

Pre- Ph.D. Course work (Physics)

Paper –II : Material Characterization and Instrumentation

Unit I

Synthesis of materials: Bulk Synthesis: Solid State Route, Sol Gel, Co- precipitation, Combustion methods, Thin film fabrication: spin coating, dip coating, evaporation methods, Vacuum techniques, vacuum pumps (Rotary and Diffusion pumps), vacuum gauges.

Unit II

Structural and composition characterization: Basics of X – ray diffraction (XRD), grazing incidence and powder XRD, Scanning Electron Microscope, Energy dispersive X – ray analysis, X – ray photoelectron Spectroscopy, Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM) and Transmission Electron Microscope.

UNIT III

Optical spectroscopy and Raman Spectroscopy: Review of molecular and vibrational spectroscopy, Basic principle, instrumentation, advantages and limitations, Fourier Transform Infrared Spectroscopy (FTIR), UV- Vis. Spectroscopy, and Raman Spectroscopy, analysis of spectrum

UNIT IV

Electric and thermal measurements: a.c. and d.c.electrical conductivity measurements as a function of temperature and frequencies. Magnetoresistance measurements, specific heat measurements, Impedance spectroscopy: A.C. impedance spectroscopy, Thermo Gravimetric analysis (TGA),differential thermal analysis (DTA) and differential scanning calorimetric (DSC) analysis.

UNIT V

Magnetic characterization: Characterization of magnetic materials, ferromagnetic, multiferroic, spin glass materials and underlying principles, Vibrating Sample Magnetometer (VSM), SQUID magnetometer, a.c. susceptibility and d.c. magnetization measurements

Reference Books

1. Materials Science and Engineering (John Wiley & Sons, Inc.) By William D. Callister, Jr.
2. Introduction to Ceramics, W.D. Kingery
3. Introduction to Nanoscience and Nanotechnology, K.K. Chattopadhyay and A.N.Banerjee
4. Materials Science of Thin films, M. Ohring
5. Handbook of Vacuum Technology, Karl Jousten
6. Fundamentals of Molecular Spectroscopy, C.N. Banwell
7. Elements of X – ray diffraction, B.D. Cullity
8. A SQUID hand book, Ed. John Clark, and A.I. Braginskii
9. Magnetic sensors and magnetometers, PavelRipka

Pre- Ph.D. Course work (Physics)

Paper III: Advanced Materials

Unit I

Linear and non linear dielectric materials, Ferroelectric, piezoelectric and electro-optic materials, composite materials, Liquid crystals, Materials for solar cells and Fuel cells.

Unit II

Colossal magnetoresistance materials, magneto caloric materials, Multifunctional materials, magnetic field induced polarization and electric field induced magnetization.

Unit III

Properties of Individual Nano-particles, metal nano clusters, magnetic clusters, semiconductor nanoparticles, optical properties, methods of synthesis of nano particles,

Unit IV

Carbon allotropes, fullerene, carbon nano tubes, graphene, graphite oxide and applications, Applications of carbon materials, Functionalization of graphene and carbon nanotubes

Unit V

Low dimensional systems, preparation, size & dimensionality effects, excitons, single electron tunneling, applications of quantum nanostructures, self assembly, process of self assembly

Computational Techniques: Basics of ab-initio calculations, basic principles of density functional theory (DFT), exchange correlation energy functional, applications of DFT

Reference Books

1. Colossal magnetoresistance charge ordering and related properties of manganese oxides, C.N. R. Rao and B. Raveau
2. Dielectric relaxation in solids, A.K.Jonscher
3. Dielectrics and Waves, R. Von Hippel
4. Physics of Low dimensional semiconductors, J.H.Davies
5. Carbon Nanotubes, Dresselhaus M.S., Dresselhaus G. and Avouris P.
6. Carbon Nanomaterials, YuryGogotsi
7. Computational Chemistry, Lewars
8. Density Functional Theory: A practical approach, David S. Sholl, Janice A. Steckel

Pre- Ph.D. Course work (Electronics)

Paper – II: Basic Electronic instrumentation and electronic material characterization

Unit I

Semiconductor devices, diodes, junctions, transistors, field effect devices, homo and heterojunction devices, Optoelectronic devices, including solar cells, photodetectors, and LEDs; Highfrequency devices

Unit II

Operational amplifiers and their applications, Analog signal processing, Digital logic levels, Digital techniques and applications (registers, counters, comparators and similar circuits); A/D and D/A converters; Interfacing using IEEE488 bus.

Unit III

Vacuum techniques, Vacuum pumps (Rotary, Diffusion pumps, Turbo molecular pump), Vacuum gauges, Thin Film and Thick Film synthesis: Physical methods (Vacuum evaporation, sputtering (D.C. & RF), PLD, etc.), film thickness measurements

Unit IV

Transducers, transducer characteristics, selection of instrumentation transducers, transducer as an electrical element, Instrument probes, power measurements.

Unit V

Fluctuation and noise in measurement system, types of noise, noise in frequency domain, source of noise, signal to noise ratio and experimental design, signal to noise enhancement, digital correlation and autocorrelation methods.

Reference Books:

1. Fundamentals of electronics, Malvino and Leach
2. Physics of Semiconducting devices, S.M.Sze
3. Measurement, Instrumentation and Experiment design in Physics and Engineering, MichealSayer and Abhai Man Singh
4. Materials Science of Thin films, M. Ohring
5. Handbook of Vacuum Technology, Karl Jousten

Pre- Ph.D. Course work (Electronics)

Paper III: Electronic materials and devices

Unit I

Linear and non linear dielectric materials, Ferroelectric, piezoelectric and electro-optic materials, composite materials, Liquid crystals, quasi-crystalline materials, hydride materials,

Unit II

Functional materials for device fabrication, sensor materials, shape memory alloys, hydrogen storage materials, solar cell fabrication and photovoltaic materials.

Unit III

Carbon allotropes, fullerene, carbon nano tubes, graphene, graphite oxide and applications, Applications of carbon materials, Functionalization of graphene and carbon nanotubes

Unit IV

Lithographic processes: Various types of lithographic processes, Photolithography, Electron beam lithography, Ion beam lithography, and advances in the field. Photoresists, Sensors fabrication, and FET fabrication.

Unit V

Nano machines and nano devices: Micro electromechanical systems, Nano electromechanical systems NEMS's, Carbon nanostructures, carbon nanotube, graphene and applications.

Reference Books

1. Dielectric relaxation in solids, A.K.Jonscher
2. Dielectrics and Waves, R. Von Hippel
3. Physics of Low dimensional semiconductors, J.H.Davies
4. Carbon Nanotubes, Dresselhaus M.S., Dresselhaus G. and Avouris P.
5. Carbon Nanomaterials, YuryGogotsi
6. Principles of Lithography 3rd EDITION, H.J. Levinson