## DEPARTMENT OF PHYSICS

Course Structure and Syllabi for Pre Ph.D Programme

### SUBJECT – 1

| S.No | Course Code | Title of the Course |
|---|---|---|
| 1 | 24CMGT01T | Research Methodology |

### SUBJECT - 2

| S.No | Course Code | Title of the Course |
|---|---|---|
| 1 | 24CMGT02T | Research and Publication Ethics |

### CORE SUBJECTS

### Choose any Two subjects from the following list

| S.No | Course Code | Title of the Course |
|---|---|---|
| 1 | 24CPHY01T | Solid State Physics |
| 2 | 24CPHY02T | Quantum Mechanics |
| 3 | 24CPHY03T | Physics of Semiconductor Devices |
| 4 | 24CPHY04T | LASER, Holography & Fiber Optics |
| 5 | 24CPHY05T | Condensed Matter Physics |
| 6 | 24CPHY06T | Synthesis and Characterization of Nano Materials |
| 7 | 24CPHY07T | Vacuum and Thin Film Technology |
| 8 | 24CPHY08T | Solar Energy |

# SOLID STATE PHYSICS (24CPHY01T)

## 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).

**References:**

1. **Solid State Physics** by C. Kittel, John willey & Sons, NewYork
2. **Solid State Physics** by A.J. Dekkar, Macmillan, London
3. **Solid State Physics** by R.L.Singhal, Kedarnath & Ramnath Co. Meerut
4. **Elementary Solid State Physics** by M. Ali Omar, Pearson Educations.
5. **Solid state and semiconductor Physics** by J.P.McKelvey, Harper& Row, John Willey & Sons. NewYork
6. **Solid State Electronic Devices** by B.G. Streetman, Pearson Education (Singapore) 2007.
7. **High $T_C$ Superconductivity** by C.N.R. Rao and S.V. Subramanyam, Prof. of International inference Super.
8. **Solid State Physics** by S.O. Pillai, New Age Publishers.
9. **Solid State Physics** by S.L. Kakani and C. Hemarajan, Pearson Educations.
10. **Elementary Language of Solid State Physics** by Stiddard, Academic press, New York, 1975.
11. **Characterization of nanostructured materials** by Z.L.Wang, Wiley, John & Sons.
12. **Principles of Instrumental analysis** by D.A.Skoog, F.L.Hollen and T.A.Niemann, Mac Grow Hill.

# QUANTUM MECHANICS (24CPHY02T)

**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

**References:**

1. **Quantum Mechanics** by S.L. Kakani and H.M. Chandalia,
2. **Advanced Quantum Mechanics** by B.S. Rajput, Pragatiprakasan, NewDelhi
3. **Quantum Mechanics by** V.K. Thankappan, Wiley Eastern Limited

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

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

6. **An introduction to Quantum Mechanics by** P.T. Mathews Mc Graw Hill Publishing Company.

# PHYSICS OF SEMICONDUCTOR DEVICES (24CPHY03T)

## 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.

**References:**

1. **Introduction to Semiconductor Materials and Devices** by M.S.Tyagi, John Wiley & Sons (Asia) Pvt. Ltd., Singapore, 2000.
2. **Microwave Devices and circuits** by SAMUEL Y.LAO, Prentice-Hall of India, 1999.
3. **Microwave and Radar Engineering** by M.Kulkarni, UMESH publications, New Delhi, 1999.
4. **Physics of Semiconductor Devices** by S.M.Sze, 3rd Edition , Oct.2006, John Wiley
5. **Solid State Electronic Devices** by B.G. Streetman, PHI, New Delhi,
6. **Introduction to Semiconductor devices** by M.S. Tyagi, John Wiley & Sons
7. **Optical electronics** by Ajoy Ghatak and K. Thygarajan, Cambridge Univ.Press.

# LASERS, HOLOGRAPHY AND FIBER OTICS (24CPHY04T)

## 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 crystalsDouble 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 gradedIndex Fibers- Total Dispersion in Graded Index Fibers-Mode coupling.

**References:**

1. **Introduction to Electrodynamics**, D.J. Griffiths, 4 th Edition, Prentice-Hall of India, ND, 2 2013.
2. **Electromagnetics**, B.B. Laud, 3rd Edition, New Age International Publishers Ltd, N D, 2011.
3. **Fundamentals of Electromagnetic theory**, 2nd Edition, S.K. Dash and S.R. Khuntia, ND, 2011.
4. **Modern Optics** by G.R. Fowels, 1989.
5. **Laser and their Applications**, M.J. Beesly, Taylor and Francis, 1976
6. **Lasers and Non-Linear Optics,** B.B. Laud, 3rd Edition, New Age International Publishers Ltd, New Delhi, 2011.
7. **Optics**, E. Hecht, Addison Wiley, 1974.
8. **Optical Fiber Communications,** Gerel Keiser, McGraw Hill Book, 2000.

# CONDENSED MATTER PHYSICS (24CPHY05T)

## 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 – Colour centres –Production of colour centres – 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.

**References:**

1. **Introduction to Solid State Physics**, Charles Kittel VII edition, John Wiley & Sons.
2. **Solid State Physics**, A.J. Dekker, McMillan Publications.
3. **Material Science and Engineering**, V. Raghavan, PHI, New Delhi.
4. **Crystal Growth**, B.R. Pamplin, Pergmon Press.
5. **Crystal Growth from High Temperature Solutions**, D. Elwell and H.J. Scheel,Academic Press.
6. **Solid State Physics**, M.A. Wahab, Narosa Publishing House.
7. **Fundamentals of Solid State Physics**, Saxena, Gupta, Saxena, Pragathi Publications,
8. Solid State Physics**, R.L. Singhal, Kedar Nath Ram Nath & Co. Pub.**

# SYNTHESIS AND CHACTERISATION OF NANOMATERIALS (24CPHY06T)

**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

**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. **Introduction Nano Technology** by Carless P.Poole Jr and Frank J.Owens. Wiley India Pvt Ltd.
3. **The chemistry of Nanomaterials: Synthesis, Properties and Appliocations, Vol-I** By C.N.R.Rao, A Muller and A.K.Cheetham, Wiley Publications 2004.
4. **Nano: The Essentials – Understanding Nano Science and Technology** by T.Pradeep, Tata Mc.Graw Hill
5. **Characterization of nanostructured materials** by Z.L.Wang, Wiley, John & Sons.
6. **Principles of Instrumental analysis** by D.A.Skoog, F.L.Hollen and T.A.Niemann, Mac Grow Hill.
7. **Encyclopedia of nanotechnology** by M.Balakrishna Rao and K.Krishna Reddy, Vol I to X, Campus books
8. **Nanotechnology: Principles and Practices** by Sulabha K.Kulkarni- Capital Publising Company

# VACUUM AND THIN FILM TECHNOLOGY (24CPHY07T)

## 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

**References:**

1. **Vacuum Technology**, A. Roth, North-Holland, 1986.
2. **Vacuum Science and Technology,** V. Vasudeva Rao, T.B. Ghosh and K.L. Chopra, Allied Publications, 1998.
3. **Handbook of Thin Film Technology**, L.I. Maissel and R.L. Glang, Mc Graw Hill Book Co., 1970.
4. **Thin Film Phenomena**, K.L. Chopra, Mc Graw Hill Book Co., New York, 1969.
5. **Vacuum Deposition onto Webs, Films and Foils,** Charles A. Bishop, Elsevier, London, 2011.
6. **The Materials Science of Thin Films**, M. Ohring, Academic Press, New York, 1992.
7. **The User's Guide to Vacuum Technology**, J.F .O'Henlon, John Wiley & Sons, 2003.

# Solar Energy (24CPHY08T)

**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.

**References:**

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.
3. **Science and Technology of Photovoltaics**, P. Jayarama Reddy, BS Publications, 2004.
4. **Fundamentals of Solar Cells**, A.L. Farenbruch and R.H. Bube.
5. **Terrestrial Solar Photovoltaics**, Bhattacharya.
6. **Amorphous Silicon Solar Cells**, K.Takahashi & M.Konagai, North Oxford Academic Press, 1986.
7. **Thin Film Solar Cells**, K. L. Chopra and Das, Plenum.