ANNAMACHARYA UNIVERSITY

(ESTD UNDER AP PRIVATE UNIVERSITIES (ESTABLISHMENT AND REGULATION) ACT,
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RAJAMPET, YSR District, AP – 516126, INDIA

Course Structure and Syllabi for Pre-Ph.D. Programme

PHYSICS

SUBJECT-1

S. No	Course Code	Title of the Course
1	26CPHY01T	Research Methodology for Sciences

SUBJECT-2

S. No	Course Code	Title of the Course
1	26CMGT02T	Research and Publications ethics for Sciences and Humanities

CORE SUBJECTS

Choose any **Two** subjects from the following list

S. No	Course Code	Title of the Course
1	26CPHY01T	Solid State Physics
2	26CPHY02T	Quantum Mechanics
3	26PHY03T	Condensed Matter Physics
4	26CPHY04T	LASER, Holography & Fiber Optics
5	26CPHY05T	Physics of Semiconductor Devices
6	26CPHY06T	Synthesis and Characterization of Nano Materials
7	26CPHY07T	Vacuum and Thin Film Technology
8	26CPHY08T	Solar Energy

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Title of the Course	**:**	SOLID STATE PHYSICS
Course Code	**:**	26CPHY01T
Course offered to	**:**	Physics
Credits	**:**	4

Course Objectives

1. To provide a strong foundation in the basic concepts of lattice energies and lattice vibrational spectra.
2. To introduce the knowledge of Transport Phenomenon of charge carriers and band theory of solids.
3. To explain the key principles of semiconductor materials.
4. To describe the behavior of superconducting materials and its applications.
5. To explain the characterization techniques for determining the various physical properties of materials.

Course Outcomes: Students will be able to

1. analyze the lattice energies and lattice vibrational spectra.
2. understand the Transport Phenomenon of charge carriers and band theory of solids.
3. apply principles of semiconductor materials.
4. understand the behavior of superconducting materials and its applications.
5. analyze the characterization techniques for determining the various physical properties of materials.

UNIT – I: Lattice Energies and Lattice Vibrations

Origin of chemical binding in ionic and Van der Waals crystals – Elastic properties – Stress and strain – Elastic moduli - Lattice energy calculations for ionic and van der Waals crystals – Lattice vibrations: Mono and diatomic one dimensional infinitely long lattices – Vibrational spectra – Infrared absorption in ionic crystals – Vibrational spectra of finite lattice – Quantization of lattice vibrations – Phonons – Properties – Experimental measurement of dispersion relation.

UNIT – II: Transport Phenomena and Band Theory

Concept of electrical and thermal resistivity – Expression for thermal and electrical conductivities for metals – Lorenz number - Different scattering mechanisms – Matheissens rule- Formulation of Boltzmann transport equation – Relaxation time approximation – Distribution function.

Sommerfeld model –– Electron-lattice interaction (Quantitative only) – Motion of electron in periodic potential – Bloch function - Kronig - Penny model – Formation of energy bands in solids –

Concept of effective mass – Brillouin zones – Different schemes of representation of E versus K curves – Distinction between metals, insulators and semiconductors.

UNIT – III: Semiconductor Physics

Intrinsic and extrinsic semiconductors – Expression for position of Fermi levels and carrier concentrations – Variation of Fermi level with temperature – Carrier mobility, conductivity and their variation with temperature – Direct and indirect band gap semiconductors – Differences and examples – Hall effect - Continuity equation – Drift and Diffusion – Einstein relation – Generation, Recombination and life time of non-equilibrium carriers – Heyness- Schockley experiment – Determination of life time, diffusion length of minority charge carriers.

UNIT – IV: Superconductivity

Concept of zero resistance – Magnetic behavior – Distinction between a perfect conductor and superconductor – Meissner effect – Isotope effect – Specific heat behavior – Two- fluid model – Expression for entropy difference between normal and superconducting states – London's equations – Penetration depth – BCS theory –Josephson junctions – SQUIDS and its applications - Applications of superconductors – High TC superconductors –Properties.

UNIT – V: Characterization Techniques

Basic principles, working and applications of X-Ray Diffraction (XRD)- Scanning electron microscopy (SEM) -Transmission electron microscopy (TEM)- Atomic force microscopy (AFM).

Prescribed Textbooks:

1.Solid State Physics by C. Kittel, John willey & Sons, NewYork

2.Solid State Physics by A.J. Dekkar, Macmillan, London

References:

1.Solid State Physics by R.L.Singhal, Kedarnath & Ramnath Co. Meerut

2.Solid State Physics by S.O. Pillai, New Age Publishers.

3.Solid State Physics by S.L. Kakani and C. Hemarajan, Pearson Educations.

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Title of the Course	**:**	QUANTUM MECHANICS
Course Code	**:**	26CPHY02T
Course offered to	**:**	Physics
Credits	**:**	4

Course Objectives

1. To provide a strong foundation in quantum dynamics
2. To introduce the knowledge of Angular momentum and approximation methods
3. To explain the key principles of Scattering Theory.
4. To describe the properties of identical particles and molecules.
5. To explain the relativistic quantum theory.

Course Outcomes: Students will be able to

1. understand the principles in quantum dynamics.
2. apply the angular momentum and approximation methods in various fields.
3. describe the principles of Scattering Theory.
4. understand the properties of identical particles and molecules.
5. apply the various equations in relativistic quantum theory.

UNIT - I: Formulation and Quantum Dynamics

Postulates of quantum mechanics-Schoedinger's time independent wave equation - Eigen values and Eigen functions for finite potential well and step barrier – Quantum mechanical tunneling-Simple harmonic oscillator– Wave functions in coordinate and momentum representation

Equations of motion- Schrodinger Picture- Heisenberg Picture- Interaction Picture- Equivalence of various Pictures- Poisson and Commutation brackets and their properties.

UNIT - II: Angular Momentum and Approximate Methods:

Motion in a central potential- Orbital angular momentum- L_x, L_y, L_z, L^2, L_+, and L_- – operators-commutation relations- Eigen values and Eigen functions of L^2 and L_z- Spin angular momentum and Pauli's spin matrices

Time independent perturbation theory for non-degenerate levels: The perturbed harmonic oscillator, the normal Helium atom, The Stark effect of the plane rotator. Time dependent perturbation theory: Transition to continuum (Fermi Golden rule)-The WKB approximation.

UNIT - III: Scattering Theory

Quantum theory of scattering – Partial wave analysis – Scattering by a rigid sphere – Greens function in scattering theory. Born approximation – Validity of Born approximation – Optical theorem.

UNIT: IV- Identical Particles and Molecules

Identical particles- Indistinguishability of Identical particles- Construction of Symmetric and Anti-symmetric wave functions- Pauli's Exclusion Principle- Hydrogen molecule- Spin-orbit interaction

UNIT – V: Relativistic Quantum Theory

Klein – Gorden Equation – Probability Current Density – Inadequacies of K.G. Equation – Dirac's Relativistic Equation for a Free Particle - Dirac`s Matrices – Dirac`s Equation in Covariant form

Prescribed Textbooks:

1.Quantum Mechanics by S.L. Kakani and H.M. Chandalia,

2.A Textbook of Quantum Mechanics by P.M. Mathews and K. Venkatesan, Tata Mc Graw Hill Publishing Company.

References:

1.Advanced Quantum Mechanics by B.S. Rajput, Pragatiprakasan, NewDelhi

2.Quantum Mechanics by V.K. Thankappan, Wiley Eastern Limited

3.Quantum Mechanics by S.L. Gupta, V. Kumar, H.V. Sharma and R.C. Sharma Jai Prakash Nath and Company.

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Title of the Course	**:**	CONDENSED MATTER PHYSICS
Course Code	**:**	26CPHY03T
Course offered to	**:**	Physics
Credits	**:**	4

Course Objectives

1. To provide basic knowledge of crystal growth and defects in crystals.
2. To explain the properties of dielectrics and ferroelectrics
3. To explain the properties of ferromagnetic and anti-ferromagnetic materials.
4. To describe the Photoconductivity and various types of luminescence.
5. To explain the behavior of different functional materials.

Course Outcomes: Students will be able to

1. understand the methods of crystal growth and various defects in crystal.
2. understand the properties of dielectric and ferroelectric materials.
3. understand the properties of ferromagnetic and anti-ferromagnetic materials.
4. apply the principles of photoconductivity and various types of luminescence in various fields.
5. analyze the behavior of Functional materials at various conditions.

UNIT - I: Crystal Growth and Imperfections in Crystals

Crystal growth: Nucleation and growth – Homogeneous and heterogeneous nucleation – Classification of crystal growth techniques – Melt growth: Bridgman, Czochralski techniques.

Imperfections: Classification of imperfections – Point defects – Schottky and Frenkel defects - Expressions for equilibrium defect concentrations – Line defects – Dislocations – Edge and Screw dislocations – Burger vector – Estimation of dislocation densities – Mechanism of creep – Experimental determination of creep activation energy.

UNIT- II: Dielectrics and Ferroelectrics

Dielectrics: Introduction – Dipole moment – various types of polarization – Electronic, ionic and orientational polarization **–** Langevin's theory – Lorentz field – Clausius-Mosotti equation – Measurement of dielectric constant – Applications of dielectrics.

Ferroelectrics: Piezo, Pyro and ferroelectric crystals– Spontaneous polarization – Classification and properties of ferroelectrics - Ferroelectric domains – Oxygen ion displacement theory – Applications of ferroelectrics.

UNIT- III: Ferromagnetism and Anti-ferromagnetism

Ferromagnetism: Introduction – Weiss molecular field theory – Temperature dependence of spontaneous magnetization – Heisenberg model – Exchange interaction – Ferromagnetic domains – Magnetic bubbles – Bloch wall – Thickness and energy – Ferromagnetic spin waves – Magnons – Dispersion relations.

Anti-ferromagnetism: Introduction – Two sub lattice model of anti-ferromagnetism – Ferri magnetism - Ferrites – Structure – Applications – Multiferroics.

UNIT-IV: Photoconductivity and Luminescence

Photoconductivity – Simple model – Influence of traps – Space charge effects – Determination of photoconductivity - Luminescence – Various types: Thermoluminescence, Electroluminescence, Photoluminescence, Cathodoluminescence and Chemiluminescence - Excitation and emission – Decay mechanisms – Applications.

UNIT - V: Functional materials

Amorphous semiconductors: Band structure – Electronic conduction – Optical absorption – Applications. Liquid crystals: Classification – Orientational order and intermolecular forces – Magnetic effect – Optical properties – Applications- Polymers: Classification –Structural property correlation – Molecular weight – Crystallinity in polymers – Applications.

Prescribed Textbooks:

1.Material Science and Engineering, V. Raghavan, PHI, New Delhi.
2.Crystal Growth, B.R. Pamplin, Pergmon Press.

References:

1.Introduction to Solid State Physics, Charles Kittel VII edition, John Wiley & Sons.
2.Solid State Physics, A.J. Dekker, McMillan Publications.
3.Crystal Growth from High Temperature Solutions, D. Elwell and H.J. Scheel, Academic Press.

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RAJAMPET, YSR District, AP – 516126, INDIA

Title of the Course	**:**	LASER, HOLOGRAPHY AND FIBER OPTICS
Course Code	**:**	26CPHY04T
Course offered to	**:**	Physics
Credits	**:**	4

Course Objectives

1. To provide basic principles of electromagnetic theory.
2. To explain the various methods to produce Lasers and principles of Non-Linear Optics
3. To explain the principles of Holography and Fourier Optics.
4. To describe principles of Fiber Optics in communication field.
5. To explain the various manufacturing methods of optical fiber and signal transmission in Fibers.

Course Outcomes: Students will be able to

1. understand the principles of electromagnetic theory.
2. apply the principles Lasers and non-Linear Optics in various fields.
3. apply the principles of Holography and Fourier Optics in various fields.
4. apply the principles of Fiber Optics in communication field.
5. analyze various manufacturing methods of optical fiber and signal transmission in Fibers.

UNIT – I: Electromagnetic Theory

Maxwell's equations, Wave equation, Propagation of light in isotropic dielectric medium – Dispersion, Propagation of light in conducting medium-skin depth, Reflection and refraction at the boundary of a dielectric interface – Fresnel's equations, Propagation of light in crystals Double refraction.

Electromagnetic radiation; Retarded potentials, Radiation from moving point charge, Radiation from oscillating dipole (electric and magnetic dipoles), Radiation from linear antenna – Radiation resistance, electric quardrupole radiation, Lienard – Wiechert potentials.

UNIT – II: Lasers and Non-Linear Optics

Basic principles of lasers – Spontaneous and stimulated emission – Coherence - Population inversion- Einstein coefficients – Pumping schemes – Threshold condition for laser oscillation – Losses and Q-factor – Ruby laser and GaAs laser – Gas Lasers-Argon ion laser, Co_2 laser - Laser applications.

Basic Principles – Origin of optical nonlinearity - Harmonic generation – Second harmonic generation – Phase matching condition – Third harmonic generation – Optical mixing –

Parametric generation of light – Parametric light oscillator – Frequency upconversion – Self focusing of light - Guided wave optics - Pulse compression - Optical solutions.

UNIT – III: Holography and Fourier Optics

Introduction to Holography – Basic theory of Holography – Recording and reconstruction of Hologram – Diffuse object illumination – Speckle pattern – Fourier transform Holography – Applications of Holography.

Introduction to Fourier optics– Two dimensional Fourier transforms – Transforms of Dirac-Delta function – Optical applications – linear systems- The convolution integral – convolution theorem- Spectra and correlation – Parsevel's formula – Auto correlation and cross-correlation – Apodization – Array theorem – Fourier methods in diffraction - Fraunhouffer diffraction of single slit, double slit and transmission grating using Fourier method.

UNIT – IV: Fiber Optics

Total internal reflection - Optical fiber modes and configuration – Single mode fibers – Graded index fiber structure – Fiber materials and fabrication – Mechanical properties of fibers – Fiber optic cables – Attenuation – Signal distortion on optical wave guides- Erbium doped fiber amplifiers – Solitons in optical fibers - Block diagram of fiber optic communication system - Applications of optical fibers in communication and medicine.

UNIT-V: Manufacturing and Assessment of Fibers

The Manufactures & Assessment of Silica Fibers: Fiber production Methods- Cables- Splices & connectors- Fiber Assessment- Comparisons between Optical Fibers and conventional Electrical Transmission Lines.

Electromagnetic Wave-Propagation in Graded-Index Fibers: Modes in graded-Index Fibers. The equivalence of the WKB Approximation & Ray Model- Intermodal Dispersion in graded Index Fibers- Total Dispersion in Graded Index Fibers-Mode coupling.

Prescribed Textbooks:

1. Lasers and Non-Linear Optics, B.B. Laud, 3rd Edition, New Age International Publishers Ltd, New Delhi, 2011.

2. Modern Optics by G.R. Fowels, 1989

References:

1. Fundamentals of Electromagnetic theory, 2nd Edition, S.K. Dash and S.R. Khuntia, ND, 2011.
2. Laser and their Applications, M.J. Beesly, Taylor and Francis, 1976

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Title of the Course	**:**	PHYSICS OF SEMICONDUCTOR DEVICES
Course Code	**:**	26CPHY05T
Course offered to	**:**	Physics
Credits	**:**	4

Course Objectives

1. To provide basic knowledge on principles of p-n junction and metal-semiconductor interfaces.
2. To explain the principle, operation and applications of various junction diodes.
3. To explain the principle, operation and applications of various junction transistors.
4. To describe principles of Power Devices and Semiconductor Technology.
5. To explain the operation of various sinusoidal oscillators.

Course Outcomes: Students will be able to

1. understand the principles of p-n junction and metal-semiconductor interfaces.
2. analyze the operation of various junction diodes using in electronic fields.
3. analyze the operation of various junction transistors using in electronic field.
4. analyze the operation of Power Devices and Semiconductor Technology using in electronic field.
5. analyze the operation of various sinusoidal oscillators using in electronic field.

UNIT - I: Junctions and Interfaces

p-n Junctions: Description of p-n Junction action – Junction in equilibrium- Application of bias – Energy band diagrams- Abrupt junction – Calculation of the built-in voltage - Electric field and potential distributions – Expression for depletion layer capacitance, Static I-V characteristics of p-n junction diodes- Ideal diode model- Derivation of ideal diode equation. Real diodes – Carrier generation – Recombination in the junction depletion region, I-V characteristics of real diodes. Electrical breakdown in p-n junctions: Zener and Avalanche breakdown in p-n junctions, Applications of breakdown diodes-Metal-Semiconductor interfaces - Ohmic and Schottky contacts.

UNIT- II: Junction Diodes

Tunnel diode - I-V characteristics - Schottky barrier diode: operation and applications- Varactor diode-Gunn diode-IMPATT diode - TRAPATT diode:basic principle, operation and its applications-Solar cell – Structure - Principle of operation – Solar cell parameters – Light Emitting Diodes (LEDs) -Semiconductor lasers: principle of operation and applications.

UNIT - III: Junction Transistors

Bipolar junction transistors: Principle of operation- Analysis of the ideal diffusion transistor – Calculation of terminal currents, DC parameters. Ebers-Moll Equations – Four regions of operation of a bipolar transistor - Real transistors - Carrier recombination in the Emitter-Base junction depletion region – Effect of collector bias variation - Avalanche multiplication in the collector – base junction and base resistance- Junction field-effect transistors: Basic Structures and the operating principle of MOSFET, I-V characteristics of an ideal MOSFET- Charge Coupled Devices (CCD)- principle of operation.

UNIT – IV: Power Devices and Semiconductor Technology

Power rectifiers-Thyristors- Some special thyristor structures-Bidirectional thyristors – SCR SCR as switch- SCR as half-wave rectifier- SCR as full-wave rectifier- TRIAC-DIAC.

Technology of Semiconductor Devices: Crystal growth and Wafer preparation, Methods of p-n junction formation- Growth and deposition of dielectric layers- Planar technology-Masking and lithography-Pattern definition-Metal deposition techniques.

UNIT-V: SINUSOIDAL OSCILLATORS

Operation of oscillator- Essentials of an oscillator circuit- Frequency stability of oscillator-Colpitt's oscillator - Hartley oscillator- Crystal oscillators - Phase shift oscillator-Wien bridge oscillator - Beat frequency oscillator-Negative resistance oscillators.

Prescribed Textbooks:

1.Microwave Devices and circuits by SAMUEL Y.LAO, Prentice-Hall of India, 1999.

2.Physics of Semiconductor Devices by S.M.Sze, 3rd Edition, Oct.2006, John Wiley

References:

1.Introduction to Semiconductor Materials and Devices by M.S.Tyagi, John Wiley & Sons (Asia) Pvt. Ltd., Singapore, 2000.

2.Solid State Electronic Devices by B.G. Streetman, PHI, New Delhi,

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Title of the Course	**:**	SYNTHESIS AND CHACTERISATION OF NANOMATERIALS
Course Code	**:**	26CPHY06T
Course offered to	**:**	Physics
Credits	**:**	4

Course Objectives

1. To provide basic knowledge on various methods for synthesis of nanomaterials.
2. To explain the various preparation methods of nanomaterials.
3. To explain the various compositional and structural characterization techniques of nanomaterials.
4. To describe the basic principles and applications of surface and spectroscopic techniques.
5. To explain the various Device Characterization Techniques.

Course Outcomes: Students will be able to

1. understand the various methods for synthesis of nanomaterials.
2. understand various preparation methods of nanomaterials.
3. analyze the compositional and structural characterization techniques of nanomaterials.
4. analyze the surface and spectroscopic techniques.
5. analyze the various Device Characterization Techniques.

Unit-I: Synthesis of nanomaterials

Introduction to synthesis of nano materials- Bottom-up approach and Top-down approach with examples-Physical methods: Inert gas condensation-Arc Discharge- RF-plasma-Plasma arc technique-Electric explosion of wires-Lasers ablation-Laser pyrolysis-Ball milling-Molecular beam epitaxial-Electro deposition

Chemical methods: Nanocrystals by chemical reduction-Photochemical synthesis Electrochemical synthesis-Nanocrystals of semiconductors and other materials by arrested precipitation-Emulsion synthesis-Sonochemical routes

Unit-II: Preparation Methods

Thermolysis route – Spary pyrolysis and solved metal atom dispersion-Sol-gel method Solvothermal and hydrothermal routes- Solution combustion synthesis- Chemical vapor deposition (CVD) method and other variants- Biological methods: use of bacteria, fungi, actinomycetes for nano-particle synthesis- Magnetotic bacteria for natural synthesis of magnetic nano-particles-Role of plants in nano particle synthesis.

Unit-III: Compositional and structural Characterization techniques

X-Ray Photoelectron Spectroscopy (XPS)- Physical Vapor Deposition Techniques: Thermal sputtering- Physical Vapor deposition (PVD) method-Chemical Vapor Deposition (CVD) method- Energy Dispersive X-Ray Analysis (EDAX)-Principles and applications of X-Ray Diffraction: Small angle X-Ray Diffraction and Wide angle X-Ray Diffraction-Electron

Diffraction-Electro probe microanalysis (EPMA)-Ion beam techniques: SIMS & RBS

Unit-IV: Surface and Spectroscopic Techniques

Basic principles and applications of scanning probe techniques (SPM)-Scanning tunneling microscopy (STM).

Spectroscopic techniques: UV-Visible spectroscopy- Infrared (IR) & Fourier Transform infrared (FTIR) Spectroscopy- Raman Spectroscopy.

Unit-V: Device Characterization Techniques

Hall Measurement, capacitance, and voltage measurements, I-V analysis. Magnetic & Dielectric

Characterization: SQUID- Dielectric Measurements-Impedance and ferroelectric measurements

Prescribed Textbooks:

1. Characterization of nanostructured materials by Z.L.Wang, Wiley, John & Sons.

2. Introduction Nano Technology by Carless P.Poole Jr and Frank J.Owens. Wiley India Pvt Ltd.

References:

1.Inorganic Materials Synthesis and Fabrication by J.N.Lalena, D.A.Cleary, E.E.Carpenter, N.F.Dean, John Wiley & Sons Inc.

2.The chemistry of Nanomaterials: Synthesis, Properties and Appliocations, Vol-I By C.N.R.Rao, A Muller and A.K.Cheetham, Wiley Publications 2004.

3.Nanotechnology: Principles and Practices by Sulabha K.Kulkarni- Capital Publising Company

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Title of the Course	**:**	VACUUM AND THIN FILM TECHNOLOGY
Course Code	**:**	26CPHY07T
Course offered to	**:**	Physics
Credits	**:**	4

Course Objectives

1. To provide basic knowledge on various vacuum pumps and gauges for Production and Measurement of Vacuum
2. To explain the construction and operation of vacuum systems
3. To explain the various methods for preparation of thin films
4. To describe the theories and stages in growth of thin film and thickness measurements of thin films
5. To explain the various characterization techniques of thin films and its applications.

Course Outcomes: Students will be able to

1. understand the operation of various vacuum pumps and gauges for production and measurement of vacuum.
2. understand construction and operation of vacuum systems.
3. apply the various methods for preparation of thin films
4. analyze the theories and stages in growth of thin film and thickness measurements of thin films
5. analyze the various characterization techniques of thin films and its applications.

UNIT - I: Production and Measurement of Vacuum

Vacuum pumps: Fundamentals of kinetic theory applicable to vacuum technology- Mechanical Pumps: Rotary pump, Roots pump: Dry Pumps- Turbo molecular pump – Diffusion pump – Sorption pump – Cryogenic pump – Sputter ion pump. (1,2)

Vacuum Gauges: Thermal conductivity (Pirani) gauge- McLeod gauge – Ionization gauges: Penning gauge, Hot cathode ionization gauge – Bayard –Alpert gauge – Partial pressure measurements gauges: Magnetic deflection mass spectrometer – Quadruple mass spectrometer

UNIT - II: Construction and Operation of Vacuum Systems

Valves for medium and high vacuum – Devices for transmitting motion – Working vessel – Pump combinations – Design of vacuum systems - Leaks and leak detection.

Vacuum application: Vacuum metallurgy- Space simulators- Freeze drying – Vacuum in electrical applications (Drying, Impregnation, circuit breakers)

UNIT - III: Preparation of Thin Films

Physical Methods: Vacuum evaporation:– Thickness distribution of evaporated films (Point and Ring sources) - Resistive heating, Electron beam evaporation, Co-evaporation Pulsed laser ablation – Epitaxial thin deposition: Close-space vapour transport (CSVT) and molecular beam epitaxy. Sputtering: Glow discharge, DC and RF sputtering, Reactive sputtering and magnetron sputtering.

Chemical methods: Electroplating – Spray pyrolysis – Chemical vapour deposition (CVD), Plasma enhanced chemical vapour deposition (PECVD) and Metal organic chemical vapor deposition (MOCVD)

UNIT - IV: Growth and Thickness Measurements of Thin Films

Growth of thin films: Condensation, Nucleation and growth of thin films – Langmuir Frenkel theory of condensation – Theories of thin film nucleation – Capillarity theory – Statistical or Atomistic theory – Comparison of the nucleation theories – The four stages film growth – Incorporation of defects during growth.

Thickness measurement: Multiple beam interferometer (MBI) methods – Quartz crystal thickness monitor, Stylus profiler.

UNIT – V: Characterization of Thin Films and Applications:

Thickness measurement techniques-Multiple beam interferometry (MBI)-Stylus method, Surface analytical techniques: Auger Electron Spectroscopy (AES), X-ray Photoelectron Spectroscopy (XPS), Secondary Ion Mass Spectroscopy (SIMS) and Rutherford Back Scattering (RBS) Applications of Thin Films: Thin film resistors – Thin film capacitors –Thin film solar cells – Gas sensors – Transparent conducting coatings - Thin films for superconducting devices – Hard coatings, Photolithography

Prescribed Textbooks:

1.Vacuum Technology, A. Roth, North-Holland, 1986.

2. Handbook of Thin Film Technology, L.I. Maissel and R.L. Glang, Mc Graw Hill Book Co., 1970

Reference Books:

1.Thin Film Phenomena, K.L. Chopra, Mc Graw Hill Book Co., New York, 1969.
2.The Materials Science of Thin Films, M. Ohring, Academic Press, New York, 1992.

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Title of the Course	**:**	SOLAR ENERGY
Course Code	**:**	26CPHY08T
Course offered to	**:**	Physics
Credits	**:**	4

Course Objectives

1. To provide basic knowledge on parameters and operation of solar cell.
2. To explain the solar and thermal radiation parameters.
3. To explain the various methods for preparation of silicon photovoltaics.
4. To explain various methods for preparation of multijunction solar cells.
5. To explain the performance of photovoltaic module.

Course Outcomes: Students will be able to

1. understand the parameters and operation of solar cell.
2. understand the solar and thermal radiation parameters.
3. apply the various methods for preparation of silicon photovoltaics.
4. apply the various methods for preparation of multijunction solar cells.
5. analyze the performance of photovoltaic module in various configurations.

UNIT - I: Fundamentals

Photovoltaic effect-Types of interfaces: Homojuction, Heterojunction and Schottky barrier - Choice of semiconductor materials for fabrication of homojunction solar cells - Equivalent circuit of a solar cell-Solar cell output parameters -Fill-factor-Conversion efficiency-Quantum efficiency-Effect of series and shunt resistance on the efficiency of solar cells-Variation of Opencircuit voltage and short circuit current with intensity of incident light-Effect of temperature on IV characteristics-p-n heterojunction solar cells - Criteria for choosing absorber and window layers.

UNIT – II: Solar and Thermal Radiation:

Spectral distribution of Extra-terrestrial radiation – Solar Constant-Concept of Zenith Angle and Air-Mass- Definitions of Declination, Hour Angle, Solar and Surface Azimuth Angles. Direct, Diffuse and Total Solar Radiations

UNIT – III: Silicon Photovoltaics

Single crystal silicon (c-Si) ingot growth – Float Zone and Czochrolski methods – silicon wafer fabrication – wafer to cell formation - I-V characteristics and spectral response of c-Si solar cells. Factors limiting the efficiency - Polysilicon wafer fabrication methods – EFG and SRG

methods. Amorphous Silicon - Differences in properties between crystalline silicon and amorphous (a-Si) silicon- a-Si deposition by glow discharge method – Electrical and optical properties of a-Si. Outline of a-Si solar module processing steps.

UNIT – IV: Thin Film Solar Cells

Principle of multijunction cells – Structure and fabrication of GaInP/GaAs/Ge triple junction solar cell –Metamorphic solar cells. CdTe/CdS and CuInGaSe/CdS (CIGS) solar cells - Cell configuration – Techniques used for the deposition of each layer- Cell characteristics- Organic solar cells – Configuration and principle – Types of organic solar cells, Dye-sensitized (DS) solar cells – Principle – Configuration and performance-Basic concept of quantum dot-Nano wire (NW) -Hot carrier and plasmonic solar cells.

UNIT - V: Solar Photovoltaic Systems

Photovoltaic Module Assembly: Description of steps involved in the fabrication of Silicon Photovoltaic Module - Performance of Photovoltaic Module - Module Protection - Modules in series and in parallel - Use of Bypass and Blocking Diodes, Solar photovoltaic system - components – PV Array, battery, invertor and load. Applications of solar photovoltaic systems. Stand alone, Hybrid and Grid connected PV systems.

Prescribed Textbooks:

1. Solar Photovoltiacs – Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI Learning Pvt. Ltd.
2. Solar Power Generation – Technology, New concepts and Policy, P. Jayarami Reddy, CRC Press, 2012.

Reference books:

1.Science and Technology of Photovoltaics, P. Jayarama Reddy, BS Publications, 2004.
2.Fundamentals of Solar Cells: Photovoltaic Solar Energy Conversion: A.L. Farenbruch and R.H. Bube, Academic Press, 2012.