electronics.
9. Understanding of sensors.
10. Understanding of transducers.

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Semester - II

Paper (IV) – Semiconductor Packaging & Assembly

(PGD SPCD 204, Credits Theory 04, Lectures 60)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
II	PGD SPCD 204	Semiconductor Packaging & Assembly	8	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Completed undergraduate degree in science stream with B.Sc. in Computer Science/Mathematics/Physics/Electronics or B.Tech. or B.Sc. in Chemistry/Biology/Biotechnology/Microbiology/BCA			
Objectives of The Course :	➢ To introduce packaging technology to the students ➢ To introduce package configurations ➢ To make understand the chip scale technology ➢ To introduce flip chip technology ➢ To explain the interconnections & wire bonding ➢ To explain different types of integrations ➢ To explain chip level packaging ➢ To explain wafer level packaging ➢ To explain the PCB & correlated electrical issues			

Unit - I : Introduction To Packaging & Package Types

Introduction To Packaging : Introduction, Electronics packaging, Levels of packaging, Wafer fabrication, Chip carrier, Types of chips carrier, Peripheral packages, Electrical interposer (Silicon, Glass, Ceramic).

Package Types : Area array packages, Pin grid array, Ball grid array, Land grid array, Package configurations, Chip scale package, Packaging efficiency, Flip chip technology, Single chip packages, Surface mount Technology **(15 Lectures)**

Unit - II : Interconnections & Advanced Packaging

Interconnections : Interconnections, Flip chip bonding, Advanced packaging- Multichip module, System on chip, System in package, 2D, 2.1D, 2.3 D IC Integration, 2.5D integration, 3D integration, Package on package, Hybrid bonding, Silicon photonics (Waveguide, grating coupler, Edge coupler, etc.), Concept of Copackaging, Temperature cycling & thermal shock. **(15 Lectures)**

Unit - III : Chip Level Packaging

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. **(15 Lectures)**

Unit - IV : Printed Circuit Board (PCB) Design & Electrical Issues

Printed Circuit Board (PCB) : PCB, Surface Mount Technology & 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 & Design Challenges, Thermal Management, Heat transfer fundamentals, Thermal conductivity and resistance, Conduction, convection & radiation–cooling requirement.
(15 Lectures)

References :

1. Semiconductor Packaging by Venkat Bhat.
2. VLSI Fabrication Technology by S.M. Sze, McGraw-Hill.
3. Silicon Technology by S.K. Gandhi, Wiley India, 2nd Ed, 2009.
4. VLSI : Fabrication, Characterization & Packaging by S.K. Gupta, New Age International.
5. Surface Mount Technology : Principles & Practice by R.P. Prasad, CRC Press.

E-Resources :

1. MIT Open Courseware : https://ocw.mit.edu/courses/6-777j-design-and-fabrication-of-microelectromechanical-devices-spring-2007/0747e840cd680c26f540ccff7bc17c47_07lecture19.pdf
2. An Introduction To Electronics Systems Packaging : https://nptel.ac.in/courses/108108031
3. https://ocw.mit.edu/courses/6-780-semiconductor-manufacturing-spring-2003/resources/projects/
4. https://ocw.mit.edu/courses/6-780-semiconductor-manufacturing-spring-2003/resources/lecture-notes/

Course Learning Outcomes :

1. To understand the IC packaging & package types.
2. To understand the interconnections & advanced packaging.
3. To understand the concept of chip level packaging.
4. To understand the PCB design.
5. To understand the electrical issues in PCB design.

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Semester - II

Paper (I) – Project Work/Dissertation

(PGD SPCD 212, Credits 06)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
II	PGD SPCD 211	Project Work/Dissertation	8	06
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Project Work/Dissertation related to Semiconductor Physics & Chip Design in a company/research institute/university/college		
Prerequisites	Completed undergraduate degree in science stream with B.Sc. in Computer Science/Mathematics/Physics/Electronics or B.Tech. or B.Sc. in Chemistry/Biology/Biotechnology/Microbiology/BCA			
Objectives of The Course :	The project should involve implementing existing techniques and developing new algorithms, models, or tools in semiconductor device design, modeling, simulation, or manufacturing to generate meaningful research outcomes. Students should apply their knowledge of Semiconductor Technology, VLSI Design, Packaging, and Fabrication to solve practical design and application problems. They should also identify suitable research topics through a thorough literature review of standard research articles and study state-of-the-art methods. Relevant EDA tools, simulation software, and fabrication-related frameworks should be used to demonstrate results with practical significance and to develop the required research components. Students are required to submit a detailed project report on the selected topic in accordance with the guidelines prescribed by the department. The project will be assessed through presentations and viva-voce during the semester, and the final evaluation will be conducted at the end of the semester as per departmental guidelines issued from time to time. With prior permission from the Chairperson and on the recommendation of the concerned supervisor, the candidate may also visit research laboratories or institutions.			