

Outline of the Syllabus:

Semester - I

Credit: 27

S. No.	Course Code	Title of the course	Credit /wk	Remarks L/T/P
1.	NST-101	Elements of Physics	4	4/0/0
2.	NST-103	Elements of Physical Chemistry	4	4/0/0
3.	NST-105	Nanoparticles and Microorganisms, Bionanocomposites	3	3/0/0
4.	NST-107	Elements of Material Science and properties of Nanomaterials	4	4/0/0
5.	NST-109	Nanotechnology & Society	1	NEUS
6.	NST-111	Basic Mathematics / Life Sciences	2	2/0/0
7.	NST-151	Laboratory-I	6	0/0/12
8.	NST-153	Self Study-I	3	**

L = Lecture , T = Tutorial , P = Practical

NEUS => Non Evaluative University Scheme

Semester - II

Credit: 29

S. NO.	Course Code	Title of the course	Credit /wk	Remarks L/T/P
1.	NST-102	Fabrication techniques and Characterisation of Nanomaterials	4	4/0/0
2.	NST-104	Soft Synthetic Routes & Some Novel Nanomaterials	4	4/0/0
3.	NST-106	Nanodevices & Nanosensors	4	4/0/0
4.	NST-108	Scientific Computation & Simulation	3	3/0/0
5.	NST-110	Solutions & Surface Phenomenon	4	4/0/0
6.	NST-112	Business Enterprise in Nanotechnology & Project Management	1	NEUS
7.	NST-152	Laboratory-II	6	0/0/12
8.	NST-154	Self Study-II	3	**

NEUS => Non Evaluative University Scheme

Semester - III

Credit: 24

S. No.	Course Code	Title of the course	Credit /wk	Remarks L/T/P
1.	NST-201	Advanced Nanomaterials	3	3/0/0
2.	NST-203	Semiconductor nanostructures and nanoparticles	3	3/0/0
3	Electives (any 2) NST-205 NST-207 NST-209 NST-211	Molecular Nanoelectronics Photonics & Plasmonics Carbon Nanotubes & Functionalisation Computational Nanoscience	2x3=6	6/0/0each
4	NST- 251	IPR & Nanotechnology	1	NEUS
5	NST-253	Self Study	2	**
6	NST-255	Minor Project / Summer training	9 (5+4)	**

NEUS => Non Evaluative University Scheme

Semester - IV

Credit: 25

S. NO.	Course Code	Title of the course	Credit /wk	Remarks
1.	NST-202	Project Work /Internship (Seminar)	20	**
2.	NST-204	Comprehensive Viva Voce	5	NEUS

NEUS => Non Evaluative University Scheme

Total Credits: 105

Credits Required for the Degree: 100



Detailed Syllabi

Semester-I

Course Code: NST-101

Title: Elements of Physics

L/T/P: 4/0/0

Unit-I: Introduction to Quantum Mechanics: Wave-particle duality, Schrödinger equation and expectation values, Uncertainty principle. Solutions of the one-dimensional Schrodinger equation for free particle, particle in a box, particle in a finite well, linear harmonic oscillator. Reflection and transmission by a potential step and by a rectangular barrier.

Unit-II: Solution of Time independent Schrödinger equation at higher dimensions and more complicated systems Particle in a three dimensional box, linear harmonic oscillator and its solution, density of states, free electron theory of metals. The angular momentum problem. The spin half problem and properties of Pauli spin matrices.

Unit-III Approximate methods, Time independent and time dependent perturbation theory for non-degenerate and degenerate energy levels, the variational method, WKB approximation, adiabatic approximation, sudden approximation

Unit-IV: Statistical Mechanics, Microstates and entropy and its statistical definition, Entropy of mixing, Gibb's free energy, Gibb's paradox, phase space density, ergodic hypothesis, Liouville's theorem, The microcanonical-, canonical- and grand canonical- ensemble and their connections, Fluctuations. Classical Statistical systems, Boltzman statistics Liouville's theorem, The microcanonical-, canonical- and grand canonical- ensemble and their connections, Fluctuations. Classical Statistical systems, Boltzman statistics and quantum statistical systems, Fermi-Dirac and Bose-Einstein Statistics and their applications (An overview).

References: (NST 101)

1. Quantum Physics – A. Ghatak
2. Quantum Mechanics-Mc Quarie
3. Quantum Mechanics - Bransden and Joachen
4. Quantum Mechanics - Vol 1&2 - Cohen-Tannoudji
5. Quantum wells, Wires & Dots,; Theoretical & Computational Physics of Semiconductors Nano-structures, Paul Harrison
6. Quantum Hetero-structures: Micro-electronics and opto-electronics, VV Mitin, VA Kochelap, MA Stroschio.
7. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, 2nd Edition by Eisberg, Robert; Resnick, Robert
8. Principles of Quantum Mechanics 2nd ed. - R. Shankar
9. Thermodynamics and Statistical Mechanics - A N Tikhonov, Peter T Landberg, Peter Theodore Landsberg
10. Thermodynamics and Statistical Mechanics by John M. Seddon , J. D. Gale
11. Statistical Physics by K. Huang
12. Statistical Mechanics-Landau &Lifshitz
13. Statistical Mechanics – Sonntag.
14. Statistical Mechanics – Mc Le Leland

Course Code: NST-103

**Title: Elements of Physical
Chemistry**

L/T/P: 4/0/0

Unit I- Chemical Bonding: Atomic Bonding in solids, Types of bond: Metallic, Ionic, Covalent and vanderwaals bond; Hybridisation; H- bonding Molecular orbital theory for simple molecules such as diatomic molecule etc.

Types of Material: Metals, Semiconductors, Composite materials, Ceramics, Alloys, Polymers.

Unit II- Overview to Thermodynamics: The first and second laws of thermodynamics. Thermodynamic functions, heat capacity, enthalpy, entropy. Phase equilibrium in one component system, real gases, the interactions between gases. Ehrenfest classification of phase transition, the physical liquid surface; surface tension, curved surfaces, capillary action.

Theory of Solution and related topics: Liquid mixtures: free energy as a function of composition, ideal solutions and excess functions.

Equilibrium Electrochemistry; electrochemical cells, Methods for calculation of thermodynamic equilibrium. Electrochemical processes.

Unit III- Diffusion-Fick's Law, mechanisms of diffusion; generation of point defects; self-diffusion; the influence of the pressure and pressure gradient; Kirkendall effect; fast diffusion; influence of isotropic state; experimental methods of investigation of diffusion.

Unit IV- Reaction Kinetics and Photochemistry: Zero, First & Second order reactions. Dependence of k on Temperature. An overview of collision and activated complex theory. Steady State approximation.

Laws of Photochemistry, Fluorescence, Phosphorescence, Chemiluminescence, Jablonski diagram and quenching, Photochemistry of nanomaterials.

References: (NST 103)

1. Physical Chemistry, 1st Edition –Ball.
2. Thermodynamics-Glasston.
3. Principals of Physical Chemistry-Marron-Pruton.
4. Advanced Physical Chemistry – Atkins Peter, Paula Julio
5. Inorganic chemistry-Cotton-Wilkinson.
6. Introduction to Theoretical Chemistry – Jack Simons.

Course Code NST-105

Title: Nanoparticles & Micro-organisms

Bionanocomposites

L/T/P: 3/0/0

Unit – I Biological Methods of Synthesis: Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis

UNIT – II Microorganisms for synthesis of nanomaterials and for toxicity detection
Natural and artificial synthesis of nanoparticles in microorganisms; Use of microorganisms for nanostructure formation, Testing of environmental toxic effect of nanoparticles using microorganisms;

Unit – III Nanocomposite biomaterials, teeth and bone substitution, Natural nanocomposite systems as spider silk, bones, shells; organic-inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposite material; Use of synthetic nanocomposites for bone, teeth replacement.

Unit – IV Nanobio Systems, Nanoparticle-biomaterial hybrid systems for bioelectronic devices, Bioelectronic systems based on nanoparticle-enzyme hybrids; nanoparticle based bioelectronic biorecognition events. Biomaterial nanocircuitry; Protein based nanocircuitry; Neurons for network formation. DNA nanostructures for mechanics and computing and DNA based computation; DNA based nanomechanical devices. Biosensor and Biochips.

References: (NST – 105)

1. Bionanotechnology: Lessons from Nature by David S. Goodsell
2. Nanomedicine, Vol. IIA: Biocompatibility by Robert A. Freitas
3. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology - Hari Singh Nalwa
4. Nanobiotechnology; ed. C.M.Niemeyer, C.A. Mirkin.
5. Nanocomposite Science & Technology Ajayan, Schadler & Braun
6. BioMEMS (Microsystems) - Gerald A. Urban
7. Introduction to Nanoscale Science and Technology (Nanostructure Science and Technology) - Massimiliano Di Ventra
8. Nanosystems: Molecular Machinery, Manufacturing, and Computation - K. Eric Drexler
9. Springer Handbook of Nanotechnology - Bharat Bhushan
10. Nanobiotechnology; ed. C.M.Niemeyer, C.A. Mirkin.
11. Nanofabrication towards biomedical application: Techniques, tools, Application and impact – Ed. Challa S., S. R. Kumar, J. H. Carola.
12. Nanomedicine, Vol. I: Basic Capabilities
13. Nanomedicine, Vol. IIA: Biocompatibility - Robert A. Freitas
14. Dendrimers I, II, III, Ed. F. Vogtle

Course Code: NST-107

**Title: Elements of Material Science
and Properties of Nanomaterials**

L/T/P: 4/0/0

Unit-I Solid State Physics (Overview): Amorphous, crystalline, crystals, polycrystals, symmetry, Unit Cells, Crystal Structures (Bravais Lattices), , Crystallographic Directions, Crystallographic Planes, Miller Indices, Bragg's Law, X-ray Diffraction.

Imperfections of crystal structure: point defects, Grain boundaries, phase boundaries, Dislocations Screw, Edge and Mixed Dislocations generation of defects by quenching, by plastic deformation and by radiation, interaction between point defects and dislocations

Unit-II Electronic Properties, Classification of materials: Metal, Semiconductor, Insulator, Band structures, Brillouin zones, Mobility, Resistivity, Relaxation time, Recombination centers, Hall effects.

Unit -III Confinement and transport in nanostructure, Current, reservoirs, and electron channels, conductance formula for nanostructures, quantized conductance. Local density of states. Ballistic transport, Coulomb blockade, Diffusive transport, Fock space.

Dielectric properties: Polarisation, Ferroelectric behaviour.

Unit-IV Optical Properties, Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence.

References: (NST - 107)

1. Introduction to Solid State Physics -C. Kittel
2. Solid State Physics- A.J. Dekker
3. Solid State Physics -R.K Puri and V.K.Babar
4. The Physics and Chemistry of Solids - Stephen Elliott & S. R. Elliott
5. Scanning Probe Microscopy: Analytical Methods (NanoScience and Technology)- Roland Wiesendanger
6. Advanced X-ray Techniques in Research and Industries - A. K. Singh (Editor)
7. X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials, 2nd Edition - Harold P. Klug, Leroy E. Alexander
8. Transmission Electron Microscopy: A Textbook for Materials Science (4-Vol Set)- David B. Williams and C. Barry Carter
9. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton
10. Structures and Properties of Solid State Materials – B. Viswanathan.
11. Basic Solid State Chemistry – Anthony R. West.

Course Code: NST-109

Title: Nanoscience & Society

L/T/P: 1/0/0

By the end of the course the students should be able to :

- analyse and construct communications with the public;
- analyse and construct policy documents and briefings, etc.;
- analyse case studies of research ethics and place development activities into wider ethical regimes.

The Course shall be NEUS.

References: (NST - 109)

1. Concept Document “Nanoscience & Technology Initiative” of DST, GOI, New Delhi, 2002.
2. Winner, Langdon, “Societal Implications of Nanotechnology”, Testimony to ---- on science of the US House of Representatives, 2003.
3. Ethics in Engineering, M.Martin & R. Schinzinger, 4th edition, McGraw-Hill[0-07-283115-4];
4. Nanotechnology Regulation and Policy Worldwide (Artech House), Jeffrey H. Matsuura 2006.

Course Code: NST-111

Title: Basic Mathematics /Life Science

L/T/P: 2/0/0

The syllabi shall be framed keeping in mind the background of the students admitted to the course. This shall be a introductory qualifying course for two broad streams of students i.e. students with and without mathematics background respectively.

Course Code: NST-151

Title: Laboratory-I

L/T/P: 0/0/6

Each student may be asked to perform 6-8 experiments according to the list of experiments provided by DST.

Course Code: NST-153

Title: Self Study-I

L/T/P: ***

The nature and the contents of the course shall be decided at the beginning of the semester keeping in view the background of the students.

Semester-II

Course Code: NST-102

**Title: Fabrication techniques and Characterisation
of Nanomaterials**

L/T/P: 4/0/0

Unit – I Fabrication of Nanomaterials by Physical Methods: -Inert gas condensation, Arc discharge, RF-plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and Electro deposition.

Unit – II Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, X-ray diffraction

Unit – III Optical Microscope and their description, operational principle and application for analysis of nanomaterials, UV-VIS-IR Spectrophotometers, Principle of operation and application for band gap measurement

Unit – IV M based nanolithography and nanomanipulation, E beam lithography and SEM based nanolithography and nanomanipulation, Ion beam lithography, oxidation and metallization. Mask and its application. Deep UV lithography, X-ray based lithography.

References: (NST-102)

1. Fabrication of fine pitch gratings by holography, electron beam lithography and nano-imprint lithography (Proceedings Paper) Author(s): Darren Goodchild; Alexei Bogdanov; Simon Wingar; Bill Benyon; Nak Kim; Frank Shepherd
2. Microfabrication and Nanomanufacturing- Mark James Jackson
3. A Three Beam Approach to TEM Preparation Using In-situ Low Voltage Argon Ion Final Milling in a FIB-SEM Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830-831 Cambridge University Press.
4. Processing & properties of structural nanomaterials - Leon L. Shaw (editor)

Course Code: NST-104

Title: Soft Synthetic Routes & Some Novel Nanomaterials

L/T/P: 4/0/0

Unit-I Chemical Routes for Synthesis of Nanomaterials: Chemical precipitation and co-precipitation; Metal nanocrystals by reduction, Sol-gel synthesis; Microemulsions or reverse micelles, myle formation; Solvothermal synthesis; Thermolysis routes, Microwave heating synthesis; Sonochemical synthesis; Electrochemical synthesis; , Photochemical synthesis, Synthesis in supercritical fluids

Unit-II Nanocomposites: An Introduction: Types of Nanocomposite (i.e. metal oxide, ceramic, glass and polymer based); Core-Shell structured nanocomposites Superhard Nanocomposite: Synthesis, applications and milestones.

Unit-III Nanopolymers: Preparation and characterization of diblock Copolymer based nanocomposites, Nanoparticles polymer ensembles; Assembly of polymer-Nanoparticles composite material; Fabrication of polymer-mediated organized Nanoparticles assemblies; Applications of Nanopolymers in Catalysis

Unit-IV Metal Nanoparticles: Size control of metal Nanoparticles and their characterization; Study of their properties: Optical, electronic, magnetic; Surface plasmon band and its application; Role in catalysis, Alloy Nanoparticles, Stabilization in Sol, Glass, and other media, Change of bandgap, Blueshift, Colour change in sol, glass, and composites, Plasmon Resonance.

References: (NST - 104)

1. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge UK 2005.
2. Nanocomposite science and technology – P.M. Ajayan, L.S. Schadler, P.V. Braun, Wiley, New York.
3. Active Metals: Preparation, characterization, applications – A. Furstner, Ed., VCH, New York 1996.
4. Characterization of nanophase materials – Z.L Wang (ed), Wiley-VCH, New York 2000.
5. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
6. Nanostructured Silicon – based powders and composites – Andre P Legrand, Christiane Senemaud, Taylor and Francis, London New York 2003.
7. Polymer – clay Nanocomposite – T.J. Pinnayain, G.W. Beall, Wiley, New York 2001.
8. Block Co-polymers in Nanoscience – Massimo Lazzari, Guojun Liu, Sebastien Lecommandoux, Wiley, New York 2007.
9. Chemistry of nanomaterials : Synthesis, properties and applications by CNR Rao et.al.

Course Code : NST-106

Title : Nanodevices & Nanosensors

L/T/P: 4/0/0

Unit-I Quantum and classical regimes of electron transport, mesoscopic transport. Diffusive transport: Boltzman transport equation, electron mobility and diffusion coefficient, Drift-diffusion model. Quantum electron transport; Double barrier Resonant-Tunneling structures: Coherent tunneling and sequential tunneling, Negative differential resistance, single electron tunneling, Coulomb blockade.

Unit-II Introduction to MEMs / NEMs, Electronic Transport in Nanostructures, Semiconductor devices to Single electron Transistors

Unit-III Nanosensors: Temperature Sensors, Smoke Sensors, Sensors for aerospace and defense: Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers, nano-cutting tools, Integration of sensor with actuators and electronic circuitry Biosensors.

Unit-IV State of Art Ion-beam exchange in Nanostructure material. Nanostructure based Photovoltaic Cells.

References: (NST 106)

1. Sensors: Micro & Nanosensors, Sensor Market trends (Part 1&2) by H. Meixner.
2. Between Technology & Science : Exploring an emerging field knowledge flows & networking on the nanoscale by Martin S. Meyer.
3. Nanoscience & Technology: Novel structure and phenomea by Ping Sheng (Editor)
4. Nano Engineering in Science & Technology : An introduction to the world of nano design by Michael Rieth.
5. Enabling Technology for MEMS and nano devices -Balles, Brand, Fedder, Hierold.
6. Optimal Synthesis Methods for MEMS- G. K. Ananthasuresh
7. MEMS & MOEMS Technology and Applications- P. Rai Choudhury
8. Processing Technologies- Gandhi
9. From Atom to Transistor- Supriyo Datta

Course Code: NST-108

Title: Scientific Computation & Simulation
L/T/P: 3/0/0

Unit-I Computational physics in Science & Technology, brief introduction to the Linux operating system; A review of the numerical techniques (Interpolations, differentiation, integration; Nonlinear equations, the bisection methods, Newton's method, root finding; Differential equations, Euler's method, the Runge-Kutta method; Matrices-inverting, finding eigenvalues and eigenfunctions, etc.).

Unit-II Simple problems based on section –I Using Matlab, Mathematica (mechanics, optics and quantum mechanics)/Atomistix and related softwares, Introduction to Labview software

Unit-III Introduction to Monte Carlo techniques, Random processes in science, Monte Carlo integration.

Unit-IV Applications and examples based on the Monte Carlo technique: Random walk, Percolation, Ising model, etc.

References: (NST 108)

1. Handbook of Theoretical and Computational Nanotechnology, Eds. Michael Rieth and Wolfram Schommers, 2006.
2. Introductory Computational Physics Kelvin and Godunov (Cambridge).
3. Computational Physics, R.C. Verma, K.C. Sharma & P.K. Ahluwalia.

Course Code: NST-110

Title: Solutions and Surface Phenomenon

L/T/P: 4/0/0

Unit – I Adsorptions on Solid Surfaces Freundlich and Langmuir Adsorption Isotherm. Gibbs Isotherm. Homogeneous and Heterogeneous Catalysis and its fundamental understanding at nanoscale. Role of nanometal and semiconductor particles in industry.

Unit – II Surface Chemistry: Colloidal state: Interfacial Properties, Origin of Charge on Colloidal Particles, Determination of size of colloidal particles; Types of surfactants: Anionic, cationic, amphoteric, zwitterionic & non-ionic (non-ionic); Theory of surfactants; CMC – Effect of chemical structure, temperature; Kraft temperature; Emulsions & gels

Unit – III Phase Behaviour of Concentrated Surfactant Systems: Micelle type, Micellar growth, Micellar solution saturation; Structure of liquid; crystalline phases; Phase rule, Phase diagram, Binary and ternary phase diagrams of two components & three components, Surfactant geometry & packing; Introduction to microemulsion

Unit–IV Phase Transformations: Mechanisms of phase transformation; homogeneous and heterogeneous nucleation; spinodal decomposition; grain growth; precipitation in solid solution; transformation with constant composition; order-disorder transformations; Martensitic transformation

References: (NST 110)

1. Surfactants and Polymers in Aqueous Solution – K. Holmberg, B. Jonsson, B. Kronberg, B. Lindman, Wiley – England 2004.
2. Dynamics of Surfactant Self – Assemblies – Raoul Zana (Ed.), Taylor & Francis.
3. “Colloidal Dispersion” – Russel W. B, Saville D. A & Schowalter W. R, Cambridge University Press, 1989.
4. Fundamentals of Interface and Colloid Science – Lyklema J, Academic Press, Vol- 2
5. Introduction to Surface Physics – Martin Prutton, Oxford University Press (1994)
6. Introduction to Thermodynamics of Materials, - Gaskell, David R, 4th edition (1995), Taylor and Francis Publishing.

Course Code: NST-112

Title: Business Enterprise in Nanotechnology & Projectmanagement

L/T/P:1/0/0

Nanotechnology is differentiated from the other major technologies like IT and Biotechnology by its far more interdisciplinary nature and its broader sphere of impact. Nanotechnology potentially affects very large product delivery supply-chain and therefore requires a greater degree of understanding and integration and customer base to extract maximum benefit.

Basics of Program Evaluation & Review Techniques (PERT) and Critical Path Method (CPM).

The Course shall be NEUS.

References: (NST: 112)

1. Concept Document "Nanoscience & Technology Initiative" of DST, GOI, New Delhi.

Course Code: (NST-152)

Title: Laboratory-II

L/T/P: 0/0/6

Each student may be asked to perform 6-8 experiments according to the list of experiments provided by DST.

Course Code: (NST-154)

Title: Self Study-II

L/T/P: 0/0/0

The nature and the contents of the course shall be decided before the start of the semester keeping in view the background of the students.

Semester- III

Course Code: NST-201

Title: Advanced Nanomaterials

L/T/P: 3/0/0

Unit-I Fundamentals of magnetic materials, Dia, Para, Ferro, Antiferro, Ferri, Superpara magnetic materials AND giant and colossal magneto-resistance. Important properties in relation to nanomagnetic materials..

Unit-II Nanostructure Magnetism; Effect Bulk Nanostructuring of Magnetic property; Giant and colossal Magnetic resistance; Super Para Magnetism in metallic nanoparticle; Super para magnetism / FM in Semi-conduction quantum dots.

Unit-III Carbon Nano Structures: Introduction; Fullerenes, C60, C80 and C240 Nanostructures; Properties & Applications (mechanical, optical and electrical).

Unit-IV Thermo Electric Materials (TEM): Concept of phonon, Thermal conductivity, Specific heat, Exothermic & endothermic processes. Different types of TEM; Bulk TEM Properties. One dimensional TEM; Composite TEM; Applications.

References: (201)

1. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
2. Physics of Magnetism - S. Chikazumi and S.H. Charap.
3. Physical Theory of Magnetic Domains - C. Kittel .
4. Magnetostriction and Magnetomechanical Effects - E.W. Lee.
5. Nanoscale materials -Liz Marzan and Kamat.
6. Physical properties of Carbon Nanotube-R Satio.
7. Applied Physics Of Carbon Nanotubes : Fundamentals Of Theory, Optics And Transport Devices - S. Subramony & S.V. Rotkins.
8. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.
9. CARBON NANOTECHNOLOGY- Liming Dai.
10. Nanotubes and Nanowires- CNR Rao and A Govindaraj RCS Publishing.
11. CRC Handbook of Thermoelectrics, Ed. CR Rowe

Course Code: NST-203

Title: Semiconductors Nanostructure & Nano-particle

L/T/P: 3/0/0

Unit –I Semiconductor nanoparticles Synthesis, Cluster compounds, quantum-dots from MBE and CVD, wet chemical methods, reverse micelles, electro-deposition, pyrolytic synthesis, self-assembly strategies.

Unit –II Semiconductor nanoparticles: size–dependant physical properties, Melting point, solid-state phase transformations, excitons, band-gap variations-quantum confinement, effect of strain on band-gap in epitaxial quantum dots, single particle conductance.

Unit-III Semiconductor nanoparticles – applications, Optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, surface-trap passivation in core-shell nanoparticles, carrier injection, polymer-nanoparticle, LED and solar cells, electroluminescence, barriers to nanoparticle lasers, doping nanoparticles, Mn-Zn-Se phosphors, light emission from indirect semiconductors, light emission from Si nanodots.

Unit-IV Semiconductor nanowires, Fabrication strategies, quantum conductance effects in semiconductor nanowires, porous Silicon, nanobelts, nanoribbons, nanosprings.

References: (NST – 203)

1. Encyclopedia of Nanotechnology- Hari Singh Nalwa
2. Springer Handbook of Nanotechnology - Bharat Bhusan
3. Handbook of Semiconductor Nanostructures and Nanodevices Vol 1-5- A. A. Balandin, K. L. Wang.
4. Nanostructures and Nanomaterials - Synthesis, Properties and Applications - Cao, Guozhong.

Electives

Course Code: NST 205

Title: Molecular Nanoelectronics

L/T/P: 3/0/0

Unit –I Introduction: Recent past, the present and its challenges, Future, Overview of basic Nanoelectronics.

Unit –II Molecular Electronics Components: Characterization of switches and complex molecular devices, polyphenylene based Molecular rectifying diode switches. Technologies, Single Electron Devices, Quantum Mechanical Tunnel Devices, Quantum Dots & Quantum wires.

Unit –III Nanoelectronic & Nanocomputer architectures and nanotechnology: Introduction to nanoelectronic and nanocomputers, Quantum DOT cellular Automata (QCA), Single electron circuits, molecular circuits Nanocomputer Architecture.

Unit –IV Spintronics: Introduction, Overview, History & Background, Generation of Spin Polarization Theories of spin Injection, spin relaxation and spin dephasing, Spintronic devices and applications, spin filters, spin diodes, spin transistors.

References: (NST 205)

1. Nanoelectronics & Nanosystems: From Transistor to Molecular & Quantum Devices: Karl Gosser, Jan Dienstuhl and others.
2. Concepts in Spintronics – Sadamichi Maekawa
3. Spin Electronics – David Awschalom
4. From Atom to Transistor-Supriyo Datta

Course Code: NST 207

Title: Photonics and Plasmonics

L/T/P: 3/0/0

Physics of Linear Photonic Crystals: Maxwell's Equations, Bloch's Theorem, Photonic Band Gap and Localized Defect States, Transmission Spectra, Nonlinear Optics in Linear Photonic Crystals, Guided Modes in Photonic Crystals Slab

Technology, Materials, and Fabrication of Photonic Crystals: Choices of Materials: Semiconductors, Amorphous, and Polymers, Fabrications of Photonic Crystals Structures (1-D, 2-D, 3-D)

Applications of Photonic Crystals Devices: 1-D Photonic Crystals, Couplers, Waveguides, High-Q Cavities, etc, 2-D Photonic Crystals, Photonic Crystal Fibers, 4 Tunable Photonic Crystal Filters

Physics of Nonlinear Photonic Crystals: 1-D Quasi Phase Matching, Nonlinear Photonic Crystal Analysis, Applications of Nonlinear Photonic Crystals Devices, Materials: LiNbO₃, Chalcogenide Glasses, etc, Wavelength Converters, etc

Elements of Plasmonics: Introduction to Plasmonics, merging photonics and electronics at nanoscale dimensions, single photon transistor using surface plasmon, nanowire surface plasmons-interaction with matter, single emitter as saturable mirror, photon correlation, and integrated systems. All optical modulation by plasmonic excitation of quantum dots, Channel plasmon-polariton guiding by subwavelength metal grooves, Near-field photonics: surface plasmon polaritons and localized surface plasmons, Slow guided surface plasmons at telecom frequencies.

References: (NST 207)

1. The Handbook of Photonics By Mool Chand Gupta, John Ballato
2. Nanotechnology for Microelectronics and Optoelectronics - J. M. Martinez-Duart, Raúl J. Martín-Palma, Fernando Agullo-Rueda
3. Nanoplasmonics, From fundamentals to Applications vol 1 & 2- S. Kawata & H. Masuhara
4. Optical Properties of Photonic Crystals-K. Sakoda
5. Applied Photonics by Chai Yeh
6. Silicon Photonics: An Introduction by Graham T. Reed, Andrew P. Knights

Course Code: NST 209

Title: Carbon Nanotube & Its Functionalisation

L/T/P: 3/0/0

Preparation of Carbon Nano-Tubes: CVD and other methods of preparation of CNT

Properties of Carbon Nanotubes: Electrical, Optical, Mechanical, Vibrational properties etc.

Applications of Carbon Nanotubes: Field emission, Fuel Cells, Display devices

Functionalization of Carbon Nanotubes: Carbon Nanotubes, Functionalization of Carbon Nanotubes, Reactivity of Carbon Nanotubes,

Covalent Functionalization: Oxidative Purification, Defect Functionalization –Transformation and Modification of Carboxylic Functionalization like Amidation, Thiolation, Halogenations, Hydrogenation, Addition of Radicals, Addition of Nucleophilic Carbenes, Sidewall Functionalization through Electrophilic Addition, Cycloadditions, Carbenes Addition, Addition of Nitrenes, Noncovalent Exohedral Functionalization, Endohedral Functionalization

Other Important Carbon based materials: Preparation and Characterization Fullerene and other associated carbon clusters/molecules, Graphene-preparation, characterization and properties, DLC and nanodiamonds.

References: (NST 209)

1. Nanoscale materials -Liz Marzan and Kamat
2. Physical properties of Carbon Nanotube-R Satio
3. Applied Physics Of Carbon Nanotubes : Fundamentals Of Theory, Optics And Transport Devices - S. Subramony & S.V. Rotkins
4. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell
5. CARBON NANOTECHNOLOGY- Liming Dai
6. Nanotubes and Nanowires- CNR Rao and A Govindaraj RCS Publishing

~~**Metal based nanocomposites:** Metal Oxide or Metal Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Metal metal nanocomposites, some simple preparation techniques and their new electrical and magnetic properties.~~

~~**Design of Super hard materials:** Super hard nanocomposites, its designing and improvements of mechanical properties.~~

~~**New kind of nanocomposites:** Fractal based glass metal nanocomposites, its designing and fractal dimension analysis. Electrical property of fractal based nanocomposites. Core Shell structured nanocomposites.~~

~~**Polymer based nanocomposites:** Preparation and characterization of diblock Copolymer based nanocomposites; Polymer carbon nanotubes based composites, their mechanical properties, and industrial possibilities.~~

References: (NST 211)

1. Nanocomposites Science and Technology — P. M. Ajayan, L.S. Schadler, P. V. Braun
2. Physical Properties of Carbon Nanotubes — R. Saito
3. Carbon Nanotubes (Carbon , Vol 33) — M. Endo, S. Iijima, M.S. Dresselhaus
4. The search for novel, superhard materials — Stan Veprjek (Review Article) JVST A, 1999
5. Electromagnetic and magnetic properties of multi-component metal oxides, hetero
6. Nanometer versus micrometer sized particles — Christian Brosseau, Jamal Ben, Youssef, Philippe Talbot, Anne-Marie Kohn, (Review Article) J. Appl. Phys, Vol 93, 2003
7. Diblock Copolymer, — Aviram (Review Article), Nature, 2002

Course Code: NST 211

Title: Computational Nanoscience

L/T/P: 3/0/0

Unit – I Introduction to Matlab and Mathematics (and their open source counterparts-Scilab and Octave); examples from nano-optics and nano-electronics.

Unit – II Monte Carlo Simulations; Computational methods and Simulations from ab initio to multiscale Modeling.

Unit – III Molecular dynamics, computing and simulations.

Unit – IV Nanodesign Nano-CAD, Modeling of Nanodvices. Applications and examples problems based on Molecular dynamics simulations.

References: (NST: 213)

1. Introduction to Computer simulation methods. Gould, Tobochnik et al (Addition weekly-2006)

Course Code: NST 213

Title: IPR & Nanotechnology

L/T/P: 1/0/0

Nanotechnology with its vast potential applications in day to day life will surely face lot of legal challenges. The objective of this course will be focused towards sensitizing the students towards relating IPR with relation to Nano Science.

Course Code: (NST-253)

Title: Self Study-II

L/T/P: 0/0/0

The nature and the contents of the course shall be decided before the start of the semester keeping in view the background of the students.
