

SAURASHTRA UNIVERSITY



Accredited by NAAC With “A” Grade

[3rd Cycle]

Faculty of Science

Syllabus

for

B.Sc. / M.Sc. (Applied Physics) Integrated

Semester - X

Under

Department of Nanoscience

&

Advanced Materials

Saurashtra University,

University Road, University Campus

Rajkot– 360005

Gujarat, India

SYLLABUS FOR
SEMESTER X : CORE - X : PAPER- XIII
ION BEAMS IN MATERIAL SCIENCE

UNIT I: Ion interaction with matter

Ion stopping, energy losses, effective charge of moving ion, high energy and low energy losses, Fermi- Teller model, Firsov and Linhard Scharff model, ion range and distribution, straggling, ion backscattering, concept of ion channeling and ERDA

UNIT II: Ion beam processes

Radiation damage and structure change: defects formation under ion implantation, points defects, line defects, columnar defects; sputtering, phase transformations, ion beam mixing, radiation enhanced diffusion, impurity incorporation, ion induced epitaxial crystallization

UNIT III: Nano-structuring by Ion beams

Synthesis of nanostructured materials under electronic excitation and nuclear energy loss, nanostructures within ion track and at the surface by self-organization, high energy sputtering of nanomaterials, nano-patterning: ripple formation, nano-dot formation.

UNIT IV: Ion beam-based techniques for material analysis

Rutherford backscattering spectrometry (RBS): Principle, Kinematics, instrumentation, backscattering spectrum, Depth Profiles and applications, Elastic recoil detection analysis(ERDA): Principle, Kinematics, instrumentation and applications, Secondary ion mass spectroscopy (SIMS): Principle, instrumentation working and applications, Nuclear reaction analysis (NRA): Principle, instrumentation, working and applications.

Reference Book:

1. Introduction to High Energy Physics (2nd edition) by D. H. Perkins.
2. Swift Heavy Ions for Materials Engineering and Nano structuring, Springer, Awasthi D. K. and Mehta, G. K.
3. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy
4. Introduction to Experimental Nuclear Physics by R. M. Singru
5. Materials Science with ion beam, Harry Bernas, Springer 2010

SYLLABUS FOR
SEMESTER X : ID - 2 : PAPER- XIV
NANOTECHNOLOGY AND ENVIRONMENT

UNIT-I: Nanotechnology as a tool for sustainability

Nanotechnology for sustainable and cleaner environment, reducing the impact of greenhouse gases, energy harvesting, sustain biodiversity.

UNIT-II: Potential impacts of nanomaterials

Toxicological impacts of Nanomaterials: Introduction, Fullerenes, Single-walled carbon nanotubes, Multi-walled carbon nanotube, Carbon based materials, Titanium dioxides, Iron oxides, Cerium dioxides, Copper nanoparticles, quantum dots, Environmental impact.

Ecotoxicological impacts of nanomaterials: Introduction, Microorganisms, Ecotoxicity, Bioavailability and Cellular uptake of nanoparticles, interaction with microbial cell, Antibacterial activity

UNIT-III: Environmental applications of nanomaterials

Nanomaterials for ground water remediation: Introduction, Reactivity, Fate and Life time, Delivery and transport issues, Targeting.

Membrane Processes: Overview of membrane processes, Transport principles for membrane processes, membrane fabrication using nanomaterials, Nanoparticle membrane reactors, Active membrane systems.

Nanomaterials as Adsorbents: Introduction, Adsorption at the oxide nanoparticles/solution interface, Nanomaterial-based adsorbents for water and waste water treatments

UNIT-IV: Nanotechnology for Environmental Burden Reduction, Waste Treatment and Pollution control

Introduction, Environmental burden reduction, Treatment of industrial and agriculture wastes, Nanomaterials for non-point source pollution control.

Text Books:

1. Emerging Trends of Nanotechnology in Environment and sustainability – Karthiyayini Sidharan, Springer, Switzerland, 2018.
2. Environmental Nanotechnology- M. R. Wiesner, J.Y. Bottero, McGraw-Hill, New York-2007.

SYLLABUS FOR
SEMESTER X : ELECTIVE GROUP C - 3 : PAPER XV
SWIFT HEAVY IONS FOR MATERIAL MODIFICATIONS

UNIT I: Fundamentals

Range distribution, Atomic and lattice planes and disorders, Energy and particles, Bohr velocity radius, Cross section: angular, Energy transfer differential Scattering cross section, Reduced cross section, computer simulations of surface scattering

UNIT II: Instrumentation

Instrumentation for ion technology, ion sources, accelerators, beam lines, experimental stations and sample handling, energy stabilization, energy calibration, implanter and their applications, detectors and Data acquisition, data reduction and handling

UNIT III: Swift heavy ions for synthesis and modifications of nanostructured materials

Introduction, Synthesis of nanostructured materials under electronic excitation, nanostructures using self organization, modification in metal-dielectric nanocomposite films, tailoring mechanical and optical properties of nanostructures

UNIT IV: Effect of swift heavy ions on functional oxides

Introduction to functional oxides and effects of swift heavy ions (SHI) irradiation on the properties of functional oxides

Effect of SHI irradiation on the properties of High T_c – superconductor: structure, microstructure and transport properties

Effect of SHI irradiation on the properties of CMR manganites: structure, microstructure and transport properties

Reference/Text books

- 1) Ion implantation and synthesis of Material, M Nastasi and J W Mayer, Springer 2006.
- 2) Handbook of Radiation effects, 2nd Edition, Andrew Holmes Siedel and Len Adans 2002.
- 3) Material Science with Ion Beam, Harry Bernas, Springer 2010.
- 4) Ion Bombardment modification of Surface Fundamentals & Application, Orlando Auciello and Roger Kelly Elsevier, 1984.
- 5) Nano Fabrication by Ion Beam Sputtering, T Som and D Kanjilal
- 6) Swift heavy ions for materials engineering and nanostructuring, D.K. Avasthi and G.K. Mehta, Capital publishing company, New Delhi (2011)

SYLLABUS FOR
SEMESTER X : ELECTIVE GROUP C - 4 : PAPER XVI
NANOSTRUCTURING WITH ION BEAMS

UNIT I: Introduction to ion implantation and basic crystallography studies:

Ion implantation and its applications, Lattices, Crystal systems, Symmetry, Primitive and non primitive cells, Lattice directions and planes, Crystal structure, Atom sizes and coordination, Stereographic projection

UNIT II: Interaction of energetic ions with solids:

Stopping cross sections, Ion ranges, Energy transfer to the surface, Displacement cascades and generation of defects: Bulk damage, Formation of surface vacancies and adatoms, extended surface damage

Sputtering from elemental targets: Linear collision cascade, Sputtering from single crystals, Composition changes in multicomponent materials, Preferential sputtering, Surface binding energies of alloys, Processes effecting composition changes

UNIT III: Regimes of ion induced pattern formation and Surface evolution:

Ion-induced orientation: Bradley-Harper (B-H) instability regime; Surface-induced orientation: Ehrlich Schwoebel (E-S) instability regime; thermal ion-induced patterns and kinetic roughening; Nonroughening behaviour

Morphology-dependent sputter yield and the B-H instability; Defect diffusion and other mechanisms; Diffusion on isotropic surfaces: Mullins and Herring approach; Diffusion on stepped surfaces; Mobile defect species; Roughening kinetics induced by surface diffusion; Radiation enhanced viscous flow; Ballistic diffusion

UNIT IV: Ion beam directionality in patterning and Nanoscale functionalization of patterned surfaces

Bradley-Harper linear instability model: Curvature-dependent sputtering and smoothing via thermal diffusion; Experiments and simulations of patterning in the BH instability regime: Time evolution of ripple wavelength and amplitude; Exponential growth rate of the ripples; Ripple travelling velocity; Energy dependence; Temperature and flux dependences of ripple wavelength and growth rate

Application of patterned semiconductor surfaces: Plasmonics, thin film/nanoscale magnetization, light trapping, cold cathode electron emission; Application of patterned oxide surfaces: Resistive switching.

Books:

- 1) Ion implantation and synthesis of Material, M Nastasi and J W Mayer, Springer 2006.
- 2) Handbook of Radiation effects, 2nd Edition, Andrew Holmes Siedel and Len Adans2002.
- 3) Material Science with Ion Beam, Harry Bernas, Springer 2010.
- 4) Ion Bombardment modification of Surface Fundamentals &Application, Orlando Auciello and Roger Kelly Elsevier, 1984.
- 5) Nano Fabrication by Ion Beam Sputtering, T som and D Kanjilal
- 6) Swift heavy ions for materials engineering and nanostructuring, D.K. Avasthi and G.K. Mehta, Capital publishing company, New Delhi (2011)