

**ANNA UNIVERSITY TIRUCHIRAPPALLI**  
**Tiruchirappalli – 620 024**  
**Regulations 2008**  
**Curriculum**

**M.TECH NANOSCIENCE AND TECHNOLOGY**

**SEMESTER I**

S.No.	Subject Code	Subject	L	T	P	C
<b>Theory</b>						
1	NT5101	Fundamentals of Nanoscience and Technology	3	0	0	3
2	NT5102	Physics and Chemistry of Nanomaterials	3	0	0	3
3	NT5103	Advanced Nanomaterials Characterization I	3	0	0	3
4	NT5104	Nanomaterials	3	0	0	3
5	NT5105	Cellular and Molecular Biology	3	0	0	3
6	MA5152	Mathematical Modeling and Simulation	3	0	0	3
<b>Total</b>						
7	NT5106	Cellular and Molecular Biology Laboratory	0	0	6	2
8	NT5107	Modeling and Simulation Laboratory	0	0	6	2
<b>Total</b>						<b>22</b>

**SEMESTER II**

S.No.	Subject Code	Subject	L	T	P	C
<b>Theory</b>						
1	NT5151	Synthesis of Nanomaterials	3	0	0	3
2	NT5152	Advanced Nanomaterials Characterization II	3	0	0	3
3	NT5153	Processing of Nanomaterials	3	0	0	3
4	NT5154	Nanotechnological Applications	3	0	0	3
5	NT5155	Nanopervasive Devices	3	0	0	3
6	NT5001	Elective I	3	0	0	3
<b>Practical</b>						
7	NT5156	Advanced Nanomaterials Laboratory I	0	0	6	2
8	NT5157	Advanced Nanomaterials Laboratory II	0	0	6	2
<b>Total</b>						<b>22</b>

### SEMESTER III

S.No.	Subject Code	Subject	L	T	P	C
<b>Theory</b>						
1	NT5201	Chemical Nanotechnology	3	0	0	3
2	NT5202	Theory of Nanostructures	3	0	0	3
3	NT5002 / NT5004	Elective II / Elective IV	3	0	0	3
4	NT5003 / NT5005	Elective III / Elective V	3	0	0	3
<b>Practical</b>						
5	NT5203	Functional Nanomaterials Laboratory	0	0	6	2
6	NT5204	Project Phase I	0	0	6	2
<b>Total</b>						<b>16</b>

### SEMESTER IV

S.No.	Subject Code	Subject	L	T	P	C
<b>Practical</b>						
1	NT5251	Project Work (Phase II)	0	0	24	12
<b>Total</b>						<b>12</b>

\* **Choice of Electives:** Either II and III or IV and V combinations are to be chosen in Semester III

**Total Credits to be Earned for the Award of the Degree = 72**

### LIST OF ELECTIVES

S.No.	Subject Code	Subject	L	T	P	C
<b>ELECTIVE I</b>						
1	<b>NT5001</b>	Nanotechnology for Energy Systems	3	0	0	3
2		Bio-energy and Conversion	3	0	0	3
<b>ELECTIVE II</b>						
1	<b>NT5003</b>	Nanoelectronics	3	0	0	3
2		Nanoelectronics and Sensors	3	0	0	3
<b>ELECTIVE III</b>						
1	<b>NT5002</b>	Nanophotonics	3	0	0	3
2		Nanoscale Magnetic Materials and Devices	3	0	0	3
<b>ELECTIVE IV</b>						
1	<b>NT5004</b>	Nanobiotechnology	3	0	0	3
2		Biomaterials and Tissue Engineering	3	0	0	3
<b>ELECTIVE V</b>						
1	<b>NT5005</b>	Nanomedicine and Drug Delivery Systems	3	0	0	3
2		Nanotechnology in Healthcare	3	0	0	3

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**Curriculum**

**M.TECH NANOSCIENCE AND TECHNOLOGY**

**SEMESTER I**

**FUNDAMENTALS OF NANOSCIENCE AND TECHNOLOGY**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**UNIT I      BASICS AND SCALE OF NANOTECHNOLOGY      9**

Introduction – Scientific revolutions – Time and length scale in structures – Definition of a nano system – Top down and bottom up approaches – Evolution of band structures and Fermi surface – Dimensionality and size dependent phenomena – Fraction of surface atoms – Surface energy and surface stress – Misnomers and misconceptions of Nanotechnology

**UNIT II      FORCES BETWEEN ATOMS AND MOLECULES      9**

Thermodynamic aspects of intermolecular forces – Strong intermolecular forces – Covalent and coulomb interactions – Interactions involving polar molecules – Interactions involving the polarization of molecules – Van der Waals forces – Repulsive forces, total intermolecular pair potentials, and liquid structure – Special Interactions – Hydrogen bonding, Hydrophobic, and Hydrophilic interactions.

**UNIT III      POLYMER TECHNOLOGY      9**

Basic concepts of polymer science - Type of polymerization – condensation – addition – copolymerization – order in crystalline polymers – hydrocarbon plastics – natural and synthetic elastomers – acrylic polymers – polyamides – polyesters – cellulosic polymers – thermosetting resins – Conducting polymers – Macromolecular properties – dendrimers.

**UNIT IV      BIOMEDICAL TECHNOLOGY      9**

Tissue engineering principles - Inorganic and composite materials for biomedical strategies – Design and fabrication of scaffolds – Processing techniques for architecture of scaffold – Electrospinning – Organ specific material fabrication – Bone – Gastro intestinal- nerve tissue regeneration .

**UNIT V      NANOSCALE MATERIALS IN NATURE      9**

Biological building blocks – Self-assembly – Peptide nanowire and protein nanoparticles – Nucleic acids – Genetic code – Protein synthesis – Biological nanostructure – Polymers at surfaces – Micelles, bilayers, vesicles – Multilayer films – Bionanomachines – biological membranes.

**Total: 45**

## **TEXTBOOKS**

1. Wilson M., Kannangara K., Smith G., Simmons M. and Raguse B., “Nanotechnology: basic science and emerging technologies”, Overseas Press, 2005.
2. Poole C.P. and Owens J.F., “Introduction to Nanotechnology” Wiley- Interscience, 2003.

## **REFERENCES**

1. Ratner M.A. and Ratner D., “Nanotechnology: A Gentle Introduction to the Next Big Idea”, First Edition, Prentice Hall PTR, 2002.
2. Billmeyer, F.W., Textbook of Polymer Science, John-Wiely and Sons(Asia) Pte. Ltd, 2003
3. Michael. K.,and Wolfgang. F.,“Nanotechnology: An Introduction to Nanostructuring Techniques”, Wiley-VCH, 2007
4. Paul. H Chu “Biomaterials fabrication and processing handbook” Taylor Francis group, 2008
5. Jacob N. Israelachvili “Intermolecular and surface forces” Academic Press, 2008

# PHYSICS AND CHEMISTRY OF NANOMATERIALS

L	T	P	C
3	0	0	3

## UNIT I INTRODUCTION TO PHYSICS OF THE SOLID STATE 9

Structure – Size dependence of properties – Crystal structures – FCC Nanoparticles – Tetrahedrally bonded semiconductor systems – Lattice vibrations, Energy bands – Insulators-semiconductor and conductors – reciprocal space – Energy bands and band gaps in semiconductors – Effective masses – Fermi surfaces – Localized particles – Donors, acceptors and deep traps – Mobility – Excitons

## UNIT II QUANTUM PHYSICS 9

Basis of Quantum Physics – Heisenberg's Uncertainty Principle – De Broglie's concept – Schrödinger wave equation – Operators – Physical imperfection of wave function – Normalised and orthogonal wave function – Statement and illustrations – Particle in 1D and 3D box – Quantum-size-effect (QSE) – Size-induced metal-insulator-transition (SIMIT)

## UNIT III PROPERTIES OF NANOMATERIALS 9

Dielectric properties: Polarization – Ferroelectric theory – Optical properties: Optical Absorption and Transmission – Nano size effects – Optical response – Quantum effect – Magnetic properties: Magnetism in small systems – Magnetism in coupled nano systems – Influence of Nano structuring on Mechanical properties

## UNIT IV CHEMISTRY ASPECTS 9

Photochemistry and Electrochemistry of Nanomaterials – Catalysis – Homogenous – Heterogeneous – Nano catalysis – Nano porous materials – TiO<sub>2</sub> – Photocatalysis – Catalytic applications of Au and Ag nanoparticles – Sonochemistry of nanoparticles .

## UNIT V MOLECULAR BASICS OF NANOTECHNOLOGY 9

**Atomic structure:** Chemical bonds– Ionic interactions –Covalent bonds – Coordinative bonds – Metal bonds – Hydrogen bridge bonds – Polyvalent bonds – van der Waals interactions – Dipole-dipole interactions. **Chemical Structure:** Binding topologies – Building blocks of covalent architecture – Units for a coordinate architecture – Building blocks for weakly bound aggregates – Assembly of complex structure through the internal hierarchy of binding strengths – Reaction probability and reaction equilibrium.

**Total: 45**

### TEXTBOOKS

1. Charles P. Poole and Frank J. Owens, "Introduction to Nanotechnology" Wiley- Interscience, 2003.
2. Rao, C. N. R. and Cheetham, A.K., "The Chemistry of Nanomaterials: Synthesis, Properties and Applications", Wiley-VCH, 2004.

### REFERENCES

1. Anderson, E.E., "Modern Physics and Quantum Physics", Macmillan Co., 1971.
2. Ozin, G.A. and Arsenault, A.C., "Nanochemistry: A Chemical Approach to Nanomaterials", Royal Society of Chemistry, 2005.
3. Alan S. Edelstein and Robert C. Cammarata, "Nanomaterials: Synthesis, Properties and Applications", CRC Press, 1998.
4. Klabunde, K.J., "Nanoscale - Materials in Chemistry", John Wiley and Sons, Inc., 2001.

# ADVANCED NANOMATERIALS CHARACTERIZATION I

L T P C  
3 0 0 3

## UNIT I X-RAY DIFFRACTION 9

X-ray powder diffraction – Single crystal diffraction techniques – Determination of accurate lattice parameters – Nanostructural analysis – Profile analysis – Particle size analysis using Scherer formula.

## UNIT II QUANTITATIVE ANALYSIS 9

Electron Energy Loss Spectroscopy – High Resolution Imaging Techniques – High Resolution Electron Microscopy (HREM) – Atom probe field ion microscopy – X-Ray Photoelectron Spectroscopy – EDAX and WDA analysis – EPMA – ZAF corrections – Quartz Crystal microbalance.

## UNIT III THERMAL ANALYSIS METHODS 9

Principle and Instrumentation of Thermogravimetry (TGA – Differential Thermal Analysis (DTA) and Differential scanning calorimetry (DSC) – Importance of thermal analysis for nanostructures – Thermo mechanical analyzer (TMA).

## UNIT IV SPECTROSCOPIC TECHNIQUES I 9

Introduction to Molecular Spectroscopy – Atomic Spectroscopy – Infrared (IR) Spectroscopy – Microwave Spectroscopy – Nanomaterials characterization – Raman Spectroscopy – Surface enhanced, resonance enhanced and coherent anti-Stokes Raman scattering (CARS) Applications – Optical absorption and emission spectroscopy – photoluminescence – Fluorescence spectroscopy.

## UNIT V SPECTROSCOPIC TECHNIQUES II 9

Electron Spin Resonance Spectroscopy – Nuclear Magnetic Resonance (NMR) Solid state NMR – Applications of NMR Spectroscopy in nanomaterials – Dynamic Nuclear Magnetic Resonance – Double Resonance Technique.

**Total: 45**

### TEXTBOOKS

1. Pradeep, T., “Nano: The Essentials”, Tata McGraw Hill, New Delhi, 2007.
2. Cullity, B. D., “Elements of X-ray Diffraction”, 4th Edition, Addison Wiley, 1978.

### REFERENCES

1. Loretto, M. H., “Electron Beam Analysis of Materials”, Chapman and Hall, 1984.
2. Rose, R.M., Shepard, L.A. and Wulff, J., “The Structure and Properties of Materials”, Vol. IV: Electronics Properties, Wiley Eastern Ltd, 1968.
3. Silverstein, M.R., Bassler, C.G. and Morrill, C.T., “Spectrometric Identification of Organic Compounds”, John Wiley and Sons, 1991.
4. Skoog, D.A., Holler, F.J. and Nieman, T.A. “Principles of Instrumentation analysis”, 5th Edition, Thomson Learning, 1998.

# NANOMATERIALS

**L T P C**  
**3 0 0 3**

## **UNIT I CARBON AND INORGANIC NANOTUBES 9**

Carbon– Types of carbon – Phase diagram of carbon – Nanotubes – Synthesis – Purification – Functionalization and solubilization – Properties – Applications – Inorganic nanotubes – Synthesis and functionalization properties – Applications

## **UNIT II FULLERENES AND MOLECULAR MIMICS 9**

Synthesis – purification – Reactivity – *in car* Fullerene – Functionalization – Oxidation, amination, thiolation and carboxylic acid Functionalization – Sidewall chemistry – Catenanes, rotaxanes – Synthesis and uses as molecular switches.

## **UNIT III NANOCRYSTALS AND NANOCOMPOSITES 9**

Synthesizing metal and semiconductor nanocrystals – Programmed assemblies – One, two and three dimensional arrangements properties – Optical and luminescent applications.

Organic / inorganic materials – Polymer nanocomposites – Ceramic nanocomposites – Metal nanocomposites – Synthesis – Properties – Characterizations – Applications of nanocomposites.

## **UNIT IV BIOMATERIALS 9**

Types of biomaterials, compatibility issues, biopolymers and their properties in vitro and in vivo– metals and ceramics as biological implants – Pathological calcification, mechanical breakdown in biological environment – Blood material interactions, carcinogenesis and coagulation due to blood material interactions.

## **UNIT V IMPLANTS 9**

Cardiovascular applications – Nonthrombogenic treatment strategies – Dental implants – Adhesives and sealants – Ophthalmologic Applications – Orthopedic replacements – Sutures and burn dressings – Artificial organs – Implant associated Infection.

**Total: 45**

### **TEXTBOOKS**

1. Rao, C. N. R., Müller, A. and Cheetham, A.K., “Nanomaterials Chemistry”, Wiley-VCH, 2007.
2. Fernando Langa De La Puente and Jean-Francois Nierengarten “Fullerenes: Principles and Applications” RSC publications, 2007.

### **REFERENCES**

1. Wilson, M., Kannangara, K., Smith, G., Simmons, M. and Raguse, B., “Nanotechnology: Basic Science and Emerging Technologies”, Overseas Press, 2005.
2. Rao, C.N.R, “Nanotubes and Nanowires”, RSC Publications, 2005.
3. Thomas Twardowski, “Introduction to Nanocomposite Materials: Properties, Processing”, DES Tech Publications, 2007
4. Ratner, B.D., “Biomaterials Science : An Introduction to Materials in Medicine” Academic Pres, 1996.
5. Kelsall, R.W., Geoghegan, M., Hamley, I.W., “Nanoscale Science and Technology”, John Wiley and Sons, 2005.

## CELLULAR AND MOLECULAR BIOLOGY

L	T	P	C
3	0	0	3

### UNIT I CELL STRUCTURE AND FUNCTION OF ORGANELLES 9

Eukaryotic and prokaryotic cells – Principle of membrane organization – Cytoskeletal proteins – types of cell division, mitosis and meiosis – cell cycle and molecules, structural organization and multiplication of bacteria, viruses, algae and fungi.

### UNIT II DNA STRUCTURE 9

Components of DNA – Purine bases, pyrimidine bases, deoxyribose sugar – Physical and chemical properties of DNA, chemical modifications – Introduction of DNA nanotechnology – Primary, secondary, super secondary, tertiary, quaternary structures – the methods to determine, prediction methods, utilization of genomic databases.

### UNIT III AMINO ACIDS AND PROTEINS 9

Structure and reactions of amino acids – hydrophilic and hydrophobic amino acids – table of standard amino acid abbreviations and side chain properties – nonstandard amino acids – biochemistry of proteins – cellular functions of proteins – introduction to protein based nanotechnology.

### UNIT IV LIPIDS AND CARBOHYDRATES 9

Categories of lipids – Biological function of lipids – Structure of monosaccharides, disaccharides, oligosaccharides and polysaccharides – Carbohydrate metabolism – Role of lipids and carbohydrates in nanotechnology.

### UNIT V BASICS IN IMMUNOTECHNOLOGY 9

Innate immunity, adaptive immunity – Cells of reticulo endothelial system – Antigen presenting cells and its pathways, complement system and its pathways – Tumor immunology – Life cycle of HIV virus – Monoclonal antibodies synthesis and applications

**Total: 45**

### TEXTBOOKS

1. Watson, J., Baker.T., Bell.S., Gann.A., Levine.M., and Losick.R., “Molecular Biology of the gene”, Addison-Wesley, 2000.
2. Nelson, D.L., Fox.M.M., “Lehninger Principles of Biochemistry”, W.H.Freeman, 2004.

### REFERENCES

1. Alberts.B., Alexander.J., Julian., Martin., Keith., and Peter.W., “Molecular Biology Of The Cell”, Garland Science, 2002.
2. Lewin.B., “Genes IX”, Sudbury: Jones and Bartlett, 2007.
3. Janis.K., “Immunology” W H Freeman, 2006

## MATHEMATICAL MODELING AND SIMULATION

L	T	P	C
3	0	0	3

### UNIT I MATHEMATICAL MODELING AND NUMERICAL METHODS 9

A simple mathematical model – Roots of equations: The Bisection method – The False-position method – The Newton, Raphson method – The Secant method, Roots of polynomials: Muller’s methods, Bairtow’s method – Numerical Differentiation – Integration

### UNIT II MATHEMATICAL MODELING 9

Mathematical modeling – Linear Optimization – Advantages and limitations – Process control – Transport phenomena – Concept of physical domain and computational domain – Assumptions and limitations in numerical solutions

### UNIT III STATISTICAL MODELING 9

Statistical models – discrete distributions – continuous distributions – Poisson processes – empirical distributions

### UNIT IV SIMULATION 9

Basic concepts of simulation – Data manipulation, data exchange of the structure, properties and processing of materials – Three dimensional models for capillary nanobridges and capillary forces – Molecular dynamics simulation

### UNIT V MONTE CARLO METHODS 9

Basics of the Monte Carlo method – Algorithms for Monte Carlo simulation – Applications to systems of classical particles – Modified Monte Carlo techniques – Percolation system – Variation Monte Carlo method – Diffusion Monte Carlo method – Quantum Monte Carlo method

**Total: 45**

### TEXTBOOKS

1. Winston,W.L., “Operations research: Applications and algorithms”, 4th Edition, Thomson, 2004.
2. Erwin,K., “Advanced Engineering Mathematics”, John Wiley and Sons, 2004.

### REFERENCES

1. Schilling, R.J., and Harris,S.L., “Applied Numerical Methods for Engineers using MATLAB and C”, Thomson publishers, 2004.
2. Frenkel,D and Smith.B., “Understanding Molecular Simulation from Algorithm to Applications”, Kluwar Academic Press, 1999.
3. Ohno, K., Esfarjani, K. and Kawazoe, Y., “Introduction to Computational Materials Science from ab initio to Monte Carlo Methods”, Springer-Verlag, 1999.

**NT5106**

**CELLULAR AND MOLECULAR BIOLOGY LABORATORY**

**L T P C**  
**0 0 6 2**

**LIST OF EXPERIMENTS**

1. Microscopic observation of bacterial and animal cell
2. Temporary preparation of cell / tissues
3. Permanent preparation of cell / tissues
4. Squash preparation of onion root tip for mitosis
5. Squash preparation of grasshopper testis for meiosis
6. Preparation of buccal smear for epithelial cells
7. Isolation and purification of genomic DNA
8. Isolation and purification of plasmid DNA
9. Estimation and purification of proteins
10. Redox measurement of enzyme- catalyse protease
11. Cytotoxicity/cell viability- Tryphan blue exclusionary
12. Fluorescence labeling of nucleic acid
13. Absorbance spectra of bioconjugated molecule

**NT5107**

**MODELING AND SIMULATION LABORATORY**

**L T P C**  
**0 0 6 2**

**LIST OF EXPERIMENTS**

1. Numerical Modeling in Materials Science
2. Simulation Experiment- Design and Analysis
3. Systems Optimization and Analysis
4. Advanced Modeling, Simulation- Based Optimization
5. Molecular Simulation
6. Simulation with MATLAB
7. Image Processing with MATLAB
8. Monte Carlo Simulation
9. Atom Manipulation and Patterning

## SEMESTER II

### SYNTHESIS OF NANOMATERIALS

L	T	P	C
3	0	0	3

#### UNIT I PHYSICAL CHEMISTRY OF SOLID SURFACES NANO STRUCTURES 9

Gibbs free energy, Chemical potential – Surface energy, Isotropic and Anisotropic – Means of reducing surface energy – Chemical potential as a function of surface curvature – Ostwald ripening.

#### UNIT II ZERO AND ONE DIMENSIONAL NANO STRUCTURES 9

Basic requirements, Fundamentals of Nucleation; Homogeneous (theory) and heterogeneous (qualitative) synthesis of Zero-Dimensional metal, semiconductor and oxide nano particles – Sonochemistry and microwave synthesis of nanoparticles – Synthesis of nano wires and nano rods (1-D) – Vapour liquid solid (VLS) and Solution Liquid Solid (SLS) methods – Lithography.

#### UNIT III THIN FILMS 9

Fundamentals of Film growth – Vacuum science – Physical vapor deposition (PVD) – Chemical Vapor Deposition (CVD) – Atomic Layer Deposition (ALD) – Superlattices – Electrochemical Deposition – Sol-Gel Films.

#### UNIT IV NANOSTRUCTURED POLYMERS 9

Macromolecular structural control – Living polymerization – Polymer Conformational control – Morphology of Block copolymers – Nanostructures based on Bulk phase separation and Lyotropic Mesophases – Core-crosslinked and Shell-crosslinked systems – Nanocages – Rod-coil diblock copolymers – Nanostructures from Polymerized Surfactant Assemblies.

#### UNIT V BIOLOGICAL METHODS 9

Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis – Magnetotactic bacteria for natural synthesis of magnetic nanoparticles, mechanism of formation – Viruses as components for the formation of nanostructured materials, Synthesis process and application – Role of plants in nanoparticle synthesis.

**Total: 45**

#### TEXTBOOKS

1. Cao, G., “Nanostructures and Nanomaterials: Synthesis, Properties and Applications”, Imperial College Press, 2004.
2. Rao, C. N. R., Müller, A., Cheetham, A. K., “The Chemistry of Nanomaterials: Synthesis, properties and applications”, Vol. 1, Wiley-VCH, 2004.

#### REFERENCES

1. Ajayan, P.M., Schadler, L.S., Braun, P.V., “Nanocomposite Science and Technology”, Wiley-VCH Verlag, 2003.
2. Gaponenko, S.P., “Optical Properties of semiconductor nanocrystals”, Cambridge University Press, 1980.
3. Edelstein, A.S., and Cammarata, R.C., “Nanomaterial: Synthesis, Properties and Applications”, Taylor and Francis Group, 1996.

## ADVANCED NANOMATERIALS CHARACTERIZATION II

L	T	P	C
3	0	0	3

### UNIT I OPTICAL MICROSCOPY 9

Principle – Types of Microscopes – Lenses – Lens defects and corrections – Magnification – Resolving power – Depth of field and Depth of focus – Design of an Optical Microscope (OM) – Applications – Photomicrography. Types of Optical Microcopies (qualitative): Confocal Laser Scanning Microscopy (CLSM) – Fluorescence Microscopy – Phase Contrast Microscopy (PCM) – Brewster Angle Microscopy (BAM) – Total Internal Reflection Fluorescence Microscopy (TIRFM) – Second Harmonic Imaging Microscopy (SHIM).

### UNIT II FUNDAMENTALS OF ELECTRON MICROSCOPY 9

Theory and principle of Electron Microscope – Electron sources – Electron lenses. Methods for producing Vacuum: Rotary pump – Vapor-Diffusion pump – Turbo Molecular pump – Combination vacuum systems. Methods of measuring vacuum: Pirani gauge – Penning gauge – Hot-Cathode gauge. Electron Micrographic Techniques: Silver Graphic process – Photographic process – Transmission Electron Micrography – Scanning Electron Micrography.

### UNIT III TYPES OF ELECTRON MICROSCOPES 9

TEM: Theory and Modes of operation – Medium and High Voltage TEM – High Resolution TEM (HRTEM). Specimen Preparation in TEM: Staining –Sectioning – Shadow Casting and Replica Techniques – Preparation for Non-biological samples – Applications of TEM. SEM: Theory of operation – Specimen-Beam interactions – Machine variables – Ultra High Resolution SEM (UHRSEM) – Environmental SEM (ESEM) – Scanning Transmission Electron Microscope (STEM). Specimen Preparation in SEM: Mounting – Coating – Special methods for various sample types – Biological sample preparation – Applications of SEM

### UNIT IV FORCE MICROSCOPY 9

AFM: Basic concepts – Interactive forces – AFM – Principle and instrumentation – Force curves and force measurements – Modes of imaging – Probes – Tip functionalization – Applications – Types of force microscopy – Lateral Force Microscopy (LFM) – Electrostatic force Microscopy (EFM) – Magnetic Force microscopy (MFM) – Scanning Thermal Microscope (SThM) – Near-field Scanning Optical Microscope (NSOM)

### UNIT V TUNNELING MICROSCOPY 9

STM: Theory – Tunneling between metals and metal and semiconductors – Tersoff-Hoffman theory – Instrumentation – Piezoelectric scanner – Vibration isolation – Electronics and control – Tip treatment – Applications – Scanning tunneling spectroscopy.

**Total: 45**

## **TEXTBOOKS**

1. Goldstein, J., Newbury, D.E., Joy, D.C., and Lym, C.E., "Scanning Electron Microscopy and X-ray Microanalysis", Science, 2003.
2. Flegler, S.L., Heckman, J.W. and Klomparens, K.L., "Scanning and Transmission Electron Microscopy: A Introduction", WH Freeman and Co, 1993.

## **REFERENCES**

1. Haynes, R., Woodruff, D.P. and Talchar, T.A., "Optical Microscopy of Materials", Cambridge University press, 1986.
2. Paul E.W., "Introduction to Atomic Force Microscopy Theory Practice Applications". Pacific Nanotechnology, 2007.
3. Julian Chen.N, C., "Introduction to Scanning Tunneling Microscopy", Oxford University Press, Inc., 1993.
4. Magonov, S.M., and Whangbo, M-H., "Surface Analysis with STM and AFM: Experimental and Theoretical Aspects of Image Analysis", VCH Publishers, Inc., 1996.

## PROCESSING OF NANOMATERIALS

**L T P C**  
**3 0 0 3**

### **UNIT I NANO FABRICATION AND NANO MANUFACTURING 9**

Nano fabrication: Soft lithography – Manipulative techniques – Carbon nanomaterials – Laser Nano fabrication.

Nano manufacturing: Semiconductor manufacturing – Soft lithographic technique – Molding nanoimprint lithography – Lithographically induced self assembly – Dip-pen Lithography

### **UNIT II LITHOGRAPHIC TECHNIQUES 9**

AFM based nanolithography and nanomanipulation – E-beam lithography – SEM based nanolithography and nanomanipulation – Ion beam lithography – Oxidation and Metallization – Masking and its applications

### **UNIT III BOTTOM-UP AND TOP-DOWN TECHNIQUES 9**

Bottom- up Techniques: Self assembly – Self-assembled monolayer – Directed assembly – Layer-by-layer assembly – Langmuir-Blodgett Technique

Top-down Techniques: Photolithography – Extreme ultraviolet lithography – X-ray lithography

### **UNIT IV BIOSENSORS AND QUANTUM DEVICES 9**

Generation of Biosensors – Immobilization, characteristics, applications – Conducting polymer based sensors – DNA Biosensors – Optical sensors – Biochips

Quantum devices: Quantum layers – Quantum wells – Quantum dots – Quantum wires

### **UNIT V ORGANIC ELECTRONIC AND NANOPROCESSING 9**

Organic light emitting diode (OLED) – Organic field effect transistor (OFET). Nanoprinting: Introduction, Characteristics and Applications

**Total: 45**

### **TEXTBOOKS**

1. Jakson. M. J., “Microfabrication and Nanomanufacturing”, Taylor and Francis Group, 2006

### **REFERENCES**

1. Wan-Li.X, Jing.C., “Frontiers in Biochip technology”, , Birkhauser 2006
2. Tsakalakos.T., Anatolevich O.I., Vasudevan. A. K., “Nanostructures: Synthesis, functional properties and applications”, Springer, 2003

## NANOTECHNOLOGICAL APPLICATIONS

L	T	P	C
3	0	0	3

### UNIT I MEDICINAL APPLICATIONS 9

Therapeutic applications of Nanoparticles / nanoparticulate Delivery systems – Cancer therapy – Intracellular targeting – treatment of respiratory diseases – per oral absorption – ocular delivery – Gene delivery – Brain delivery – prolonged systemic circulation.

### UNIT II APPLICATIONS IN CHEMISTRY 9

Nanocatalyst for petrochemical industries – Liquid crystal and flexible flat panel display – Colloid chemistry and particles in nanotechnology – Membranes in Nanotechnology – Interaction of Nanoparticles with Lipid Membrane – Nanotechnology in Paints and coatings.

### UNIT III ENVIRONMENT REMEDIATION 9

Nanoparticle applications in waste water treatment – Oxidative Degradation of the Thiocarbamate Herbicide, Molinate using Nanoscale Zero Valent Iron - Permeable Reactive Barrier– Molecular Oxygen Activation by ZEA(Zero Valent Iron, EDTA and Air) – Hierarchical self-assembled nano-structures for adsorption of heavy metals.

### UNIT IV APPLICATIONS IN INFORMATION AND COMMUNICATION 9

Nanomaterials with novel optical, electrical, and magnetic properties – Faster and smaller non-silicon-based chipsets, memory, and processors – New-science computers based on Quantum Computing- Faster and smaller telecom switches, including optical switches- Higher-speed transmission phenomena based on plasmonics and other quantum-level phenomena.

### UNIT V CONSUMER GOODS APPLICATIONS 9

Food packaging using nanocomposite coating - the detection of chemical and biological substances for sensing biochemical changes in foods – self-cleaning in household items – Optics - anti-reflective ultra thin coating - scratch resistance coating – Nanotreated fabrics for spill resistant, stain proof, wrinkle resistant and static proof – sunscreen based nanoparticles.

**Total: 45**

### TEXTBOOKS

1. Park.J.B.,and Lakes R.S., “Biomaterials”, Plenum, 1992.
2. Hillie, T., and Mbhuti H., "Nanotechnology and the challenge of clean water." Naturenanotechnolgy, Vol. 2 2007:.

### REFERENCES

1. Sung. H.J., Francis C. I., “Nanotechnology for Environmental Remediation”, Birkhäuser, 2006
2. Waldner. J., “Nanocomputers and Swarm Intelligence”. ISTE, 2007.
3. Minoli.D., “Nanotechnology Applications to Telecommunications and Networking”, Wiley-Interscience, 2005.

# NANO PERVASIVE DEVICES

L	T	P	C
3	0	0	3

## UNIT I PERVASIVE COMPUTING CONCEPT 9

Pervasive computing and Ubiquitous computing – Ambient Computing – Principles of Pervasive computing – Relationship of Wireless, Internet and Ubiquitous Computing – Wearable computing – Context aware computing.

## UNIT II PERVASIVE DEVICE TECHNOLOGIES 9

Pervasive Computing devices and Interfaces – Device technology trends – PDA in Pervasive Computing – Introduction, PDA software Components, Standards, emerging trends, PDA Device characteristics – Mobile computing devices characteristics, Adaptation – Data dissemination and Management – Heterogeneity – Interoperability – Context awareness – User Interface design issues – Difference between UI design for mobile devices and conventional systems — Mobile device technology overview – Windows CE- Symbian – J2ME – Pocket PC.

## UNIT III DEVICE CONNECTIVITY AND PERVASIVE ARCHITECTURE 9

IEEE 802.11 technologies - Infrared technologies - Bluetooth networks - Personal Area Networks – Mobility Management, Mobile IP, Mobile agents, Connecting issues and protocols – PDA Based Access Architecture – XML and its role in Pervasive Computing – Wireless Application Protocol (WAP) Architecture – Wireless Mark-Up language (WML) – Pervasive Web application Architecture.

## UNIT IV SENSOR NETWORKS AND RFID's 9

Introduction to sensor networks – Sensor Node Architecture – Sensor Network Architecture – Types of sensor networks – Platforms for wireless sensor networks – Application of wireless sensor networks – Introduction to RFID, transponder and reader architecture – Types of tags and readers – Frequencies of operation – Application of RFID Technologies.

## UNIT V APPLICATIONS OF PERVASIVE DEVICES 9

Voice Enabling Pervasive Computing – Voice Standards – Speech Applications in Pervasive Computing – Applications of Pervasive Computing – Retail, Healthcare, Sales force automation – Tracking applications.

**Total: 45**

### TEXTBOOK

1. Burkhardt, Henn, Hepper, Rintdorff, Schaeck, “Pervasive Computing”, Addison Wesley, 2002.

### REFERENCES

1. Adelstein.F., Gupta.S.K.S.,”Fundamentals of mobile and pervasive computing” Tata McGra Hill, 2005.
2. Uwe Hansman, Lothat Merk, Martin S.N., and Thomas.S.,: “Principles of Mobile Computing, Second Edition”, Springer- Verlag, 2003

### LIST OF EXPERIMENTS

1. Synthesis of Zero Valent Iron Nanoparticle
2. Preparation of Cadmium Sulphide Nanomaterial
3. Synthesis of Cobalt Nanomaterial by polyol method
4. Synthesis of Copper-Cobalt alloy nanomaterial by polyol method
5. Synthesis of Zinc Oxide Nanoparticle
6. Synthesis of Silver Nanoparticle using ice bath method
7. Synthesis of Silver Nanoparticle using polyol method
8. Synthesis of Silver Nanoparticle using Gallic acid method
9. Synthesis of Gold Nanoparticle

### LIST OF EXPERIMENTS

1. Characterization of different nanoparticles using XRD studies and UV-Visible Spectrophotometer
2. Determination of particle size analysis of Zero Valent Iron Nanoparticle (ZVIN)
3. Preparation of Solid-Lipid nanoparticles
4. Synthesis of Polymer nanoparticles
5. Synthesis of gold/silver nanoparticles using Plant extract
6. Crystal growth experiment using constant temperature bath
7. Multi ferrites bimetallic nanoparticles synthesis

## SEMESTER III

### CHEMICAL NANOTECHNOLOGY

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#### UNIT I CHEMISTRY OF NANOPARTICLES 9

Synthesis by Organic Molecule Templates – Molecular Self-Assembly – Spatially Constrained Synthesis - Biomimetic Synthesis – Oxide Nanoparticles – Particle size – Particle shape – Particle density – Composite structure – Pore structure – Surface modification of inorganic Nanoparticles by organic functional groups

#### UNIT II ADVANCED POLYMERIC MATERIALS 9

Polymer chain statistics – Static light scattering – Hydrodynamics of polymer solutions – Thermodynamics of polymer solutions – Polymer blends – Solubility parameters and group contribution methods – High performance thermoplastics – Polymer material for photovoltaic applications – Synthetic biomedical polymers – Optical fibers – Assembly of polymer – Nanoparticle composite material – Fabrication of polymer – Applications of polymers in catalysis.

#### UNIT III SUPRAMOLECULAR CHEMISTRY 9

Dendrimers and their applications – From molecular to supramolecular Chemistry, Molecular Recognition, Anionic Coordination Chemistry and Recognition of Anionic Substrates, Multiple Recognition Applications.

#### UNIT IV NANOCATALYSIS 9

Types of catalysis – Homogeneous, heterogeneous and biocatalysis – Catalysis by nanoparticles – Physical properties of free and supported nanoparticles – Reactivity of supported metal nanoparticles – Gold nanoparticles – Preparative methods and properties – Reactions – Water gas shift – vinyl acetate synthesis – hydrogenation – CO oxidation – Heck reaction – Commercial application.

#### UNIT V ELECTROCHEMISTRY OF NANOMATERIALS 9

Electrochemistry of Semiconductor Nanostructures, Nanostructured Metal Oxide Films. Electrochemistry with Nanoparticles – Preparation of Nanostructures, Electrochemistry with Metallic Nanoparticles – Monolayer protected nanoclusters, Nanoelectrode Ensembles, Single Electron Events, Probing Nanoparticles using Electrochemistry Coupled with Spectroscopy – Nanosensors – Biosensors – Chemical Sensors –Electrocatalysis.

**Total: 45**

## **TEXTBOOKS**

1. Hosokawa.M., Nogi.K., Naito.M. Y., “Nanoparticle Technology Handbook” Vol. I, Elsevier, 2007
2. Pignataro.B., “Tomorrow’s Chemistry Today, Concepts in Nanoscience, Organic Materials and Environmental Chemistry”, Wiley-Vch Verlag GmbH, 2008.

## **REFERENCES**

1. Carraher.C. E., Seymour . R. B., “Polymer Chemistry”, CRC / Taylor and Francis, 2008
2. Rao. C. N. R., Müller.A., Cheetham.A. K., “The Chemistry of Nanomaterials: Synthesis, Properties and Applications”, Wiley-Vch Verlag GmbH, 2004
3. Ozin.G.A., Aresenault.A.C., “Nanochemistry: A Chemical Approach to Nanomaterials”, RSC Publishing, 2005.
4. Br’échignac.C ., Houdy.P., Lahmani. M., “Nanomaterials and Nanochemistry”, Springer-Verlag, 2007

# THEORY OF NANOSTRUCTURES

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## UNIT I SEMICONDUCTOR PHYSICS AND INTERACTING SUBSYSTEM 9

Semiconductor-Doping – Concept of effective mass – Optical properties of semiconductors –Phonon-Phonon, Electron-Electron, Electron-Phonon, Electron-Photon and Phonon-Photon interactions – Inhomogeneities

## UNIT II ELECTRICAL PROPERTIES OF SEMICONDUCTOR NANOCRYSTALS 9

Introduction – Theory of Electron Transfer between Localized States – Experimental techniques – Nanocrystals and Photoinduced electron transfer – Nanocrystal-based devices: Light-Emitting Diodes- Photodiodes

## UNIT III SEMICONDUCTOR NANOSTRUCTURES 9

Semiconductor nanowires – Fabrication strategies – Quantum conductance effects in semiconductor nanowires – Porous Silicon – Nanobelts – Nanoribbons – Nanosprings

## UNIT IV FUNDAMENTALS OF NANOMAGNETISM 9

Introduction – Magnetic fundamentals – Magnetic Storage Fundamentals – Electron Transport in Magnetic Multi-layers – Particulate Nanomagnets – Geometrical Nanomagnets – Fabrication using Scaling technique – Characterization using Various Techniques: Imaging Magnetic Microspectroscopy – Magnetic Force Microscopy

## UNIT V SPIN TRANSPORT ELECTRONICS IN MAGNETIC METALLIC SYSTEMS 9

High-Density Data Storage and High-Sensitivity Read Heads – The GMR Effect – Spin Valves – Magnetic Tunnel Junctions – Device Applications for Spin Valves and Magnetic Tunnel Junctions – Magnetoresistive Random Access Memory – Spintronics Devices: Light-Emitting Diode – Nuclear Spin Quantum Computer

**Total: 45**

### TEXTBOOKS

1. Robert W. K., Mark G., Ian W. H., “Nanoscale Science and Technology”, John Wiley and Sons, 2005.
2. Jan G.K., and Andreas G., “Semiconductors for Micro and Nanotechnology - An Introduction for Engineers”, Wiley-VCH Verlag GmbH, 2002

### REFERENCES

1. Balandin A. A., Wang K. L., “Handbook of Semiconductor Nanostructures and Nanodevices” Vol 1-5, 2005
2. Cao, G., Nanostructures and Nanomaterials-Synthesis, Properties and Applications, Academic Press, 2004.
3. Victor I.K., “Semiconductors and Metal Nanocrystals: Synthesis and Electronic and Optical Properties”, Marcel Dekker, 2004.

## **FUNCTIONAL NANOMATERIALS LABORATORY**

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### **LIST OF EXPERIMENTS**

- 1) Liposome synthesis
- 2) Synthesis of Chitosan nano and micro particles
- 3) Synthesis of bio-functionalized nanoparticles
- 4) Thin film deposition of inorganic nanoparticles by thermal evaporation.
- 5) Preparation of Nanowires from silver nanoparticle
- 6) Preparation of Nanowires using cuprous oxide
- 7 Synthesis of Core-shell nanoparticles
- 8) Nanotubes synthesis using Titanium dioxide

# ELECTIVE I

## NANOTECHNOLOGY FOR ENERGY SYSTEMS

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### UNIT I ENERGY SOURCES 9

Conventional fossil fuels – Unconventional fossil fuels – Oil shale, Tar sands, Clathrates – Application of nanotechnology to fossil fuels: Extraction of fossil fuels, Catalysis and syngas, usage of fossil fuels, Thermoelectrics, Superstrength materials – Nuclear fission and Nuclear fusion – Solar energy (direct and indirect sources) – Tidal energy- Energy challenges, development and implementation of renewable energy technologies

### UNIT II ENERGY RELATED APPLICATIONS 9

Applications of nanotechnology to fission and fusion energies – Applications of nanotechnology to geothermal energy – Applications of nanotechnology to direct and indirect solar energy sources – Nanotechnology enabled renewable energy technologies.

### UNIT III MOLECULAR NANOTECHNOLOGY AND ENERGY EFFICIENCY 9

Molecular Nanotechnology (MNT) vs Prometheus – Fuel Cells, Fuel Cell Catalysts and Fuel Cell Electrolyte – Catalysis – High Strength Materials – Energy Storage – Portable power sources – Batteries, Capacitors and Fuel cells – Electro synthesis – MNT, nanofabrication and distributed fabrication – Passive handling – Smart Materials, High Temperature Superconductors – MNT and Solid State Energy System

### UNIT IV HYDROGEN STORAGE METHODS 9

Hydrogen storage methods , Gaseous and Liquid Storage – Materials based Storage – Chemical storage – Physical storage – Hydrogen Storage Challenges – Status of Hydrogen Storage Technologies – safety in hydrogen storage – Advanced storage methods – hydride storage materials for automotive applications.

### UNIT V BIOFUELS 9

Microbiology and basic terminology, Metabolic pathway in the microorganisms and bioenergy - Biohydrogen production from biomass – Biomethane production from biomass – Bioethanol production from biomass – Value-added chemicals production from biomass – Aqueous wastes containing biodegradable organic matter, animal residues – Gasohol as a substitute for Leaded Petrol –Esterification of Oils to Produce Bio-Diesel – Applications of nanotechnology in biofuels.

**Total: 45**

### TEXTBOOKS

1. Twidell.J., and Weir .T., “Renewable Energy Resources,” E and F N Spon Ltd, 1986.
2. Shatwell.R.A., “Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures , in Fuel cell technology handbook”. CRC Press, 2003.

### REFERENCES

1. Vielstich, “Handbook of fuel cells: Fuel cell technology and applications”, CRC Press, 2003.
2. Olsson.L., Ahring. B. K., “Biofuels” , Springer, 2007

## BIO-ENERGY AND CONVERSION

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3	0	0	3

### UNIT I BIOMASS FORMATION 9

Biomass resources: Classification and characteristics – Techniques for biomass assessment – Application of remote sensing in forest assessment – Biomass estimation – Nanotechnology role in formation of biomass.

### UNIT II THERMOCHEMICAL CONVERSION 9

Different processes: Direct combustion, incineration, pyrolysis, gasification and liquefaction – Economics of thermo chemical conversion.

### UNIT III BIOLOGICAL CONVERSION 9

Biodegradation and biodegradability of substrate – Biochemistry and process parameters of biomethanation – Biogas digester types – Digester design and biogas utilisation – Chemical kinetics and mathematical modeling of biomethanation process – Economics of biogas plant with their environmental and social impacts – Bioconversion of substrates into alcohol-methanol and ethanol production, organic acids, solvents, amino acids, antibiotics etc.

### UNIT IV CHEMICAL AND WASTE CONVERSION 9

Hydrolysis and hydrogenation – Solvent extraction of hydrocarbons –Solvolysis of wood – Bio-crude and bio-diesel –Chemicals from biomass. Anaerobic digestion of sewage and municipal wastes – Refuse derived solid fuel – Land fill gas generation and utilization

### UNIT V POWER GENERATION 9

Utilization of gasifier for electricity generation – Operation of spark ignition and compression ignition engine with wood gas, methanol, ethanol and biogas – Biomass integrated gasification/combined cycles systems –Sustainable cofiring of biomass with coal – Biomass productivity: Energy plantation and power programme - Conventional sources of energy using Nanotechnology

**Total: 45**

### TEXT BOOK

1. Anthony S. P., “Biochemical and Photosynthetic aspects of Energy Production”, Academic Press, 1980
2. David B., “Bio Energy Technology Thermodynamics and costs”, Ellis Hoknood, Chichester, 1984
3. Mittal J., “Profit From Nanotechnology” NSTC Publication , 2005.

### REFERENCES

1. El -Halwagi M.M., “Biogas Technology : Transfer & Diffusion”, Elsevier Applied SC, 1986
2. Ravindranath N. H., and Hall D. O., “Biomass, Energy, and Environment: A Developing Country Perspective from India”, Oxford University Press, 1995

## ELECTIVE II

### NANOELECTRONICS

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#### UNIT I CONVENTIONAL AND INNOVATIVE ELECTRONIC DEVICES 9

MOS Transistors – Structure and Technology – Electrical Characteristics – Bipolar Transistors – Structure and Technology – Resonant Tunneling Diode – Principle and Technology – Applications – Quantum Cascade Laser – Principle and Structure – Applications of Quantum Cascade Lasers – Single Electron Transistor – Principle – Technology – Applications – Carbon Nanotube Devices – Structure and Technology – Carbon Nanotube Transistors

#### UNIT II MEMORY DEVICES AND OTHER ELECTRONIC DEVICES 9

Static and Dynamic Random Access Memories (SRAM and DRAM) – CMOS, Optical and Ferroelectric memories – Electro-Optic Effect: Introduction – Electro-optic effect in KDP crystals – Longitudinal mode – Transfer mode – Electro-optic effect in Lithium Niobate crystals – Surface Acoustic Wave devices

#### UNIT III NANOSENSORS 9

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 – Gas-sensitive FETs – Resistive semiconductor gas sensors – Electronic noses

#### UNIT IV NANOCOMPUTERS, NANO-ARCHITECTONICS, AND NANO-ICs 9

Introduction – Nano-Electronics and Nanocomputer Fundamentals – Nanocomputer Architecture – Hierarchical Finite – State Machines and Their Use in Hardware and Software Design – Reconfigurable Nanocomputers – Mathematical Models for Nanocomputers – Nanocompensator Synthesis and Design Aspects

#### UNIT V QUANTUM DOTS AND QUANTUM DOT ARRAYS 9

Introduction – Synthesis of Quantum Dots – Colloidal Nanocrystals – Quantum Dots grown via Vapor-Phase deposition – Unique optical properties – Quantum-Dot Arrays – Applications: Quantum – Dot Solar cells – Background – Quantum-Dot Solar Cell Configurations

**Total: 45**

#### TEXTBOOKS

1. Goser K., Glosekotter P., Dienstuhl J., “Nanoelectronics and Nanosystems: From transistors to molecular devices”, Springer 2004
2. Rainer Waser, “Nanoelectronics and information technology: Advanced electronic materials and novel devices”, Wiley-VCH Verlag, 2005

#### REFERENCES

1. Mick.W., Kamali K., Geoff.S., Michelle .S., Burkhard R., “Nanotechnology: basic science and emerging technologies”, Overseas Press 2005.
2. Victor I.K., “Semiconductors and Metal Nanocrystals: Synthesis and Electronic and Optical Properties”, Marcel Dekker, 2004

# NANOELECTRONICS AND SENSORS

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## UNIT I SEMICONDUCTOR NANODEVICES 9

Single-Electron Devices; Nano scale MOSFET – Resonant Tunneling Transistor - Single-Electron Transistors; Single-Electron Dynamics; Nanorobotics and Nanomanipulation; Mechanical Molecular Nanodevices; Nanocomputers: Theoretical Models; Optical Fibers for Nanodevices; Photochemical Molecular Devices; DNA-Based Nanodevices; Gas-Based Nanodevices; Micro and Nanomechanics.

## UNIT II ELECTRONIC AND PHOTONIC MOLECULAR MATERIALS 9

Preparation –Electroluminescent Organic materials - Laser Diodes - Quantum well lasers:- Quantum cascade lasers- Cascade surface-emitting photonic crystal laser- Quantum dot lasers- Quantum wire lasers:- White LEDs - LEDs based on nanowires - LEDs based on nanotubes- LEDs based on nanorods High Efficiency Materials for OLEDs- High Efficiency Materials for OLEDs - Quantum well infrared photo detectors.

## UNIT III THERMAL SENSORS 9

Thermal energy sensors -temperature sensors, heat sensors- Electromagnetic sensors- electrical resistance sensors, electrical current sensors, electrical voltage sensors, electrical power sensors, magnetism sensors - Smoke Sensors, Sensors for aerospace and defense: Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers - Chemical sensors - Optical and radiation sensors.

## UNIT IV GAS SENSOR MATERIALS 9

Criteria for the choice of materials, Experimental aspects – materials, properties, measurement of gas sensing property, sensitivity; Discussion of sensors for various gases, Gas sensors based on semiconductor devices.

## UNIT V BIOSENSORS 9

Principles- DNA based biosensors – Protein based biosensors – materials for biosensor applications- fabrication of biosensors—future potential.

**Total: 45**

### TEXT BOOKS

1. Ranier W., “Nano Electronics and Information Technology”, Wiley, 2003.
2. Drexler K.E., “Nano systems”, Wiley, 1992.

### REFERENCES

1. Petty M. C., Bryce M. R., and Bloor D., “Introduction to Molecular Electronics”, Oxford University Press, 1995.
2. H. Meixner, Sensors: Micro & Nanosensors, Sensor Market trends (Part 1&2) Vch Verlagsgesellschaft Mbh, 1995

## ELECTIVE III

### NANOPHOTONICS

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#### UNIT I QUANTUM CONFINED MATERIALS 9

Quantum dots – Optical transitions – Absorption-inter-band transitions – Quantum confinement intraband transitions – Fluorescence / Luminescence – Photoluminescence / Fluorescence – Optically excited emission – Electroluminescence emission

#### UNIT II PLASMONICS 9

Internal reflection and evanescent waves – Plasmons and Surface Plasmon Resonance (SPR) – Attenuated total reflection – Grating SPR coupling – Optical waveguide SPR coupling – SPR dependencies and materials – Plasmonics and Nanoparticles

#### UNIT III NEW APPROACHES IN NANOPHOTONICS 9

Near-Field Optics – Aperture near-field optics – Apertureless near-field optics – Near-field scanning optical microscopy (NSOM or SNOM) – SNOM based detection of plasmonic energy transport – SNOM based visualization of waveguide structures – SNOM in nanolithography – SNOM based optical data storage and recovery

#### UNIT IV BIOPHOTONICS 9

Interaction of light with Cells – Tissues – Nonlinear optical processes with intense laser beams – Photoinduced effects in biological systems – Generation of optical forces – Optical trapping and manipulation of single molecules and cells in optical confinement – Laser trapping and dissection for biological systems – Single molecule biophysics – DNA protein interactions

#### UNIT V PHOTONIC CRYSTALS 9

Important features of photonic crystals – Presence of photonic bandgap – Anomalous Group Velocity Dispersion – Microcavity – Effects in Photonic Crystals – Fabrication of photonic crystals – Dielectric mirrors and interference filters – Photonic Crystal Laser – PC based LEDs – Photonic crystal fibers (PCFs) – Photonic crystal sensing

**Total: 45**

#### TEXTBOOKS

1. Masuhara.H., Kawata S., and Tokunaga F., “Nano Biophotonics”, Elsevier Science, 2007
2. Shalaev V. M., and Kawata S., “Nanophotonics with Surface Plasmons (Advances in Nano-Optics and Nano-Photonics)”, Elsevier, 2007

#### REFERENCES

1. Saleh B.E.A., and Teich A.C., “Fundamentals of Photonics”, John-Wiley and Sons, 1993
2. Ohtsu M., Kobayashi K., Kawazoe T., and Yatsui T., “Principles of Nanophotonics (Optics and Opto electronics)”, University of Tokyo, 2003
3. Prasad P.N., “Introduction to Biophotonics”, John Wiley and Sons, 2003
4. Joannopoulos J. D., Meade R. D., and Winn J. N., “Photonic Crystals”, Princeton University Press, 1995

## NANOSCALE MAGNETIC MATERIALS AND DEVICES

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### UNIT I OVERVIEW OF MAGNETISM IN SOLIDS 9

Introduction – Magnetic fundamentals – Spontaneous Magnetization and Curie Temperature – Magnetic Parameters – Stoner-Wohlfarth threshold – Antiferromagnetic materials – Memory Fundamentals – Magnetic Storage Fundamentals.

### UNIT II FUNDAMENTALS OF NANOMAGNETISM 9

Electron Transport in Magnetic Multi-layers – Spintronics - Spin Polarized Electron Tunneling – Interlayer Exchange Coupling – Spin Relaxation in Magnetic Metallic layers and Multi-layers - Non-Equilibrium Spin Dynamics in Laterally Defined Magnetic Structures

### UNIT III FABRICATION AND CHARACTERIZATION 9

Particulate Nanomagnets – Geometrical Nanomagnets – Fabrication Techniques Scaling – Characterization using Various Techniques – Imaging Magnetic Microspectroscopy – Study of Ferromagnetic & Antiferromagnetic Interfaces – Optical Imaging – Lorentz Microscopy – Electron Holography of Magnetic Nanostructures –Magnetic Force Microscopy

### UNIT IV APPLICATIONS AND DEVICES 9

Magnetic Data Storage – Introduction – Magnetic Media – Properties – Materials Used – Write Heads – Read Heads – Magnetoresistance – General – in Normal Metals and in Ferromagnetic Materials

### UNIT V MEMORY AND DATA STORAGE 9

Future of Magnetic Data Storage - Magneto-Optics and Magneto-optic recording – Kerr Effect – Faraday Effect – Magnetic Semiconductors – Spintronics devices and noise reduction.

**Total: 45**

### TEXT BOOKS

1. Hadis M., “Advanced semiconductor and organic Nano-techniques” – Vol. I, Academic Press, 2003
2. Yimei Zhu, “Modern Techniques for Characterizing Magnetic Materials”, Springer, 2005

### REFERENCES

1. Hans P.O., and Hopster H., “Magnetic Microscopy of Nanostructures”, Springer 2004
2. Bland J.A.C., and B. Heinrich.B., “Ultra thin Magnetic Structures III – Fundamentals of Nanomagnetism”, Springer 2004
3. Nicola A.S., “Magnetic Materials : Fundamentals and Device Applications”, Cambridge University Press 2003.

## ELECTIVE IV

### NANOBIOTECHNOLOGY

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#### UNIT I NATURAL NANOCOMPOSITES 9

Natural nano composite materials – Biomineralisation – Biologically synthesized nano structures – metals, ceramic and, silica deposition vesicles –Nanotechnology in Agriculture, Fertilizers and pesticides.

#### UNIT II SMART NANOPARTICULATE SYSTEMS 9

Thermo responsive delivery systems, pH responsive Delivery systems, External stimuli based delivery systems (Magnetic, photosensitive and ultra sound sensitive delivery systems) – Stealth nanoparticles , multi targeting systems

#### UNIT III PROTEIN AND DNA BASED NANOSTRUCTURES 9

S-Layer proteins, Biotemplating – Engineered nanopores –Protein based nanostructure formation – Nanoparticle, biomaterial hybrid systems – *De Novo* Designed Structures – Biomolecular Motors – DNA-Protein nanostructures, Biomimetic fabrication of DNA-based metallic nanowires, conjugates and networks.

#### UNIT IV NANOBIOELECTRONICS 9

DNA based nanomechanical devices – Biology inspired concepts – DNA as a biomolecular template, DNA branching for network formation – Bioelectronics – Nanoparticle enzyme hybrids – Biorecognition events of Nanoparticles – DNA analyzer as biochip – Biomimetic ferritins.

#### UNIT V THERAPEUTIC AND DIAGNOSTIC APPLICATIONS OF NANOPRTICLES 9

Gene Therapy using nanoparticles – Nanofluids (Aqueous dispersed applications of nanoparticles) – Nanoparticles in bioanalytical Techniques (Quantum dots, SPR based and peptide based sensors) – Advances in cancer therapy.

**Total: 45**

#### TEXTBOOKS

1. Niemeyer C.M., and Mirkin C.A., “Nanobiotechnology: Concepts, applications, and perspectives”, by Wiley-VCH Verlag GmbH ,2004
2. Robert A. F. Jr. “Nanomedicine: Basic Capabilities” Vol.1, Landes Biosciences, 2003.

#### REFERENCES

1. Oded Shoseyov and Ilan Levy, “Nanobiotechnology: bioinspired devices and materials of the future”, Humana Press Inc.2008
2. <http://www.jnanobiotechnology.com/info/quickguide.asp>

## BIOMATERIALS AND TISSUE ENGINEERING

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### UNIT I BIOMEDICAL APPLICATIONS 9

Overview of materials science and types of materials used in biomedical applications – Polymer chemistry – Polymer physics and processing – Mechanical properties of polymers – Polymer biodegradation and design of biodegradable polymers – Inorganic materials in biomedical applications – Hybrid materials in biomedical applications – Introduction to surface properties and analysis – Protein adsorption – Cell adhesion – Surface modification and immobilization.

### UNIT II DRUG DELIVERY SYSTEMS 9

Immune response to biomaterials – Inflammation, Anticoagulation & Fibrinolysis – Bacterial adhesion and infection, sterilization of biomaterials – Hydrogels and natural biomaterials – Biomaterials used in drug delivery systems – In vitro evaluation of biomaterials – Angiogenesis in biomaterials – In vivo evaluation of biomaterials, animal models – Clinical applications of biomaterials.

### UNIT III TISSUE ENGINEERING 9

Introduction to Scaffolds – Collagen – GAG Analogs of Extracellular Matrix – Tissue engineering – Hydrogels for tissue engineering – Hydrogels from natural polymers – Synthetic polymers – Polypeptides and future perspectives.

### UNIT IV CARDIOVASCULAR BIOMATERIALS AND TISSUE ENGINEERING 9

Cardiovascular biomaterials and tissue engineering: Protein Adsorption, Coagulation, Platelets, Cell Adhesion/Integrins, Endothelial Cells, Matrices for Tissue Engineering, Smart Biomaterials, Tissue Engineered Heart Valves, Tissue Engineered Blood Vessels, Infection in Cardiovascular Devices.

### UNIT V TISSUE ARCHITECTURE 9

Nanoprobes, nems, use of ultrashort pulse lasers for tissue welding, tissue contouring, tissue regeneration – New nanotechnological methods for *in vivo* recreation of tissue architecture – Reinforcement of nano particles for bone tissue engineering – Characterization of porous components for tissue engineering – Other biomaterials for skin, nerve, fat, regeneration.

**Total: 45**

### TEXTBOOKS

1. Ratner B.D., Hoffman A.S., Schoen F.J., and Lemons J.E., “Biomaterials Science: An Introduction to Materials in Medicine”, Academic Press, 1996.
2. Park J.B., and Lakes R.S., “Biomaterials”, Plenum, 1992.

### REFERENCE

1. Fung Y.C., “Biomechanics: Mechanical Properties of Living Tissues”, Springer, 1993.

## ELECTIVE V

### NANOMEDICINE AND DRUG DELIVERY SYSTEMS

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#### UNIT I PROSPECT OF NANO-MEDICINE 9

History of the idea – The Biological and Mechanical Traditions – Nano-medicine – Taxonomy – Bio-Pharmaceuticals – Implantable Materials – Implantable Devices – Surgical Aids – Diagnostic Tools – Genetic Testing – Imaging – Nanoparticles Probe – Case Analysis – 1) Resiprocytes – Mechanical Artificial Red Cells – 2) Using DNA as a construction medium

#### UNIT II NANOCARRIERS FOR DRUG DELIVERY 9

Fundamentals and rationale of sustained / controlled/ targeted drug delivery – Factors influencing the design and performance of sustained release / controlled / targeted release products – Needs and Requirements of nanocarriers – Nanoparticle Flow: Implications for Drug Delivery – Polymeric Nanoparticles as Drug Carriers and Controlled Release Implant Devices

#### UNIT III NANOPARTICULATE SYSTEMS FOR DRUG DELIVERY 9

Polymer used for the formulation of controlled drug delivery systems – Classification and applications of polymers – Polymeric Micelles as Drug Carriers – Dendrimers as Nanoparticulate Drug Carriers – Nanocapsules preparation, Characterization and Therapeutic Applications

#### UNIT IV LIPID BASED NANOCARRIERS 9

Liposomes for Genetic Vaccines and cancer therapy – Recent Advances in Microemulsions as Drug Delivery Vehicles – Lipoproteins as Pharmaceutical Carriers – Solid Lipid Nanoparticles as Drug Carriers – Lipidic core nanocapsules

#### UNIT V NANO CARRIERS AS DRUG TARGETING TOOLS 9

Nanoparticulate Drug Delivery systems for the delivery of drugs to the Gastro-Intestinal Tract, Reticuloendothelial System, Cardiovascular System , lungs, Brain, and Lymphatic.

**Total: 45**

#### TEXTBOOKS

1. Parag D., and Ashish., “Nano Medicines”, Pentagon Press, 2006.
2. Vladimir P.T., “Nanoparticulates as Drug Carriers”, Imperial College Press, 2006.

#### REFERENCE

1. Reza.A., Kentus. L., “Smart Nanoparticles in nanomedicine “, Voume 8, Kentus Books, 2005

# NANOTECHNOLOGY IN HEALTHCARE

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## **UNIT I NANOTECHNOLOGY IN PHARMACEUTICAL APPLICATIONS 9**

Human anatomy – Form function and physiology – Developmental prolog – Principle of development – Neurophysiology – Sensory physiology and muscle physiology - Trends in nanobiotechnology – Protein and peptide based compounds for cancer, diabetes, infectious diseases and organ transplant – therapeutic classes –focused pharmaceutical delivery systems.

## **UNIT II IMMUNOASSAY TECHNIQUES 9**

Understanding of antibody-based diagnostic techniques (immunoassay) – micro and nano-immunosensors – Bio-Barcode Assay – Use of magnets, gold, DNA and antibodies – therapies and diagnostics for cancer and central nervous system disorders.

## **UNIT III IMPROVED MEDICAL DIAGNOSTICS 9**

Improved diagnostic products and techniques – *in vivo* imaging capabilities by enabling the detection of tumors, plaque, genetic defects and other disease states-ability to control or manipulate on the atomic scale – Nanobot medical devices – Logic and intelligence embedded into medical devices – Standalone sensing and computing devices.

## **UNIT IV PROSTHETIC AND MEDICAL IMPLANTS 9**

New generations of prosthetic and medical implants – artificial organs and implants – artificial scaffolds or biosynthetic coatings – biocompatibility and reduced rejection ratio – retinal, cochlear, and neural implants, repair of damaged nerve cells, and replacements of damaged skin, tissue, or bone.

## **UNIT V METHODS FOR DIAGNOSIS 9**

Animation of the PCR – DNA Profiling – Cantilever Sensors – Targeted Drug Delivery – Magnetic Nanoparticles – Cancer cell targeting – Stem Cell Scaffolds – Electrochemical Impedance Spectroscopy (EIS) – Tethered Lipid Membranes.

**Total: 45**

### **TEXT BOOKS**

1. Brian, R. E., “Chemical Sensors and Biosensors” Wiley, 2002.
2. Gorton L., “Biosensors and modern biospecific analytical techniques, Comprehensive Analytical Chemistry” Elsevier, 2005.

### **REFERENCES**

1. David W., “The Immunoassay Handbook” 3rd Edn. Elsevier, 2005.
2. Allen J.B., Larry R.F., “Electrochemical Methods: Fundamentals and Applications” Wiley, 2nd Edn, 2001.
3. Vladimir M. M., “Ultrathin Electrochemical Chemo- and Biosensors: Technology and Performance in Chemical Sensors and Biosensors” Vol.2. Springer, 2004.