NANOTECHNOLOGY

Programme Structure-2017

Course Code	Course Title	Lecture (L) Hours Per Week	Tutorial (T) Hours Per Week	Practical (P) Hours Per Week	Total Credits
NAT2152	Basics of Nanoscience	3	-	-	3
NAT2251	Properties of Nanomaterials	3	-	-	3
NAT2352	Vacuum Science & Clean Room Technology	2	-	2	3
NAT2452	Synthesis of Nanomaterials	2	-	2	3
NAT2552	Characterization Techniques	3	-	-	3
NAT2652	Industrial Applications of Nanomaterials	3	-	-	3
	TOTAL				**18**

NANOTECHNOLOGY

Syllabus - Semester First

BASICS OF NANOSCIENCE

Course Code: NAT2152 **Credit Units: 03**

Course Objective:
To enable the students to understand the science of nanomaterials.

Module I: Introduction to Quantum Mechanics & Crystal structure
De-Broglie hypothesis, Uncertainty Principle, Schrödinger Equation, Operator, Particle in a 1D box, Particle in a 3D box (qualitative) , Crystal structure, Crystal orientation, Crystal planes, Bravais lattice, Miller Indices, Atomic Packing Density, crystal symmetry ,ZnS, Diamond and NaCl crystal structure, Melting point, Coordination number, Atomic Bonding.

Module II: Introduction to Nanoscience
Emergence of Nanoscience with special reference to Feynman and Drexler, Role of particle size, Spatial and temporal scale, Exciton, Concept of confinement, strong and weak confinement with suitable examples, Development of quantum structures, Basic concept of quantum well, quantum wire and quantum dot. Density of states of 1D,2D & 3D structure, surface effect

Module III: Types of Nanomaterials
Nanoclusters, Solid solutions, Thin film, Nanocomposites (Metal Oxide and Polymer based), Core Shell Nanostructure, Buckyballs, Carbon nano tubes and, Zeolites minerals, Dendrimers, Micelles, Liposomes, Block Copolymers, Porous Materials, ,Metal Nanocrystals ,Semiconductor nanomaterials.

Examination Scheme:

Components	A	CT	S/V/Q	HA	EE
Weightage (%)	5	10	8	7	70

CT: Class Test, HA: Home Assignment, S/V/Q: Seminar/Viva/Quiz, EE: End Semester Examination; A: Attendance

Text & References:

- Material Science & Engineering – An Introduction by William D. Callister Jr.
- Grain growth and control of microstructure and lecture in polycrystalline materials by V. Lu. Novikov & Vladimi Novikov
- Nanoscale Materials- Liz Marzan & Kamat
- Introduction to Nanotechnology by Charles P. Poole, Jr., Frank J. Owens

Syllabus - Semester Second

PROPERTIES OF NANOMATERIALS

Course Code: NAT2251 **Credit Units: 03**

Course Objective:
To enable students to understand properties of bulk and nanomaterials

Course Contents:

Module I: Electronic & Magnetic
Classification of materials: Metal, Semiconductor, Insulator, Band structures, Brillouin zones, Mobility, resistivity, relaxation time, and recombination centers, Hall effect Quantum Hall effect. Quantum Tunneling , Coulomb Blockade, single electron transistor .
Origin of magnetic Moment in materials, Revisit to Different kind of magnetism in nature: Dia, para, ferro magnetic, Domain structure, antiferro, feri & superparamagnetism, nanomagnetic materials: Fe, Fe_3O_4, Ferrites, Ferro-fluids

Module II: Optical & Thermal
Photo-conductivity, Photovoltaic effect, optical absorption & transmission, photoluminescence, fluorescence, phosphorescence, electroluminescence, LED, Concept of phonon, thermal conductivity, specific heat, exothermic & endothermic heat, Thermoelectric effect, Thermoelectric material(TEM) properties .

Module III: Mechanical
Stress- Strain curve, True Stress True strain, Hardness, compressive & tensile strengths, Fracture toughness Fatigue, Creep and other elastic properties of materials, Deformation behavior of Nanomaterials

Examination Scheme:

Components	A	CT	S/V/Q	HA	EE
Weightage (%)	5	10	8	7	70

CT: Class Test, HA: Home Assignment, S/V/Q: Seminar/Viva/Quiz, EE: End Semester Examination; A: Attendance

Text & References:

- Processing & properties of structural naonmaterials by Leon L. Shaw (editor)
- Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al. Wiley VCH Verlag Gmbh & Co, Weinheim
- Nanostructure and Nanomaterials: Synthesis , Properties and Application by G. Cao, Imperial College Press, 2004

Syllabus - Semester Third

VACUUM SCIENCE AND CLEAN ROOM TECHNOLGY

Course Code: NAT2352 **Credit Units: 03**

Course Objective:
To enable students to understand vacuum science, their production, measurement, about clean room technology

Course Contents:

Module I: Vacuum Science and Technology
Vacuum and its different units, Kinetic Theory of Gases, Gas flow in vacuum systems, Physical Parameters at low pressure, classification of vacuum ranges, Application of Vacuum technology, Throughtput & pumping speed, flow rate & conductance in vacuum system

Module II: Production & Measurement of Vacuum
Types of Vacuum Pumps (Rotary, diffusion, Turbo, Cryo & Ion) - Basic Principles and applications, Production of low, medium high and ultra high vacuum, Vacuum gauges , Leak detection techniques

Module III: Clean Room Technology
Clean rooms:Introduction, needs and Types, Basics of clean room standards, design of clean room & clean air devices, High efficiency air filtration, Clean room disciplines, Cleaning of clean room, Quality control, Industrial and Scientific application of clean room

Examination Scheme:

Components	CT	HA	A	S/V/Q	EE
Weightage (%)	15	5	5	5	70

CT: Class Test, HA: Home Assignment, S/V/Q: Seminar/Viva/Quiz, EE: End Semester Examination; A: Attendance

Text & References:

- Vacuum Science and Technology, VV Rao, TB Ghosh, K L Chopra- Allied Publishers Pvt. Ltd.
- Handbook of Vacuum Science and Technology, Dorothy M. Hoffman, Academic Press, An Imprint of Elsevier
- Clean Room Technology:Fundamental of Design, testing & operation by William Whyte; John – Wiley & Sons 2002

Syllabus - Semester Fourth

SYNTHESIS OF NANOMATERIALS

Course Code : NAT2452 **Credit Units: 03**

Course Objective:
To enable students to understand the different methods of synthesis of nonmaterial.

Course Contents:

Module I: Physical Methods:
Physcal Vapour Deposition (PVD), Inert gas condensation, Arc discharge, DC sputtering, Ion sputtering, RF & Magnetron sputtering ,Pulse Laser Deposition (PLD), Ball Milling, Molecular beam epitaxy, Electro-deposition,

Module II: Chemical Methods:
Metal nanocrystals by reduction, Sol- gel, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Liquid-liquid interface.

Module III: Self assembly and Lithography
Self assembly, Process of self assembly, colloids, Introduction to Lithography, E-beam Lithography.

Examination Scheme:

Components	CT	HA	A	S/V/Q	EE
Weightage (%)	15	5	5	5	70

CT: Class Test, HA: Home Assignment, S/V/Q: Seminar/Viva/Quiz, EE: End Semester Examination; A: Attendance

Text & References:

- Handbook of nanoscience, Eng. & Technology by W. Gaddand, D. Bernner, S.L. Solnki & G.J. Infrate (Eds) , CRC press 2002
- Nanostructure and Nanomaterials: Synthesis , Properties and Application by G. Cao, Imperial College Press, 2004
- Nanoscience & Technology: Novel structure and phenomea by Ping Sheng (Editor)
- Nano Engineering in Science & Technology : An introduction to the world of nano design by Michael Rieth.

Syllabus - Semester Fifth

CHARACTERIZATION TECHNIQUES

Course Code: NAT2552 **Credit Units: 03**

Course Objective:
To enable students to understand the instrumental techniques for characterization of nanomaterials

Course Contents:

Module I: Structural characterization techniques
X-ray diffraction (XRD) technique, particle size determination using XRD, Applications of XRD, Electron diffraction and its application, neutron diffraction and its applications

Module II: Optical and Electron Microscopy
Introduction to Optical microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Scanning Tunneling Microscopy

Module III: Spectroscopic Techniques
UV visible spectroscopy, Infrared Spectroscopy and Fourier Transform Infrared Spectroscopy, Raman Spectroscopy, Photoluminescence (PL), Photoelectron Spectroscopy (X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy & Ultra Violet Photoelectron Spectroscopy)

Examination Scheme:

Components	CT	HA	A	S/V/Q	EE
Weightage (%)	15	5	5	5	70

CT: Class Test, HA: Home Assignment, S/V/Q: Seminar/Viva/Quiz, EE: End Semester Examination; A: Attendance

Text & References:

- Elements of X-ray diffraction, B D Cullity- Addison-Wesley Publishing Company, Inc.
- Encyclopedia of Materials Characterization, C. Richard Brundle and Charles A. Evans, Jr
- Web based different sources
- Willard, Merritt, Dean, Settle - Instrumental Methods of Analysis, 7th edition

Syllabus - Semester Sixth

INDUSRIAL APPLICATION OF NANOMATERIALS

Course Code: NAT2652 **Credit Units: 03**

Course Objective:
To enable students to understand the applications of nano materials and associated technology in industrial sector.

Course Contents:

Module I: Nano-Electronic Technologies
Nano capacitors, Quantum tunneling, Single electron transistors, Coulomb blockade, Nano lithography, Data storage, Nano-photonics, Nano electronic and Magnetic devices, Spintronic, Carbon based materials: Carbon Nano-tube (CNC), Graphene. Sensors & Nano-sensors.

Module II: Accelerator Technologies
Introduction to Accelerators, Accelerating cavities and RF measurement, Superconducting materials, Niobium, Niobium-copper and other advance composite materials, NbN, NbAlGa, Mg3B.

Module III: Sustainable energy technologies
Solar energy, Hydrogen energy and Nano-materials, Carbon nanotube fuel cells, Hydrogen storage, Thermoelectricity, Re-chargeable batteries, Energy savings, Nano-lubricants, Nano-composites and Nano-catalysts.

Examination Scheme:

Components	A	CT	S/V/Q	HA	EE
Weightage (%)	5	15	5	5	70

CT: Class Test, HA: Home Assignment, S/V/Q: Seminar/Viva/Quiz, EE: End Semester Examination; A: Attendance

Text & References:

- Bharat Bhushan: .Handbook of Nanotechnology, Springer
- Jurgen Schulte: Nanotechnology: Global Strategies, Industry Trends and Applications Graham
- T Smith: Industrial Metrology, Bing Zhou: Nanotechnology in Catalysis
- Luisa Filipponi and Duncan Sutherland: Nanotechnologies: principles, applications, implications and hands on activities
- José A.Rodríguez and Marcos Fernández-García: Synthesis, properties and applications of oxide nanoparticles wiley
- Mick Wilson: Nanotechnology: Basic Science and Emerging Technologies, Chapman and hall/CRC Press
- http://www.nano.gov/you/nanotechnology-benefits