Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal (M.P.)

Syllabus for Entrance Examination for Admission in Ph.D. Program

NANOTECHNOLOGY

NANO SCALE MECHANICS

Wave-particle duality; Wave functions in coordinate and momentum representations; Commutators and Heisenberg's uncertainty principle; Matrix representation; Dirac's bra and ket notation; Schroedinger equation (time-dependent and time-independent); Eigen value problems such as particle-in-a-1D , 2D and 3D box,.; Tunneling through a barrier.

MATERIAL SCIENCE

Elements of crystallography; diffraction methods for structure determination; bonding in solids; elastic properties of solids; defects in crystals; lattice vibrations and thermal properties of solids; free electron theory; band theory of solids; metals, semiconductors and insulators; transport properties; optical, dielectric and magnetic properties of solids;

SYNTHESIS OF NANOMATERIALS

Top-down techniques : Nanostructures by mechanical milling (ball milling) and mechanical attrition, Lithography -immersion lithography, Electron and ultraviolet (EUV) ,photolithography, X- ray lithography, Electron beam lithography, focused ion beams. Nanosphere lithography – Molecular self-assembly, soft lithography, molecular manipulation by STM and AFM

Bottom-up techniques: Chemical vapor deposition (CVD), Physical vapour deposition (PVD) thermal and e beam evaporation, Pulsed laser ablation, pulse laser deposition. Chemical Routes: chemical precipitation and co-precipitation, chemical bath deposition (CBD), Sol-gel synthesis, and spray pyrolysis

CHARACTERIZATION OF NANOMATERIALS (I)

Spectroscopic techniques : Spectrophotometers, UV-Vis spectrophotometers, IR spectrophotometers, Fourier Transform Infrared radiation (FTIR), photoluminescence, electroluminesce and thermoluminescence spectroscopy, Nearfield scanning optical microscopy (NSOM)

Diffraction techniques : X-ray Diffraction (XRD), powder and single crystal Diffraction, X-ray fluorescence (XRF), X ray photoelectron spectroscopy (XPS), Energy Dispersive X-ray analysis (EDAX), Extended X ray absorption fine structures (EXAFS), Dispersive high pressure XRD

CHARACTERIZATION OF NANOMATERIALS (II)

Surface analysis: Scanning tunneling microscopy (STM), Contact and non contact atomic force microscopy (AFM), Conductive AFM, Magnetic force microscopy (MFM)

Elemental analysis: Nuclear magnetic resonance (NMR) and Raman spectroscopy: description and analysis. Surface analysis methods: Secondary ion mass spectroscopy (SIMS), Auger electron spectroscopy, Electron spectroscopy for chemical analysis.

Electron microscopic techniques: Scanning Electron Microscopy (SEM), Transmission electron microscopy (TEM), High resolution TEM Field emission SEM, Electron energy loss spectroscopy (EELS)

PROPERTIES OF NANOSTRUCTURES

Electrical transport properties in semiconductor nanostructures: Density of states: Quantum wells, Q wires and Q dots. quantization of conductance, coulomb blockade, Kondo effect, ballistic transport.

Vibrational and thermal properties of low-dimensional materials,: phonons, quantization of phonon modes, 0D, 1D, 2D, and 3D phonons, heat capacity and thermal transport at nanoscale

Nano fluid mechanics: flow of nanofluid, electrophoresis dielectrophoresis: Size selective separation of dielectric nano particles, nano and micro fluid channels, low reynold number fluid dynamics, optical tweezer.

Linear and nonlinear optical properties: Size Quantization effect, Optical blue shift phenomenon, , interactions between Nanoparticles, coupled dipoleapproximation, Light detection in nano-structures; scanning near-field microscopy, single-molecule detection.

Metamaterials: Negative refractive index metamaterials, super resolving metamaterials, negative refractive index lenses. Plasmonic nanowire metamaterials.

CARBON NANOTUBES

Structure and properties of C_{60}, Graphene, Carbon nanotubes and its types, Synthesis techniques for CNT preparation, purification techniques. Properties of Carbon Nanotubes and Graphene: Optical, Electrical and electronic properties, Mechanical, Thermal and vibrational properties.

Applications of Carbon Nanotubes :Fuel cells, CNT FETs, Light emitting displays and flat panel displays, hydrogen storage, solar panels.

NANOELECTRONICS

Nanoscale devices: Resonant tunneling diodes, single electron transistor, modulation-doped field effect transistor MODFETs, and Heterojunction Bipolar Transistors (HBTs) **Nanostructure magnetism:** Giant magneto resistance effect (GMR), Anisotropic magneto resistance (AMR) and Colossal magneto resistance (CMR), Magnetic multilayered thin films and nanowires, super paramagnetism and ferromagnetism in semiconducting quantum dots.

NANOBIOTECHNOLOGY

Physics of Biological sytems Interaction of biomolecules with surfaces, basic concepts of cell and molecular biology, Dendrimers, micelles, liposomes, block coplymers, Bionanomaterials: Biomimtric Systems, bioceremics & nanotherapeutics, microorganisms for synthesis of nanomaterials, biomembranes. Bio-functionalization of gold, magnetic and polymer nanoparticles and CNTs, Nano dental materials, metal nanoparticles and drug delivery vechicles– Nanoshells–Tectodentrimers.

STATISTICS AND RESEARCH APTITUDE

Mean, median, mode, basic concepts of probability, coefficient of variance, standard error, standard deviation, and correlation and regression analysis. Student t-test, F-test, analysis of variance (ANOVA), data graphics and data interpretation. Principles and various models of statistical optimization techniques, optimization softwares.

National and international scenario of scientific research, literature reviewing, reference citation, scientific and research journals, impact valuation, research article and patent drafting, various scientific websites, abstracts.