SYLLABUS FOR MASTER OF SCIENCE
(M.Sc.) IN NANO-SCIENCE & NANOTECHNOLOGY

Syllabus for M.Sc Nanoscience and Nanotechnology from 2013-2014

Eligibility: B.Sc (Physics /Chemistry/ Zoology/ Botany/ Biotechnology/Biochemistry)

Course Code	Course Title	Core/ Elective	Credits			
			L	T	P	C
I SEMESTER						
NSNT - C001	Introductory Physics	C	3	0	0	3
NSNT - C002	Introductory Chemistry	C	3	0	0	3
NSNT - C003	Introductory Biology	C	3	0	0	3
NSNT - C004	Introduction to Nanoscience and Nanotechnology	C	3	0	0	3
NSNT - C005	Nanoscience - Practical-I	C	0	0	4	4
NSNT - E001	Introduction to Material Science	E	3	0	0	3
	Soft Skill		2	0	0	2

Course Code	Course Title	Core/ Elective	Credits			
			L	T	P	C
II SEMESTER						
NSNT - C006	Preparation of Nanomaterials	C	4	0	0	4
NSNT - C007	Properties of Nanomaterials	C	4	0	0	4
NSNT - C008	Characterization Techniques of Nanomaterials -I	C	4	0	0	4
NSNT - C009	Nanoscience Practical-II	C	0	0	4	4
NSNT - E002	Introduction to Nanobiotechnology	E	3	0	0	3
NSNT - E003	Introduction to Nanotoxicology	E	3	0	0	3
	Soft Skill		2	0	0	2

Course Code	Course Title	Core/ Elective	Credits			
			L	T	P	C
III SEMESTER						
NSNT - C 010	Nanoelectronics and Nanosensors	C	4	0	0	4
NSNT - C 011	Characterization Techniques of Nanomaterials-II	C	4	0	0	4
NSNT - C 012	Nanomaterials for Energy System	C	4	0	0	4
NSNT - C 013	Nanoscience Practical – III	C	0	0	4	4
NSNT - E 004	Applications of Nanomaterials	E	3	0	0	3
NSNT - E 005	Biomaterials & Nanobiotechnology for Tissue Engineering	E	3	0	0	3
	Soft Skill		2	0	0	2
UOM - I001	Internship		2	0	0	2

Course Code	Course Title	Core/ Elective	Credits			
			L	T	P	C
IV SEMESTER						
NSNT - C 014	Advanced Nanobiotechnology	C	4	0	0	4
NSNT - C 015	Biomedical Nanotechnology	C	4	0	0	4
NSNT - C 016	Project	C	0	0	5	5
NSNT - E006	Computational Nanoscience	E	3	0	0	3
NSNT - E007	Industrial Nanotechnology	E	3	0	0	3
	Soft Skill		2	0	0	2

NSNT- C 001 Introductory Physics C 3 0 0 3

Unit I Waves and Optics

Introduction to waves and optics – Huygen's and Fermet's principle, Diffraction, Scattering Superposition, Polarization, Fourier transformation at the speed of light, Molecular spectra, LASER, MASER.

Unit II Electricity and Magnetism

Maxwell's equations in vacuum and matter, Reflection, Refraction, Power transmission, Guided wave in wave guides fundamental concepts of Magnetism, magnetic materials – dia, para and ferromagnetism, magnetic phenomena in ferromagnetic materials, magnetic anisotropy, magnetic domains, hysteresis small particle magnetism, Magnetic materials, magnets and electrets

Unit III Basic Electronics

Classification of solids, energy levels, intrinsic and extrinsic semiconductor, Conduction in metals and semiconductors. Semiconductor diodes: Diode under forward bias condition, diode under reverse bias - Transistor basics, working principles of different transistor- I-V characteristic studies and applications of Microwave Devices.

Unit IV 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.

References:

1. Solid State Physics, S.O.Pillai, 4th Edition, New Age International Publishers, New Delhi, 2001.
2. Text Book of Electronics, S. Chattopadhyay, New Central Book Agency P.Ltd., Kolkata, 2006.
3. Craik D 1995 Magnetism: Principles and Applications (New York: Wiley)
4. Kittel C 1986 Introduction to Solid-State Physics (New York: Wiley)
5. Electromagnetic fields and waves, Paul Lorrain and Dale Corsor, W. H. Freeman & Co
6. Quantum Physics – A. Ghatak & Loganathan, McMillan
7. Quantum Mechanics-Mc Quarie
8. Quantum Mechanics - Vol 1&2 - Cohen-Tannoudji, Bernard Diu, Franck Laloe, John Wiley & Sons (2005)

NSNT- C 002 Introductory Chemistry C 3 0 0 3

Unit I

Chemical Equilibria - Activity concept, equilibrium constant and applications, ionisation constants of acids and bases. Concept of pH, hydrolysis of salts, Buffers – types, range and capacity, dissociation of polyprotic acids, common ion effect, salt effect. Electrochemistry – Conductivity of electrolytes, electrochemical cells, standard electrode potentials

Unit II

Symmetry and Group theory, Bonding models in chemistry – ionic bond, covalent bond, Coordination Chemistry - Theories of bonding in coordination compounds and electronic spectra of coordination compounds

Unit III

Thermodynamics: First, second and third law of thermodynamics. Gibbs and Helmholtz energy and chemical equilibrium. Chemical kinetics, Transition state theory ad collision theory, Heterogeneous catalysis.

Unit IV

Organic compounds – Structure and bonding, aliphatic and aromatic compounds, functional groups, nucleophiles and electrophiles, reactions and mechanisms

References:

1. Fundamentals of Analytical Chemistry - Skoog, West and Holler, Saunders College Publishing, VI Edition, 1991, and VII Edition, 1996.
2. Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
3. Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, VI Edition, Pearson Education Ltd, 2001.
4. Inorganic Chemistry – Principles of structure and Reactivity – J.E. Huheey, E.A. Keiter and R.L. Keiter, IV Edition
5. Physical chemistry Atkins
6. Physical Chemistry, .A. Alberty and R.J. Silbey

NSNT – C 003 **Introductory Biology** **C 3 0 0 3**

Unit I

Definitions, Cell Structure and functions. Eukaryotic and Prokaryotic cells, Principle of membrane organization, cytoskeletal proteins, types of cell division, mitosis and meiosis Structure and functions of proteins – Amino acids and peptides. Proteins- primary, secondary and tertiary structures, Protein folding, haemoglobin and myoglobin

Unit II

Enzymes – Mechanism of actions – enzyme kinetics – Regulation of activities – Bioenergetics – Role of ATP – Biological oxidation – Respiratory chain and oxidative phosphorylation

Unit III

Carbohydrates – Biological significance. Lipids of physiological significance. Overview of metabolism and catabolism – glycolysis. Cholesterol – synthesis, transport and excretion, glycoproteins and extracellular matrix, Biooxidation, fatty acid synthesis, phospholipids and membranes

Unit IV

Nucleic Acids: Structure, functions and replications of information macromolecules. Metabolism of purines and pyrimidine nucleotides. Organization, replication and repair of DNA. RNA and protein synthesis – Stem cell and function.

References:

1. Lehninger, Principles of Biochemistry, Cox and Nelson, V Edn,2008
2. L. Stryer, Biochemistry, 4th Edn., 1995
3. Haper's Illustrated Biochemistry, R.K, Murray, D.K. Granner and V.W. Rodwell, McGraw Hill , New Delhi, 2003.

NSNT – C 004 Introductions to Nanoscience and Nanotechnology C 3 0 0 3

Unit I

Background to nanoscience and nanotechnology - scientific revolutions - nanosized effects- surface to volume ratio- – atomic structure – molecules & phases – energy at the nanoscale molecular and atomic size -quantum effects- types of nanotechnology and nano machines

Unit-II

Definition of a nano system - classification of nanocrystals - dimensionality and size dependent phenomena; Quantum dots, Nanowires and Nanotubes, 2D films; Nano & mesopores – top down and bottom up- Misnomers and misconception of Nanotechnology- importance of the nanoscale materials and their devices -size dependent variation in mechanical, physical and chemical, magnetic, electronic transport, reactivity etc.,

Unit III :

Nanostructured materials-metal-semiconductor-ceramics and composites- size dependent properties - uniqueness in these properties compared to bulk and microscopic solids– nanomaterials and nanostructures in nature- superhydrophobicity, self-cleaning - antifogging.

Unit-IV

Recent special nanomaterials - Carbon based nanomaterials – CNT- graphene- core-shell structures- Micro and Mesopores Materials- Organic-Inorganic Hybrids- ZnO- Silicon -- DNA- RNA- Nanoproducts

References:

1. "Nanostructures & Nanomaterials: Synthesis, Properties &Applications" G. Cao, Imperial College Press, 2004.
2. Nanomaterials, Nanotechnologies and Design: An introduction for engineers and Architects, Micheal F. Ashby, P.J. Ferreria, D.L. Schodek,
3. Introduction to Nanoscience and Nanotechnology, Gabor .L et al,
4. Fundamentals of Nanotechnology, Hornyak, G. Louis, Tibbals, H. F., Dutta, Joydeep, CRC Press, 2009
5. Nanomaterials: An introduction to synthesis, properties and application, Dieter Vollath, WILE-VCH, 2008

NSNT- C 005 Nanoscience Practical-I C 0 0 4 4

1. Protein Estimation - Lowry and Bradford methods
2. Chromatography – Gel Filtration, Ion exchange, Affinity chromatography, TLC
3. Polyacrylamide and agarose gel electrophoresis
4. Microscopy – Fluorescence Microscope experiments
5. MTT assay for cell viability and growth
6. Isolation of DNA and demonstration of apoptosis of DNA laddering
7. Estimations of blood glucose, blood urea, uric acid and creatinine
8. DNA Estimation
9. Cell Counting

NSNT- E 001 Introductions to Materials Science E 3 0 0 3

Unit I

Crystal Structure and crystal defects, Structure of Matter- Amorphous, crystalline, crystals, polycrystals, symmetry, Unit Cells, Crystal Structures (Bravais Lattices), Crystallographic Directions, Crystallographic Planes, Miller Indices, Chemical Bonding- Atomic Bonding in solids, Types of bond: Mettalic,Ionic, Covalent and Vander Waals bond; Hybridisation; H-bonding. Crystal defects

UNIT II Conducting and Semiconducting Materials

Draw backs of classical theory – Fermi distribution function – Density of energy states(derivation) – effect of temperature on Fermi energy (Qualitative), Origin of band gap in solids (qualitative treatment only) – Concept of effective mass of electron and hole – Law of mass action – Carrier concentration in an intrinsic semiconductor (derivation) – electrical conductivity – band gap determination – Carrier concentration in n-type and p-types semiconductors (Qualitative) – Variation of Fermi level with temperature and impurity concentration (Qualitative) – Hall effect – Determination of Hall coefficient.

UNIT III Magnetic and Dielectric Materials

Origin of magnetic moment – Bohr magneton – Weiss theory of paramagnetism, ferromagnetism – Domain theory of ferromagnetism, Hysteresis – Ferites – magnetic recording and readout – Storage of data – Tapes and floppy - magnetic disk drives. Dielectric materials: Electronic, Ionic, Orientational, Spontaneous and space charge polarization – Complex dielectric constant RC equivalent network – dielectric loss – different types of dielectric breakdown — Classification of insulating materials (qualitative)

Unit IV Thermal, Optical and Mechanical Properties of materials

Heat capacity. Thermal expansion. Thermal conductivity. Thermal stresses Optical Properties Basic concepts. Optical properties of metals. Optical properties of non metals. Application of optical phenomena. Mechanical Properties of Materials - Elastic deformation. Plastic deformation. Interpretation of tensile stress-strain curves, Yielding under multiaxial stress. Yield criteria and macroscopic aspects of plastic deformation.

References:

1. Elements of Solid state Physics, by J.P. Srivastava, Prentice Hall of India Private Limited.
2. Introduction to Solid State Physics, by Charles Kittel, Seventh Edition.
3. Solid state Physics, by S.O.Pillai, New Age international Publishers
4. Materials Science and Engineering, by V. Raghavan, Fourth Edition
5. Introduction to Solid State Theory, by Madelung
6. Quantum theory of Solid State, by Callaway,
7. Quantum theory of Solid State, by Kittel

NSNT - C 006 Preparations of Nanomaterials C 4 0 0 4

Unit I Mechanical methods

Grinding – high energy ball milling – types of balls – WC and ZrO_2 - material – ball ratio – medium for grinding –limitations in getting required grain size for low melting point materials – typical systems –severe plastic deformation – melt quenching and annealing

Unit II Physical Methods

Vapor deposition and different types of epitaxial growth techniques- pulsed laser deposition, Magnetron sputtering – Deposition progress and Micro lithography – laser ablation – RF/DC magnetron sputtering –microwave plasma evaporation control of grain size-scale up process

Unit III Chemical Methods

Sol-gel technique – solvothermal methods-control of grain size – co-precipitation hydrolysis – sonochemical method combustion technique – colloidal precipitation template process – growth of nanorods –solid-state sintering- grain growth. Electrodeposition - electrospinning technique. Arc method-carbon nanotubes- other nanotubes and nanorods –nanosprings –rings chemical routes for nanotubes and nanorods – ion beam induced nanostructures.

Unit IV Nanoporous Materials

Nanoporous materials – Silicon - Zeolites, mesoporous materials - nanomembranes and carbon nanotubes - AgX photography, smart sunglasses, and transparent conducting oxides – molecular sieves – nanosponges.

References:

1. A . Roth, Vacuum Technology North – Holland Pub.,II Edition (1982)
2. H.Gleiter, Progress in Materials Science Vol.33p.223 (1989)
3.The Chemistry of Nanomaterials :Synthesis , Properties and Applications ., A.Muller, A.K.Cheetham (Eds.),(2004) WILEY-VCH Verlag GmbH&Co.,Weinheim
4.C.C.Koch , Nanostructured Materials Vol.2 p.109 (1993)
5.Janos H .Fendler (Editor) Nanoparticles and Nanostructured Films Preparation , Characterization and Applications , Wiley –VCH (1998)

NSNT – C 007 Properties of Nanomaterials C 4 0 0 4

Unit I Electronic Properties

Introduction, Properties of materials & nanomaterials, role of size in nanomaterials. Electronic Properties, Electronic materials, Band structures, Brillouin zones, Mobility, Resistivity, Relaxation time, Recombination centers, Hall effects, Confinement and transport in nanostructure. Ballistic transport, Coulomb blockade, Resonant Tunnelling.

Unit II Magnetic and Dielectric properties

Brief review on Dia, Para, Ferromagnetic materials, Superparamagnetism and it s limit. Important properties in relation to nanomagnetism-GMR, TMR, Transport in a magnetic field, Quantum Hall Effect, spin value, spin tunnelling junctions- size induced magnetism on Au and Ag nanoparticles-Dielectric properties- Effect of particle size on dielectric properties, Ferroelectrics and multiferroics.

Unit III Optical Properties

Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence, Band gap engineering, Size effect of metal Nano particles, Surface Plasmon resonance phenomena, optical properties of semiconductor nanoparticles.

Unit IV Mechanical Properties

Micro hardness- nanoindentation- fracture toughness- superplasticity- plastic nature of nanoceramics- nanomembrances-inter connected pores - Bulk nanostructured materials- influence of porosity. Hall-Petch relation, microstructure – dislocation interactions at low and high temperatures; effects of diffusion on strength and flow of materials; methods of enhancing or retarding diffusion; grain boundary sliding and grain boundary migration.

References :

1. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
2. Nanomaterials Handbook- Yury Gogotsi
3. Encyclopedia of Nanotechnology- Hari Singh Nalwa
4. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens
5. Physical Theory of Magnetic Domains - C. Kittel
6. Robert E. Newnham, Properties of materials, Oxford university press, 2005
7. Wole Soboyejo, Mechanical properties of engineered materials, Marcel Dekker Inc.,2002.

NSNT- C 008 Characterization Techniques of Nanomaterials – I C 4 0 0 4

Unit I Introduction to spectroscopy

Basic principles and applications of UV-Vis-NIR, FTIR, FT-Raman, Photoluminescence, NMR, ESR and Light Scattering methods.

Unit II X – ray techniques

X-ray powder diffraction –Quantitative determination of phases; Structure analysis, single crystal diffraction techniques - Determination of accurate lattice parameters - structure analysis-profile analysis - particle size analysis using Scherer formula- Particle Size Analyzer- Ellipsometry- thickness measurements

Unit III Electron Spectroscopy

X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy, X-Ray Characterization of Nanomaterials – EDAX and WDA analysis – EPMA - Applications to nanomaterials characterization

Unit IV Mechanical, Magnetic and electrical properties measurement

Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of Nanoindentation load-displacement curves- Nanoindentation data analysis methods-Hardness testing of thin films and coatings- MD simulation of nanoindentation. Vibration Sample Magnetometer, Impedance Spectroscopy- PPMS, - Measurement of Magnetic and electrical properties of nanomaterials.

References:

1. Elements of X-ray Diffraction B. D. Cullity, Addison Wesley, 1977
2. Transmission Electron Microscopy: A Textbook for Materials Science David B Williams, C Barry Carter, (1996) Plenum Press, New York
3. Impedance Spectroscopy: Theory, Experiment, and Applications, E. Barsoukov and J. Ross Macdonald (Editors) (2000) John Wiley & Sons (P)Ltd.
4. Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, (1995) CRC Press
5. Nanoindentation, By Anthony C Fischercripps, Anthony C. , Springer science and Bussiness media publications, 2011
6. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, Elsevier, 2009.

NSNT – C 009 **Nanoscience Practical -II** **C 0 0 4 4**

1. Synthesis of Silver Nanoparticles by Chemical reduction method and their UV-VIS absorption studies.
2. Synthesis of Gold Nanoparticles by Chemical reduction method and their UV-VIS absorption studies.
3. Synthesis of Silver Nanoparticles by Polyol method and their UV-VIS absorption studies.
4. Synthesis of Gold Nanoparticles by Polyol method and their UV-VIS absorption studies.
5. Synthesis of TiO_2 Nanoparticles by Sol-Gel Method and Characterize using XRD and SEM analysis.
6. Synthesis of Ceria Nanoparticles and Characterize using XRD and SEM analysis.
7. X-ray diffraction studies of synthesised of TiO_2 nanoparticles and measuring the crystallite size.
8. Synthesis of Ceria Nanoparticles by Co-Precipitation Method.
9. SERS studies of Gold nanoparticles
10. SERS studies of Silver nanoparticles
11. Synthesis of Quantum dots and Photoluminescence studies.
12. SPR studies of metal nanoparticles.

NSNT - E 002 Introduction to Nanobiotechnology E 3 0 0 3

Unit I

Bio-mineralised Inorganic Nanomaterials – Nanostructures and Dynamics of Biocompatible surfactant monolayers and bilayers – Bio-interface, Bio-conjugation, Bio-matrix based on bioinspired phospholipids polymers.

Unit II

Self-assembly of ionic-complementary peptides and their applications in nano-biotechnology –from nanocluster assays to optical biochips for nano-biotechnology –bioactive nanomaterials in bone grafting and tissue engineering- inorganic /polymer nano composites for dental restoration and bone replacement applications.

Unit III

DNA based artificial nanostructures: fabrication, properties and applications – Nucleic acid engineered nanomaterials and their applications: Protein patterning for applications in biomaterials and biodevices. Polymers nanofibers and their applications in bioengineering – functional polymers for bone tissue engineering applications – applications of nanotechnology in tissue engineering.

Unit IV

Vesicles and liposomes in sensor technology –Self-assembling nanostructured injectable polymeric gels for drug delivery - Engineering surface erodable polyanhydrides with tailored microstructure for controlled drug and protein delivery

References:

1. Challa S.S.R. Kumar (Ed) Biological and pharmaceutical nanomaterials : Wiley - VCH Verlag GmbH& Co, KgaA.
2. Ninmeyer C.M, Mirkin C.A (Eds) 2005. Nanobiotechnology
3. H.S. Nalwa (Ed) Handbook of Nanostructured Bioaterials and their applications in nanobiotechnology, American Scientific Publishers.2005

NSNT – E 003 Introduction to Nanotoxicology E 3 0 0 3

Unit I

Introduction – Definition of terms-Toxicity-Hazards and hazard types-risk and assessment of risk.

Unit II

Mechanism of Nanosize particle toxicity-Passage through biological membranes-toxicokinetics

Unit III

Nanopollution – Nanomaterials in environment-sources of pollution-transport through environment

Unit IV

Human exposure to nanosized materials-measurement-Threshold-permissable limits

Unit V

Portals of entry and target tissue-routes of entry of pollutants-distribution and target tissue.

References:

1. Nanotechnology: Health and Environmental Risks, Jo Anne Shatkin, CRC Press, 2008
2. Nanotechnology: Environmental Health and Safety,Risks, Regulation and Management, Matthew Hull and Diana Bowman, Elsevier, 2010
3. Principles and Methods of Toxicology. Edited by A.W. Hayes. Taylor and Francis, 2008.

NSNT- C 010 Nanoelectronics and Nanosensors C 4 0 0 4

Unit I. Digital Electronics

OP-Amp, RS Flip Flops, J-K Master Slave Flip Flops, Types of registers, D/A and A/D Counters, Bipolar Junction Transistor, FET, MOSFET, Single Electron Tunnelling.

Unit II. Semiconductor Nanodevices

Single-Electron Devices, Nano scale MOSFET – Resonant Tunnelling Transistor - Single-Electron Transistors; Single-Electron Dynamics; Nanorobotics and Nanomanipulation; Molecular nanowires-Organic LED, Organic FETs- CNT and Graphene FTE, SiNW FET.

Unit III. Electronic and Photonic Materials

Single Electron Tunnelling phenomena- Coulomb blockade-Coulomb staircase - RSD and Resonant tunnelling transistor- Quantum structures based LEDs - OLED and photo detectors-Magnetic quantum dots and their applications.

Unit IV. Nanosensors

Micro and nano-sensors, Fundamentals of sensors, biosensor, micro fluids, MEMS and NEMS, Packaging and characterization of sensors, Method of packaging at zero level, dye level and first level.-Thermal energy sensors -temperature sensors, heat sensors-Electromagnetic sensors- electrical resistance sensors, electrical current sensors, electrical voltage sensors, electrical power sensors, magnetism sensors - Mechanical sensors -pressure sensors, gas and liquid flow sensors, position sensors - Chemical sensors - Optical and radiation sensors- Gas Sensor-Bio Sensors- DNA based biosensors-Packaging and method of packaging.

References:

1. W. Ranier, “Nano Electronics and Information Technology”, Wiley, (2003).
2. K.E. Drexler, “Nano systems”, Wiley, (1992).
3. M.C. Pettey, “Introduction to Molecular Electronics”.
4. Frank J. Owens and Charles P. Poole Jr., The physics and chemistry of nanosolids, Wiley Interscience Publishers, 2006.
5. Kouroush Kalantar – Zadeh, Benjamin Fry, Nanotechnology enabled sensors, Springer Verlag New York, (2007) ISBN-13: 9780387324739

NSNT C 011 Characterization Techniques of Nanomaterials - II C 4 0 0 4

Unit I

Principles, Overview of Instrumentation and Sample preparation, Experimental techniques adopted in: Scanning Electron Microscopy: SEM and FESEM -Transmission Electron Microscopy (TEM) – HRTEM- application for analysis of Nanomaterials.

Unit II

Scanning Tunnelling Microscopy(STM) ,Atomic Force Microscopy AFM)-Non-contact-contact- Tapping- conducting mode-.Near Field Scanning Optical Microscopy; Scanning capacitance Microscopy- Scanning Microwave Microscope- Magnetic Force Microscopes MFM)- Chemical Force Microscope (CFM)- Applications for analysis of nanomaterials .

Unit III

Optical and Confocal microscopes- Use of polarized light microscopy – Phase contrast microscopy – Interference Microscopy – hot stage microscopy - surface morphology – Etch pit density and hardness measurements. -Confocal Microscopes - Confocal Raman – Application in Nanobiotechnology. Fluorescence Microscope

Unit IV

Principle and Instrumentation of Thermogravimetry; Differential Thermal Analysis and Differential scanning calorimetry-Importance of thermal analysis for nanostructures. New Advances and challenges in biological and biomedical materials characterizations- Dynamic light scattering spectroscopy.

References:

1. J.Goldstein, D. E. Newbury, D.C. Joy, and C.E. Lym, "Scanning Electron Microscopy and X-ray Microanalysis", 2003.
2. S.L. Flegler, J.W. Heckman and K.L. Klomparens, "Scanning and Transmission Electron Microscopy: An Introduction", WH Freeman & Co, 1993.
3. P.J.Goodhew, J.Humphreys, R.Beanland, "Electron Microscopy and Analysis",
4. R.Haynes, D.P.Woodruff and T.A.Talchar, "Optical Microscopy of Materials", Cambridge University press, 1986.
5. R.M.Rose, L.A.Shepard and J.Wulff, "The Structure and Properties of Materials", Wiley Eastern Ltd,

NSNT – C 012 Nanomaterials for Energy System C 4 0 0 4

UNIT I Fundamental Concepts in Energy Systems

Electrochemical Cell, Faraday's laws, Electrode Potentials, Thermodynamics of Electrochemical cells, Polarization losses in electrochemical cells, Electrode process and kinetics, Electrical double layer, Photoelectrochemical cell, thermoelectric effect.

UNIT II Nanomaterials for Energy Conversion Systems

Issues and Challenges of functional Nanostructured Materials for electrochemical Energy, Conversion Systems, Fuel Cells, Principles and nanomaterials design for: Proton exchange membrane fuel cells (PEMFC); Direct methanol fuel cells (DMFC); Solid-oxide fuel cells (SOFC), Current status and future trends.

UNIT III Nanomaterials for Photovoltaic Solar Energy Conversion Systems

Principles of photovoltaic energy conversion (PV), Types of photovoltics Cells, Physics of Photovoltaic cells, Organic photovoltaic cell cells, thin film Dye Sensitized Solar Cells, Quntum dot (QD) Sensitized Solar Cells (QD-SSC), Organic- Inorganic Hybrid Bulk Hetero Junction (BHJ-SC) Solar cells, Current status and future trends.

UNIT IV Nanomaterials for Energy Storage Systems

Issues and Challenges of functional Nanostructured Materials for electrochemical Energy Storage Systems, Primary and Secondary Batteries (Lithium ion Batteries), Cathode and anode materials, Capacitor Electrochemical supercapacitors, electrical double layer model, Principles and materials design, Nanostructured Carbon based materials, Nano-Oxides, Novel hybrid electrode materials, Current status and future trends.

References:

1. Electrochemical methods: Fundamentals and Applications, Allen J. Bard and Larry R. Faulkner, 2nd Edition John Wiley & Sons. Inc (2004).
2. D. Linden Ed., Handbook of Batteries, 2nd edition, McGraw- Hill, New York (1995).
3. G.A. Nazri and G. Pistoia, Lithium Batteries: Science and Technology, Kulwer Acdemic Publishers, Dordrecht, Netherlands (2004).
4. J. Larmine and A, Dicks, Fuel Cell System Explained, John Wiley, New York (2000).
5. Science and Technology of Lithium Batteries-Materials Aspects: An Overview, A. Manthiram, Kulwer Academic Publisher (2000).
6. M.S. Whittingham, A.J, Jacobson, Intercalation Chemistry, Academic Press, New York (1982).
7. M. Wakihara, O. Yamamoto, (Eds.) Lithium Ion Batteries: Fundamentals and Performance, Wiley –VCH, Weinheim (1996)

NSNT - C 013 **Nanoscience Practical-III** **C 0 0 4 4**

1. Synthesis of ZnO Quantum dots/nanoparticless by Polyol method and characterize them by SEM with EDAX and PL studies.
2. Fabrication of Polymer Nanofibers by Electrospining Method and characterize using SEM.
3. Synthesis of Hydroxyapatite by Sol-gel method and Characterize using XRD analysis.
4. Fabrication of metal oxide thin film coatings using spin coating technique.
5. Electrical Conductivity measurements using Impedance Analyser
6. Synthesis of metal oxide nanoparticles using high energy ball milling
7. Fabrication of self assembled monolayer thin films by Langmuir-Blodgett method.
8. Determine the particle size using particle size analyzer.
9. Analyzing the functional group of some polymers by FTIR spectroscopy.
10. Antibacterial studies of silver nanoparticles by MIC method.
11. Testing the cell viability of metal oxide nanoparticles using tissue culture technique.
12. Fabrication of nanofilms by spray – pyrolysis technique.
13. Electrochemical properties of synthesized nanoparticles using cyclic voltametry studies.

NSNT – E 004 Applications of Nanomaterials E 3 0 0 3

Unit I

Electronic Applications: Applications of nano in IC chips, STM based lithography-Molecular electronics- LEDs-Memories – CNT and Graphene based Electronic devices - transistor based sensors and its general applications- Applications of Nanomaterials in Space

Unit II

Applications of Nanomagnetic materials: Nanomagnetism- Bionanomagnetism- type of magnet materials –tag and drag drug delivery – hyperthermia- hypothermia-MRI

Unit III

Application of Nanomaterials in storage devices. Types of storage devices- solid state memory- types of memory devices- role of nanoelectronics for memory devices –GMR-AMR effect- ultra –small head design- Longitudinal recording media- Superparamagnetic limit and its applications. Phase Change Memory Devices, FeRAM, MRAM, RRAM and Probe storage, molecular memory and atomic memory

Unit IV

Environmental Applications- Bioremediation- removal of bacteria and microbes- sensors for DNA- Proteins, and Biological applications – self assembly systems- tissue culture-nanopharma

References:

1. The Chemistry of Nanomaterials: Synthesis, Properties and Applications. C.N.R. Rao ,A. Muller, A.K.Cheetam (Eds.),(2004) WILEY-VCH Verlag GmbH&Co.,Weinheim
2. "Nanomaterials" B. Vishwanathan, 2010, Narosa Publishers
3. Nanofabrication towards biomedical applications, C.S.S.R.Kumar , J.Harmones .C.Leusenner (Eds), (2005) WILEY-VCH Verlag GmbH&Co., Weinhei
4. Synthesis, Properties, and Applications of Oxide Nanomaterials José A. Rodríguez, Marcos Fernández-García, Copyright © 2007 John Wiley & Sons, Inc.
5. Advanced Magnetic Structures, David Sellmyer and Ralph Skomski, Springer 2009

NSNT -E 005 Biomaterials and Nanobiotechnology for Tissue Engineering E 3 0 0 3

Unit I

Orthopedic: Orthopedic implants – material s used – modes of failure4 – wear debris, stress and strain imbalances at the tissue implant interface. Dental: Dental materials used – modes of dental implant failure – debris, stress and strain imbalances at the tissue implant interface.

Unit II

Cartilage: Cartilage materials used – modes of cartilage implant failure –wear debris, stress and strain imbalances at the tissue implant interface; Vascular materials used – modes of vascular implant failure – wear debris; stress and strain imbalances at the tissue implant interface.

Unit III

Bladder: Bladder implant materials used – modes of bladder implant failure – stress and strain imbalances at the tissue implant interface

Unit IV

Advantages of Nanomaterials use as implants – biological response of implanted materials – desirable and undesirable reactions of the body with implanted materials. Protein interactions with implanted materials: - cellular recognition of Proteins Adsorbed on material surfaces – adhesion – migration differentiation – Cellular Extra cellular Matrix deposition leading to tissue regeneration – foreign-body response – inflammatory response

Reference:

1. William A. Goddard, Sergey Edward Lyshevski, Donald W. Brenner (Ed) Handbook of Nanoscience, Engineering and Technology CRC press 2003
2. Mark A. Ratner, Daniel Ratner (Ed) Nanotechnology; a gentle introduction to the next big idea; Prentice Hall PTR; 2003
3. Joachim Schummer, Davis Baird (Ed) Nanotechnology Challenges: implications for philosophy, Ethics and society ; World scientific ; 2006
4. Richard S. Silberglitt, Philip S. Anton, James Schneider (Ed.) . The global technology revolution: Bio/nano/materials trends and their synergies with information; Rand corporation;2001
5. William Sims Bainbridge, Mihail C. Roco (Ed) Societal implication of Nanosciences and Nanotechnology; Springer;2001
6. Jon J. Kellar (Ed) Functional fillers and nanoscale minerals; new markets/ new horizonsSME science; 2006
7. Davis Baird, Alfred Nordmann, Joachim Schummer (Eds) Discovering the nanoscale; IOP press; 2004
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NSNT – C 015 Bio - Medical Nanotechnology C 4 0 0 4

Unit I.

Bio ceramics for implant coating: calcium phosphates - hydroxy epilates Ti_6Al_4V and other biomedical alloys - implant tissue interfacing – metal organic CVD – use of tricalcium phosphate – biomimetic and solution based processing – osteo porosis – osteo plastic – regeneration of bones by using bio compactable ceramics – biointeractive hydro gels – PEG coating and surface modifications – PEG hyrogels patterned on surfaces – PEG based hyrogels

Unit II.

Tissue Engineering : scaffolds for tissue fabrications – materials for scaffolds – materials for hydrogel scaffolds – scaffolds fabrications technologies – textile technologies – particulate –leaching techniques – phase separation – design of three-dimensional pore architecture – nano-featured and bioactive scaffolds – nano-fiber scaffolds – nanocomposite scaffolds – bioactive scaffolds – scaffolds for stem cells – micro and nanopatterned scaffolds - scaffolds and stem cells – Engineering biomaterial to control cell function – building structure into engineered tissues – fibrous proteins and tissue engineering .

Unit III

Nanomedicine: Diagnosis of diseases, treating and preventing of diseases – targeted for drug delivery – ligand coupled nanoparticle features – methods for coupling targeting ligands to nanoparticles – targeting modalities – barriers to tumor targeting *in vivo* – MRI contrast enhancement - future line of action – Gene delivery – Bio molecular motors - Nanoscale transport systems: molecular shuttle powered by Biomolecular motors

Unit IV:

Nanopharmacy: multi-targeted drugs – delivery of nucleic acids- barriers to therapeutic applications – interaction of organic molecules of the drug with pathological tissue – ligand targeted nanoparticles drug delivery: combining multiple functions - formation of nucleic acid core particle – protective steric coating – surface exposed ligands targeting specific tissues –biocompatible core-shell nanoparticles for medicine – configuration of core – shell structure with different cores, shells and biomolecules-least toxicity-nanocapsules-methods of changing surface characteristics- future prospects.

References

1. Robert.W.Kelsall, Ian.W.Hamley, Mark Geoghegan (Ed), Nano Scale Science And Technology, John Wiley and son, ltd., 2005
2. H.Fujita (Ed), Micromachines As Tools For Nanotechnology, Springer, 2003
3. Mick Wilson Kamali Kannangara Geooff Smith Michelle, Simmons Urkhard Raguse, Nano Technology, Overseas India private Ltd., 2005.
4. Gunter Schmid , Nano Particles, Jhon wiley and sons limited, 2004
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NSNT – C 014 **Advanced Nanobiotechnology** C **4 0 0 4**

Unit I

Biosynthesis of Nanoparticles: Biomineralization - Microbial Nanoparticle production. Biofunctionalizaion of gold nanoparticles – phospholipids polymer nanoparticles – magnetic nanoparticles – CNT – metallic nanoparticles

Unit II

Magnetosomes: Magnetosomes and their biomedical applications – Magnetosome formation – cultivation of magnetotactics Bacteria – Characterization of Magnetosomes – Magnetic cells, isolated magnetosomes.

Unit III

Applications of Biosensors: Biosensors using CNT- FET; DNA detection – glucose detection, CNT based electrochemical biosensor – optical biosensor with metal nanoparticles. Quantum dot based sensors-Dendrimer based biosensor, regent biosensor based on nanoparticles.

Unit IV

Medical Devices: Imaging, implantable sensors, cell specific gene therapy, DNA chips and micro arrays, Surface immobilized protein nano structures Forensic Applications: Collection and analysis of evidence of different types of crime scenes including drugs, DNA analysis, blood splattering, serology, toxicology

References::

1. Nano bio-technology: Concepts, Applications and Perspectives, Christ of M. Niemeyer, Wiley, 2004
2. Microcapsules and Nano particles in Medicine and Pharmacy; M. Donbrow (Editor), CRC Press, 1992
3. Liposomes in Biological Systems; G. Gragoradias & C. Allison, Wiley; 1980 4. Methods in Enzymology, Vol. 112,
4. DNA Arrays: Technologies and experimental strategies ed. E.V. Grigorenko, CRC Press 2002.
5. Robert.W.Kelsall, Ian.W.Hamley, Mark Geoghegan, Nano Scale Science And Technology, John Wiley and son, ltd., 2005
6. H.Fujita (Ed), Micromachines As Tools For Nanotechnology, Springer, 2003
7. Mick Wilson Kamali Kannangara , Geooff Smith Michelle Simmons, Urkhard Raguse Nano Technology, Overseas India private Ltd., 2005.
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NSNT – C 016 **PROJECT** **C 0 0 5 5**

NSNT-E 006 **Computational Nanoscience** **E 3 0 0 3**

Unit I

Introduction: Computational aspects of physics, chemistry and biology- high- performance computers- parallel computing- algorithms- computational complexity- Bio-O notation- P, NP, NP-complete and NP hard algorithms- decision and optimisation problems- examples: travelling salesman problem, Hamiltonian path problem, satisfiability problem.

Unit II

Computational physics: General theory and methods- optical and vibrational properties of materials- mechanical behaviour- multiscale modelling of materials- large- scale simulations- materials at high pressure and high temperature- alloys and nanostructures- semiconductors and electronic materials. Nano grain formation and stability- transport in nanostructures- quantum confined systems- growth aspects of nanotubes- theoretical study of carbon nanotubes- thermal properties of nanostructures-

Unit III

Computational chemistry: General computational chemistry- theory and methods- molecular mechanics- molecular dynamics- theory and applications- combinatorial chemistry- kinetics and collision dynamics- polymers and colloids- solid state and surface chemistry- catalysis, separation and reactions – formulations and QSAR- molecular electronic structure.

Unit IV

Computational Biology: Bioinformatics- algorithms in bioinformatics- molecular modelling- structural bioinformatics- algorithms- computational genomics- computational drug/ molecular design- self-replicating/organizing systems. DNA nanotechnology- DNA and protein computers.

References:

1. Introduction t Algorithms, U. Manber (1989), Addison Wesley, USA
2. Computational Complexity, C.H. Papadimitriou (1994), Addison Wesley, USA
3. Computational methods in physics, chemistry and Biology, P. Harrison (2001), John Wiley and Sons, USA
4. A computational approach to chemistry, D.M. Hirst (1990), Blackwell Scientific Publications, USA
5. Introduction to computational molecular Biology, J. Setubal and J. Meidains (1997), PWS Publishing company, USA
6. Molecular Dynamics Simulations, J.M. Haile (1992), John Wiley and Sons, USA
7. The Art of Molecular Dynamics Simulations, D.C, Rapaport (1995), Cambridge University Press, UK
8. Computational Neuroscience, J. Feng (2004), Chapman and Hall/CRC, USA.

NSNT E 007 Industrial Nanotechnology E 3 0 0 3

Unit I

Semiconductor Nanostructures and devices, Fabrication and Applications of different types of semiconductor Nanostructures- Silicon horizontal and vertical core shell Nanowires- Integrated circuits- Sensors- Electro optical devices.

Semiconductor Quantum dots (QDs) – QD LASER- Quantum cascade LASER-QD optical memory-Present and future trends.

Unit II

Nanoscale Magnetic Materials: Application in magnetic storage devices- storing and reading device – current trends of spin based electronic devices.

Optical storage devices: Near field optical recording- holographic data storage- AFM based recording technology.

Unit III

Nano Electro Mechanical Systems: Overview- Nano-Electromechanical systems - fabrication process- choice of materials, performance of different structures - advantages and disadvantages of different approaches. Applications in sensors, Micro actuators - Extension to the Nanoscale.

Unit IV

Industrial Applications of Nanomaterials: Nanoparticles and Micro –organism, Nano-materials in bone substitutes & Dentistry, Food and Cosmetic applications, Textiles, Paints, Catalysis, Drug delivery and its applications, Biochips- analytical devices, Biosensors.

References:

1. Dr.Parag Diwan And Ashish Bharadwaj, Nano Electronics, Pentagen press, 2006
2. Turner.C.W. and Van Duzer.T, Principles of Superconductive Devices and Circuits, 1981
3. Yariv.A, Principles of Optical Electronics, John Wiley, New York, 1984
4. M C Petty, M R Bryce, D Bloor (eds.), 'Introduction to Molecular Electronics', Edward Arnold, London, 1995 (ISBN 0-340-58009-7)
5. D D C Bradley, Current Opinion in Solid State & Materials Science Vol. 1, 789 (1996)
6. Rainer Waser, Nano Electronics And Information Technology, John Wiely and sons publication, 2003