School of Physical Sciences
Solapur University, Solapur
Choice Based Credit System (CBCS)
(w. e. f. June 2016-2017)

M.Sc- Physics (Materials Science)

Semester- III

HCT - 3.1 Semiconductor Devices (C)	- 70+30=100
HCT - 3.2 Atomic, Molecular and Nuclear Physics(C)	- 70+30=100
SCT - 3.1 Dielectric & Ferroelectric Properties of Materials	-70+30=100
SCT - 3.2 Materials Processing	- 70+30=100
Practical – V	- 70+30=100
Project – I	- 70+30=100

Semester IV

HCT - 4.1 Microelectronics (C)	- 70+30=100
HCT - 4.2 Physics of Nano Materials	- 70+30=100
SCT - 4.1 Magnetic Materials	- 70+30=100
SCT - 4.2- Advanced Techniques of Materials Characterization	- 70+30=100
Practical – VI	- 70+30=100
Project – II	- 70+30=100

The practical’s examination at Sem.III & Sem. IV shall be of 2 laboratory practical’s of 35 marks each & 1 project presentation. Each practical & project presentation shall carry 70 Marks.

(C) Indicates common courses of the school.

30 marks are for internal evaluation.

M.Sc-II, SEME. III, PHYSICS (Materials Science)
HCT - 3.1: SEMICONDUCTOR DEVICES (C)
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Unit I : MIS Structure and MOS FETs (12)

Schottky diode, MIS structures, basic equations in flat band conditions, MIS capacitances, current flow mechanisms in MS junction and MIS junction, depletion and enhancement type MOS FETS, capacitances in MOS FETs, quantitative analysis of I - V characteristics, thresholds in MOSFETS, charge trapping and flat band voltage, study of CMOS devices.

Unit II: Power Devices (12)

Power diodes, ratings, reverses recovery characteristics, fast recovery diodes, Power transistors, Switching characteristics, construction of SCR, two transistors analogy, I - V characteristics, gate trigger characteristics, turn on and turn - off times, losses, reverse recovery characteristics, SCR ratings, dv/dt and di/dt characteristics, thyrister types, construction and characteristics of DIACs and TRIACs, static induction thyristors, , light activated thyristors, Gate turn off thyristors (GTO), MOS controlled thyristors, programmable Unijunction transistors, Silicon Unidirectional switch (SUS) , IGBT

Unit III: Charge Coupled and Transferred Electron Devices (12)

Charge storage, surface potential under depletion, construction of basic two and three phase of CCD, mechanism of charge transfer, Oxide Charges, charge trapping and transfer efficiency, dark current, buried channel CCD, application of CCD, Transferred Electron Effect, NDR (Negative differential resistivity of voltage and current controlled devices), formation of gunn domains, uniform and accumulation layer, operation modes, transistors and quenched diodes, layers and modes of operation, LSA mode of operation, frequency responses and overall device performance of Gunn devices.

Unit IV: Optoelectronic and Advanced Solid State Devices (15)

Light emitting diodes, Performance of LEDs, emission spectra, visible and IR LEDs, semiconductor LASER: p-n junction lasers, heterojunction lasers, materials for semiconductor LASER, threshold current density, effect of temp. Quantum well hetero structures,

Detectors: photoconductors, photocurrent gain and detectivity, photodiode types : p-n junction, p-i-n, avalanche characteristics, quantum efficiency, response speed, noise and optical absorption coefficient, efficiency, Solar cells – current voltage characteristics

Reference Book/Text Book:

1. D.A. Roustan: Bipolar Semiconductor Devices.
2. Mauro Zambuto: Semiconductor Devices.
3. D. Nagchoudhari: Semiconductor Devices.
4. Karl Hess: Advanced theory of semiconductors devices.
5. S. M. Sze: Physics of Semiconductor Devices 2nd edition..
6. A Dir - Bar - Lev: Semiconductor and Electronic Devices.
7. M. H. Rashid: Power Electronics.
8. P. C. Sen: Power electronics
9. B. G. Streetman and S. Banergee : Solid state Electronic Devices

M.Sc-II, SEME. III, PHYSICS (Materials Science)

HCT - 3.2: ATOMIC, MOLECULAR AND NUCLEAR PHYSICS (C)

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Unit I: Atomic structure and Atomic Spectra (10)

Quantum states of an electron, Quantum numbers, spectroscopic terms and selection rules, Pauli's Exclusion principle, Electron spin, Vector atom model, Spin-orbit coupling (LS and JJ coupling), fine structure, Hund's rule etc. Features of one electron and two electron spectra, hyperfine structure, Lande splitting factor (g), Zeeman effect (Normal and Anomalous).

Unit II: Molecular Spectra (10)

Molecular energy states and associated spectra, Types of molecular spectra. Pure rotational; spectra, Diatomic molecule as a rigid rotator, Diatomic molecule as a non-rigid rotator, its Energy levels, Spectra, Rotation spectra of polyatomic molecules, Linear, Spherical top, Symmetric top, Asymmetric molecules, Vibrating diatomic molecule as a Harmonic and Anharmonic oscillator, Vibration-Rotation Spectra, molecule as vibrating rotator, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Franck-Condon principle.

Unit III: Nuclear Forces and Nuclear Models (16)

Nuclear Forces:

Introduction, Nature of nuclear force, Deuteron (Properties, non-excited and excited states), elements of deuteron problem, Neutron-Proton (n-p) scattering at low energies, Theory of n-p scattering, proton-proton (p-p) scattering at low energies; its theory, Low energy n-n scattering, Charge Independence and charge symmetry of nuclear forces. Similarities between n-n and p-p forces, Non-central forces, its properties, Ground state of deuteron, Magnetic moment, Electric Quadrupole moment, Saturation of Nuclear forces, High energy n-p and p-p scattering.

Nuclear Models:

Constitution of the nucleus; neutron-proton hypothesis, Nature of nuclear force, stable nuclides, Liquid drop model: Semi-empirical mass formula, applications of semi-empirical mass formula, Limitations of liquid drop model, Nuclear shell model: Shell model and it's evidence, Limitations of shell theory, Fermi gas model, Extreme Single Particle model, Individual Particle model, Superconductivity model.

Unit IV: Nuclear Reactions (12)

Types of Nuclear Reactions, Conservation laws, Nuclear reaction kinematics, Nuclear Transmutations, Charged particle reaction spectroscopy, Neutron spectroscopy, Nuclear reactions-Q values and kinematics of nuclear cross-sections, Analysis of cross section classical and partial analysis, its energy and angular dependence, Thick Target yield, Requirements for a reaction, Reaction mechanism, General features of cross-section, Inverse reaction, Compound Nucleus – introduction, its reactions and disintegration, Different stages of a Nuclear Reactions, Statistical Theory of Nuclear Reactions, Direct reactions, stripping reactions and shell model, Giant Resonance, Heavy ion reactions, Nuclear shock waves.

References:

1. Introduction to atomic spectra, H. E.White, Mc-Graw hill, International Edition.1962.
2. Molecular structure and spectroscopy 2nd Edi., G. Aruldhas, PHI learning Pvt. Ltd. NewDelhi.
3. Fundamentals of Molecular Spectroscopy, Colin Banwell, McGraw-Hill Publishing Company.
4. Introduction to Atomic and nuclear Physics, Harvey E. White, Van Nostrand Reinhold Company, 1964.
5. Nuclear Physics, D.C. Tayal, Himmalaya Publishing House, 5th Edi. 2008.
6. Introductory nuclear Physics, Kenneth S. Krane, John Wiley and Sons, 1988.
7. Nuclear Physics, Irving Kaplan, Addison-wesley publishing company, Inc,1962.
8. Concepts of Nuclear Physics, Bernard L Cohen, Tata McGraw-Hill publishing company limited, 1971.
9. Nuclear Physics, S. N. Ghoshal, S. Chand and company limited, 1994.

M.Sc-II, SEME. III, PHYSICS (Materials Science)

SCT– 3.1 (MS): DIELECTRIC AND FERROELECTRIC PROPERTIES OF MATERIALS

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Unit I: Introduction (06)

Maxwells equations, Amperes law, Faradays law, Gauss law in presence of dielectric, Electric field, Electric flux density, Polarization, Permittivity, electric susceptibility, Dipole moment , Polar and non-polar dielectrics.

Unit II: Electric Polarization and Relaxation (18)

Fundamentals: Force acting on the boundary between two different dielectric materials, Force elongating a dielectric fluid, Dielectrophoretic force, Electrostriction force, Electrostatic induction , Electric polarization and relaxation in static electric fields, Vacuum space, Conducting materials.

Dielectric Materials and its Polarization: Mechanism of electric polarization, Electronic polarization, Classical and Quantum Mechanical Approach, Atomic or Ionic Polarization, Orientational polarization, Polarizability, Spontaneous polarization, Space charge polarization, Hopping polarization, Interfacial polarization, Classification of dielectric materials, Non-ferroelectric and ferro-electric materials, Internal fields, Local fields for Non-dipolar materials, Clausius-Mosotti Equation.

Dielectrics in AC field: Lorentz - Lorenz equation, Reaction Field for dipolar materials, Electric polarization and relaxation in time -varying electric fields, Time domain approach and the frequency - domain approach, Complex permittivity, Time dependent electric polarization, Kramers - Kronig equations, Debye equations, Absorption, and Dispersion for dynamic polarizations, Effects of the local field, Effects of DC conductivity, Cole - Cole plot, Temperature dependence of complex permittivity, Field dependence of complex permittivity of ferroelectric materials, Insulating materials, Dielectric relaxation phenomena.

Unit III: Optical and Electro-Optic Processes (06)

Modulation of light, Double refraction and birefringence, Quarter - Wave plate, Electro - Optic effects: Linear Electro – Optic effect, Photorefractive effect, Magneto - Optic effect, Faraday effect, Voigt effect, Acousto-Optic effect.

Unit IV: Ferroelectrics, Piezoelectrics and Pyroelectrics (18)

Ferroelectrics: Ferroelectric phenomena, Representative crystal, types of ferroelectrics: Properties of Rochelle salt, $BaTiO_3$, Theory of ferroelectric displacive transitions, Thermodynamic theory, Ferroelectric and antiferroelectric transition, Formation and dynamics of ferroelectric domains, Experimental evidence of domain structure, Applications of ferroelectric materials

Piezoelectrics: Piezoelectric phenomena, Phenomenological approach to piezoelectric effects, Piezoelectric parameters and their measurements, Piezoelectric materials and their applications.

Pyroelectrics: Pyroelectric phenomena, Phenomenological approach to pyroelectric effects, Pyroelectric parameters and their measurements, Pyroelectric and thermally sensitive materials, NTC and PTC materials, Applications of pyroelectric materials.

References Books :

1. Kwan Chi Kao and F. R. de Boer;Dielectric Phenomena in Solids, Elsevier Academic Press (2004).
2. J. P. Srivastava, Elements of Solid State Physics, 2nd Edi Prentice – Hall of India(P) Ltd. (2007)
3. Charles Kittle; Introduction to Solid State Physics, 7th Edition, John Wiley & Sons, (1996).
4. Saxena, Gupta, Saxena; Fundamentals of Solid State Physics, PragatiPrakashan, (2012).
5. A. J. Dekkar; Solid State Physics, 1st Ed. Macmillan (2000).
6. M.A. Wahab; Solid State Physics: Structure and Properties of Materials, Alpha Science International (2005)
7. S.O. Pillai; Solid State Physics, 6th Ed., New Age International (p) Ltd publishers, (2005)
8. Neil W. Ashcroft, N. David Mermin, Solid State Physics; Saunders College, (1976).

M.Sc-II, SEME. III, PHYSICS (Materials Science)

SCT– 3.2 (MS): MATERIAL PROCESSING

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Unit I : Vacuum Technology (08)

Principles of vacuum pump – principle of different vacuum pumps : roots pump, rotary, diffusion turbo molecular pump, cryogenic-pump, ion pump, ti-sub limitation pump, importance of measurement of vacuum, Concept of different gauges, bayet - albert gauge, pirani, penning, pressure control.

Unit II : Physical Vapor Deposition & CVD Techniques (08)

Thermal evaporation, resistive evaporation, Electron beam evaporation, Laser ablation, Flash and Cathodic arc deposition, laser ablation, laser pyrolysis, molecular beam epitaxy, electro deposition.

Chemical Vapor Deposition Techniques (09)

Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types boundaries and flow, Different kinds of CVD techniques: Atmospheric pressure CVD (APCVD) – Low pressure CVD (LPCVD) – Plasma enhanced chemical vipor deposition (PECVD) or –The HiPCO method – Photo-enhanced chemical vapor deposition (PHCVD) – LCVD Laser –Induced CVD, Metallorganic CVD (MOCVD), Thermally activated CVD, Spray pyrolysis,etc.

Unit III : Electrical Discharges used in Thin Film Deposition (08)

Sputtering, Glow discharge sputtering, Magnetron sputtering, Ion plating, oxidizing and Nitriding, Atommic layer deposition (ALD), Importance of ALD technique, Atomic layer growth.

Unit IV : Conditions for the Formation of Thin Films (10)

Environment for thin film deposition,deposition parameters and their effects on film growth, formation for thin films (sticking coefficient, formation of thermodynamically stable cluster – theory of nucleation), capillarity theory, microstructure in thin films, adhesion, properties of thin films, Mechanical ,Electrical, and optical properties of thin films, few applications of thin films in various fields, Quartz crystal thickness for measurement of film thickness.

Unit V :Adsorption And Diffusion in Thin Films (10)

Physisorption – Chemisorption –Work function changes induced by induced by adsorbates – Two dimensional phase transititions inadsorbate layers – Adsorption kinetics – Desorption techniques. Fundamentals of diffusion – Grain Boundary Diffusion –Thin Film DiffusionCouples –Inter Diffusion –Electromigration in thin films –Diffusion during film growth, Stress in Thin Films.

Reference Books:

1. Hand book of Thin films Technology : L I Maissel and R Clang.
2. Thin film Phenomena : K L Chopra.
3. Physics of thin films,vol.12,Ed George Hass and others.
4. Vacuum deposition of thin films – L Holland.
5. Milton Ohring,Materials Science of Thin films Published by Academic Press Limited (1991)
6. L.B.Freund and S.Suresh,Thin Film Materials,(2003)
7. Hans Luth, Solid Surfaces, Interfaces and Thin Films' 4th edition,Springer Publishers (2010)
8. HaraldIbach, Physics of Surfaces and Interfaces,Springer Publishers (2006). AMY
9. R L Banshow

M.Sc-II, SEME. IV, PHYSICS (Materials Science)

HCT - 4.1: MICROELECTRONICS (C)

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Unit I: Single crystalline Silicon and crystal structure (12)

(111) and (100) planes, Characteristics of substrates: physical (dimensional), electrical, dielectric, mechanical, Wafer cleaning process and wet chemical etching techniques, Environment for VLSI technology: clean room and safety requirements.

Epitaxial Process

Epitaxial Growth: VPE, LPE and MBE techniques, Mechanism, Chemistry and growth kinetics, evaluation of grown layer.

Unit II: Oxidation and Impurity Incorporation (12)

Oxide growth: dry, wet, rapid thermal oxidation; Deal Grove model of thermal oxidation, plasma oxidation, orientation dependence of oxidation rate, electronic properties of oxide layer, masking characteristics, oxide characteristics.

Impurity Incorporation: Interstitial and substitutional diffusions, diffusivity, laws governing diffusion, constant source and instantaneous source diffusion, Solid Source, liquid source and gas source Boron and Phosphorus diffusion systems, Ion implantation, annealing; Characterization of impurity profiles, buried layers

Unit III: Lithographic and Deposition Techniques (12)

Lithography: Types, Optical lithography –contact, proximity and projection printing, masks, resists: positive and negative, photo - resist pattering, characteristics of a good photo - resist, Mask generation using co-ordinaton graph and electron beam lithography.

Deposition Techniques for polysilicon and metals

Chemical Vapour deposition techniques: CVD technique for deposition of polysilicon, silicon dioxide and silicon nitride films;

Metallisation techniques: Resistive evaporation and sputtering techniques. (D.C. and magnetron), Failure mechanisms in metal interconnects; multilevel metallisation schemes.

Unit IV: Device fabrication, Assembling and Packaging (12)

Masking Sequence and Process flow for pnp and npn devices , p-MOS and n-MOS, Die separation, bonding and attachments, encapsulation, package sealing, flat package, PGA (Printed Grid Array), BGA (Ball Grid Array)

Reference Books:

1. S.M.Sze (Ed), "VLSI Technology", 2nd Edition, McGraw Hill, 1988.
2. Streetman," VLSI Technology". Prentice Hall, 1990

3. C.Y. Chang and S.M. Sze (Ed), "VLSI Technology", McGraw Hill Companies Inc., 1996.
4. S.K.Gandhi, "VLSI fabrication Principles", John Wiley Inc., New York, 1983.
5. Sorab K. Gandhi, “The Theory and Practice of Microelectronics”, John Wiley & Sons
6. A.S Grove, “Physics and Technology of semiconductor devices”, John Wiley & Sons,
7. Integrated Ckts: Design principles and Fabrication: Warner.

Topics for Tutorials/Seminars: The problem/ exercise / short questions answers/ block diagrams given in the reference books will from the Tutorial Course.

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HCT - 4.2: PHYSICS OF NANO MATERIALS

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Unit I: Introduction (10)

Background of Nanoscience and Nanotechnology, Definition of Nanoscience and Nanotechnology, Possible Applications of Nanotechnology, Top-down and Bottom-up approach (Brief).

Band Structure and Density of States at Nanoscale: Introduction, Energy Bands, Density of States at Low - dimensional Structures, Quantum confinement – semiconductors, quantum wells, quantum wires, quantum dots, quantum rings. Manifestation of quantum confinement, quantum confinement effect, dielectric quantum confinement, effective mass approximation, core-shell quantum dots.

Unit II: Properties of Nanomaterials (12)

Optical properties: Absorption, transmission, Beer-Lamberts law (derivation), Photoluminscence, Fluorescence, Phosphorescence, Cathodoluminscence, Electroluminescence, Surface Plasmon resonance (SPR), effect of size of nanoparticles (metal, semiconductor) on absorption and SPR spectra.

Electrical transport: Electrical Conduction in Metals, Classical Theory - The Drude Model Quantum Theory - The Free Electron Model Conduction in Insulators/Ionic Crystals, Electron Transport in Semiconductors, Various Conduction Mechanisms in 3D (Bulk), 2D(Thin Film) and Low – dimensional Systems**,** Thermionic Emission Field – enhanced Thermionic Emission (Schottky Effect), Field - assisted Thermionic Emission from Traps (Poole - Frenkel Effect), Hopping Conduction, Polaron Conduction.

Unit III: Growth Techniques and Characterization Tools of Nanomaterials (18)

Growth techniques: Introduction, Top - down vs. Bottom - up Technique, Lithographic Process and its limitations , Nonlithorgraphic Techniques ,Plasma Arc Discharge Sputtering ,Evaporation, Chemical Vapour Deposition ,Pulsed Laser Deposition ,Molecular Beam Epitaxy, Sol - Gel Technique , Electrodeposition , Different chemical routes, Other Processes.

Characterization Tools of Nanomaterials: Scanning Probe Microscopy (SPM): Introduction, Basic Principles of SPM Techniques, The Details of scanning Tunneling Mocroscope (STM), General Concept and Definite Characteristics of AFM, Scanned - Proximity Probe Microscopes Laser Beam Deflection, AFM Cantilevers ,Piezoceramics, Feedback Loop Alternative Imaging Modes. Electron Microscopy: Introduction, Resolution vs. Magnification Scanning Electron Microscope SEM Techniques, Electron Gun Specimen Interactions Environmental SEM (FESEM), Transmission Electron Microscope, High Resolution TEM Contrast Transfer Function. Near-field scanning optical microscopy (SNOM/NSOM), UV-Vis single and dual beam spectrophotometer, photoluminescence spectrometer, X-ray diffractometer.

Unit IV: Some Special Topics in Nanotechnology (08)

Introduction ,The Era of New Nanostructure of Carbon Buckminsterfullerene, Carbon Nanotubes, Nanodiamond, BN Nanotubes Nanoelectronics ,Single Electron Transistor, Molecular Machine, Nano-biometrics.

Reference Books:

1) **Introduction to Nanoscience and Nanotechnology:** K.K. Chattopadhyay and A.N. Banerjee, PHI Publisher
2) **Nanoscience and Technology:** V. S. Murlidharan, A. Subramanum.
3) **Nanotubes and Nanofibers:**YuryGogotsi
4) **A Handbook of Nanotechnology :** A. G. Brecket
5) **Instrumentations and Nanostructures:** A. S. Bhatia
6) **Nanotechnology: Nanostructures and Nanomaterials -** M. B. Rao
7) **Nanotechnology-Principles and practices -** S. K. Kulkurni (Capital Publication Company)

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SCT - 4.1: MAGNETIC MATERIALS

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Unit I: Introduction (10)

Measurement of Field Strength, Hall Effect, Electronic Integrator or Fluxmeter, Magnetic Measurements in Closed Circuits, Demegnetizing Fields, Magnetic Shielding, Demagnetizing Factors, Magnetic Measurements in Open Circuits, Instruments for Measuring Magnetization, Vibrating - Sample Magnetometer, Altering (Field) Gradient Magnetometer - AFGM or AGM, (also called Vibrating Reed Magnetometer), Magnetic Circuits and Parameters, Permanent Magnet Materials, Susceptibility Measurements.

Unit II: Magnetism in Materials (20)

Diamagnetism and Para magnetism:

Introduction, Magnetic Moments of Electrons, Magnetic Moments of Atoms, Theory of Diamagnetism, Diamagnetic Substances, Classical Theory of Para magnetism, Quantum Theory of Para magnetism, Gyro magnetic Effect, Magnetic Resonance

Ferromagnetism: Introduction, Molecular Field Theory, Exchange Forces, Band Theory, Ferromagnetic Alloys, Theories of Ferromagnetism

Antiferromagnetism: Introduction, Molecular Field Theory, Above $T_{N,}$ Below $T_{N,}$ Comparison with Experiment, Neutron Diffraction, Antiferromagnetic, Ferromagnetic, Rare Earths , Antiferromagnetic Alloys.

Ferrimagnetism: Introduction, Structure of Cubic Ferrites, Saturation Magnetization, Molecular Field Theory, Above Tc, Below Tc, General Conclusions, Hexagonal Ferrites, Other Ferromagnetic Substances, y - $Fe_2O_{3,}$ Garnets, Alloys.

Unit III: Magnetic Anisotropy, Magnetostriction and the Effects of stress (12)

Magnetic Anisotropy: Introduction, Anisotropy in Cubic Crystals, Anisotropy in Hexagonal Crystals, Physical Origin of Crystal Anisotropy, Anisotropy Measurement, Torque Curves, Torque Magnetometers, Anisotropy Measurement (from Magnetization Curves), Fitted Magnetization Curve, Anisotropy Constants, Polycrystalline Materials

Magnetostriction: Introduction, Magnetostriction of Single Crystals, Cubic Crystals, Magnetostriction of Polycrystals, Physical Origin of Magnetostriction, Form Effect, Effect of Stress on Magnetic Properties, Effect of Stress on Magnetostriction, Applications of Magnetostriction, ΔE Effect, Magnetoresistance.

Unit IV: Domains and the Magnetization Process (08)

Introduction, Domain Wall Structure, Neel Walls, Magnetostatic Energy and Domain Structure, Uniaxial Crystals, Cubic Crystals, Domain Wall Motion, Magnetization in Low Fields, Magnetization in High Fields, Shapes of Hysteresis Loops.

Reference Books:
1. K. H. J. Buschow& F. R. de Boer: Physics of Magnetism and MagneticMaterials.
2. C. Kittle : Introduction to SolidState Physics.
3. Azoroff : Introduction to Solids.
4. Saxena, Gupta, Saxena: Fundamentals of SolidState Physics.
5. R. L. Singhal: SolidState Physics.
6. V. Raghavan: Materials Science and Engineering.
7. A. J. Dekkar :SolidState Physics.

M.Sc-II, SEME. IV, PHYSICS (Materials Science)

SCT - 4.2: ADVANCED TECHNIQUES OF MATERIALS CHARACTERIZATION

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Unit I: Microscopic Techniques: (25)

Optical Microscopy and limitations: Principle of Diffraction of light, Airy Disc, Resolution and magnification ;Rayleigh Criteria, Numerical aperture, Major lens defects. Different kinds of optical microscopes (Bright field ,Stereo , Phase contrast ,Differential Interference Contrast ,Fluorescence ,Confocal ,Polarizing light microscope)

Electron Microscopy: Limitations of Light microscopy and advantages of electron microscopy. Wavelength of electrons, Theoretical Resolving power, Source of electron emission .Electron Focusing , Effect of magnetic fields, Electrostatic and magnetic focusing , Optical Column, Magnetic lenses.Vacuum requirements. Schematic of complete SEM

Scanning Electron Microscopy(SEM):Interaction of electrons with matter. Secondary electron emission(SEE),Yield of SEE ,Universal yield curve, Beam scanning and Magnification in SEM, Secondary electrons Detector, Back scattered electrons detector.Electronics. Image analysis.Size histogram. Sample preparation .

Transmission Electron Microscopy(TEM) : Principle of operation, Lens systems, Schematic of TEM ,Apertures, Bright Field Image, Dark Field Image ,.Electron Diffraction, Bragg's Condition, Selective Area Electron Diffraction (SEAD), Image analysis. Sample preparation

Scanning Tunneling Microscopy

Historical perspective, Electron tunneling ,Principle of STM imaging , STM image interpretation ,STM implementation in instrument , Pizoelectric drive, Tip preparation, Vibration isolation, Data acquisition and analysis,Application of STM , high resolution imaging of surfaces, Spectroscopy, Lithography,Currentfluctuation,Limitation of STM and solution,

Atomic Force Microscopy:Priciple and equations of force curves ,Contact and Non contact modes, Amplitude modulation and Frequency modulation ,Forfe versus distance curve,,Experimental details of AFM, Practical applications .

Unit II: X-Ray Photoelectron Spectroscopy (10)

Definition of surface, Different Probes for Surface-characterization. Necessity of Ultra High Vacuum, Photoelecton Emission, Introduction and Basic Theory , Historical Perspective ,Instrumentation ,Vacuum System. Energy analyzers, X-Ray Source,Electron Energy Analyzer . Sample Selection and Preparation , Sample Charging .X-Ray Beam Effects., Spectral Analysis ,Core Level Splitting .,Linewidths. Elemental Analysis: Qualitative and Quantitative ,Secondary Structure ,Angle-Resolved XPS, Depth profiling.

Auger Electron Spectroscopy **(5)**

Basic principle, Auger Transitions, Kinetic Energies of Auger Electrons, Sensitivity of detection, Instrumentation,Electron Energy Analyzers ,Electron Detector, Sample preparation, Data analysis, Qualitative and Quantitative analysis.

Unit III: Raman Spectroscopy **(8)**

Introduction, Quantum theory of Raman effect, Classical theory of Raman effect, Polarizability and vibrational modes in molecules, IR active and Raman active modes , Introduction to lattice phonon, Optical and acoustical phonon modes, Transverse and Longitudinal modes and their coupling, Examples of Raman Spectra in carbon systems-diomond, carbon nano tubes etc.

Unit IV: Resonance spectroscopy **(6)**

Nuclear magnetic resonance and Electron Spin Resonance Spectroscopies.

Properties of Nuclear Spins ,Nuclear Spin Interactions in Solids General Structure of the Internal Hamiltonians , Quantum Mechanical Calculations, Quantum Mechanical Description of NMR , The NMR Signal—Zeeman Interaction ,High Resolution Solid State NMR Methods , Dipolar Decoupling ,Magic-Angle Spinning (MAS), Cross-Polarization (CP) The CP-MAS Experiment ,NMR Spectra.

EPR Condition, Continuous Wave-EPR, EPR Lineshape: Relaxation Times, Electron-Nuclear Interactions: Hyperfine Structure

Reference Books:

1) Handbook ofApplied Solid State Spectroscopy, D. R. Vij, Springer

2) Phtoelectron and Auger Spectroscopy,T.A.Carlson, Plenum Press , 1975

3) Practical Guide to Surface Science and Spectroscopy,Yip-WahChung,Academic Press

4) Fundamebntal of Molecular Spectroscopy, C.N.Banwell,TataMc-Graw Hill.