Physics
Pre-Ph.DSyllabus

S. No	Pre-Ph.DCourse-1-Subjects	Subject Code
1.	Solid State Physics	PH24BP101
2.	Nanomaterials:Theory and Physics of Nanomaterials	PH24BP102
3.	Principles of Nuclear Physics	PH24BP103
4.	Nuclear Radiation and Analytical Techniques	PH24BP104
5.	Vacuum Science and Technology of Thin Films	PH24BP105
6.	Advances in Ferro Electric Materials	PH24BP106
7.	Soft Magnetic Materials	PH24BP107
8.	Applied Spectroscopy	PH24BP108

S. No	Pre-Ph.DCourse-1I-Subjects	Subject Code
1.	Physical Characterization Techniques of Materials	PH24BP201
2.	Nanomaterials: Instruments and Applications	PH24BP202
3.	Nuclear Radiation Detectors and Accelerators	PH24BP203
4.	Radiation Protection and Dosimetry	PH24BP204
5.	Thin Films: Characterization Techniques and Properties	PH24BP205
6.	Advances in Ferro electric Materials- II	PH24BP206
7.	Material Characterization Techniques	PH24BP207
8.	Spectroscopic Techniques	PH24BP208

(PH24BP101)Solid State Physics

(Pre-Ph.D Course-1)

UNIT I: Crystallography

The nature of the crystalline state, basic definitions, Periodic Array of Atoms, Basis and the Crystal structure, Lattice Translation Vectors, 14 Bravais lattices, Crystal symmetry: point groups, space groups, symmetry-related properties, Describing lattice planes and directions in crystals: Miller indices, Reciprocal lattice vectors, Reciprocal lattice unit cells.

UNIT II: Lattice Vibrations and Heat Capacity

Elastic waves, Equation of Motion in the One-Dimensional Lattice, Elastic Waves in Continuous Media, Waves of Lattice Vibration and the Dispersion Relation w(k), phonon, Einstein Model for Lattice Heat Capacity, Density of States, Debye Density of States, Debye Cut-off Frequency, and Debye Cut-off Wave Vector, Debye Model of the Lattice Heat Capacity and Debye Temperature, Crystal Momentum, Thermal Conductivity.

UNIT III: Free electron and Band theory of Solids

FREE ELECTRON FERMI GAS

Energy Levels in One Dimension, Effect of Temperature on the Fermi-Dirac Distribution, Free Electron Gas in Three Dimensions, desnity of states,Heat Capacity of the Electron Gas, Electrical Conductivity and Ohm's Law

ENERGY BANDS

Nearly Free Electron Model, Origin of the Energy Gap, Bloch Functions, Kronig-Penney Model, Wave Equation of Electron in a Periodic Potential, Crystal Momentum of an Electron, Number of Orbitals in a Band, Metals and Insulators.

UNIT IV: Dielectric and Ferroelectric properties of materials

Introduction, fundamental definitions, local field, Clausius-Mossotti relation, different types of electric polarizations - electronic, ionic, and dipolar polarizations (qualitative and quantitative), temperature and frequency dependence of polarization, dielectric loss, hopping mechanism, piezoelectricity and ferroelectricity; spontaneous polarization in BaTiO3.

UNIT V: Magnetic Properties

Introduction, fundamental definitions, Weiss theory of ferromagnetism, domain theory of ferromagnetism, hysteresis, Eddy current losses; ferrites (structure) - normal, inverse and mixed ferrites, super exchange interaction (Neel model), initial permeability, effect of frequency on permeability- domain wall relaxation and spin resonance.

Textbooks:

1. “Introduction to solid state Physics 8th edition” by Charles Kittel; Wiley India.

2. "Introduction to Phonons and Electrons" Liang-fu Lou (2003) World Scientific, Singapore

Reference Books:

1. "The Basics of Crystallography and Diffraction" Christopher Hammond (2015) Oxford

University Press, UK

(PH24BP102)Nanomaterials Theory and Physics of Nano-materials

(Pre-Ph.D Course-1)

UNIT I: **Concepts of Nano-technology**

Nano size, top-down and bottom-up approaches, size matters reduction of dimensionality and surface to volume ratio, changes to the system total energy, changes to the system structure, structural properties, thermal properties, chemical properties, mechanical properties, magnetic properties, optical properties and electronic properties of nano-scale systems

UNIT II: Nano materials

Introduction, materials used in nanotechnology, Fullerenes – discovery, variations of Bucky balls, Bucky tubes, Properties of Fullerenes - aromaticity, chemistry of Fullerenes, solubility of fullernes and quantum mechanics of fullernes, synthesis of nano-materials –ball milling and sol gel methods

UNIT III: Carbon nanotubes

Discovery, structure of nano tubes, Types of nano tubes-single walled nano tubes (SWNT) and multi walled nanotubes (MWNT), types of SWNT- chiral, armchair and zig zag, properties of nanotubes – strength, electrical conductivity, thermal conductivity, transport, optical activity and chemical activity.

UNIT IV: Theory of Nano tubes

The continuum shell theories of mechanics of carbon nano tubes, parameterization of continuum theories for single wall carbon nano tube repeat space theory applied to carbon nano tubes, modelling and analysis of carbon nano tube bucking using thick shell theory – Effective medium theory of optical properties of CNTs. Theory of electric charge enhancements in carbon nano tubes.

Unit V: Synthesis of Nano tubes

Growth mechanisms of CNT – tip growth and root growth, Arc Discharge method – synthesis of SWNT and MWNT, Laser Ablation method, Plasma Enhanced CVD, Laser Assisted Thermal CVD, and Flame synthesis, purification of CNTs – Oxidation, Annealing, Magnetic purification

References

1. Nano technology by William Illsey Alkinson, Jaico Books

2. Applicability of the continuum shell theories, VM Harik, TS Gate & MP Nemeth, NASA

3. Wondrous world of Carbon Nanotubes by M.Daenen and R.D. de Fouw

(PH24BP103)Principles of Nuclear Physics

(Pre-Ph.D Course-1)

Unit I: Nuclear Matter

Properties of nuclear matter, size, shape, charge distribution, magnetic dipole and electric quadrupole moments, spin, parity, binding energy, Weizsaecker formula – Nuclear masses

Unit II: Nuclear Decay and Forces

Nuclear stability, Alpha, Beta, Gamma decays and their selection rules, Characteristics of nuclear forces, Nucleon – nucleon interaction, Meson theory of nuclear forces

Unit III: Nuclear Models

Nuclear liquid drop model, Nuclear shell structure – basics of the nuclear shell model, Collective rotational and vibrational models of nuclei, Nuclear excitations – collective excitations and gaint resonances

Unit IV: **Nuclear Reactions**

Types of nuclear reaction and their features, Nuclear kinematics, Direct nuclear reactions and its applications in nuclear spectroscopy, Compound nuclear reactions, Nuclear fusion and fission

Unit V: Nuclear Spectroscopy

Study of nuclear structure through in-beam gamma ray spectroscopy, Population of high spin states, Discrete gamma ray spectra, Rotational alignment, Back-bending phenomenon. Nuclear deformation – Normal and highly deformed structures

References:

1. Basic Ideas and Concepts in Nuclear Physics: an introductory approach, K. Heyde

2. M. A. Preston and R. K. Bhaduri, (1982), Structure of the Nucleus, Addison-wesley

3. Nuclear Reactions, Daphne F. Jackson

4. Introductory nuclear physics, Kenneth S. Krane

5. Nuclear Structure by Bohr and Mottelson

(PH24BP104)Nuclear Radiation and Analytical Techniques

(Pre-Ph.D Course-1)

Unit I: Radiation Measurement and Protection

Types of nuclear radiation, Measurement of nuclear radiation, Measurement of exposure, Radiation absorbed dose, Kerma, Calculation of absorbed dose from exposure, Sources of radiation, Radiation protection, Protection of personnel against nuclear radiation, Radiation monitoring

Unit II: Radioisotopes and their Applications

Radioisotopes and their separation techniques, General applications of radioisotopes, Radioisotopes in medicine, Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT)

Unit III: Radiation Therapy

Types of radiation therapy, External beam radiation (teletherapy), Internal radiation therapy (brachytherapy), Dose depth relations, Radionuclide Therapy-Radioiodine Treatment of Thyroid Disorder, Dosimetry Aspects

Unit IV: X-Ray based Analytical Techniques

Interaction of X-rays with matter, Basic principles and instrumentation of X-ray Fluorescence (XRF), Wavelength Dispersive X-Ray Fluorescence (WDXRF), Total reflection X-ray Fluorescence (TXRF), Particle-Induced X-ray Emission (PIXE), X-Ray Photoelectron Spectroscopy (XPS)

Unit V: Nuclear Analytical Techniques

Principle and experimental set-up of Rutherford Backscattering Spectroscopy (RBS), Mossbauer Spectroscopy (MS), Neutron Activation Analysis (NAA), Nuclear Reaction Analysis (NRA), Particle Induced Gamma Ray Emission (PIGE), and Accelerator Mass Spectrometry (AMS)

References

1. Text Book of Nuclear Medicine by John. Harbert and A.F.G.Rocha.

2. Nuclear Medicine By J.H.Thrall and HarvveyV.Ziessman
3. Atomic and Nuclear Analytical Methods by H.R.Verma, Springer-Verlag Berlin Heidelberg 2007
4. John Lilley, Nuclear Physics, Principles and Application, John Wiley (2002).
5. K.M.Varier, A.Joseph and P.P.Pradyurnan, Advanced Experimental Techniques in Modern Physics, Pragati Prakashan, Meerut (2006).
6. H. Cember, Introduction to Health Physics, Pergamon Press, New York (1983).

(PH24BP105)Vacuum Science and Technology of Thin Films

(Pre-Ph.D Course-1)

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.

(PH24BP106)Advances in Ferro Electric Materials

(Pre-Ph.D Course-1)

Unit I: Dielectrics

Review of Fundamentals – the three vectors D, E, and P. Dielectric susceptibility, Complex Dielectric constant, Macroscopic and Microscopic Electric fields, Clausius – Mossotti Relation, Polarization Mechanisms, Electronic, Ionic and Dipolar Polarizations and their temperature dependence Frequency Dependence of Dipolar Polarizability, Ionic Polarizability, Electronic Polarizability, Ferro electricity, Curie – Weiss law and Curie Temperature, Theories of Ferro electricity, Ferro electric Hysteresis, Classification of Ferro electric crystals, Ferro elasticity, piezoelectricity, Mathematical Description and Piezoelectric coefficients, pyroelectricity, pyroelectric responsivity, Pyroelectric Energy Conservation [1&2]

Unit II: Magnetic materials

Quantum theory of Diamagnetism, Origin of paramagnetic moments – the Orbital Magnetic moment, the spin magnetic moment, the total magnetic moment, classical and quantum theory of para-magnetism, ferro-magnetism, Weiss theory of spontaneous magnetization, temperature dependence of spontaneous magnetization, Nature and origin of the Weiss Molecular Field theory, Exchange interaction, Hysteresis, Weiss theory of Hysteresis, Ferro magnetic Domains, Anti Ferro magnetism, Neel Temperature, Ferri magnetism, Molecular field theory of Ferri-magnetism, Ferristesuan – Spinel Inverse spinel and mixed ferrites [1&2]

Unit III: Diffusion in solids and sintering

Diffusion in Crystalline solids, Laws Diffusion, Chemical Potential, Diffusional Flux Equations, Temperature Dependence of Diffusion coefficient, Determination of Activation Energy, Sintering-Driving Force for sintering, Mechanisms of sintering, Theoretical analysis of sintering, Numerical simulation of sintering, sintering Diagrams, Liquid Phase sintering – Elementary Features of Liquid phase sintering, stages of liquid phase sintering, The Basic mechanisms of liquid phase sintering, Hot pressing with a Liquid Phase, Activated Sintering [3 &4]

Unit IV: Grain Growth and Microstructure Control

Introduction, General Features of Grain Growth – Grain Growth and Coarsening, Driving Force and Grain Growth, Normal and Abnormal Grain Growth, Effect of Grain size on Properties, Attainment of High Density, Ostwald Ripening – The LSW theory, Ostwald Ripening Controlled by Interface Reaction, Time Dependent Ostwald Ripening, Normal Grain Growth in Dense solids, Computer Simulation of Normal Grain Growth, Abnormal Grain Growth in Dense solids – Causes of Abnormal Grain Growth, Grain Growth and Pore Evaluation in Porous Solids – Thermo dynamics of Pore Boundary interactions, Grain Growth in very Porous solids, Grain Growth in less Porous solids, Pore mobility, Structure Determination – Bragg's Law, Electron Diffraction, Neutron Diffraction, Mossbauer Effect [1 &3]

Unit V: Conventional and Modern Physics of Ferroelectrics

Theory of Polarization – A modern approach: Fallacy of Clausius – Mossotti Picture, Fallacy of Defining Polarization via the Charge Distribution, Landau Primer for Ferroelectrics – Introduction, Landau – Devonshire Theory: General Phenomenology, Second Order (Continuous) Transition, First order (Discontinuous) transition, Coupling to Strain, Soft Modes, Domains, Landau-Ginzburg Thory: General Considerations, Displacive and Order – Disorder Transitions, Diffuse Phase Transitions – Dielectric Relaxators, Recent Developments in Bulk Ferro electricity, What causes Ferro electricity and what causes Ferro magnetism? Multiferroics – The scarcity of Ferro magnetic Ferroelectrics, Magnetoelectric coupling, composites [5 & 6]

References:

1. Introduction to Solid state Physics by Charles Kittel, Wiley Eastern Ltd, New Delhi
2. Solid state physics by R.L. Synghal Kedar Nath Ram Nath & Co, Meerut
3. Ceramic Processing and Sintering by M.N. Rahaman, Second Edition, Marcel Dekkar Inc, New York
4. Material science by Vijaya and Rangarajan,Tata McGraw Hill Publishing Company Ltd., New Delhi
5. Principles and Applications of Ferro electrics and Related Materials by M.E. Lines and A.M. Glass, Clarendon Press 1977, Oxford
6. Physics of Ferro electrics Modern Perspective by Rabe, Ahn, Jean Marc Triscon, Springer Series, 2007

(PH24BP107)Soft Magnetic Materials

(Pre-Ph.D Course-1)

Unit I Magnetic orders

Magnetism in solid state: Spin of electrons, Hund's rules, magnetism of 3d transition metals and alloys; Magnetic interactions: Direct and Indirect Exchange interactions; Collective Magnetism: ferro, antiferro, ferri, helical order and spin glass; Magnetic Anisotropy; magnetostriction; Crystal field effects, ligand fields, Transition metal ions- Jahn- Teller effect, Quenchingof the orbital angular momentum.

Unit II: Ferrimagnetic Materials

Introduction to ferrimagnetism, Classes of Crystal Structures in Ferrites, Hexagonal Ferrites, Magnetic Rare Earth Garnets, Intrinsic and Extrinsic Properties of Ferrites, Mixed Ferrites for Property Optimization, Temperature Dependence of Initial Permeability, Time Dependence—Initial Permeability (Disaccomodation), Chemistry Dependence—Low Field Losses (Loss Factor), Chemistry Considerations for Hard Ferrites, Saturation Induction—Microwave Ferrites and Garnets, Ferrites for Memory and Recording Applications.

Unit III: Dilute Magnetic Semiconductors

Band Structure of II–VI and III–V DMS; Exchange Interactions in DMS: s–d Exchange Interaction, p–d Exchange Interaction, d–d Exchange Interactions-Super exchange, Double Exchange, RKKY; Magnetic Properties- Paramagnetism, Carrier-Induced Ferromagnetism.

Unit IV: Nanomagnetism

Introduction to Magnetic properties of nanoparticles, reduction in magnetization with particle size, surface magnetism, shape and size effects on magnetic anisotropy, single domain particles, Spin reversal in uniaxial magnetic nanoparticles, superparamagnetism, blocking temperature, magnetism in thin films.

Unit V: Multiferroics

Magnetoelectric materials, magnetoelectric coupling, Multiferoics, Type-1 and Type-2 multiferroics, Approaches to the coexistence of ferroelectricity and magnetism, Independent systems, Ferroelectricity induced by lone-pair electrons, Geometric ferroelectricity in hexagonal manganites, Spiral spin-order-induced multiferroicity, magnetoelectric coupling.

References:

1. Fundamentals of Magnetism, Mathias Getzlaff Springer-Verlag Berlin Heidelberg 2008
2. Modern Ferrite Technology 2nd Ed., Alex Goldman (2006) Springer New York, NY
3. Cibert, J., Scalbert, D. (2008). Diluted Magnetic Semiconductors: Basic Physics and Optical Properties. In: Dyakonov, M.I. (eds) Spin Physics in Semiconductors. Springer Series in Solid-State Sciences, vol 157. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-78820-1_13
4. “Chapter 4 Diluted magnetic semiconductors” J. Kossut, W. Dobrowolski, Handbook of Magnetic Materials, Elsevier, Volume 7 (1993) 231-305
5. Nanoparticle magnetism, Georgia C. Papaefthymiou, Nano Today, 4 (2009) 438-447
6. Majetich, S. A., and M. Sachan. "Magnetostatic interactions in magnetic nanoparticle assemblies: energy, time and length scales." Journal of Physics D: Applied Physics 39.21 (2006): R407.
7. Nanomagnetism- Ultrathin Films, Multilayers and Nanostructures (2006) Editors: D.L. Mills, J.A.C. Bland Elsevier Science
8. Multiferroicity: the coupling between magnetic and polarization orders, K. F. Wang, J.-M. Liu and Z. F. Ren, Advances in Physics, 58, No. 4, 321–448, 2009
9. Multiferroic Materials - Properties, Techniques, and Applications Edited ByJunling Wang 1st Edition(2016) CRC Press USA

(PH24BP108)Applied Spectroscopy

(Pre-Ph.D Course-1)

UNIT I: Molecular Spectroscopy

Introduction – Rotational structure of electronic bands of diatomic molecules – Fortrat diagram – General relations – Combination relations for $^1\Sigma$ - $^1\Sigma$ and $^1\Sigma$ – $^1\pi$ bands – Evaluation of rotational constants with reference to above transition. Isotope effect in electronic spectra of diatomic molecules – Vibrational effect and rotational effect. Potential energy curves and dissociation energy and pre-dissociation energy. Vibrations of polyatomic molecules: CO_2 and H_2O).

UNIT II: Raman Spectroscopy

Introduction – Theory of Raman Scattering – Rotational Raman Spectra – Vibrational Raman Spectra – Mutual Exclusion Principle – Laser Raman Spectroscopy – Polarization of Raman Scattered Light – Single Crystal Raman Spectra

UNIT III: Fourier Transformation

Raman Investigation of Phase Transitions – Resonance Raman Scattering – Structure Determination using FTIR and Raman Spectroscopy. Fourier Transform (FT) Raman Spectroscopy and its additional advantages over the conventional Raman Spectroscopy, Surface enhanced Raman Scattering-Coherent Anti-Stokes Raman Spectroscopy.

UNIT IV: Spectrophotometry

Introduction – Beer's law – Absorptivity – UV and visible absorption – Instrumentation – Essential parts of spectrophotometer – Gratings and prisms – Radiant energy sources – Filters – Photosensitive detectors – Barrier layer cells – Photo emissive cells – Photomultiplier tubes IR spectrophotometry – Fourier Transform Infrared (FTIR) Spectrometer – Molecular structure – Qualitative and Quantitative analysis – The most sensitive lines of the elements – Method of identifying elements – Microphotometer

UNIT V: Phosphorescence Spectroscopy and High Resolution Spectroscopy

Introduction – Normal and Resonance Fluorescence – Intensities of Transitions – Nonradioactive decay of fluorescent molecules – Phosphorescence and the nature of the triplet state – Population of the triplet state – Delayed Fluorescence – Excitation spectra – Experimental methods

High Resolution Spectroscopy: Introduction – Light detectors – Single photon counting technique – Phase sensitive detectors – Laser optogalvanic spectroscopy –Laser cooling and its applications

References:

1. Molecular spectra and Molecular structure Volume I by G. Herzberg (2nd Edition, Van. Nostrand London)
2. Fundamentals of Molecular Spectroscopy by C.N. Banwell (Tata Mc Graw-Hill Publishing Company Ltd, 1983)
3. Spectroscopy by Straughan and Walker (volume 2 and Volume 3, John Wiley and Sons, 1976)
4. Molecular Structure and Spectroscopy by G. Aruldhas (Printice-Hall of India, Pvt. Ltd., 2001
5. Instrumental Methods of Analysis by Willard, Merritt, Dean and Settle (CBS Publishers, New Delhi,(2001)
6. High Resolution Spectroscopy by J.M. Hollas, Wiley, 2nd edition, 1998.
7. Fundamentals of Molecular Spectroscopy by C.N. Banwell (Tata Mc Graw-Hill Publishing Company, New Delhi, 1983)

(PH24BP201)Physical Characterization Techniques of Materials

(Pre-Ph.D Course-2)

UNIT I: Materials processing

Conventional ceramic method, ball-milling, PVD, RF sputtering, sol-gel, chemical co precipitation, auto-combustion. Heat treatment: calcination, green body density, sintering, annealing, bulk density and porosity.

UNIT II: Diffraction and Imaging

X-ray diffraction- Bragg's law, powder X • ray diffractometer • construction and working, crystalline phase analysis, fundamentals of transmission electron microscopy and scanning electron microscopy, study of crystal structure using TEM, study of microstructure using SEM • scanning electron microscopy with EDS • construction and working, grain size and chemical analysis.

UNIT III: Molecular Spectroscopy

Fundamentals of IR, Raman, Uv-Vs, XPS and Photoluminescence, Techniques for measuring

IR spectra, Raman spectra, Uv-Vs spectra, XPS spectra and Photoluminescence spectra.

UNITIV: Transport Properties

Measurement of DC and AC conductivity, Impedance Spectroscopy- Impedance-Related Functions, Measurement Systems-Impedance Analysers, Measurement of Magnetoresistance, measurement of Hall effect, measurement of thermoelectric power.

UNIT V: Magnetic and Dielectric measurements

Magnetic resonance methods - Electron spin resonance- A simple EPR spectrometer; Vibrational Sample Magnetometer-Hysteresis and Related Properties; Magnetostriction measurement; SQUID magnetometry; P-E hysteresis measurements- Hysteresis and Related Properties; measuring d33.

Textbooks:

1. Materials Characterization Techniques, Sam Zhang, Lin Li, Ashok Kumar, 92008) CRCpress

2. “Impedance Spectroscopy Theory, Experiment, and applications”, 2ndEdited by Evgenij Barsoukov, J.Ross Macdonald, (2005) John Eiley & Sons.

3. “Ceramic Processing and Sintering”, by Mohamed N. Rahaman, (2003) CRC Press

Reference Books:

1. “Electron paramagnetic resonance: elementary theory and practical applications”2ndJohn A. Weil, James R. Bolton (2007) John Wiley & Sons.

2. “Handbook of Nanophase and Nanostructured Materials: Volume I: Synthesis” by Z.L. Wang, Yi Liu, Ze Zhang (2002) Springer.

3. Measuring Piezoelectric d33 coefficients using the Direct Method by Mark Stewart, Will Battrick & Markys Cain http://eprintspublications.npl.co.uk/2768/1/mgpg44.pdf

4. “An overview of magnetostriction, its use and methods to measure these properties” N.B. Ekreem, A.G. Olabi, T. Prescott, A. Rafferty, M.S.J. Hashmi, Journal of Material Processing Technology, 191 (2007) 96-101. https://doi.org/10.1016/j.jmatprotec.2007.03.064

5. Vibrating Sample Magnetometer https://tinyurl.com/VSMinstrument

6. Ferroelectric Hysteresis Measurement & Analysis, M. Stewart, M. G. Cain, and D. A. Hall (1999) National Physical Laboratory, UKhttps://tinyurl.com/PEhysteresis

(PH24BP202)Nanomaterials: Instruments and Applications

(Pre-Ph.D Course-2)

Unit I: Nanoelectronics

Fabrication of Integrated Circuits, substances deposited for integrated circuits – polysillicon, silicon dioxide, metals, Microelectromechanical Systems(MEMS) – materials in MEMS technology, MEMS processes – deposition, phololithography, wet and dry etching, Applications of MEMS.

Unit II: Nanoelectromechanical Systems (NEMS)

Nanowires- Production of nanowires, conductivity of nanowires, Nanocircuits – Production of nanocircuits, applications of nanocircuits, Quantum Wires – CNTs as quantum wires, Quantum Wells –fabrication of quantum wells, Applications of quantum wells

Unit III: Molecular Nanotechnology

Smart materials and Nano sensors, manufactories, self replacing machines, types of molecular machines – synthetic, biological and theoretical machines, Nanorobotics – theory, Nubots, applications, DNA nanotubes, DNA Polyhedra, DNA nanomechanical devices, potential social impacts of molecular nanotechnology.

Unit IV: Analytical instruments

Atomic Force Microscope(AFM) – Principle, imaging modes, tapping modes and applications, Scanning tunnelling microscope(STM) – tunnelling, working; STM related techniques; Electron beam lithography, ion beam sculpting.

Unit V: Nano medicine

Drug delivery, nano particles as controlled drug delivery devices, Surgery, Nano particle targeting, nano Robols, cell repair machines, Insulin loaded Nano capsules, Nano bio technology and applications.

Reference Books:

1. Nanotechnology by William lllsey Atkinson, Jaico Books.
2. Principles of Nanotechnology by Phani Kumar
3. Nanotechnology by Ratner and Ratner
4. Wondrous world of Carbon Nanotubes by M. Daenen and R.D. de Fouw

(PH24BP203)Nuclear Radiation Detectors and Accelerators

(Pre-Ph.D Course-2)

Unit I: Interaction of Radiation with Matter

Interaction of photons with matter, Photo-electric effect, Compton scattering, Rayleigh scattering, Pair production, Attenuation coefficients, Interaction of charged particles with matter – Energy loss of charged particles, Bremsstrahlung, Cherenkov radiation, Interaction of neutrons with matter

Unit II: Properties of Radiation Detectors

Modes of detector operation, detector sensitivity, detector response, pulse-height spectra, Energy resolution, detection efficiency, dead time, methods for measuring detector dead time

Unit III: Nuclear Radiation Detectors

Gas detectors -Geiger-Muller counters, Alpha/Beta counters, Scintillation detectors – Basic principle, photo multiplier tubes and photodiodes, Solid state detector –Germanium detectors [HPGe], Lithium drifted Silicon detectors [Si (Li)]

Unit IV: Experimental Nuclear Physics Techniques

Gamma ray spectroscopy with hyper pure germanium detectors, Charged particle spectroscopy for particle identification, Neutron detection and energy measurement, Neutron-gamma energy discrimination.

Unit V: Particle Accelerators

Introduction, Production of charged particles using particle accelerators - Cockcroft-Walton accelerator, Van de Graff accelerator, Tandem Van de Graff accelerator, linear accelerator (LINAC), Cyclotron, Synchrotron

References

1. Radiation detection and measurement, Glenn F. Knoll, John Wiley & Sons. Inc.

2. Techniques for nuclear and particle physics experiments, W. R. Leo, Springer Berlin, Heidelberg
3. Accelerator Physics, S. Y. Lee, World Scientific
4. Particle Accelerator Physics, H. Wiedemann
5. Experimental Techniques in High-energy Nuclear and Particle Physics, edited by Thoma Ferbel

(PH24BP204)Radiation Protection and Dosimetry

(Pre-Ph.D Course-2)

UNIT I Radiations and Dosimeter

Basic Concepts of Radiation and Dosimetric Units: Radiation & need for its measurements, physical features of radiations, conventional sources of radiation, tissue equivalent materials, radiation dose, Definition of dose quantities :- Fluence, kerma, exposure, absorbed dose, Dose equivalent, Quality factor Q, effective dose equivalent, determination of dose equivalent, Radiation quality

UNIT II: Radiation Physics Applications

Archaeological applications: Carbon dating; limitations and accuracy. Industrial Applications: Smoke detection, blockage/leakage detection of buried pipelines, thickness gauge, nondestructive testing. Agricultural Applications: benefits of radiation processing of food items, sterilization. Medical Applications: sterilization of medical equipment's, diagnosis and radiotherapy: in-vivo and in-vitro. Space Exploration: nuclear batteries/RTG. Practical applications and some simple numerical problems.

UNIT III Measurement of Radiation Dose

Measurement of Radiation Dose: Thermo-luminescent dosimetry (TLD):- Theoretical aspects of thermos-luminescence, Characteristics of TL dosimeters, commercial TLD dosimeters, - LiF, $Li_2B_4O_7$, $CaSO_4$, $MgB4O_7$.,TLD instrumentations, Applications of TLD. An introduction to Photoluminescence (PL), Solid state Nuclear Track dosimetry, Internal dosimetry, External dosimetry.

UNIT IV Radiation Effects & Protection:

Effects of radiations exposure, Biological effects of radiation, acute and delayed effects, stochastic and non-stochastic effects, Dose response characteristics, Relative Biological Effectiveness (RBE). History of radiation protection standards, current limits of radiation exposure, protective barriers for radiation sources, protection for sealed sources, radiation surveys, personal monitoring.

Permissible dose to occupational and non-occupational workers, safe handling of radioactive materials. ALARA, ALI and MIRD concepts, Radiation waste and its disposal.

UNIT V: Safety in Nuclear Medicine

Performance check of radiation measuring and monitoring instruments, work place and environmental(stack) monitoring, Permissible radiation limits for controlled and supervised area, Contamination limits, Radiation protection survey and contamination checks, Air-borne contamination, estimation of gases effluent discharge, dose apportionment and dose budgeting. Radiological safety aspects during servicing and maintenance. Unusual occurrences and its handling procedures: Failure of cooling system, target foil ruptured, spillage, power failure, excessive exposure, personnel contamination; Protective and Emergency equipment requirements in medical cyclotron facility.

Text Books:

1. G.F. Knoll, ‘Radiation Detection and Measurement’, 3rd Edn., John Wiley & Sons Inc., 2000
2. Physics for Radiation Protection: A Handbook, James E. MartinWiley online library,2006.
3. Atoms, Radiation and Radiation Protection, James E. Turner Wiley-VCH 2007.
4. Radiation Protection in health sciences, Marilyn E. Noz and Gerald Q. Maguire Jr. World Scientific 2007.
5. Jeffry A. Siegel, Radiation Safety in Nuclear Medicine. 2nd Edition, Elsevier, 2007
6. Michael G.Stabin, Radiation Protection and Dosimetry – An Introduction to Health Physics, Springer, 1st Edition, 2007.

(PH24BP205)Thin Films: Characterization Techniques and Properties

(Pre-Ph.D Course-2)

UNIT I: X-ray and Electron microscopy techniques

X-ray Diffractometer (XRD), Wide angle X-ray Scattering(WAXS), X-ray photoelectron spectroscopy (XPS).

Electron microscopic techniques

Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), Scanning probe microscopy (SPM), Transmission Electron Microscopy (TEM).

UNIT II: Spectroscopic techniques

UV-VIS-NIR spectroscopy, Photoluminescence and Raman spectroscopy; Energy dispersive spectroscopy, and Rutherford Backscattering Spectrometry (RBS), Spectroscopic Ellipsometer

UNIT III: Electrical characteristics

Electrical resistivity-Four probe method, I-V and C-V characteristics, Theories of conduction in discontinuous films, Electronic conduction in thin insulating films, Transport phenomenon in semiconducting and dielectric thin films, Thermoelectric properties of thin films.

UNIT IV: Optical properties

Reflection, refraction and transmission in thin films, Optical constants -Optical band gap-spectroscopic ellipsometer measurements

UNIT V: Dielectric properties

Dielectric polarizations - Frequency and temperature dependent of dielectric properties (dielectric constant, loss factor and capacitance), Ac conductivity, Experimental techniques for dielectric films.

Text Books:

1. Yan, g Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd, 2008.

2. K. L. Chopra,Thin Film Phenomena, Mc Grow-Hill Book Company, New-York, USA, 1969.

3. A. Goswami, Thin film fundamentals , New Age International Pub., New Delhi, 2003.

4. L.I. Maissel and R. Glang, Hand Book of Thin Film Technology, McGraw Hill Inc. New York, 1970.

5. M. Ohring, Materials Science of Thin Films, 2nd ed., Academic Press, San Diego, New York, Boston, London, 2002.

(PH24BP206)Advances in Ferroelectric Materials – II

(Pre-Ph.D Course-2)

Unit I: Ferroelectric Materials

General Classification of Ferroelectric Materials: Corner Sharing Octahedra, Tetrahedral Oxygen Groups, Hydrogen Bonded Compounds and polymers, properties and Characteristics of some Important Ferroelectric Materials: The Ferroelectric perovskites – Barium Titanate, Lead Titanate, Sodium Niobate, Lithium Niobate, Antiferroelectric and cell Doubling pervoskites – Lead Zirconate, Lead Zirconate Titanate, Tungsten Bronze Type Structures – Strontium Barium Niobate, Barium Sodium Niobate, other Ferroelectrics-Magnetic Ferroelectrics, Electronic Ferroelectrics and Non Bulk Ferroelectrics, Multiferroics – $BiFeO_3$ and $YMnO_3$ (3&4)

Unit II: Fabrication of Ceramic Materials

Powder Preparation by Mechanical Methods: Solids State Reaction (Stoichiometry, Calcination, Sintering etc.) – Ball Milling, Hardness, Considerations, Types of Hardness, Density and Hardness, Normalized Density, Knoop Hardness and Normalized Density, Powder preparation by Chemical Methods – Sol Gel Processing : Preparation Techniques, Thin Film Growth of Complex Oxides: Vacuum Chamber, Temperature Control and Monitoring, Pulsed Laser Deposition – Laser, Targets, Ablation Process and Film Growth using PLD, Sputter Deposition – Sputtering Process, The Sputtering of Insulators, Process Gas, Oxide Molecular Beam Epitaxy – Hardware, RHEED, Fundamentals of Growth (1,2 &3)

Unit III: Structure and Microstructure Characterization

X-Ray Diffraction : Experimental Methods – Laue Method (Introduction, Cameras, Specimen Holders, Collimators and Shapes of Laue Spots), Debye Scherre Method (Specimen Preparation and Film Loading) Grain Size, Particle Size, Preliminary Treatment of Data, Indexing Patterns of Cubic Crystals, Indexing Patterns of Non Cubic Crystals – Graphical Methods, Indexing Patterns of Non Cubic Crystals – Analytical Methods, Determination of Number of Atoms in a Unit Cell, Determination of Atom Positions, Microstructure Determination Techniques – Scanning Electron Microscopy, Scanning Tunnelling Microscopy and Transmission Electron Microscopy (5)

Unit IV: Other characterization Techniques

Small Signal Dielectric Measurements, Pyroelectric Measurements – Voltage Responsivity, Current Responsivity and Normalized Detectivity, Experimental Constraints, Measurement of Piezoelectric Coefficients – Experimental Techniques (Berlin Court D-33 Meter etc.), Hysteresis Measurement, Experimental Techniques for DC Resistivity Measurement- Two Probe Method and Four Probe Method, Determination of Chemical Composition – Optical Atomic Spectroscopy and X-Ray Fluorescence Spectroscopy, Thermal Analysis – Differential Thermal Analysis and Differential Scanning Calorimetry (2&4)

Unit V: Application of Ferroelectrics

Sensors, Ultrasonic Cleaners, Flow Detectors, High Voltage Generators, Electromechanical Transducers, Actuators, Optical Information Storage Devices, Underwater Acoustics, Heterodyne Detection, Pyroelectric Imaging, Ferroelectric Memory Technology – Electrically Read Memories, Optically Read Memories, High Capacity Memories, Electro – Optic Modulators, Travelling Wave Modulators, Potential Future Applications (Ferroelectric Nano Structures, Field Effect Devices, Ferroelectric Device Fabrication using Atomic Force Microscopy, Ferroelectric Cooling Devices) (4)

References

1. Some Fundamentals of Mineralogy and Geochemistry by L. Bruce Railsback
2. Ceramic Processing and Sintering by M.N. Rahaman, Second Edition, Marcel Dekker Inc. New York.
3. Physics of Ferroelectrics - Modern Perspective by Rabe, Ahn , Jean Marc Triscon, Springer Series, 2007
4. Principles and Applications of Ferroelectrics and Related Materials by M.E. Lines and A.M. Glass, Clarendon Press 1977, Oxford.
5. X-Ray Diffraction by B. D. Cullity, Adison Wesley Publishing Company, Inc. 1956, Masachusetts.

(PH24BP207)Material Characterization Techniques

(Pre-Ph.D Course-2)

UNIT-I: Magnetic Measurements:

Magnetometry: Vibrating Sample Magnetometery, Thermomagnetic Analysis, Superconducting quantum interference device (SQUID), Spintronic measurements.

UNIT-II: X-Ray Techniques

XAFS and XANES Spectroscopy, X-Ray Magnetic Circular Dichroism, Single crystal and powder x-ray diffraction, X-Ray Diffraction Techniques for Liquid Surfaces and Monomolecular Layers, Small-angle X-ray scattering (SAXS). Inelastic x-ray scattering, Synchrotron radiation sources: advantages and special features of synchrotron radiation.

UNIT III: Neutron Scattering Techniques

Neutron Powder Diffraction, Single-Crystal Neutron Diffraction, Magnetic Neutron Scattering, Small-angle neutron scattering (SANS), Phonon and dynamics studies by inelastic and quasi elastic neutron scattering. Neutron reflectometry for thin films.

UNIT IV: Microscopy

Optical, polarizing and confocal microscopy, Scanning Electron Microscopy (SEM) and Transmission electron microscopy (TEM). Elemental analysis by Energy dispersive and wavelength dispersive X-ray analysis. Sample preparation for TEM by ion milling and shadow techniques. AFM and STM: Basic principles and different modes of operation. Magnetic Force Microscopy (MFM).

UNIT V: Thermal Analysis

Thermogravimetric analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC), Pressurized TGA (PTGA), Thermo mechanical analysis (TMA), Dilatometry (DIL), Evolved gas analysis (EGA)

Text Books:

1. John Clarke and Alex I. Braginski, ‘The SQUID Handbook: Fundamentals and Technology of SQUID and SQUID Systems’, Wiley-VCH, 2004.
2. ‘Solid State Magnetism’, John Crangle, Edward Arnold – UK, 1991.
3. J. Daillant and A. Gilaud, ‘X-ray and Neutron Reflectivity’, Springer, 2009.
4. T.L. Alfard, L.C. Feldman and J.W. Mayer, ‘Fundamentals of Nanoscale Film Analysis’, Springer, 2007.
5. R. F. Egerton, ‘Physical Principles of Electron Microscopy: An Introduction to TEM, SEM and AEM’, Springer, 2005. 6. S. Zhang, L. Li and A. Kumar, ‘Materials Characterization Techniques’, CRC Press, 2009.

(PH24BP208)Spectroscopic Techniques

(Pre-Ph.D Course-2)

Unit-I: Raman Spectroscopy

Instrumentation, Basic Components of Raman system, Spectrometer and Detectors, Raman Spectroscopy of Solid and Liquids, Raman spectroscopy of Materials, Qualitative versus Quantitative Raman, Vibrational Analysis, Spectral Analysis by Group Theory, Character Table

Unit –II IR-Spectroscopy

Instrumentation, Basic Components, IR-sources, Spectrometer and Detectors, Infrared absorption spectroscopy, Fourier transformed infrared spectroscopy attenuated total Reflectance (ATR) spectroscopy, diffuse reflectance spectroscopy.

Unit-III Electronic Spectroscopy Techniques

Instrumentation, Basic Components, UV-Visible sources, spectrometer and detectors, UV-Vis spectroscopy, Absorption., Transmission, Reflection, Photoluminescence, spectroscopy, florescence and phosphorescence, circular dichroism

Unit-IV Advance Spectroscopy Techniques

Surface Enhanced Raman Spectroscopy, UV Resonance Raman Spectroscopy, Tera hertz Spectroscopy, Laser Induced Breakdown Spectroscopy (LIBS)

Unit –V Other Techniques

Particle Induced X-ray emission, Nuclear Magnetic Resonance (NMR) spectroscopy, Electron Spin Resonance (ESR) Spectroscopy

Text and Reference Books

1. Modern Spectroscopy, 4th Edition , J.Michael Hollas , Wiley
2. Chemical Application of Group Theory , 3rd Edition By F.Albert Cotton , Willey
3. Introduction to Molecular Spectroscopy : By Goron M.Barrow , Mc Grraw Hill New York

4. Handbook of Vibrational Spectroscopy , Vol0-I & II: By John M.Chalmers and Peter R.Griffiths, Wiley

5. Condensed Matter Optical Spectroscopy : An illustrated Introduction by Luhan Ionita , CRC Press

6. Handbook of Raman Spectroscopy : From the Research laboratory to the process line : By Lan R. Lewis , Howell Edwards .CRC Press

7. Infrared and Raman Spectroscopy of Biological Materials : By Hans Ulklrich Grelich , Bing Yan CRC Press

8. Terahertz Spectroscopy : Principles and Applications , By Susan L.Dexheimer , CRC Press

9. NMR and Chemistry : An Introduction to modern NMR Spectroscopy , Fourth Edition By J.W. Akitt , B.E Mann , CRC Press

10. Laser Spectroscopy : Basic Concepts and Instrumentation 2nd Edition By Wolfgang Demtroder Springs