AFFILIATED INSTITUTIONS

ANNA UNIVERSITY, CHENNAI

REGULATIONS - 2009

CURRICULUM II TO IV SEMESTERS (FULL TIME)

M.TECH. NANOSCIENCE AND TECHNOLOGY

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	NT9321	Photonics	3	0	0	3
2.	NT9322	Mechanical processing and properties of Nanostructure Materials	3	0	0	3
3.	NT9323	Physicochemical methods for characterization of Nanomaterials	3	0	0	3
4.	NT9324	Imaging techniques for Nanotechnology	3	0	0	3
5.	NT9325	Nanotechnology in Health Care	3	0	0	3
6.	NT9326	Product Design, Management Techniques and Entrepreneurship	3	0	0	3
PRACTICAL						
7.	NT9328	Nanometrology and Microscopy	0	0	4	2
		TOTAL	**18**	**0**	**4**	**20**

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	NT9331	Lithography and Nanofabrication	3	0	0	3
2.	E1	Elective-I	3	0	0	3
3.	E2	Elective-II	3	0	0	3
4.	E3	Elective-III	3	0	0	3
PRACTICAL						
5.	NT9135	Project Work (Phase – I)	0	0	8	6
		TOTAL	**12**	**0**	**8**	**18**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1.	NT9341	Project Work (Phase – II)	0	0	16	12
		TOTAL CREDIT	**0**	**0**	**16**	**12**

ELECTIVE PAPERS – Nanoscience and Technology – Materials Stream

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	NT9001	Top down Manufacturing Methods	3	0	0	3
2.	NT9002	Bottom up synthesis of Nanostructures	3	0	0	3
3.	NT9003	Nanoelectronics and Sensors	3	0	0	3
4.	NT9004	Semiconductor Nanostructures & Nano-particles	3	0	0	3
5.	NT9005	Nanotechnology for Energy systems	3	0	0	3
6.	NT9006	Molecular Electronics	3	0	0	3

ELECTIVE PAPERS – Nanoscience and Technology – Biology Stream

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	NT9007	Nanoparticles and Microorganisms, Bionanocomposites	3	0	0	3
2.	NT9008	Optical Properties of Nanomaterials, Nanophotonics and Plasmonics	3	0	0	3
3.	NT9009	MEMS and Bio MEMS	3	0	0	3
4.	NT9010	Advanced Drug Delivery Systems	3	0	0	3
5.	NT9011	Biomolecular machines	3	0	0	3
6.	NT9012	Biosensors	3	0	0	3
7.	NT9013	Biophotonics	3	0	0	3
8.	NT9014	Nanocomposites	3	0	0	3

NT9321 **PHOTONICS** **L T P C**
3 0 0 3

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 PERIODS

REFERENCES

1. H.Masuhara, S.Kawata and F.Tokunaga, Nano Biophotonics, Elsevier Science,2007.
2. V.M. Shalaev and S.Kawata, Nanophotonics with Surface Plasmons (Advances in
3. Nano-Optics and Nano-Photonics), 2007.
4. B.E.A. Saleh and A.C.Teich, Fundamentals of Photonics, John-Weiley & Sons. New York, 1993.
5. M.Ohtsu, K.Kobayashi, T.Kawazoe, and T.Yatsui, Principles of Nanophotonics (Optics and Optoelectronics), University of Tokyo, Japan, 2003.
6. P.N. Prasad, Introduction to Biophotonics, John Wiley & Sons, 2003.
7. J.D.Joannopoulos, R.D.Meade and J.N.Winn, Photonic Crystals, Princeton University Press, Princeton, 1995.

NT9322 MECHANICAL PROCESSING AND PROPERTIES OF NANOSTRUCTURED MATERIALS **L T P C 3 0 0 3**

UNIT I PROCESSING OF METALS AND ALLOYS 6

Understanding the following processes from the viewpoints of mechanics and processes: rolling, forging, extrusion, wire drawing, sheet metal forming.

UNIT II PROCESSING OF POLYMERS 6

Special techniques like injection moulding, thermoforming, vacuum and pressure assisted forming.

UNIT III PROCESSING OF POWDERS OF METALS AND CERAMICS 8

Selection and characterization of powders, compacting and sintering; mechanical working. Production of Porous and Dense Composite Components: Metal- polymer- and ceramic- based composites.

UNIT IV PROCESSING OF STRUCTURAL AND FUNCTIONAL NANOCRYSTALLINE MATERIALS 10

Properties required of nanocrystalline materials used for structural, hydrogen storage, magnetic and catalytic applications; processing techniques; techniques for retaining the nanocrystalline structure in service.

UNIT V MICROSTRUCTURE AND PROPERTIES: 15

Properties slightly dependent on temperature and grain size; properties strongly dependent on temperature and grain size; strengthening mechanisms; enhancement of available plasticity; grain size evolution and grain size control; Hall-Petch relation, microstructure – dislocation interactions at low and high temperatures; effects of diffusion on strength and flow of materials; methods of enhancing or retarding diffusion; grain boundary sliding and grain boundary migration; current limitations on approaches based on dislocation theory; possibilities for predictive design.

TOTAL : 45 PERIODS

REFERENCES

1. A. H. Cottrell “The Mechanical Properties of Matter”, John Wiley, New York- London, 1964.
2. P. Haasen, “Physical Metallurgy”, Cambridge University Press, Cambridge, UK, 1978.
3. G. E. Dieter, adapted by D Bacon, “Mechanical Metallurgy”, SI Metric edition, MaGraw-Hill, Singapore, 1988.
4. K. A. Padmanabhan, “Mechanical Properties of Nanostructured Materials”, Materials Science and Engineering, A 304-306 (2001) 200-205.
5. C. C. Koch, “Nanostructured Materials: Processing, Properties and Applications”, 2nd Edition, Ed.: 2007.

NT9323 PHYSICOCHEMICAL METHODS FOR CHARACTERIZATION OF NANOMATERIALS **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 - structure analysis - profile analysis - particle size analysis using Scherer formula.

UNIT II THERMAL ANALYSIS METHODS **9**

Principle and Instrumentation of Thermogravimetry; Differential Thermal Analysis and Differential scanning calorimetry-Importance of thermal analysis for nanostructures.

UNIT III QUALITATIVE AND QUANTITATIVE ANALYSIS **9**

Electron Energy Loss Spectroscopy; High Resolution Imaging Techniques- HREM, Atom probe field ion microscopy-X-Ray Photoelectron Spectroscopy, X-Ray Characterization of Nanomaterials – EDAX and WDA analysis – EPMA – ZAP corrections.

UNIT IV SPECTROSCOPIC TECHNIQUES **9**

Introduction to Molecular Spectroscopy and Differences-With Atomic Spectroscopy-Infrared (IR) Spectroscopy and Applications- Microwave Spectroscopy- Raman Spectroscopy and CARS Applications-Electron Spin Resonance Spectroscopy; New Applications of NMR Spectroscopy; Dynamic Nuclear Magnetic Resonance; Double Resonance Technique.

UNIT V NANOINDENTATION **9**

Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of nanoindentation load displacement curves-Nanoindentation data analysis methods-Hardness testing of thin films and coatings- MD simulation of nanoindentation.

TOTAL : 45 PERIODS

REFERENCES

1. B. D.Cullity, “Elements of X-ray Diffraction”, 4th Edition, Addison Wiley, 1978.
2. M. H.Loretto, “Electron Beam Analysis of Materials”, Chapman and Hall, 1984.
3. R.M.Rose, L.A.Shepard and J.Wulff, “The Structure and Properties of Materials”, Wiley Eastern Ltd,
4. B.W.Mott, “Micro-Indentation Hardness Testing”, Butterworths, London, 1956.

NT9324 IMAGING TECHNIQUES FOR NANOTECHNOLOGY **L T P C 3 0 0 3**

UNIT I OPTICAL MICROSCOPY **9**

Optical microscopy- Use of polarized light microscopy – Phase contrast microcopy – Interference Microscopy – hot stage microscopy - surface morphology – Etch pit density and hardness measurements.

UNIT II SCANNING ELECTRON MICROSCOPY **12**

Basic design of the scanning electron microscopy – Modes of operation– Backscattered electrons – secondary electrons- X-rays – typical forms of contrast– Resolution and contrast – enhancement – Specimen Preparation, Replicas Various-application of SEM.

UNIT III TRANSMISSION ELECTRON MICROSCOPY 9

Basic principles - Modes of operation – Specimen preparation – Diffraction in imperfect crystals – Dislocations – precipitates – Structure of Grain boundaries and interfaces-HRTEM use in nanostructures.

UNIT IV ATOMIC FORCE MICROSCOPY 9

Basic concepts-Interaction force-AFM and the optical lever- Scale drawing- AFM tip on nanometer scale structures- force curves, measurements and manipulations-feed back control-different modes of operation –contact, non contact and tapping mode-Imaging and manipulation of samples in air or liquid environments-Imaging soft samples. Scanning Force Microscopy-Shear force Microscopy-Lateral Force Microscopy-Magnetic Force microscopy.

UNIT V SCANNING TUNNELING MICROSCOPY 6

Principle- Instrumentation- importance of STM for nanostructures – surface and molecular manipulation using STM -3D map of electronic structure.

TOTAL : 45 PERIODS

REFERENCES

1. J.Goldstein, D. E. Newbury, D.C. Joy, and C.E. Lym, “Scanning Electron Microscopy and X-ray Microanalysis”, 2003.
2. S.L. Flegler, J.W. Heckman and K.L. Klomparens, “Scanning and Transmission Electron Microscopy: A Introduction”, WH Freeman & Co, 1993.
3. P.J.Goodhew, J.Humphreys, R.Beanland, “Electron Microscopy and Analysis”,
4. R.Haynes, D.P.Woodruff and T.A.Talchar, “Optical Microscopy of Materials”, Cambridge University press, 1986.

NT9325 NANOTECHNOLOGY IN HEALTH CARE L T P C
3 0 0 3

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- i*n 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 PERIODS

REFERENCES

1. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester; 2002.
2. Biosensors and modern biospecific analytical techniques, Wilson & Wilson's Comprehensive Analytical Chemistry; Ed. L Gorton; Elsevier, Amsterdam, London; 2005.
3. The Immunoassay Handbook; Ed. David Wild; 3rd ed.; Amsterdam: Elsevier; 2005.
4. Electrochemical Methods: Fundamentals and Applications; Allen J Bard and Larry R Faulkner; Wiley, New York, Chichester : 2nd ed.; 2001.
5. Ultrathin Electrochemical Chemo- and Biosensors: Technology and Performance in Springer Series on Chemical Sensors and Biosensors; Volume Two; Ed. Vladimir M. Mirsky; Springer, Berlin; 2004

NT9326 PRODUCT DESIGN, MANAGEMENT TECHNIQUES AND ENTREPRENEURSHIP LT P C

3 0 0 3

UNIT I PRODUCT DESIGN 9

Concept generation- Product Architecture- Industrial Design Process- Management of Industrial design Process and Assessing the quality of Industrial Design - Establishing the product specification

UNIT II PRODUCT DEVELOPMENT 9

Criteria for selection of product- Product development process- Design for Manufacture - Estimate the manufacturing cost- Reduce the support cost- Prototyping- Economics of Product development projects - Elements of Economic analysis- financial models - Sensitive analysis and influence of the quantitative factors.

UNIT III MANAGEMENT TECHNIQUES 9

Technology Management - Scientific Management - Development of management Thought-Principles of Management- Functions of management-planning- organization- Directing, Staffing and Controlling- Management by objective- SWOT analysis- Enterprise Resource planning and supply chain management.

UNIT IV ENTREPRENEURIAL COMPETENCE & ENVIRONMENT 9

Concept of Entrepreneurship- Entrepreneurship as a career- Personality Characteristic a successful Entrepreneur- Knowledge and skill required for an Entrepreneur- Business environment- Entrepreneurship Development Training - Center and State government policies and Regulations - International Business.

UNIT V MANAGEMENT OF SMALL BUSINESS 9

Pre feasibility study - Ownership - budgeting - project profile preparation - Feasibility Report preparation - Evaluation Criteria- Market and channel selection- Product launching - Monitoring and Evaluation of Business- Effective Management of Small business.

TOTAL : 45 PERIODS

REFERENCES

1. Karal, T.Ulrich Steven, D.Eppinger, "Product Design and Development", McGraw- Hill International, editions, 2003.
2. S.Rosenthal, "Effective Product Design and Development", Irwin, 1992.
3. H.Koontz and H.Weihrich, "Essentials of management", McGraw Hill Publishing company, Singapore international edition, 1980.
4. J.J.Massie, "Essentials of Management" Prentice Hall of India Pvt. Ltd., 1985.
5. Hisrich, "Entrepreneurship" Tata Mc Grew Hill, New Delhi, 2001

NT9328 EXPERIMENTS FOR PRACTICAL –III – NANOMETROLOGY MICROSCOPY

L T P C
0 0 4 2

1. Determination of size and lateral dimensions of various samples (pollen grains, strands of hair) using a high magnification optical microscope.

2. Synthesis of SiO_2 polysphere film and morphology characterization using a Optical microscope.

3. Surface topography of a sputtered Au film using AFM; thickness across a step.

4. Surface topography of a freshly cleaved mica using AFM; step measurements

5. Surface topography of a polymer film on glass using AFM in the non-contact (tapping) mode; Phase imaging

6. Nanoindentation on a polycarbonate substrate using AFM; F-D curves and hardness determination.

7. Dip-pen lithography using AFM with molecular inks.

8. Surface topography of a sputtered Au film using STM; current and height imaging.

9. Surface topography of a freshly cleaved HOPG using STM; step measurements

10. Scanning Tunneling Spectroscopy (STS) on Multi walled Carbon Nanotubes deposited on HOPG.

TOTAL : 60 PERIODS

NT9331 LITHOGRAPHY AND NANOFABRICATION L T P C
3 0 0 3

UNIT I PATTERNING OF THIN FILMS 15

Introduction - Necessity for a clean room- different types of clean rooms-construction and maintenance of a clean room- Lithography -Optical lithography- Optical projection lithography- Multistage scanners resolution- Photomask- Binary mask- Phase shift mask - Attenuated phase shift masks - alternating phase shift masks - Off axis illumination- Optical proximity correction - Sub resolution assist feature enhancement-Optical immersion lithography- Optical interferometric lithography- Holographic lithography.

UNIT II MASKLESS OPTICAL LITHOGRAPHY 5

Maskless optical projection lithography - Zone plate array lithography-Extreme ultraviolet lithography.

UNIT III ELECTRON BEAM LITHOGRAPHY 5

Scanning electron-beam lithography- maskless EBL- parallel direct-write e-beam systems-electron beam projection lithography - Scattering with angular limitation projection e-beam lithography- Projection reduction exposure with variable axis immersion lenses.

UNIT IV X-RAY LITHOGRAPHY 5

Ion beam lithography- Focusing ion beam lithography - Ion projection lithography - Projection focused ion multi-beam - Masked ion beam lithography- Masked ion beam direct structuring- atom lithography.

UNIT V NANOIMPRINT LITHOGRAPHY AND SOFT LITHOGRAPHY 15

Nanoimprint lithography (NIL)- NIL- hot embossing- UV-NIL- Soft Lithography- Moulding/Replica moulding: Printing with soft stamps- Edge lithography -Dip-Pen Lithography-set up and working principle. Etching techniques- Reactive Ion etching- RIE reactive ion etching- Magnetically enhanced RIE- IBE Ion beam etching- Other etching techniques.

TOTAL : 45 PERIODS

REFERENCES

1. D. S. Dhaliwal et al., PREVAIL –"Electron projection technology approach for next generation lithography", IBM Journal Res. & Dev. 45, 615 (2001).
2. M. Baker et al., "Lithographic pattern formation via metastable state rare gas atomic beams", Nanotechnology 15, 1356 (2004).
3. H. Schift et al., "Fabrication of polymer photonic crystals using nanoimprint lithography", Nanotechnology 16, 261, (2005).
4. R.D. Piner, "Dip-Pen" Nanolithography, Science 283, 661 (1999).

NT9341 PROJECT PHASE L T P C
0 0 16 12

Thin Film Deposition
Operation of Electrochemical Workstation.
Deposition of Polyaniline on ITO using Electrochemical Workstation.
Electroplating Ag film: Topography by AFM; Electrical characteristics by two and four probe measurement.

Electroless deposition of Au on Si substrate.
Physical vapor deposition of Cr and Au on glass substrates; X-ray diffraction measurement; Quartz crystal thickness monitor for thickness monitoring.

Preparation of (111) oriented films of Au by physical vapor deposition on mica substrate; X-ray diffraction measurement; characterization by AFM.

Micro & Nanolithography
Clean room: Familiarizing with essential terms, tools and practices
Cleaning procedure for Si wafer and observation of surface before and after cleaning with AFM.
Spin coating polymer resists, Thickness measurement using AFM.

Optolithography using PMMA resist.

Nanoscale gratings by Electron beam lithography using SEM.

Nanosphere lithography using silica nanospheres.

Microcontact printing using PDMS stamp

NT9001 TOP DOWN MANUFACTURING METHODS L T P C
3 0 0 3

UNIT I INTRODUCTION 12
Introduction to micro fabrication and Moore's law – importance of lithographic techniques-different types of lithographic techniques -Optical projection lithography- Photomask- Binary mask- Phase shift mask -Optical immersion lithography- Maskless optical projection lithography- Zone plate array lithography- Extreme ultraviolet lithography.

UNIT II E-BEAM AND ION BEAM LITHOGRAPHY 15
Principle and instrumentation - Scanning electron-beam lithography- Mask less (ML2) EBL-parallel direct-write e-beam systems-E-beam projection lithography - PREVAIL X-ray lithography - Focused ion beam lithography - Ion projection lithography - Masked ion beam direct structuring-Nanoimprint lithography and soft lithography- Nanoimprint lithography - Soft lithography- Dip-Pen lithography.

UNIT III ETCHING TECHNIQUES 5

Reactive ion etching- RIE reactive ion etching- Magnetically enhanced RIE- Ion beam etching - Wet etching of silicon - Isotropic etching - Anisotropic etching - Electrochemical etching - Vapor phase etching - Dry etching- Other etching techniques.

UNIT IV BALL MILLING TECHNIQUE 5

Nanopowders produced using micro reactors; Nanocrystalline ceramics by mechanical activation; Formation of nanostructured polymers.

UNIT V MACHINING PROCESSES 8

Micromilling/microdrilling/microgrinding processes and the procedure for selecting proper machining parameters with given specifications- EDM micro machining, laser micro/nanomachining- models to simulate micro/nanomachining processes using molecular dynamics techniques -Wet chemical etching - Dry etching - Thin film and sacrificial processes .

TOTAL : 45 PERIODS

REFERENCES

1. M. J. Jackson, “Micro fabrication and Nanomanufacturing”, CRC Press, 2005.
2. P.Rai-Choudhury, “Handbook of Micro lithography, Micro machining, and Micro fabrication”, Vol. 2, SPIE Press, 1997.
3. M. Madou, “Fundamentals of Microfabrication,” CRC Press, 1997.
4. G.Timp, “Nanotechnology”, AIP press, Springer-Verlag, New York, 1999.

NT9002 BOTTOM UP SYNTHESIS OF NANOSTRUCTURES L T P C
3 0 0 3

UNIT I THIN FILM TECHNOLOGIES – I 9

CVD Chemical vapor deposition –Atmospheric pressure CVD(APCVD) – Low pressure CVD (LPCVD) - Plasma enhanced chemical vapor deposition (PECVD) or - The HiPCO method - Photo-enhanced chemical vapor deposition (PHCVD)- LCVD Laser–Induced CVD.

UNIT II THIN FILM TECHNOLOGIES – II 9

Physical vapor deposition- Sputter technologies- Diode sputtering - Magnetron sputtering - Ion beam (sputter) deposition, ion implantation and ion assisted deposition - Cathodic arc deposition - Pulsed laser deposition.

UNIT III EPITAXIAL FILM DEPOSITION METHODS 9

Epitaxy, Different kinds of epitaxy- Influence of substrate and substrate orientation, mismatch, MOCVD Metal Organic Chemical Vapor Deposition - CCVD Combustion Chemical Vapor Deposition - ALD Atomic Layer Deposition -LPE Liquid phase epitaxy - MBE Molecular Beam Epitaxy.

UNIT IV CHEMICAL METHODS 9

Sol-gel synthesis –different types of coatings -Spin coating- Self assembly- (Periodic) starting points for self-assembly- Directed self-assembly using conventional lithography- Template self-assembly-Vapor liquid solid growth- Langmuir-Blodgett films – DNA self assembly.

UNIT V PRINTING TECHNOLOGIES 9

Screen printing- Inkjet printing- Gravure printing and Flexographic printing- Flex graphic printing- Gravure printing- Roll-to-Roll techniques.

TOTAL : 45 PERIODS

REFERENCES

1. G. Cao, "Nanostructures & Nanomaterials: Synthesis, Properties &Applications" Imperial College Press, 2004.
2. W.T.S. Huck, "Nanoscale Assembly: Chemical Techniques (Nanostructure Science and Technology)",
3. "Handbook of Nanoscience, Engineering and Technology", Kluwer publishers, 2002.

NT9003 NANOELECTRONICS AND SENSORS L T P C
3 0 0 3

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 - Mechanical sensors -pressure sensors, gas and liquid flow sensors, position sensors - 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 PERIODS

REFERENCES

1. W. Ranier, "Nano Electronics and Information Technology", Wiley, (2003).
2. K.E. Drexler, "Nano systems", Wiley, (1992).
3. M.C. Pettey, "Introduction to Molecular Electronics".

NT9004 SEMICONDUCTOR NANOSTRUCTURES & NANO-PARTICLES L T P C
3 0 0 3

UNIT I SEMICONDUCTOR FUNDAMENTALS 9

Introduction to Semiconductor physics – Fabrication techniques – Semiconductor nanostructures – Electronic structure and physical process – Principles of semiconductor nanostructures based electronic and electro-optical devices – Semiconductor Quantum Dots – Quantum Lasers – Quantum Cascade Lasers – Quantum Dot Optical Memory.

UNIT II SEMICONDUCTOR NANOPARTICLE SSYNTHESIS 9

Cluster compounds, quantum-dots from MBE and CVD, wet chemical methods, reverse micelles, electro-deposition, pyrolytic synthesis, self-assembly strategies.

UNIT III PHYSICAL PROPERTIES 9

Melting point, solid-state phase transformations, excitons, band-gap variations-quantum confinement, effect of strain on band-gap in epitaxial quantum dots, single particle conductance.

UNIT IV SEMICONDUCTOR NANOPARTICLES – APPLICATIONS 10

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

UNIT V SEMICONDUCTOR NANOWIRES 8

Fabrication strategies, quantum conductance effects in semiconductor nanowires, porous Silicon, nanobelts, nanoribbons, nanosprings.

TOTAL : 45 PERIODS

REFERENCES

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

NT9005 NANOTECHNOLOGY FOR ENERGY SYSTEMS L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Nanotechnology for sustainable energy-Materials for light emitting diodes-batteries-advanced turbines-catalytic reactors-capacitors-fuel cells.

UNIT II RENEWABLE ENERGY TECHNOLOGY 9

Energy challenges, development and implementation of renewable energy technologies - nanotechnology enabled renewable energy technologies - Energy transport, conversion and storage, Nano, micro and meso scale phenomena and devices.

UNIT III MICRO FUEL CELL TECHNOLOGY 9

Micro-fuel cell technologies, integration and performance for micro-fuel cell systems - thin film and microfabrication methods - design methodologies - micro-fuel cell power sources,

UNIT IV MICROFLUIDIC SYSTEMS 9

Nano-electromechanical systems and novel microfluidic devices - nano engines - driving mechanisms - power generation - microchannel battery - micro heat engine (MHE) fabrication - thermocapillary forces - Thermocapillary pumping (TCP) - piezoelectric membrane.

UNIT V HYDROGEN STORAGE METHODS 9

Hydrogen storage methods - metal hydrides - size effects - hydrogen storage capacity - hydrogen reaction kinetics - carbon-free cycle- gravimetric and volumetric storage capacities - hydriding/dehydriding kinetics - high enthalpy of formation - and thermal management during the hydriding reaction - distinctive chemical and physical properties - multiple catalytic effects - degradation of the sorption properties - hydride storage materials for automotive applications.

TOTAL : 45 PERIODS

REFERENCES

1. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.
2. Hydrogen from Renewable Energy Sources by D. Infield,
3. Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures by R.A. Shatwell, Fuel cell technology handbook. Hoogers. CRC Press, 2003.
4. Handbook of fuel cells: Fuel cell technology and applications by Vielstich. Wiley, CRC Press, 2003.

NT9006 MOLECULAR ELECTRONICS L T P C
3 0 0 3

UNIT I 9

Controlling surfaces and interfaces of semi-conductor sensing organic molecules- types of molecule-manipulation experiments-measurements in molecular electronics-soft and hard electronics- Electronic structure of absorbed organic molecule.

UNIT II 9

Organic semiconductor for new electronic device- photo voltaic cells Schotkey diodes FET^S digital processing and communication with molecular switches.

UNIT III 9

Molecular Electronics overview- Rectifiers- Molecular wires – Molecular switches – Data storage-photo switches-molecular magnets.

UNIT IV 9

Molecular Engineering of doped polymer for optoelectronics- Fabrication for Molecular Electronics organic FET^{s-} Organic thin film transistors.

UNIT V **9**

Bio Electronics – Molecular and Biocomputing – prototypes for Molecular Functional limits and Actuators – Molecular assembly – characterization of hybrid nanomaterials - Biomolecular optoelectronic device.

TOTAL : 45 PERIODS

REFERENCES

1. Introducing Molecular Electronics, G. Cumbertl & G. Fagas , Springer, 2005.
2. Nano and Molecular Electronics Handbook, S.C. Levshevski, CRC Press, 2007.
3. Nanoelectronics & Nanosystems: From Transistor to Molecular & Quantum Devices: Karl Goser, Jan Dienstuhl and others.

NT9007	NANOPARTICLES AND MICROORGANISMS BIONANOCOMPOSITES	LT P C 3 0 0 3

UNIT I MICROORGANISMS FOR SYNTHESIS OF NANOMATERIALS 8

Natural and artificial synthesis of nanoparticles in microorganisms; Use of microorganisms for nanostructure formation, Testing of environmental toxic effect of nanoparticles using microorganisms;

UNIT II NANOCOMPOSITE BIOMATERIALS 9

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

UNIT III NANOBIO SYSTEMS 10

Nanoparticle-biomaterial hybrid systems for bioelectronic devices, Bioelectronic systems based on nanoparticle-enzyme hybrids; nanoparticle based bioelectronic biorecognition events. Biomaterial based metallic nanowires, networks and circuitry. DNA as functional template for nanocircuitry; Protein based nanocircuitry; Neurons for network formation. DNA nanostructures for mechanics and computing and DNA based computation; DNA based nanomechanical devices. Biosensor and Biochips.

UNIT IV NANOPARTICLES AND NANODEVICES 9

Targeted, non-targeted delivery; controlled drug release; exploiting novel delivery routes using nanoparticles; gene therapy using nanoparticles; Nanostructures for use as antibiotics; Diseased tissue destruction using nanoparticles;

UNIT V TISSUE ENGINEERING 9

Major physiologic systems of current interest to biomedical engineers: cardiovascular, endocrine, nervous, visual, auditory, gastrointestinal, and respiratory. Useful definitions, The status of tissue engineering of specific organs, including bone marrow, skeletal muscle, and cartilage. Cell biological fundamentals of tissue engineering

TOTAL : 45 PERIODS

REFERENCES

1. Bionanotechnology: Lessons from Nature by David S. Goodsell
2. Nanomedicine, Vol. IIA: Biocompatibility by Robert A. Freitas
3. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology - Hari Singh Nalwa
4. Nanobiotechnology; ed. C.M.Niemeyer, C.A. Mirkin.
5. Nanocomposite Science & Technology Ajayan, Schadler & Braun

NT9008 OPTICAL PROPERTIES OF NANOMATERIALS, NANOPHOTONICS AND PLASMONICS **L T P C**
3 0 0 3

UNIT I METAL NANOPARTICLES 8

Metal Nanoparticles, Alloy Nanoparticles, Stabilization in Sol, Glass, and other media, Change of bandgap, Blueshift, Colour change in sol, glass, and composites, Plasmon Resonance.

UNIT II SEMICONDUCTOR NANOPARTICLES – APPLICATIONS 10

Optical luminescence and fluorescence from direct, bandgap semiconductor nanoparticles, surface-trap passivation in core-shell nanoparticles, carrier injection, polymer-nanoparticle LED's and solar cells, electroluminescence; barriers to nanoparticle lasers; doping nanoparticles, Mn-ZnSe phosphors; light emission from indirect semiconductors, light emission from Si nanodots.

UNIT III PHYSICS OF LINEAR PHOTONIC CRYSTALS 8

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

UNIT IV PHYSICS OF NONLINEAR PHOTONIC CRYSTALS 9

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

UNIT V ELEMENTS OF PLASMONICS 10

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

TOTAL : 45 PERIODS

REFERENCES

1. Springer Handbook of Nanotechnology by Bharat Bhushan
2. Encyclopedia of Nanotechnology- Hari Singh Nalwa.
3. The Handbook of Photonics By Mool Chand Gupta, John Ballato
4. Nanotechnology for Microelectronics and Optoelectronics - J. M. Martinez-Duart,Raúl J. Martín-Palma, Fernando Agullo-Rueda
5. Nanoplasmonics, From fundamentals to Applications vol 1 & 2- S. Kawata & H. Masuhara

NT9009 MEMS AND BIO MEMS L T P C
3 0 0 3

UNIT I MEMS MICROFABRICATION 9

Fabrication – design and application scaling issues– scaling fluidic biological systems – influence of scaling on material properties.

UNIT II MEMS MASK LAYOUT 9

Physics of mems-scaling laws heat transfer - mechanics and electrostatistics – batch fabrication – circuit integration.

UNIT III BIO MEMS 9

Engineering micro fluids-bio mems for genomics and post genomics-microfluids for bio-diagnosis lead discovery platforms.

UNIT IV MATERIALS FOR MEMS 9

Materials for mems and pro mems-silicon-metals and polymers.

UNIT V COMMERCIAL AND TECHNOLOGICAL TRENDS 9

Commercial trends in miniaturization – High density chip analysis- lab-in-chip for DNA and protein analysis – Nono HPLC system.

TOTAL : 45 PERIODS

REFERENCES

1. Marc Madou, Fundamentals of Microfabrication, CRC Press 1997.
2. Julian W. Gardner, Microsensors: Principles and Applications, Wiley 1994.
3. Gregory Kovacs, Micromachined Transducers Sourcebook, McGraw-Hill 1998.
4. Héctor J. De Los Santos, Introduction to Microelectromechanical (MEM) Microwave Systems, Artech House 1999.
5. Sergey Edward Lyshevski, Nano- and Microelectromechanical Systems, CRC Press 2000.
6. Vijay Varadan, Xiaoning Jiang, and Vasundara Varadan, Microstereolithography and other Fabrication Techniques for 3D MEMS, Wiley 2001.
7. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw-Hill 2001.
8. Remco J. Wiegerink, Miko Elwenspoek, Mechanical Microsensors (Microtechnology and MEMS), Springer Verlag 2001.

NT9010 ADVANCED DRUG DELIVERY SYSTEMS L T P C
3 0 0 3

UNIT I 9

Dendrimers- Synthesis -Nanoscale containers- Gene transfection – Nanoscafold systems- Biocompatibility of Dendromers

UNIT II 9

Microfabricated drug delivery systems – Microneedles- Micropumps-Microvalves-Implantable microchips – sustained chronic disease.

UNIT III **9**

Properties of drug targeting delivery systems-ADME hypothesis- site specific drugs-Synthetic carrier for drugs-liposomes-Antidodies.

UNIT IV **9**

Targeted Nano particles for drug delivery-Polymers nanotubes- Issues for specific disease will be addressed.

UNIT V **9**

Virus Based Nanoparticles - Modification by bioconjugation – Tumour targetting invivo – use in biomedical Imaging.

TOTAL : 45 PERIODS

REFERENCES

1. Drug Delivery: Engineering Principles for Drug Therapy, M. Salzman, Oxford University Press, 2001.
2. Drug Delivery and Targeting, A.M. Hillery, CRC Press, 2002.
3. Drug Delivery: Principles and Applications, B. Wang, Wiley Intersceince, 2005.

NT9011 **BIO MOLECULAR MACHINES** **L T P C**

3 0 0 3

UNIT I **9**

Characterization of molecular machine - energy supply - chemical fuels- molecular shuttle-electrochemical energy - molecular machines powered by light energy: molecular switching-chemical switching and electrochemical switching.

UNIT II **9**

Biomolecular machines:Transcription, translation and replication processes at single molecule level – initiation and force control of biological processes- force generation and real-time dynamics – active transport by biological motors – mechanism, dynamics and energetic of kinesin, myosin, dyneins and ATP synthase.

UNIT III **9**

Self assembled-nanoreactors - molecular nanoreactors-covalent system-nano covalent system-macro molecular nanoreactions micelles and polymers–biomacro molecular nanoreactions-Protein cages-viruses- rod shaped and cage structured.

UNIT IV **9**

Memories Logic Gates–Multistate–Mukltifunctional Systems systems.

UNIT V **9**

Fabrication and patterning of nanoscale device.

TOTAL : 45 PERIODS

REFERENCES

1. Molecular Devices and Machines: A Journey into the Nanoworld, V. Balazani, Wiley – VCH, 2003.
2. Molecular Motors, M. Schilva, Wiley,VCH. 2005.

NT9012 BIOSENSORS L T P C
3 0 0 3

UNIT I **9**

Protein based biosensors – nano structure for enzyme stabilization – single enzyme nano particles – nano tubes microporus silica – protein based nano crystalline Diamond thin film for processing.

UNIT II **9**

DNA based biosensor- heavy metal complexing with DNA and its determination water and food samples – DNA zymo Biosensors.

UNIT III **9**

Detection in Biosensors - fluorescence - absorption – electrochemical. Integration of various Techniques – Fibre optic Biosensors.

UNIT IV **9**

Fabrication of biosensors- techniques used for microfabrication -microfabrication of electrodes-on chip analysis.

UNIT V **9**

Future direction in biosensor research- designed protein pores-as components of biosensors- Moleculardesign-Bionanotechnology for cellular biosensing-Biosensors for drug discovery – Nanoscale biosensors.

TOTAL : 45 PERIODS

REFERENCES

1. Biosensors: A Practical Approach, J. Cooper & C. Tass, Oxford University Press, 2004.
2. Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007.
3. Smart Biosensor Technology, G.K. Knoff, A.S. Bassi, CRC Press, 2006.

NT9013 BIOPHOTONICS L T P C
3 0 0 3

UNIT I **9**

Interaction of light with cells, tissues, non-linear optical processes with intense laser beams, photo-induced effects in biological systems.

UNIT II **9**

Imaging techniques: Light microscopy, wide-field, laser scanning, confocal, multiphoton, fluorescence lifetime imaging, FRET imaging, Frequency-Domain lifetime imaging. Cellular Imaging, Imaging of soft and hard tissues and other biological structures.

UNIT III **9**

Single molecule spectroscopy: UV-VIS spectroscopy of biological systems, single molecule spectra and characteristics – IR and Raman spectroscopy and Surface Enhanced Raman Spectroscopy for single molecule applications.

UNIT IV **9**

Optical Force Spectroscopy: Generation 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 **9**

Biosensors, fluorescence immuoassay, flow cytometry, Fluorescence correlation spectroscopy, Fluorophores as cellular and molecular tags

TOTAL : 45 PERIODS

REFERENCES

1. Laser Tweezers in Cell Biology in Methods in Cell Biology, Vol.55, Michael P. Sheetz (Ed.), Academic Press.
2. P.N. Prasad, Introduction to Biophotonics, John-Wiley, 2003.
3. G. Marriot & I. Parker, Methods in Enzymology, Vol.360,2003.
4. G. Marriot & I. Parker, Methods in Enzymology, Vol.361,2003.

NT9014 **NANOCOMPOSITIES** **L T P C**
3 0 0 3

UNIT I NANO CERAMICS **9**

Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality.

UNIT II METAL BASED NANOCOMPOSITES **9**

Metal-metal nanocomposites, some simple preparation techniques and their new electrical and magnetic properties.

UNIT III DESIGN OF SUPER HARD MATERIALS **9**

Super hard nanocomposites, its designing and improvements of mechanical properties.

UNIT IV NEW KIND OF NANOCOMPOSITES **9**

Fractal based glass-metal nanocomposites, its designing and fractal dimension analysis. Electrical property of fractal based nanocomposites. Core-Shell structured nanocomposites.

UNIT V POLYMER BASED NANOCOMPOSITES **9**

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

TOTAL : 45 PERIODS

REFERENCES

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