BHARATHIAR UNIVERSITY COIMBATORE 641 046

M.Sc. Nanoscience and Technology (2010-11 onwards)

(The curriculum is offered by the University Department under CBCS)

Scheme of Examinations

Sem	Code No.	Subject	Class hours	University Examination			
				Internal	External	Total	Credit
I	13A	Elements of Physics	3	25	75	100	4
	13B	Materials Physics	3	25	75	100	4
	13C	Chemistry of Nanomaterials and Basics of Nanomaterials	3	25	75	100	4
	13D	Biology for Nanotechnology	3	25	75	100	4
	1EA	Electronic Devices (Elective)	3	25	75	100	4
	13P	Practical – I	6	25	75	100	4
		Supportive - I	2	12	38	50	2
II	23A	Synthesis of Nanomaterials	3	25	75	100	4
	23B	Characterization of Nanomaterials	3	25	75	100	4
	23C	Micro and Nano Fabrication	3	25	75	100	4
	23D	Nanobiotechnology	3	25	75	100	4
	2EB	Nanoelectronics (Elective)	3	25	75	100	4
	23P	Practical - II	6	25	75	100	4
		Supportive – II	2	25	75	50	2
III	33A	Nanomaterials for Drug Delivery	3	25	75	100	4
	33B	Nanotechnology for Agriculture and Environment	3	25	75	100	4
	33C	Carbon Nanostructures and Applications	3	25	75	100	4
	33D	Applications of Nanotechnology	3	25	75	100	4
	3EC	Nanoscale Magnetic Materials and Devices (Elective)	3	25	75	100	4
	33P	Practical - III	6	25	75	100	4
		Supportive - III	2	25	75	50	2
IV		Project and Viva – Voce	16	25	75	200	8
	43A	Theory paper related to project	4	25	75	100	4
						2250	**90**

Total Marks : 2250 Marks **Credits: 90**

M.Sc. – Nanoscience and Technology

Admission

Candidates holding B. Sc. in Physics, Chemistry, Biology, Biotechnology, Microbiology with Mathematics as part of their curriculum at least in the plus two level are eligible for the admission of M. Sc. Nanoscience and Technology.

About the Course:-

This M. Sc. Programme in Nanoscience and Nanotechnology is attractive to those students who wish to gain the skills and experience required to join the new generation of researchers in the field of Nanoscience and Nanotechnology. It adopts an integrated, multidisciplinary, intellectual strategy, with contributions from physics, chemistry, biology and engineering.

The course structure is as follows:

Introductory Course Modules: Nanoscience takes place at the crossroads of physics, chemistry, biology and engineering. As most students entering this M.Sc. programme have a background in just one of these disciplines, special introductory course modules are provided to eliminate knowledge deficiencies in the other disciplines.

Compulsory Course Modules: A number of course modules are offered and that covers the full range of phenomena and techniques at the nanoscale level, including synthesis, characterization, nanofabrication, nanomedicine and drug delivery systems, nanobiotechnology, nanotechnology in agriculture, Environment and its applications in Sensors, Energy Devices, Biomedical and defence applications. This compulsory part of the programme ensures the multidisciplinary background that is vital to all branches of nanoscience.

Elective Modules: Students will also have ample opportunity to further broader or deepen their knowledge further by taking elective modules according to their personal choice. The electives include subjects such as electronics, nanoelectronics, nanoparticulate materials, spectroscopy, nanoscale magnetic materials and devices, scanning probe microscopy and many more…

Internship/Master Thesis: The research project will be carried out in one of the reputed national laboratories. The research project is finalized with the public presentation of a Master's thesis.

Notes:-

1. The students of M. Sc. Course have to attend 75 % of lectures, practical and any other term work as may be prescribed by the University. The conduct and behavior of the student must satisfy the Head of the Department.
2. The Head of the Department certifies that the student has attended the course as prescribed and has conducted himself satisfactorily. In absence of such certificate the student shall not be permitted to the University Examination.
3. The University Examinations for all the terms shall be conducted at the end of the term.
4. The Credit Structure is based on M. Sc. Credit Guidelines approved by University Academic Council.

Core Paper 1: Elements of Physics (13A)

Unit–I: Classical Mechanics

Basic Principles of Classical Dynamics – Conservation laws, Conservation of Angular Momentum and Energy - Generalized and Cyclic Co-ordinates – Limitations of Newton's Law - Hamiltonians Variation Principle - D' Alemberts Principle - Derivation of Lagrangian Equation of Motion from D' Alemberts Principle and Hamilton's Principle - Simple Application of Lagrangian Equation - Hamiltonian's Canonical Equations of Motion - Compound Pendulum, Simple Pendulum, Particle in a Central Field of Force.

Unit–II: Statistical Mechanics

Fundamentals of Statistical Mechanics and Thermodynamics: Phase Space – Ensembles: Types of Ensembles – Microcanonical, Canonical, Grand Canonical Ensembles - Uses of Ensembles – Classical Distribution Law: Microstates and Macro states – Stirling's Approximation - Maxwell-Boltzman Distribution Law - Bose-Einstein Distribution Law - Fermi-Dirac Distribution Law – Comparison of the Three Distribution Laws.

Unit–III: Quantum Mechanics-I

Basis of Quantum Physics – De Broglie's Concept – Operators – Bra and Ket Notation-Normalized and Orthogonal Wave Function - Heisenberg's Uncertainty Principle – Linear Harmonic Oscillator – Hydrogen Atom - Energy Eigen value - Angular Momentum – Total Angular Momentum Operators – Commutation Relationship with Components.

Unit–IV: Quantum Mechanics-II

WKB Approximation – Variational Method – Scattering – Differential Scattering – Scattering Cross-Section - Scattering Amplitude - Stationery Perturbation Theory- Non Degenerate Case – First Order Perturbation – Evaluation of First Order Energy and Wave Function – Degenerate Case – Removal of Degeneracy in the First Order.

Text Books

1. Classical Mechanics, L.S. Gupta, V. Kumar, and H.V. Sharma, Pragati Prakashan Publication (2007).
2. Statistical Mechanics, by Gupta and Kumar, Pragati Prakashan Publication and Modern Physics, by R. Murugeshan, Ninth Edition.
3. Quantum Mechanics – Satya Prakash and C. K Singh Kedar Nath and Ram Nath Co
4. Quantum Mechanics – G. Aruldhas – Princitan Hall of India, New Delhi

Reference

1. Classical Mechanics, H. Goldstein, Charless Poole and John Safco, Addison Wesley (2000).
2. Classical Mechanics, N.C. Rana and P.S. Joag, Tata Mc Graw Hill (1991).
3. Sommerfield, Mechanics, Academic Press (1952).
4. G.H. Wannier , Statistical Physics.(2^{nd} edition).
5. Quantum mechanics, L. I. Schiff, McGraw-Hill Book Co Inc. (1949).
6. Modern Physics and Quantum Physics – E.E Anderson, Macmillan Co., India

Core Paper 2: Materials Physics (13B)

Unit-I: Introduction

Crystal Structure: Basis of Crystal Structure – Unit Cell: Primitive Cell Structures – Symmetry Operation – Types of Symmetry Operation – Translation Operation, Point Operation, Hybrid Operation – Crystal Types – Two and Three Dimensional Crystal Lattices – Indices of a Lattice Direction and a Lattice Plane - Miller Indices – Crystal Imperfections: Point Imperfections – Vacancy, Substitution and Interstitial Impurity - Elastic Constants of Crystals – Elastic Stress, Elastic Strain.

Unit-II: Free Electron Fermi Gas

Energy Levels in One Dimension – Derivation of Fermi-Dirac Distribution – Effect of Temperature on the Fermi-Dirac Distribution – Free Electron Gas in Three Dimension – Derivation of Expression for Electrical Conductivity in Metals - Derivation of Expression for Thermal Conductivity in Metals: Weidman-Franz Law - Phonons - Phonon Heat Capacity: Planck Distribution - Normal Mode Enumeration - Density of States in One and Three Dimension - Debye Model for Density of States - Debye T^3 Law.

Unit–III: Magnetism and Dielectrics

Diamagnetism: Classical Theory of Diamagnetism (Langevin's Theory) - Paramagnetism: Classical Theory of Paramagnetism (Langevin's Theory and Curie Law for Paramagnetism) – Polarization and Susceptibility –The Local Field – Dielectric Constant and Polarizability - Source of Polarizability: Electronic, Ionic and Orientation Polarization - Frequency Dependence of Total Polarization.

Unit–IV: Ferroelectricity and Superconductors

Basics of Ferroelectricity - Superconductivity: Introduction – Meissner effect – Supercurrents and Penetration Depth - Critical Field and Critical Temperature – Soft Superconductors (Type I) – Hard Superconductors (Type II) - Some Applications of Superconductors.

Text Books

1. Introduction to Solid State Physics, Charles Kittel, John Wiley & Sons Inc., 7^{th} Edition, (1996).
2. Elements of Solid state Physics, by J.P. Srivastava, Prentice Hall of India Private Limited.
3. Solid State Physics and Electronics, by R.K.Puri and V.K.Babbar, S.Chand & Company Ltd.

Reference

1. Solid State Physics, Neil W. Ashcroft and N. David Mermin, Harcourt College Publishers (1976).
2. Materials Science and Engineering, by V. Raghavan, Fourth Edition
3. Introduction to Solid State Theory, by Madelung
4. Quantum Theory of Solid State, by Callaway
5. Quantum Theory of Solid State, by C. Kittel

Core Paper 3: Chemistry of Materials and Basics of Nanomaterials (13C)

Unit-I: Atomic Structure

Inside the Atom: Atomic structure - Isotopes - Mass Spectrometer - Electronic Structure of Atoms - Evidence for the Existence of Energy Levels in Atoms - More Advanced Ideas about Electronic Structure; Bonding Between Atoms: Why Atoms Combine - Ionic Bonding - Covalent Bonding- Coordinate Bonding - Ionic and Covalent Compounds – Two Extremes - Resonance Structures; Reactions of Ions in Solution: Dissolution of Salts in Water - Ionic Equations - Producing Ions in Water by Chemical Reaction - Acids and Bases - Reactions of Acids - Acids Produced when Gases CO_2, SO_2 and NO_2 Dissolve in Water - Reactions of the Hydroxide Ion - Use of Reactions in the Identification of Ions in Solution; Oxidation and Reduction: Redox Reactions - Oxidation Numbers - Oxidizing and Reducing Agents - Writing and Balancing Redox Equations- Redox Couples - Activity Series of Metals - Corrosion of Iron - Redox Reactions in Nature.

Unit-II:Chemical Reactions

The Mole : Molecular Mass – Moles - Percentage Composition by Mass - Water of Crystallization - Calculating Amounts from Equations - Calculating Gas Volumes - Percentage Yield - Limiting Reagents; Calculating Concentrations: Concentration of Solutions- Standard Solutions- Volumetric Analysis - Other Units of Concentration - pH Scale; Gases, Liquids and Solids: Heat and Temperature - Changes in the State of Matter - Gas Laws - Kinetic Molecular Theory of Gases - Ideal Gas Equation - Adsorption of Gases on Solids - Vapour Pressure - Critical Temperature and Pressure; Solutions and Solubility : Solubility - Dynamic Nature of Dissolution - Solubility of Sparingly Soluble Ionic Compounds - Distribution of a Solute between Two Solvents - Solubility of Gases in Water - Osmosis - Colloids; Energy Changes in Chemical Reactions : Conservation of Energy - Key Points about Enthalpy Changes - Determination of ΔH in the Laboratory - Special kinds of Standard Enthalpy Change - Standard Enthalpy of Formation - Standard Enthalpy of Combustion – Nutrition - Lattice Enthalpy - Energetics of Bond Breaking and Bond Making; Speed of Chemical Reactions: Reaction Rate - Factors Affecting Reaction Rate - Reaction Rate Expressions - Examples of Rate Expressions found by Experiment - Calculations using Rate Expressions - More about First-Order Reactions - Reaction Mechanisms – Catalysis.

Unit-III: Chemical Equilibria

Dynamic Chemical Equilibria : Equilibrium Law and Equilibrium Constant - Meaning of Equilibrium Constants - Effects of Changing Concentration, Pressure and Temperature upon Equilibria - Production of Ammonia by the Haber–Bosch Process - Heterogeneous Equilibria; Acid–Base Equilibria: Ionic Equilibria in Water - Acids and Bases in Aqueous Solution - Hydrolysis of Salts - Buffer Solutions - Acid–Base Indicators - Variation of pH during an Acid–Base Titration - Buffering Action of Carbon Dioxide in Water; Organic Chemistry: Hydrocarbons : Alkanes – Alkenes – Alkynes - Aromatic Hydrocarbons: Common Classes of Organic Compounds: Halogenoalkanes – Alcohols - Carbonyl Compounds - Carboxylic Acids – Amines - Optical Isomerism - Amino Acids and Proteins - Substituted Benzene Derivatives; Separating Mixtures: Separating a Solid from a Liquid - Separating two Liquids - Separating Solids - Steam Distillation - Ion Exchange - Solvent Extraction – Chromatography.

Unit-IV: Basics of Nanomaterials

Size Effect and Properties of Nanoparticles: Particle Size - Particle Shape - Particle Density - Melting Point, Surface Tension, Wettability - Specific Surface Area and Pore - Composite Structure - Crystal Structure - Surface Characteristics - Mechanical Property - Electrical Properties - Magnetic Properties - Optical Property of Nanoparticles; Quantum Dot : Quantum Confinement in Semiconductors – Making Quantum Dots – Optical Properties – Applications.

Text Books

1. Chemistry, Rob Lewis and Wynne Evans, Palgrave MacMillan, 3rd Edition (2006).
2. Nanoparticle Technology Handbook, Ed. By Masuo Hosokawa, Kiyoshi Nogi, Makio Naito and Toyokazu Yokoyama, Elsevier (2007).
3. http://en.wikipedia.org/wiki/Quantum_Dot

Reference

1. Materials Chemistry, Bradley D. Fahlman, Springer (2008).

Core Paper 4: Biology for Nanotechnology (13D)

Unit-I

Structure and Organization of Prokaryotic and Eukaryotic Cell (Animal Cell & Plant Cell), Tissues and Organs, Cell and Tissue Culture – Application of Plant Transformation for Productivity and Performance - Green House and Green House Technology. Animal Cell Culture Technology – Applications of Animal Cell Culture-Stem Cell Culture, Artificial Organ Synthesis.

Unit-II

Introduction to Gene – Protein - Central Dogma of Cell - Molecular Targets - Estimation of RNA, Estimation of DNA, Protein Estimation.

Unit-III

Recombinant DNA Technology, Scope and Milestones in Genetic Engineering –Molecular Tools used in Genetic Engineering - Gene Cloning – Ethical Issues – Merits and Demerits of Cloning – Transgenic Organisms. Genomics and Functional Genomics - Whole Genome Analysis – Human Genome Project, Gene Therapy, Gene Delivery.

Unit-IV

Basic Immunology and Immune System – Antigen, Antibody Structure and its Types, Humoral Immunity, Cell Mediated Immunity, Introduction, to Complement System- MHC & Graft Transplantation and Graft Rejection.

Text and Reference Books

1. Immunology, Kuby J, WH Freeman & Co. (2000).
2. Immunology, Tizard, 4th Edition.
3. General Microbiology, Stanir R.Y. Ingraham J.L. Wheelis M.L. Painter R.R. McMillan Publications (1989).
4. Environmental Biotechnology, Foster C.F. John Ware D.A. Ellis, Honwood Ltd. (1987).
5. Microbiology, Pelczar MJ, Chan ECS And Krein NR, Tata McGraw Hill Edition, New Delhi, India; (2001).
6. Nanobiotechnology: Concepts, Applications and Perspectives, M. Niemeyer, Wiley, (2004).
7. Nanoscale Science and Technology, Robert.W.Kelsall, Ian.W.Hamley, Mark Geoghegan, John Wiley and Son, Ltd. (2005).
8. Micromachines As Tools For Nanotechnology, H.Fujita (Ed), Springer (2003).
9. Nano Technology, Mick Wilson Kamali Kannangara , Geooff Smith Michelle Simmons, Urkhard Raguse, Overseas India private Ltd., (2005).
10. Nano Particles, Gunter Schmid (Ed), Jhon Wiley and Sons Limited (2004)
11. Nano Biotechnology, Horizions Biosciences, K.K.Jain, (2006)
12. From Genes to Clones by Ernat-.L.Winnacker, Panima Publishing Corporation, India (2003).
14. Biotechnology : Fundamentals and Applications by S.S. Purohit , Agrobios(Ind), Jodhpur, (2002)
15. Principles of cloning by Jose Cibelli,Robert P.Lanza, Keith H.S. Campbell, Michael D.West, Academic Press (2002).

Elective Paper 1: Electronic Devices (1EA)

Unit–I: Semiconductor Physics

Electrons and Holes in an Intrinsic Semiconductor – Donor and Acceptor Impurities – Charge Densities in a Semiconductor – The Hall Effect – Conducting Modulation – Generation and Recombination of Charges – Diffusion - - Continuity Equation – Injected Minority Carrier Charge – The Potential Variation within a Graded Semiconductor – Carrier Concentrations in an Intrinsic Semiconductor – Fermi Level in a Semiconductor having Impurities – Band Structure of Open Circuit p-n Junction.

Unit–II: Basic Devices

Bipolar Junction Transistor (BJT) – Field Effect Transistor (FET) - Junction Field Effect Transistor (JFET), Metal Oxide Semiconductor Field Effect Transistor (MOSFET) and Metal-Semiconductor Junction Field Effect Transistor (MESFET): Structure, Working, I-V Characteristic Studies and its Applications.

Unit–III: Advanced Devices

Transfer Electron devices (Gunn Diode) – Principle, Working, I-V Characteristic Studies and Applications - PIN Diode: Structure, Working, - PIN Diode Parameters - PIN Diode as Switches - PIN Diode as Limiters - Photo Detectors – Photo Diode - Light Emitting Diode (LED) – Principle, Construction, Working and Characteristics – Laser - Absorption and Emission of Radiation – Population Inversion – Semiconductor and Diode Lasers.

Unit–IV: Digital Principles

Master Slave, J.K, Edge Triggered JK and D-Type Flip Flops – Set up, Hold and Propagation Delay Times - Shift Registers – Counters – Ring Counter – Up Down Counter – Synchronous Counters.

Text Books

1. Integrated Electronics – Jacob Millman and C. Hal Kias, Tat McGraw Hill Publishing Co. (1971).
2. Basic Electronics (Solid State), B.L. Theraja, S. CHAND (2006).
3. Microwaves, M.L. Sisodia, V.L. Gupta, New Age International (2001).
4. Semiconductor Devices, Kanaan Kano, Prentice Hall of India Pvt. Ltd.
5. Modern Physics, R. Murugeshan, Ninth Edition
6. Digital Computer Fundamentals, Thomas C. Bartee, Tata Mc Graw Hill
7. Optical Electronics, Ajoy Ghatak and K. Thyagarajan, Cambridge University Press
8. Digital Circuits and Microprocessors, Herbert Taub, McGraw Hill (1982).

Reference

1. Physics of Semiconductor Devices, S. M. Sze and Kwok K. Ng, Wiley Interscience, 3rd Edition (2007).
2. Introduction to Semiconductor Devices, M.S. Tyagi, John Wiley & sons.
3. Measurement Instrumentation and Experimental Design in Physics and Engineering, M. Saver and A. ManSingh, Prentice Hall, India (2000).

Practical - I (13P)

Resistivity of Semiconductors by Two Probe Method at Different Temperatures and Determination of the Band-gap

Hall Effect Experiment

Apparatus for Measurement of Susceptibility of Paramagnetic Solids by Gouy's Method

Diode Characteristics

Magnetic Hysteresis Loop Tracer

Light scattering and particle size measurements (LASER)

Measure the thickness of the given thin film by MBI.

Core Paper 5: Synthesis of Nanomaterials (23A)

Unit-I: Chemical Methods

Sol-Gel Process — Self assembly – Metal Nanocrystals by Reduction - Solvothermal Synthesis - Photochemical Synthesis - Sonochemical Routes – Reverse Micelles and Micro emulsions - Combustion Method – Template Process - Chemical Vapor Deposition (CVD) – Metal Oxide Chemical Vapor Deposition (MOCVD)

Unit-II: Physical Methods

Ball Milling – Electrodeposition - Spray Pyrolysis - Flame Pyrolysis - Inert Gas Condensation Technique (IGCT) – Thermal evaporation – Pulsed Laser Deposition (PLD) – DC/RF Magnetron Sputtering - Molecular Beam Epitaxy (MBE).

Unit-III: Biological Synthesis

Introduction - Natural Nanocomposite Materials - Biologically Synthesized Nanoparticles, Nanostructures and Synthetic Nanocomposites - Protein-Based Nanostructure Formation - DNA-Templated Nanostructure Formation - Protein Assembly - Biologically Inspired Nanocomposites - Lyotropic Liquid-Crystal Templating - Liquid-Crystal Templating of Thin Films - Block-Copolymer Templating - Colloidal Templating.

Unit-IV: Nanocomposites

Ceramic/Metal Nanocomposites - Metal Matrix Nanocomposites - Nanocomposites for Hard Coatings – Nanopolymers : Preparation and characterization of diblock Copolymer based nanocomposites – Nanoparticles polymer ensembles; Assembly of polymer – Nanoparticles composite material.

References

1. Nanoelectronics and information technology: Advanced electronic materials and novel devices (2nd edition), Rainer Waser (Ed.), Wiley-VCH Verlag, Weiheim (2005).
2. Recent Advances in the Liquid-phase syntheses if inorganic nanoparticles, Brain L.Cushing, Vladimir L.Kolesnichenko, Charles J. O'Connor, Chem Rev. 104 (2004) 3893-3946.
3. Nanocrystals: Synthesis, Properties and Applications, C. N. R. Rao, P. J. Thomas and G. U. Kulkarni, Springer (2007).
4. Nanotechnology - Enabled Sensors, Kourosh Kalantar-zadeh and Benjamin Fry, Springer (2008).
5. Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Gao, Imperial College Press (2004).
6. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge, UK (2005).
7. Nanocomposite science and technology, Pulickel M.Ajayan, Linda S.Schadler, Paul V.Braun, Wiley-VCH Verlag, Weiheim (2003).
8. Amorphous and Nanocrystalline Materials: Preparation, Properties, and Applications, A.Inoue, K.Hashimoto (Eds.,) (2000).
9. Plant Tissue Culture : Applications and Limitations, Bojwani, S.S, Elsevier, Amsterdam (1990).
10. Principles of Gene Manipulation, An Introduction To Genetic Engineering, Old RW, Primrose SB, , Blackwell Science Publications, (1993).
11. Polymer – Clay Nanocomposite – T.J. Pinnayain, G.W. Beall, Wiley, New York (2001).
12. Block Co-polymers in Nanoscience – Massimo Lazzari, Guojun Liu, Sebastien Lecommandoux, Wiley, New York (2007).

Core Paper 6: Characterization of Nanomaterials (23B)

UNIT-I: Microstructural Characterization

X-ray diffraction - Debye-Scherer formula – dislocation density – micro strain, Neutron Diffraction – Principle – Applications - comparison of X-ray and neutron powder pattern - Synchrotron Radiation – Principle and Applications –Raman Spectroscopy and Applications – Dynamic Light Scattering (DLS).

Unit-II: Physical and Chemical Characterization

Electron microscopes – scanning electron microscope (SEM) – transmission electron microscope (TEM) - atomic force microscopy (AFM) – scanning tunneling microscope (STM) - XPS – Mass Spectrometer – Secondary Ion Mass Spectrometer (SIMS) -Working Principle, Instrumentation and Applications.

Unit–III: Electrical, Mechanical and Magnetic Properties

Impedance Analysis - Micro hardness - fatigue - failure stress and strain toughness – abrasion and wear resistance, super plasticity – nanoindentation – vibrating sample magnetometer – Nuclear Magnetic Resonance (NMR).

Unit–IV: Thermal and Optical Properties

Differential scanning calorimeter (DSC) – Thermogravimetric/Diffferential Thermal Analyzer (TG/DTA) – UV – Visible Spectrophotometer - FTIR – Principle and Applications – Photoluminescence (PL) Spectroscopy.

References

1. Encyclopedia of Materials Characterization, C. Richard Brundle, Charles A. Evans Jr., Shaun Wilson, Butterworth-Heinemann Publishers (1992).
2. Handbook of Microscopy for Nanotechnology, Ed. By Nan Yao and Zhong Lin Wang, Kluwer Academic Press (2005).
3. Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Gao, Imperial College Press (2004).
4. Nanotechnology - Enabled Sensors, Kourosh Kalantar-zadeh and Benjamin Fry, Springer (2008).
5. Nanochemistry, G. B. Sergeev, Elsevier (2006).
6. Nanotechnology: Basic Science and Emerging Technologies – Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005).
7. Nanocomposite Science and Technology, Pulickel M.Ajayan, Linda S.Schadler, Paul V.Braun, Wiley-VCH Verlag, Weinheim (2003).

Core Paper 7: Micro and Nanofabrication (23C)

Unit-I: Basic Microfabrication Techniques

Basic Microfabrication Techniques: Lithography - Thin Film Deposition and Doping : Oxidation – Doping – Chemical Vapor Deposition and Epitaxy – Physical Vapor Deposition – Electroplating - Etching and Substrate Removal : Wet Etching – Dry Etching – Substrate Bonding : Si Direct Bonding – Anodic Bonding – Bonding with Intermediate Layers.

Unit-II: MEMS and NEMS

MEMS Fabrication Techniques: Bulk Micromachining - Surface Micromachining - High-Aspect-Ratio Micromachining - Nanofabrication Techniques: e-Beam and Nano-Imprint Fabrication - Epitaxy and Strain Engineering - Scanned Probe Techniques - Self-Assembly and Template Manufacturing.

Unit-III: Materials Aspects and Applications of MEMS/NEMS

Silicon - Germanium-Based Materials – Metals - Harsh Environment Semiconductors - GaAs, InP, and Related III-V Materials - Ferroelectric Materials - Polymer Materials - Future Trends - MEMS Devices and Applications - NEMS Devices and Applications - Current Challenges and Future Trends.

Unit-IV: Clean Room and Process Integration

Clean Rooms: Clean room standards – Clean room sub systems – Environment, Safety and Health Aspects – Process Integration : Junction and Oxide Isolation – LOCOS Methods – Trench Isolation – Silicon on Insulator Isolation Techniques – Semi insulating Substrates – Schottky Contacts – Implanted Ohmic Contacts – Alloyed Contacts – Multilevel Metallization – Planarization and Advanced Interconnect.

Text Books

1. Springer Handbook of Nanotechnology, Bharat Bhushan, Springer (2004).
2. Introduction to Microfabrication, Sami Franssila, John Wiley & Sons Ltd. (2004).
3. The Science and Engineering of Microelectronic Fabrication, Stephen A. Campbell, Oxford University Press (2001).

References

1. Microfabrication and Nanofabrication, Ed. By Mark J. Jackson, CRC Taylor & Fancis (2006).
2. Nano- and Microelectromechanical Systems : Fundamentals of Nano- and Microengineering, Edited by Sergey Edward Lyshevski, CRC Press (2001).

Core Paper 8: Nanobiotechnology (23D)

Unit - I: Biological Nano-objects

Structural and Functional Regulation of DNA: Geometry, Topology and Methylation : Geometry of the DNA Double Helix - The Z Conformation of DNA.- Supercoiled DNA - Methylation of DNA - Protein–Lipid Assembly and Biomimetic Nanostructures : Introduction: Biological Membranes - Lipid Membranes: Structure and Properties - Models and Methods for Characterising Membranes - Protein–Lipid Assembly - Applications of Biomimetic Membranes

Unit-II: Functionalised Inorganic Nanoparticles for Biomedical Applications and Living Machines

Synthesis and Chemical Surface Modification of Inorganic Nanoparticles – Biological Tagging in Vitro and in Animals - *In-Vivo* Applications - Living Nanomachines: Introduction - Force and Motion by Directed Assembly of Actin Filaments - Molecular Motors: Myosins and Kinesins - ATP Synthase.

Unit-III: Methods of Nanobiotechnology

Optical tools – Nanoforce and imaging – Surface methods – Mass spectrometry – Electrical Characterization and Dynamics of Transport – Microfludics : Concepts and Applications to the Life Sciences.

Unit-IV: Applications of Nanobiotechnology

Real Time PCR – Biosensors : From the Glucose electrode to the Biochip – DNA Microarrays – Protein Microarrays – Cell Biochips – Lab on a chip – Polyelectrolyte multilayers – Biointegrating materials – Pharmaceutical applications of nanoparticles carriers.

Text Book

1. Nanoscience : Nanobiotechnology and Nanobiology, Ed. By P. Boisseau, P. Houdy and M. Lahmani, Springer (2007)

References

1. Nanoelectronics and Nanosystems: From Transistors to Molecular Devices. K.Goser, P. Glosekotter, J. Dienstuhl, Springer (2004).
2. Nanotechnology: Basic Science and Emerging Technologies – Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005).
3. Nanobiotechnology**:** Concepts, Applications and Perspectives, Christof M.Niemeyer, Chad A.Mirkin, (eds.), Wiley-VCH, Weinheim, (2004).
4. Bionanotechnology : Lessons from Nature**,** by: David S. Goodsell, Wiley-Liss (2004)
5. NanoBiotechnology Protocols**,** Sandra J Rosenthal, David W.Wright, Series: Methods in Molecular Biology, (2005).
6. Protein Nanotechnology, Protocols, Instrumentation, and Applications, Tuan Vo-Dinh, Series: Methods in Molecular Biology (2005).

Elective 2: Nanoelectronics (2EB)

Unit-I : Basics of Nanoelectronics

Some Physical Fundamentals: Electromagnetic Fields and Photons – Quantization of Action, Charge and Flux – Electrons Behaving as Waves (Schrodinger Equation) – Electrons in Potential Wells – Photons Interacting With Electrons in Solids – Diffusion Process, Biological Networks – Biological Neuronal cells on Silicon – DNA and Quantum computers.

Unit-II: Quantum Electronics

Quantum electronic devices - from classical to quantum physics: upcoming electronic devices – electrons in mesoscopic structure – short channel MOS transistor – split gate transistor – electron wave transistor – electron spin transistor – quantum cellular automate – quantum dot array – principles of Single Electron Transistor (SET) – SET circuit design – comparison between FET and SET circuit design.

Unit-III: Tunneling and Flux Quantum Devices

Nanoelectronics with tunneling devices and super conducting devices – tunneling element technology RTD – circuit design based RTD –Defect tolerant circuits, Molecular electronics - elementary circuits – flux quantum devices – applications of super conducting devices.

Unit-IV: Applications

Memory devices and sensors – Nano ferroelectrics - ferroelectric random access memories – introduction – Fe RAM circuit design – ferroelectric thin film properties and integration – calorimetric sensors – electrochemical cells – surface and bulk acoustic devices – gas-sensitive FETs – resistive semiconductor gas sensors – electronic noses – identification of hazardous solvents and gases – semiconductor sensor array.

Text Books

1. Nanoelectronics and Nanosystems: From Transistors to Molecular Devices. K.Goser, P. Glosekotter, J. Dienstuhl, Springer (2004).
2. Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices (2nd edition), Rainer Waser (Ed.), Wiley-VCH Verlag, Weiheim (2005).
3. Nanotechnology: Basic Science and Emerging Technologies – Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005).

References

1. Nano and Molecular Electronics Handbook, Edited by Sergey Edward Lyshevski, CRC Press (2007).

Practical - II (23P)

Preparation of nanoparticle by co-precipitation method

Solvothermal method of preparing Metal Oxides

Thin film preparation (Sputtering and Chemical bath Deposition)

Polymer nanocomposites

Preparation of nanoparticle by ball milling.

Conductivity studies of nanocomposite material – Four probe method

Synthesis of nanocomposite materials

Dielectric Studies by Impedance (Frequency Response) Analyzer

Solvothermal method for ZnO and study its optical properties.

Study of Bacterial Adhesion on TiO_2 nanoparticles

Core Paper 9 Nanomaterials for Drug Delivery (33A)

Unit-I: The Prospect of Nanomedicine

A Noble Enterprise - Current Medical Practice - The Evolution of Scientific Medicine - Volitional Normative Model of Disease - Treatment Methodology - Evolution of Bedside Practice - Changing View of the Human Body - The Nanomedical Perspective - Nanomedicine and Molecular Nanotechnology - Nanomedicine: History of the Idea - Biotechnology and Molecular Nanotechnology – Naturophilia.

Unit-II: Nanocarriers for Drug Delivery

Needs and Requirements – Nanoparticle Flow: Implications for Drug Delivery – Polymeric Nanoparticles as Drug Carriers and Controlled Release Implant Devices – Genetic Vaccines: A Role for Liposomes – Polymer Micelles as Drug Carriers – Recent Advances in Microemulsions as Drug Delivery Vehicles – Lipoproteins as Pharmaceutical Carriers – Solid Lipid Nanoparticles as Drug Carriers

Unit-III: Nanocapsules – A New Drug Delivery System

Nanocapsules preparation, Characterization and Therapeutic Applications – Dendrimers as Nanoparticulate Drug Carriers – Cells and Cell Ghost as Drug Carriers – Cochleates as Nanoparticular Drug Carriers – Aerosols as Drug Carriers – Magnetic Nanoparticles as Drug Carriers.

Unit-IV: Nanocarriers

Nanoparticulate Drug Delivery to the Reticuloendothelial System and to Associated Disorders – Delivery of Nanoparticles to the Cardiovascular System – Nanocarriers for the Vascular Delivery of Drugs to the Lungs – Nanoparticulate Carriers for Drug Delivery to the Brain – Nanoparticles for Targeting Lymphatics – Polymeric Nanoparticles for Delivery in the Gastro-Intestinal Tract – Nanoparticular Carriers for Ocular Drug Delivery – Nanoparticles and Microparticles as Vaccines Adjuvants – Pharmaceutical NanoCarriers in Treatment and Imaging of Infection

Text Books

1. Nanomedicine, Volume I: Basic Capabilities, Robert A. Freitas Jr., Landes Bioscience, USA.
2. Nanoparticulates as Drug Carriers Edited by Vladimir P.Torchilin, Imperial College Press, North Eastern University, USA (2006) ISBN 1-86094-630-5

References

1. Nanotechnolgy for Cancer Therapy, Edited by Mansoor M. Amiji, CRC Press (2007).
2. Nanomaterials and Nanosystems for Biomedical Applications, Edited by M. Reza Mozafari, Springer (2007).
3. Nanomedicine, Vijay K. Varadan, Linfeng Chen, Jining Xie, A John Wiley and Sons, Ltd., Publication (2008).

Core Paper 10: Nanotechnology for Agriculture and Environment (33B)

Unit-I: Nanotechnology in Food

Evolution of New Technologies in the Food Sector - Public Perception of Nanotechnology Food Products - Potential Benefits and Market Drivers - Current and Projected Applications of Nanotechnology for the Food Sector - Potential Health Effects - Potential Health Risks and Governance of Risks - Adequacy of Regulatory Frameworks - Naturally Occurring Food Nanosubstances and Nanostructures – Carbohydrates – Proteins - Nanoscience Studies of Food Structure - Designing Food Nanostructures - Designer Starches - Designer (Nano)foams and Emulsions - The Status of Natural Nanostructures in Food.

Unit-II:Nanostructured Food and Packaging Materials

Natural Food Nanostructures - Naturally Occurring Food Nanosubstances and Nanostructures - Designing Food Nanostructures - The Status of Natural Nanostructures in Food - Nanomaterials for (Health)food Applications - Nano-sized Food Ingredients and Additives in Relation to Digestion of Food - Nanotechnologies in Food Packaging - Improvement of Mechanical Properties through Nanocomposites - Improvement of Barrier Properties - Improvement of the Performance of Bio-based Polymers - Surface Biocides - Active Packaging Materials - Intelligent Packaging Concepts.

Unit-III: Risk Assessment in Nanotechnology

Context for Technological Risk - Why Risk Assessment for Nanotechnology?- Adaptive Risk Assessment for Nanomaterials - Origins and Development of Risk Assessment, and the Societal Dimensions of Risk - Frameworks Addressing the Social Dimensions of Risk - How Risk Assessment Is Used in Environmental Decision Making - The Four Steps of Risk Assessment - Issues in Applying the Four Steps of Risk Assessment to Nanotechnology - Hazard Assessment - Exposure Assessment - Dose-Response Evaluation - Risk Characterization.

Unit-IV: The State of the Science

Treatment of Nanoparticles in Wastewater - Mass Balance Considerations - Case Study: SilverCare™ Washing Machine - Case Study: Socks with Nano Silver - Treatment Processes – Sedimentation - Coagulation and Flocculation - Activated Sludge - Sand Filters - Membrane Separation – Disinfection; Toxicology and Risk Assesment - Mechanisms of Toxicity - Types of Toxicological Studies – Findings - Pulmonary Toxicity Studies – i*n-vitro* Studies - Dermal i*n-vitro* Toxicity Studies - Future Directions - Antimicrobial Properties - Short-Term Toxicity Tests - Studies of Nanomaterial Toxicity to Fish - Field Studies - Environmental Exposures - Risk Assessments

Text Books

1. Nanotechnologies in Food, Edited by Qasim Chaudry, Laurence Castle and Richard Watkins, RSC Publications (2010).
2. Nanotechnology : Health and Environmental Risks, Jo Anne Shatkin, CRC Press (2008).
3. Nanotechnology and the Environment, Kathleen Sellers, Christopher Mackay, Lynn L. Bergeson, Stephen R. Clough, Marilyn Hoyt, Julie Chen, Kim Henry, Jane Hamblen, CRC Press (2009).

References

1. Environmental Nanotechnology : Applications and Impacts of Nanomaterials, Edited by Mark R. Weisner and Jean-Yves Bottero, Mc Graw Hill (2007).
2. Nanotechnology for Environmental Remediation, Sung Hee Joo and I. Francis Cheng, Springer (2006).

Core Paper 11: Carbon Nanostructures and Applications (33C)

Unit-I: Fullerenes

The Fullerenes: Molecular Allotropes of Carbon - The Discovery of the Fullerenes - Fullerene Production - Fullerene Generation by Vaporization of Graphite - Resitive Heating of Graphite - Arc Heating of Graphite - Solar Generators - Inductive Heating of Graphite - Fullerene Synthesis in Combustion - Formation of Fullerenes by Pyrolysis of Naphthalene – Endohedrals - The Formation Process; Separation and Purification – Properties – Structures - Physical and Spectroscopic Properties - Potential Applications.

Unit-II:Basics of Carbon Nanotubes

History – Molecular and Supramolecular Structure - Intrinsic Properties of Individual Single Wall Carbon Nanotubes – Chemical and Physical Properties – Electronic Properties – Vibrational Properties – Mechanical Properties.

Unit-III: Synthesis and Purification of CNT

Growth of Carbon Nanotubes by Arc Discharge and Laser Ablation - Arc Discharge Production of MWNTs - MWNT Production by Laser Ablation of Graphite - Arc Discharge Production of SWNTs - SWNT Production by Laser Ablation of Carbon-Metal Target; Growth: CVD and PECVD - Growth Apparatus - Catalyst Preparation - Growth Results- Growth Mechanisms.

Unit-IV: Characterization and Applications of Carbon Nanotubes

Electron Microscopy - Atomic Force and Scanning Tunneling Microscopy - Properties Characterization - Electrical Conductivity Measurements - Thermoelectric Measurements - Raman Spectroscopy- X-Ray Diffraction; Applications in Scanning Probe Microscopy - Development of the Atomic Force Microscope and the Role of the Scanning Probe - Mechanical Properties of Carbon Nanotubes in the Context of SPM Applications; Nanoelectronics Applications - Carrier Characterization - SWNT FETs - Intermolecular Metal-Semiconductor SWNT Heterojunctions - Single-Electron Tunneling Devices Using SWNTs; Field Emission - Structure and Microstructure of CNT Field Emitters – Chemicah .

Text Books

1. The Chemistry of the Fullerenes, Andreas Hirsch, WILEY-VCH Verlag GmbH & Co, KGaA (2002).
2. Introduction to Nanoscale Science and Technology, Edited by Massimiliano Di Ventra, Stephane Evoy and James R. Heflin, Jr., Kluwer Academic Publishers (2004).
3. Carbon Nanotubes Science and Appplications, Edited by M. Meyyappan, CRC Press (2005).

References

1. Science of Fullerenes and Carbon Nanotube, M. S. Dresselhaus, G. Dresselhaus, P. C. Eklund, Academic Press (1996).
2. Understanding Carbon Nanotubes: From Basics to Applications A. Loiseau, P. Launois, P. Petit, S. Roche, J.-P. Salvetat, Springer (2006).

Core Paper 12: Applications of Nanotechnology (33D)

Unit-I: Sensors

Sensors - Nanotechnology Enabled Sensors - Sensor Characteristics and Terminology - Static and Dynamic Characteristics; Inorganic Nanotechnology Enabled Sensors - Gas Sensing with Nanostructured Thin Films - Phonons in Low Dimensional Structures - Nanotechnology Enabled Mechanical Sensors - Nanotechnology Enabled Optical Sensors - Magnetically Engineered Spintronic Sensors; Organic Nanotechnology Enabled Sensors - Surface Interactions - Surface Materials and Surface Modification - Proteins in Nanotechnology Enabled Sensors - Nano-sensors based on Nucleotides and DNA.

Unit-II: Energy Devices

Solar Cells - Band Diagram and Operational Principle of Nanocrystalline Solar Cells - The Importance of the Nanostructure - Quantum Dot Sensitizer; Electrochemistry and Nanoscale Materials - Electrochemistry and Size Effects - Challenges of Charge Transfer - Nanomaterials and Nanostructured Films as Electro active Electrodes - Nanomaterials as Electrolytes - Nanoscale Electronic and Ionic Transport – Energy Conversion and Storage in Electrochemistry -

Overview of the Principles of Operation of Energy Conversion and Storage Devices - Lithium Ion Batteries - Fuel Cells - Photoelectrochemical Solar Cells - Electrochemical Double-Layer Capacitors - What Relevance Has Nanotechnology for Fuel Cell Systems - Fuel Cell Technology and Nanotechnology.

Unit-III: Biomedical Applications

Quantum Dots as Tracers for DNA Electrochemical Sensing Systems - Introduction - QD Bionanostructures - Characterization of QD Biostructures - Electrochemical Sensing Formats - Future Prospects; Magnetic Nanoparticles as Contrast Agents for Medical Diagnosis - Nanoparticles in Medicine - Size-Dependent Effects of Magnetic Particles – Preparation - Methods for Iron Oxide Nanoparticles and *in-vitro* Characterization – *in- vivo* Investigations - Using Nanoparticles in Animals - Magnetic Nanoparticles for Imaging and Therapy in Humans - Toxicity of Nanoparticles - Future Perspectives.

Unit-IV: Potential Defence Applications

Military applications of Nanotechnology - Electronics, photonics, magnetic - Computers, Communication - Software/Artificial Intelligence – Materials -Energy Sources, Energy Storage - Propulsion – Vehicles - Propellants and Explosives – Camouflage -Distributed Sensors - Amour, Protection - Conventional Weapons - Soldier Systems - Implanted Systems, Body Manipulation - Autonomous Systems - Mini-/Micro Robots - Bio-technical Hybrids - Small Satellites and Space Launchers - Nuclear Weapons - Chemical Weapons - Biological Weapons - Chemical/Biological Protection.

Text Books

1. Nanotechnology - Enabled Sensors, Kourosh Kalantar-zadeha and Benjamin Fry, Springer (2008).
2. Nanostructured Materials for Electrochemical Energy Production and Storage, Edited by David J. Lockwood, Springer (2009).
3. Nanotechnology in Biology and Medicine : Methods, Devices and Applications, Edited by Tuan Vo-Dinh, CRC Press (2007).
4. Military Nanotechnology: Potential Applications and Preventive Arms Control, Jürgen Altmann, Routledge, Taylor and Francis Group (2006)

References

1. Recent Trends in Fuel Cell Science and Technology, Edited by Suddhasatwa Basu, Springer (2007).
2. Nanomedicine, Vijay K. Varadan, Linfeng Chen, Jining Xie, A John Wiley and Sons, Ltd., Publication (2008).
3. Biological Nanostructures and Applications of Nanostructures in Biology : Electrical, Mechanical, and Optical Properties, Edited by Michael A. Stroscio and Mitra Dutta, Kluwer Academic Publishers (2004).

Elective 4 : Nanoscale Magnetic Materials and Devices (3EC)

Unit-I: Basics of Magnetism

Definitions and Units – Ferromagnetism - Introduction – Molecular Field Theory; Antiferromagnetism – Introduction – Molecular Field Theory; Ferrimagnetism – Introduction – Structure of Cubic Ferrites – Saturation Magnetization - Molecular Field Theory; Anisotropy – Introduction – Anisotropy in Cubic and Hexagonal Crystals – Physical Origin of Crystal Anisotropy; Magnetic Resonance – Electron Paramagnetic Resonance – Ferromagnetic Resonance – Nuclear Magnetic Resonance.

Unit-II: Basics of Nanomagnetism

Domains and the Magnetization Process – Introduction – Domain Wall Structure – Single Domain Particles; Fine Particles and Thin Films – Introduction – Single – Domain Vs Multi Domain Behavior – Coercivity of Fine Particles – Superparamagnetism in Fine Particles – Exchange Anisotropy - Induced Anisotropy in Thin Films.

Unit-III: Advanced Nanomagetism

Spintronics – Introduction - The Technical Basis of Spin Electronics – The Two-spin Channel Model - Two Terminal Spin Electronics – Giant Magnetoresistance (GMR) - Three-terminal Spin Electronics - Spin Tunneling - The Future of Spin Electronics; Study of Ferromagnet-Antiferromagnet Interfaces – Introduction - Photoemission Electron Microscopy - X-Ray Absorption Spectroscopy - X-Ray Magnetic Linear Dichroism (XMLD) - X-Ray Magnetic Circular Dichroism (XMCD) - Temperature Dependence of X-Ray Magnetic Dichroism - Experiment

Unit-IV: Applications of Nanomagnetic Materials

Magnetic Recording - Principles of Magnetic Recording - Magnetic Digital Recording - Perpendicular Recording - Possible Future Developments - Magneto-Optic Recording - Magnetic Memory - Magnetic Sensors and Giant Magnetoresistance - Optically Transparent Materials - Soft Ferrites - Nanocomposite Magnets - Magnetic Refrigerant - Ferrofluids; Biomedical Applications of Magnetic Nanoparticles - Diagnostic Applications - Therapeutic Applications - Physiological Aspects - Toxic Effects.

Text Books

1. Introduction to magnetic materials, 2nd Edition, B. D. Cullity and C. D. Graham, A John Wiley and Sons Inc. Publications (2009).
2. Magnetism: Molecules to Materials III, Edited by J.S. Miller and M. Drillon, Wiley-VCH Verlag GmbH (2002).
3. Magnetic Microscopy of Nanostructures, Edited by H. Hopster H.P. Oepen, Springer (2005).
4. Nanomedicine, Vijay K. Varadan, Linfeng Chen, Jining Xie, A John Wiley and Sons, Ltd., Publication (2008).

References

1. Modern Techniques for Characterizing Magnetic Materials Edited by Yimei Zhu, Springer (2005).
2. Ultra thin Magnetic Structures III – Fundamentals of Nanomagnetism, JAC Bland and B. Heinrich, Springer (2004).
3. Magnetic Materials : Fundamentals and Device Applications, Nicola Ann Spaldin, Cambridge University Press (2003).

Practical - III (33P)

Verification of Lambert Beer's law and determination of concentration of unknown solution by UV-Vis spectrophotometer.

Preparation of colloidal Silver (Ag) nanoparticles with trisodium citrate and their characterization by UV-Vis spectroscopy.

To study Hydrogen bonding by FT-IR spectroscopy

Preparation of metal oxide nanoparticles by microemulsion technique

Characterization of prepared metal oxide nanoparticles by XRD and determination of their size by Scherrer's Equation.

To determine the Band-Gap of given Semiconductor using Four Probe Method from Liquid Nitrogen Temp to Room Temperature

Synthesis of at least two different sizes of Nickel Oxide Nano Particles Using Sol-Gel Method

Synthesis of at least two different sizes of Copper Oxide Nano Particles Using Sol-Gel Method

Synthesis of at least two different sizes of Zinc Oxide Nano Particles Using Sol-Gel Method

Determine the wavelength of given Laser and estimate the slit width using Laser and also calculate the diameter of given thin wire using Laser.

Preparation of quantum dot (ZnS) nanoparticles and estimation of band gap from band edge

Synthesize copper oxide nanoparticles by sol-gel method and determine the average size of nanoparticles using Zetasizer.

Fabricate silver nanoparticles embedded in silica glass by ion exchange method and study surface plasmon resonance using UV-visible spectroscopy.

Fabricate copper nanoparticles embedded in silica glass by ion exchange method and determine the size of nanoparticles using optical absorption spectroscopy.

Synthesize silver nanocrystals in solution by citrate reduction method and study the effect of capping using optical absorption spectroscopy.

Study the growth kinetics of silver nanoparticles embedded in ion exchanged glass at different temperatures using optical absorption spectroscopy.

Core Paper 13: Nanostructure Control of Materials (43A)
(Theory paper related to project)

Unit-I: Processing of Nanoparticles and Films

Introduction; Particles - Nucleation and Growth - Stable Dispersion and Agglomeration - Metals, Intermetallics, Alloys, and Composites – Ceramics - Host-Derived Hybrid Materials - Stabilized Dispersions - Surfactant Membrane Mediated Synthesis; Films and Coatings– Metals - Ceramics

Unit-II: Structural Studies

X - ray Diffraction Method – Scanning Electron Microscopy – Transmission Electron Microscopy – Atomic Force Microscopy – Scanning Tunneling Microscopy – FT Infrared Spectroscopy – Raman Spectroscopy.

Unit-III: Spectroscopic Techniques

Nuclear Magnetic Resonance – Photoluminescence – UV – visible spectroscopy – Mössbauer spectroscopy – Surface Enhanced Raman Spectroscopy.

Unit-IV: Applications

Design of nanoparticles for oral delivery - Development of polymer-clay nanocomposites - Nanoparticle formation of DNA - Addressing of nanoparticles by using DNA molecules- Dendrimers and their application to organic electronics devices - Development of the thermoresponsive magnetic nanoparticle and its deployment in the biotechnology field - Development of fuel cells - Development of a high-performance secondary battery by controlling the surface structure - Pinpoint drug and gene delivery - Evaluation and applications of dispersing carbon nanotube in the polymers – Surface modification of inorganic nanoparticles by organic functional groups - Application of quantum dots for bio-medical engineering.

References

1. Nanostructured Materials : Processing, Properties and Potential Applications, Carl C. Koch Noyes Publication, New York, USA (2002).
2. Encyclopedia of Materials Characterization, C. Richard Brundle, Charles A. Evans Jr., Shaun Wilson, Butterworth-Heinemann Publishers (1992).
3. Nanoparticle Technology Handbook, Masuo Hosokawa, Kiyoshi Nogi, Makio Naito, Toyokazu Yokoyama Elsevier Publishers (2007).

Supportive I – Fundamentals of Nanotechnology

Unit-I: What is Nanotechnology

What Is Nanotechnology? - Living with Nanoparticles - Nano, Nano, Nano - Nanotechnology, a Future Trillion Dollar Business - Nanotechnology Will Develop in Stages; Nanotechnology Products and Applications - Future Applications of Nanotechnology – Medical Applications.

Unit-II: The Science of Nanotechnology

What Is Matter? - Properties of Matter Change at the Nanoscale - Matter's Smallest Particles: Matter Is Made Up of Elements - Smallest Part of An Element: The Atom - Inside the Atom: Subatomic Particles - Models of the Atoms - Atoms and Molecules - Molecules and Chemical Bonding - Molecular Self-Assembly and Nanofabrication - Soap Bubbles Self-Assemble - Using the Self-Assembly Strategy to Make Products - Other Applications of Molecular Self-Assembly - Self-Assembly in Medicine.

Unit-III: The Nanotechnology Tool Box

Optical Microscopes - Scanning Probe Microscopes - Scanning Tunneling Microscopes - Atomic Force Microscopes - Magnetic Force Microscopes - Electron Microscopes - A Scanning Electron Microscope - The Transmission Electron Microscope - Nanofabrication Cleanroom Facilities.

Unit-IV: Carbon Nanotubes, Nanowires and Nanocrystals

The Element Carbon - Fullerenes and Nanotechnology – Buckyballs - Carbon Nanotubes - How are Carbon Nanotubes Made? - Applications of Carbon Nanotubes - AFM Probe Tips - Not All Nanotubes are Carbon - Nanowires, Nanocrystals, and Quantum Dots – Nanocrystals - Quantum Dots – Nanoshells.

Text Book

1. Nanotechnology 101, John Mongillo, Greenwood Press (2007).

Supportive II- Applications of Nanotechnology

Unit-I: Nanotechnology in Medicine and Health

Cardiovascular Diseases - Cancer Detection and Diagnosis - Diabetes and Nanotechnology - Implants and Prosthetics - Nanotechnology and Burn Victims - Diagnosis and Therapy - Drug Delivery Using Nanoparticles - Nanotechnology Fights Infections - Pharmaceutical Nanotechnology Research.

Unit-II: The Business of Nanotechnology

Nanotechnologies in Businesses - Sporting Goods Equipment - Chewing Gum and Nanocrystals - Apparel Industry – Cosmetic – Appliances - Electronics and Computers - Automobile/Vehicle Industry - Aircraft Potential and Metal Rubber - Paint and Other Water Resistance Coatings - Removing Windshield Fog - Self-Cleaning Glass - Antibacterial Cleansers - Medical Bandages - Solar Energy: Photovoltaic Cells - Battery Technology - The Business of Building Atomic Force Microscopes.

Unit-III: Nanotechnology for Food, Agriculture, Livestock, Aquaculture and Forestry

Food Packaging: A Major Goal Using Nanotechnology - Foodborne Diseases - Nanosensors for Foodborne Contamination - Using Food Packaging Sensors in Defense and Security - Other Kinds of Sensors: The Electronic Nose and The Electronic Tongue - Nano Bar Codes Detect Foodborne Diseases - Agriculture and Nanotechnology - Biosensor Detects Herbicides on the Farm - A Food Safety Issue - Atomic Force Microscopy and Food Research - Sustainable Watering of Crops - Livestock Diseases - Biochips for Disease Detection in Livestock - Nanosensors to Track Livestock - Nanotechnology in Aquaculture and Fish Farming - Forest Product Industry and Nanotechnology.

Unit-IV: Nanotechnology for Sustainable Environment

Water Pollution and Nanotechnology - Nanotechnology and Safer Drinking Water - Drinking Water from the Ocean - Groundwater Pollutants - Groundwater Cleanup - Cleaning Up Organic Pollutants Using Nanotechnology - Cleaning Up Nuclear Waste Sites - Air Pollution - Environmental Protection Agency and Department of Energy - Nanotechnology and Energy Sources - Emerging Nanotechnologies and Risks - Nano Activity: Discovering the Properties of Ferrofluids.

Text Book

1. Nanotechnology 101, John Mongillo, Greenwood Press (2007).