

KALASALINGAM UNIVERSITY

Anand Nagar, Krishnankoil - 626 190

CURRICULUM FOR M.TECH. NANOTECHNOLOGY

Semester I

Code	Subject	L	T	P	C
MAT5051	Mathematical Modeling and Simulation	3	0	0	3
MNT5001	Thermodynamics of Macro and Nanoscale Systems	3	0	0	3
MNT5002	Introduction to Nanomaterials and Nanotechnology	3	0	0	3
MNT5003	Physics and Chemistry of Nanomaterials	3	0	0	3
MNT5004	Synthesis and Application of Nano-materials	3	0	0	3
MNTxxx	Elective-I	3	0	0	3
MNT5081	Nano-material synthesis and characterization I Laboratory	0	0	6	2
	Total	18	0	6	20

Semester II

Code	Subject	L	T	P	C
MNT5005	Photonics	3	0	0	3
MNT5006	Nano electronics and sensors	3	0	0	3
MNT5007	Physicochemical methods for characterization of Nanomaterials	3	0	0	3
MNT5008	Mechanical processing and properties of Nanostructured Materials	3	0	0	3
MNT5009	Product Design, Management Techniques and Entrepreneurship	3	0	0	3
MNTxxx	Elective-II	3	0	0	3
MNT5082	Nano-material synthesis and characterization II Laboratory	0	0	6	2
	Total	18	0	6	20

Semester III

Code	Subject	L	T	P	C
MNT****	Elective III	3	0	0	3
MNT****	Elective IV	3	0	0	3
MNT****	Elective V	3	0	0	3
MNT6098	Project work - Phase I	0	0	18	6
	Total	9	0	18	15

Semester IV

Code	Subject	L	T	P	C
MNT6099	Project work – Phase II	0	0	36	12
	Total	0	0	36	12

TOTAL – 67 Credits

ELECTIVES

Code	Subject	L	T	P	C
MNT5010	Top down manufacturing methods	3	0	0	3
MNT5011	Bottom up manufacturing methods	3	0	0	3
MNT5012	Lithography and Nanofabrications	3	0	0	3
MNT5013	Advanced characterization techniques for nanomaterials	3	0	0	3
MNT5014	Surface engineering and Nanometrology	3	0	0	3
MNT5015	Nanotechnology for energy systems	3	0	0	3
MNT5016	MEMS and Bio-MEMS	3	0	0	3
PBT6025	Bio-Sensors - Principle and applications	3	0	0	3
MNT6002	Nanotechnology in Health Care	3	0	0	3
MNT6003	Nanopowder handling	3	0	0	3
MNT6004	MOSFET Technologies – VLSI to Nanoscale	3	0	0	3
MNT6005	Nanomaterials and Nanomedicine	3	0	0	3
MNT6006	Industrial Nanotechnology	3	0	0	3
MNT6007	Nanobiotechnology	3	0	0	3
MNT6008	Nanotechnology and Environment	3	0	0	3

SEMESTER I

MAT5051	MATHEMATICAL MODELING AND SIMULATION	L	T	P	C
		3	0	0	3

FUNDAMENTAL PRINCIPLES OF NUMERICAL METHODS

Scientific Modeling-Numerical data and Numerical operations -Numerical Algorithms - Numerical Programs-Numerical Software - Approximations in Mathematical model building-Numerical integration-Differentiation -Variation finite element methods-Raleigh's method-Ritz method.

MATHEMATICAL MODELING

Mathematical modeling - physical simulation - advantages and limitations - process control - transport phenomena- concept of physical domain and computational domain - assumptions and limitations in numerical solutions – Finite element method and Finite difference method.

DIFFERENTIAL EQUATIONS & APPLICATIONS

Euler method, Runge-Kutta method, Multi step-differential equations-boundary values-Elliptic equations-one dimensional parabolic equation-hyperbolic equation- partial differential equations -separation of variables-wave equation-Laplace equation-nonlinear partial differential equations - approximation methods of nonlinear differential equations.

SIMULATION

Basic concepts of simulation- data manipulation, data exchange of the structure, properties and processing of materials-Three dimensional model for capillary nanobridges and capillary forces. Molecular dynamics simulation.

MONTE CARLO METHODS

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.

TEXT BOOKS

1. Chopra,S.C.and.Canale R.P.,Numerical methods for Engineers, Tata McGraw Hill, New Delhi, 2002.
2. Frenkel D and Smith,B.Understanding molecular simulation from algorithm to applications, Kluwar Academic Press, 1999

REFERENCES

1. Erwin Kreyzig,Advanced Engineering Mathematic, John Wiley & Sons, 2004.
2. Schilling R.J and Harris, S.L. Applied Numerical Methods for Engineers using MATLAB and C, Thomson publishers, New Delhi, 2004
3. Ohno,K, Esfarjani.K. and Y.Kawazoe, Introduction to Computational Materials Science from ab initio to Monte Carlo Methods, Springer-Verlag, 1999.

MNT5001	THERMODYNAMICS OF MICRO AND NANOSCALE SYSTEMS	L	T	P	C
		3	0	0	3

FUNDAMENTALS OF THERMODYNAMICS

Thermodynamic laws and relationship, concept of entropy and its relationship to heat-strategy for deriving thermodynamic relationships, general criterion for equilibrium- physical and chemical equilibria- Statistical thermodynamics: micro-and macro-states.

PHASE DIAGRAM

Unitary and multicomponent systems, Gibbs phase rule, phase diagrams relevant to macro systems and for nanoscale materials formation, theoretical and experimental aspects of first and second order phase transformations in nanoscale systems including correlation length truncation, nanoscale grain nucleation, film growth.

EQUILIBRIUM IN THERMODYNAMIC SYSTEMS

Classification of thermodynamic systems, variables- state functions-process variables-extensive and intensive properties-formulation of general criterion for equilibrium-mathematical formulation of general criterion for equilibrium-chemical potential and Gibbs free energy-Gibbs adsorption equation-chemical potential surfaces.

SURFACE PHENOMENA

Surfaces and curvature-geometry of surfaces-surface excess properties-equilibrium in systems with curved surfaces-surface tension-capillarity effects on phase diagrams- Gibbs-Wulff construction-adsorption at surfaces.

THERMODYNAMICS OF SMALL SYSTEMS

Physical phenomena unique to small systems- classical thermodynamics- non-equilibrium statistical mechanics- distinction between standard thermodynamics and the thermodynamics of small systems-thermodynamically instability.

TEXT BOOKS

1. Ragone, D.V. Thermodynamics of Materials, Volume 1 Wiley, 1995.
2. Ott.J.B and Boerio-Goates,J. Chemical Thermodynamics Advanced Application, Academic Press, San Diego, CA, 2000.

REFERENCES

1. Hill, T.L. Thermodynamics of Small Systems, Dover Publications, 2002.
2. Callen, H.B. Thermodynamics: An introduction to the physical theories of equilibrium thermostatics and irreversible thermodynamics, Wiley, 1960.
3. Gemmer, J. Michel, M. and G. Mahler. Quantum Thermodynamics: Emergence of Thermodynamical Behavior within Composite Quantum System, Springer, Berlin, 2004.

MNT5002	INTRODUCTION TO NANOMATERIALS AND NANOTECHNOLOGY	L	T	P	C
		3	0	0	3

NANOSTRUCTURES

From micro to nanotechnologies - definition of nanoscience and nanotechnology - classification of the nano materials – zero dimensional nano structures - one dimensional nanostructures – nanowires and nanorods – two dimensional nanostructures – films, nanotubes and biopolymers – three dimensional nanostructures – fullerenes and dendrimers

QUANTUM CONFINEMENT

Quantum confinement of electrons in semiconductor nanostructures, one dimensional confinement, Quantum point contacts, quantum dots, Quantum wells, Band gap engineering, Epitaxy, Landauer-Buttiker formalism for conduction in confined geometries-Quantum mechanical treatment of quantum dots-Quantum methods for information processing.

PROPERTIES - I

Electronic properties of atoms and solids, chemical bonds in nanomaterials, novel physics and chemistry of nanomaterials, size reduction and surface area, size dependant properties - electrical, magnetic, thermal and mechanical properties of nanomaterials and their applications, shape control of nanocrystals.

PROPERTIES - II

Melting point and lattice constants - mechanical properties - optical properties - surface plasma resonance - quantum size effects – surface scattering change of electronic structure – quantum transport

APPLICATIONS

Nanoparticles in pharmaceutical and medicinal field, nanomagnetic particles, Quantum dots, nanomaterials in tissue engineering, protein detection, nanostructured materials in biomedical implants, bone grafting, nanoporous membranes, drug loading and drug release, body distribution and targeting of nanoparticles, biomedical applications of nanoparticles for cancer, antifungal agents, AIDS, delivery to the brain, oral delivery, vaccines

TEXT BOOKS

- 1.C.N.R.Rao, A. Muller and A.K.Cheetham, The Chemistry of Nanomaterials, Wiley –VCH Verlag GmbH & Co. 2004
- 2.Delerne,C, Nanostructures: Theory and Modeling, Springer-Verlag Berlin Heidelberg, 2004

REFERENCES

- 1.Guozhong Cao, Nanostructures and Nanomaterials–Synthesis, Properties and Applications, Imperial College Press, London, 2004,
- 2.Michael Kohler and Wolfgang Fritzsche, Nanotechnology-an introduction to Nanostructuring techniques, Wiley-VCH, 2004
- 3.Emil Rodune, Nanoscopic materials - size dependant phenomena, Royal society of

Chemistry publishing, 2006

MNT5003	PHYSICS AND CHEMISTRY OF NANOMATERIALS	L	T	P	C
		3	0	0	3

PHYSICAL PROPERTIES

Melting point and phase transition processes-quantum-size-effect (QSE)-Size-induced metal-insulator-transition (SIMIT)- nano-scale magnets, transparent magnetic materials, and ultrahigh-density magnetic recording materials-chemical physics of atomic and molecular clusters.

PHYSICAL CHEMISTRY OF SOLID SURFACES

Surface energy – chemical potential as a function of surface curvature-Electrostatic stabilization-surface charge density-electric potential at the proximity of solid surface - Vander Waals attraction potential.

CHEMISTRY ASPECTS

Photochemistry- Photoconductivity- Electrochemistry of Nanomaterials-Diffusion in Nanomaterials-Nanoscale-Heat Transfer-Catalysis by Gold Nanoparticles - Transport in Semiconductor Nanostructures - Nanodeposition of Soft Materials- Nanocatalysis

NANOSTRUCTURES

Electronic Structure of Nanoparticles - Kinetics in Nanostructured Materials- Zero dimensional, one-dimensional and two dimensional nanostructures- clusters of metals and semiconductors, nanowires, nanorods and nanocomposites-artificial atomic clusters-size dependent properties-size dependent absorption spectra-phonons in nanostructures

NANOSYSTEMS

Single walled carbon nanotube- inorganic nanotube - Nanoparticles through homogeneous nucleation-Growth controlled by diffusion-growth controlled by surface process-influences of reduction reagents-solid state phase segregation-kinetically confined synthesis of nanoparticles-template based synthesis-nano structured polymers-conducting polymers nanocages-pillard clays- micelles

TEXT BOOKS

1. Yang. S and Shen. P. Physics and Chemistry of Nanostructured Materials, Taylor & Francis, 2000.
2. Edelstein. A. S and Cammarata, R.C, Nanomaterials: Synthesis, Properties and Applications, Institute of Physics Pub., 1998.

REFERENCES

1. Kolasinski,K.W., Surface Science: Foundations of Catalysis and Nanoscience, Wiley, 2002.
2. Joel I.Gersten., The Physics and Chemistry of Materials, Wiley, 2001.
3. Ozin G.A and Arsenault A.C, Nanochemistry , A chemical approach to nanomaterials, Royal Society of Chemistry, 2005.

MNT5004	SYNTHESIS AND APPLICATION OF NANOMATERIALS	L	T	P	C
		3	0	0	3

SYNTHESIS

Synthesis of bulk nano-structured materials –Sol-gel processing –Mechanical alloying and mechanical milling- Inert gas condensation technique-Microwave synthesis-Seed mediated growth

CHEMICAL APPROACHES

Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, clusters, colloids, zeolites, organic block copolymers, emulsion polymerization, templated synthesis, and confined nucleation and/or growth. Biomimetic Approaches: polymer matrix isolation and surface-templated nucleation and/or crystallization. Electrochemical Approaches: anodic oxidation of alumina films, porous silicon and pulsed electrochemical deposition.

PHYSICAL APPROACHES

Vapor deposition and different types of epitaxial growth techniques- pulsed laser deposition, Magnetron sputtering - Micro lithography (photolithography, soft lithography, micromachining, e-beam writing, and scanning probe patterning).

NANOPOROUS MATERIALS

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

APPLICATION OF NANOMATERIALS

Molecular Electronics and Nanoelectronics – Nanobots- Biological Applications – Quantum Devices – Nanomechanics - Carbon Nanotube – Photonics- Nano structures as single electron transistor –principle and design.

TEXT BOOKS

1. Cao, G Nanostructures & Nanomaterials: Synthesis, Properties & Applications , Imperial College Press, 2004.
2. Barriham, K. Vvedensky, D.D. Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.

REFERENCES

- 1.Gaponenko, S.P.Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
- 2.Gaddand.W.,.Brenner.D.,Lysherski.S.,and Infrate G.J. (Eds.), Handbook of Nano Science, Engg. and Technology, CRC Press, 2002.
- 3.George, J. Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005

SEMESTER II

MNT5005	PHOTONICS	L	T	P	C
		3	0	0	3

QUANTUM CONFINED MATERIALS

Quantum dots – optical transitions – absorption-inter-band transitions-quantum confinement intraband transitions-fluorescence/ luminescence–photoluminescence /fluorescence optically excited emission – electroluminescence emission.

PLASMONICS

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.

NEW APPROACHES IN NANOPHOTONICS

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.

BIOPHOTONICS

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.

PHOTONIC CRYSTALS

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.

TEXT BOOKS

1. Saleh, B.E.A.,and Teich, A.C, Fundamentals of Photonics, John-Weiley & Sons, New York,1993.
2. Ohtsu, M., Kobayashi,K., Kawazoe,T.and Yatsui, T, Principles of Nanophotonics Optics and Optoelectronics, University of Tokyo Press, Japan, 2003.

REFERENCES

1. Masuhara,H, Kawata.S., and Tokunaga,F,. Nano Biophotonics, Elsevier Science, 2007.

2. Vladimir Shalaev and Kawata,S.,Nanophotonics with Surface Plasmons (Advances in Nano-Optics and Nano-Photonics), Elsevier, 2007.
3. Prasad P.N, Introduction to Biophotonics, John Wiley & Sons, 2003.
4. Joannopolous,J.D., Meade R.D and Winn, J.N, Photonic crystals, Princeton University Press, 1995

MNT5006	NANOELECTRONICS AND SENSORS	L	T	P	C
		3	0	0	3

SEMICONDUCTOR NANODEVICES

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.

ELECTRONIC AND PHOTONIC MOLECULAR MATERIALS

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.

THERMAL SENSORS

Thermal energy sensors -temperature sensors, heat sensors- Electromagnetic sensors- electrical resistance sensors, electrical current sensors, electrical voltage sensors, electrical power sensors, magnetism sensors - Mechanical sensors -pressure sensors, gas and liquid flow sensors, position sensors - Chemical sensors - Optical and radiation sensors.

GAS SENSOR MATERIALS

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.

BIOSENSORS

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

TEXT BOOKS

1. Ranier,W., Nano Electronics and Information Technology, Wiley, 2003
2. Brian Eggins, Chemical Sensors and Biosensors, John Willey & Sons, 2002

REFERENCES

1. Drexler, K.E., Nano systems, Wiley, 1992.
2. Jacob Fraden, Hand book of modern sensors: Physics, Designs and Applications, John Wiley, 2007

3. Michael C. Petty, Molecular Electronics: From Principles to Practice, Wiley, 2008
4. Kumar, C.S.S.R. (Ed.) Nanomaterials for Biosensors, John Wiley & Sons, 2007
5. Julian W.Gardner, Microsensors: Principles and Applications, Wiley 1994

MNT5007	PHYSICOCHEMICAL METHODS FOR CHARACTERIZATION OF NANOMATERIALS	L	T	P	C
		3	0	0	3

X-RAY DIFFRACTION:

X-ray powder diffraction – single crystal diffraction- techniques - Determination of accurate lattice parameters - structure analysis - profile analysis - particle size analysis using Scherer formula.

THERMAL ANALYSIS METHODS

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

QUALITATIVE AND QUANTITATIVE ANALYSIS

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.

SPECTROSCOPIC TECHNIQUES

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.

NANOINDENTATION

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.

TEXT BOOKS

1. Cullity, B. D., Elements of X-ray Diffraction, 4th Edition, Addison Wiley, 1978.
2. Rose, R.M., Shepard L.A., and. Wulff, J., The Structure and Properties of Materials, Wiley Eastern Ltd.

REFERENCES

- 1.Loretto, M. H., Electron Beam Analysis of Materials, Chapman and Hall, 1984.
- 2.Mott, B.W., Micro-Indentation Hardness Testing, Butterworths, London, 1956.

MNT5008	MECHANICAL PROCESSING AND PROPERTIES OF NANOSTRUCTURED MATERIALS	L	T	P	C
		3	0	0	3

PROCESSING OF METALS AND ALLOYS

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

PROCESSING OF POLYMERS

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

PROCESSING OF POWDERS OF METALS AND CERAMICS

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

PROCESSING OF STRUCTURAL AND FUNCTIONAL NANOCRYSTALLINE MATERIALS

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

MICROSTRUCTURE AND PROPERTIES

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.

TEXT BOOK

1.Koch, C.C.Nanostructured Materials: Processing, Properties and Applications”, 2nd Edition, Ed.: Noyes Publications, 2007.

REFERENCES

1. Cottrell,A.H.The Mechanical Properties of Matter, John Wiley, New York- London, 1964.
2. Haasen. P.Physical Metallurgy, Cambridge University Press, Cambridge, UK, 1978.
3. Dieter G.E, adapted by D Bacon, Mechanical Metallurgy, SI Metric edition, McGraw-Hill, Singapore, 1988.
4. Padmanabhan, K.A, Mechanical Properties of Nanostructured Materials, Materials Science and Engineering, A 304-306, 2001

MNT5009	PRODUCT DESIGN, MANAGEMENT TECHNIQUES AND ENTREPRENEURSHIP	L	T	P	C
		3	0	0	3

PRODUCT DESIGN

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

PRODUCT DEVELOPMENT

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.

MANAGEMENT TECHNIQUES

Technology Management - Scientific Management-Development of management thought-Principles of Management- Functions of management-planning- Organizing- Directing, Staffing and Controlling- Management by objective- SWOT analysis- Enterprise Resource Planning and Supply Chain Management.

ENTREPRENEURIAL COMPETENCE & ENVIRONMENT

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.

MANAGEMENT OF SMALL BUSINESS

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.

TEXT BOOK

1.Karal, T.Ulrich Steven, D.Eppinger, Product Design and Development, McGraw- Hill International, Edition, 2003.

REFERENCES

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

MNT 5081	NANOMATERIAL SYNTHESIS AND CHARACTERIZATION I LABORATORY	L	T	P	C
		0	0	6	2

1. Material Synthesis through chemical route - Sol-gel, Gel-combustion
2. Material synthesis by Flame Pyrolysis
3. Nanomaterial synthesis by Electro chemical Process
4. Reactive Evaporation
5. Synthesis of Nanomaterials by biological process
6. Langmuir-Blodgett based synthesis of SAM
7. Experiments with AFM, STM and XRD
8. Surface Analysis and Atomic Manipulation
9. Particle size analysis
10. Synthesis of nano Ag, Au, TiO₂, ZnO and SnO₂
11. Micro emulsion synthesis of Nanomaterials

MNT 5082	NANOMATERIAL SYNTHESIS AND CHARACTERIZATION II LABORATORY	L	T	P	C
		0	0	6	2

1. Thin film coating using CVD (RF sputtering)
2. Thin film preparation by spin coating
3. PVD, Inert gas condensation techniques – Sample Preparation
4. Electro-deposition
5. Ball milling – Nanopowder making
6. Pulsed laser deposition (PLD) for thin film coating
7. Characterization using UV-Visible spectroscopy
8. Characterization using fluorescence spectroscopy

MNT5010	TOP DOWN MANUFACTURING METHODS	L	T	P	C
		3	0	0	3

FABRICATION

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.

E-BEAM AND ION BEAM LITHOGRAPHY

Principle and instrumentation - Scanning electron-beam lithography- Mask less (ML2) EBL- parallel direct-write e-beam systems-E-beam projection lithography - Preval X-ray lithography - Focussing ion beam lithography - Ion projection lithography - Masked ion beam direct structuring-Nanoimprint lithography and soft lithography- Nanoimprint lithography - Soft lithography- Dip-Pen lithography.

ETCHING TECHNIQUES

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.

BALL MILLING TECHNIQUE

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

MACHINING PROCESSES

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 .

TEXT BOOK

1 Jackson, M.J., Micro fabrication and Nanomanufacturing, CRC Press, 2005

REFERENCES

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

MNT5011	BOTTOM UP MANUFACTURING METHODS	L	T	P	C
		3	0	0	3

THIN FILM TECHNOLOGIES – I

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.

THIN FILM TECHNOLOGIES – II

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.

EPITAXIAL FILM DEPOSITION METHODS

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.

CHEMICAL METHODS

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.

PRINTING TECHNOLOGIES

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

TEXT BOOK

1. Cao,G Nanostructures & Nanomaterials: Synthesis, Properties &Applications Imperial College Press, 2004.

REFERENCES

1. Huck.W.T.S., Nanoscale Assembly: Chemical Techniques (Nanostructure Science and Technology).Springer, 2005
2. Gdoutos E.E. and I.M.Danies, Handbook of Nanoscience Engineering and Technology, eds., Kluwer publishers, 2002.

MNT5012	LITHOGRAPHY AND NANOFABRICATION	L	T	P	C
		3	0	0	3

PATTERNING OF THIN FILMS

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.

MASKLESS OPTICAL LITHOGRAPHY

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

ELECTRON BEAM LITHOGRAPHY

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.

X-RAY LITHOGRAPHY

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

NANOIMPRINT LITHOGRAPHY AND SOFT LITHOGRAPHY

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.

TEXT BOOK

1. Ivor Brodie and Julius J. Muray, The Physics of Micro/Nano-Fabrication (Microdevices), Academic press, 2007

REFERENCES

1. Dhaliwal D. S et al., PREVAIL –Electron projection technology approach for next generation lithography, IBM Journal Res. & Dev. 45, 615, 2001
2. Baker M.et al., Lithographic pattern formation via metastable state rare gas atomic beams, Nanotechnology 15, 1356,2004.
- 3.Schift.H et al., Fabrication of polymer photonic crystals using nano - imprint lithography, Nanotechnology 16, 261, 2005.
4. Piner R.D, Dip-Pen Nanolithography, Science 283, 661, 1999
5. Vijay Varadan, Xiaoning Jiang, and Vasundara Varadan, Microstereolithography and other Fabrication Techniques for 3D MEMS, Wiley 2001.

MNT 5013	ADVANCED CHARACTERIZATION TECHNIQUES FOR NANOMATERIALS	L	T	P	C
		3	0	0	3

OPTICAL MICROSCOPY

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

SCANNING ELECTRON MICROSCOPY

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.

TRANSMISSION ELECTRON MICROSCOPY

Basic principles - Modes of operation – Specimen preparation – Diffraction in imperfect crystals – Dislocations – precipitates – Structure of grain boundaries and interfaces- HRTEM use in nanostructures-Laser and confocal microscopy

ATOMIC FORCE MICROSCOPY

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.

SCANNING TUNNELING MICROSCOPY

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

TEXT BOOK

1. Goldstein, J., Newbury, D. E., Joy D.C, and Lym, C.E., Scanning Electron Microscopy and X-ray Microanalysis. 2003.

REFERENCES

1. Flegler, S.L. Heckman J.W and. Klomparens, K.L Scanning and Transmission Electron Microscopy: An Introduction”, WH Freeman & Co, 1993.
2. Goodhew, P.J. Humphreys, J. Beanland, R., Electron Microscopy and Analysis, Taylor and Francis, 2001
3. Haynes, R. Woodruff D.P and. Talchar, T.A., Optical Microscopy of Materials. Cambridge University press, 1986.

MNT5014	SURFACE ENGINEERING AND NANO METROLOGY	L	T	P	C
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SURFACE ENGINEERING

Introduction - surface modification processes- Carburizing, Nitriding, Nitrocarburizing, Ion Implantation- laser techniques - Coating processes: Plating, PVD, CVD and thermal spraying – characteristics, applications and limitations.

APPLICATIONS

Surface engineering and High speed grinding - advanced coatings - high performance cutting tools - high performance super-abrasive grinding wheels - metal-ceramic joining - Ultra high speed grinding - monolayer CBN grinding wheel - Machining and grinding under cryogenic environment - Micro and nano machining of glasses and ceramics in ductile regime - diamond cutting tool - diamond grinding wheel.

NANOSURFACE ENGINEERING

Engineering based on nano-materials-Nano surface engineering- nano-thermal spraying, nano-brush plating, nanocomplex additive-Crystallization of Amorphous Silicon-Superhydrophobic Applications-nano surface engineering for tribological and biomedical applications.

METROLOGY

Co-ordinate measuring machine-applications of CMM - CNC CMM applications - Computer Aided Inspection - Machine Vision - Applications in Metrology – Laser Metrology-precision instrument based on Laser - Laser Interferometer - Application in Linear and Angular measurements - Testing of machine tools using Laser Interferometer.

WEAR MECHANISMS OF SURFACE ENGINEERED MATERIALS

Abrasion, oxidation, rolling contact - sliding wear behavior of metals - ceramics - polymers - surface engineered materials.

TEXT BOOK

1. Gaylor, Shotbolt and Sharp, Metrology for Engineers, O.R.Cassel, London, 1993

REFERENCES

1. Tyrkiel.E.and Dearnley. P.A (eds), A Guide to Surface Engineering Terminology, The Institute of Materials, London, 1995
2. Thomas,P. Engineering Metrology, Butthinson & Co., 1984
3. David J.Whitehouse, The Handbook of Surface and Nanometrology, IOP publishing Limited, 2003

MNT5015	NANOTECHNOLOGY FOR ENERGY SYSTEMS	L	T	P	C
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INTRODUCTION

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

RENEWABLE ENERGY TECHNOLOGY

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.

FUEL CELL TECHNOLOGY

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

MICROFLUIDIC SYSTEMS

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.

HYDROGEN STORAGE METHODS

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.

TEXT BOOK

1. Twidell, J. and Weir, T. Renewable Energy Resources, E & F N Spon Ltd, London, 1986.

REFERENCES

1. Shatwell, R.A, Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures, Fuel Cell technology Handbook. CRC Press, 2003.
2. Vielstich, H. Handbook of fuel cells: Fuel cell technology and applications, Wiley, CRC Press, 2003.
3. Rabaey, K. and W. Verstraete, Microbial fuel cells-a novel biotechnology for energy generations. Trends Biotechnol 23,291–298, 2005

MNT5016	MEMS AND BIOMEMS	L	T	P	C
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MEMS MICROFABRICATION

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

MEMS MASK LAYOUT

Physics of MEMS-scaling laws heat transfer - mechanics and electro statistics – batch Fabrication – circuit integration.

BIO MEMS

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

MATERIALS FOR MEMS

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

COMMERCIAL AND TECHNOLOGICAL TRENDS

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

TEXT BOOK

- 1.Marc Madou, Fundamentals of Microfabrication, CRC Press 1997.
- 2.Héctor J. De Los Santos, Introduction to Microelectromechanical (MEM) Microwave Systems, Artech House 1999.

REFERENCES

- 1.Gregory Kovacs, Micromachined Transducers Sourcebook, McGraw-Hill 1998.
- 2.Sergey Edward Lyshevski, Nano- and Microelectromechanical Systems,CRC Press 2000.
- 3.Wanjun Wang and Steven A.Soper, Bio-MEMS – Technologies and Applications, CRC Press-2006
- 4.Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw-Hill 2001.

PBT6025	BIOSENSORS – PRINCIPLES AND APPLICATIONS	L	T	P	C
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INTRODUCTION

Historical perspective - Signal transduction - Physico-chemical and biological transducers - Sensor types and technologies - Main technical definitions - calibration, selectivity, sensitivity, reproducibility, detection limits, response time; Problems and trade-offs.

TRANSDUCERS

Electrochemical transducers (amperometric, potentiometric, conductimetric); Semiconductor transducers (ISFET, ENFET); Optical transducers (absorption, fluorescence, bio/chemiluminescence, SPR) - Thermal transducers - Piezoelectric and acoustic-wave

transducers - Limitations & problems to be addressed; An Overview of Performance and Applications

BIORECOGNITION SYSTEMS

Enzymes - oligonucleotides and Nucleic Acids - Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes) - Membrane receptors and transporters – Immunoreceptors – Chemoreceptors - Immobilization of enzymes, peptides, antibodies, oligonucleotides and Nucleic Acids – Immobilization of cells

TYPES OF BIOSENSORS AND FABRICATION

Catalytic biosensors: mono-enzyme electrodes - bi-enzyme electrodes: enzyme sequence electrodes and enzyme competition electrodes - Affinity-based biosensors - Inhibition based biosensors – Cell based biosensors - Biochips and biosensor arrays

Methods for biosensors fabrication - self-assembled monolayers, screen printing, photolithography, micro contact printing, MEMS – nano materials for biosensors

APPLICATIONS OF BIOSENSORS

Clinical chemistry - Test-strips for glucose monitoring, Urea determination - Implantable sensors for long-term monitoring - Drug development and detection – Pathogen detection - Environmental monitoring - Technological process control - Food quality control - Forensic science benefits

TEXT BOOKS

1. Brian Eggins, Chemical Sensors and Biosensors, John Willey & Sons, 2002
2. Kumar, C.S.S.R. (Ed.) Nanomaterials for Biosensors, John Wiley & Sons, 2007

REFERENCES

1. Jiri Janata, Principles of Chemical Sensors, Plenum Press, 1989.
2. Frontiers in Biosensors, Edited by: F. Schellr, F. Schubert, J. Fedrowitz, Birkhauser Verlag, 1995.
3. Optical Biosensors. Present & Future. Editors: F. Ligler, C. Rowe Taitt, Elsevier, 2002.
4. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley & Sons, 1998.
5. Commercial Biosensors, Graham Ramsay Editor, John Wiley & Sons, 1998.

MNT6003	NANOPOWDER HANDLING	L	T	P	C
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PROPERTIES OF NANO POWDER AND METHODS OF HANDLING

Properties of nano powders - Powder classification - physical, chemical, thermal and other properties - Friction and Impact sensitivity – Toxicity – Explosivity – Metallic powders – Manual, mechanical, automatic handling methods – charges on powders – charge distribution – charging of powders.

IGNITION OF NANO POWDERS AND DUST CONTROL

Ignition - minimum ignition energy - powder dispersion - spark, generation –characteristics - pressure concentration - flammable gases - solvent vapour -vapour clouds – decomposition - exothermic and endothermic reaction. Dust: Definition – type – concepts – exposure – dispersion – control - monitoring and measure-control of dust at the source - control approaches and strategies -occupational related diseases, carcinogens entry into human systems - House keeping and environmental protection - technological options for collection, treatment and disposal of hazardous waste - Pollution control in process industries.

NANO POWDER HAZARDS

Recognition of chemical hazards - dust, fumes, mist, vapour, fog, gases, types, concentration, Exposure vs. dose, TLV - Methods of Evaluation, process or operation description - Field Survey - Sampling methodology - Industrial Hygiene calculations - Comparison with OSHAS Standard.

HAZARD MEASUREMENT

Volume reference – resistivity of solids-powders in bulk - surface resistance -static charge, conductivity – electric field, ratio signals - minimum Ignition energy - particulate measurement - air sampler - dust monitor. Sampling instruments – types - Measurement procedures - Instruments Procedures - dust sample collection devices - personal sampling - Hazard identification and assessment in the process industries

SAFETY IN NANO POWDER HANDLING

Safety measures in powder handling – loading and unloading – pneumatic transfer – sieving - grinding and mixing – control measures – PPE - earthing – elimination of incendiary discharge. Explosion prevention – handling of nano powders in the presence of flammable gases and vapour – safety measures in industries.

TEXT BOOK

1. Joanne Shatkin, Nanotechnology: Health and environmental risks – Perspective in Nanotechnology – CRC Press, 2007

REFERENCES

1. Martin Glor, Electro Static Hazard in Powder Handling Research studies, Press Ltd., England, 1988.
2. Major hazard control-ILO Geneva, 1987.
3. Seminar on Hazard recognition and prevention in the work place-airborne dust Vol.1 and SRMC, Chennai, 4/5, Sept.2000.
4. Hand book of Occupational Safety and Health, National Safety Council, Chicago, 1982

MNT6004	MOSFET TECHNOLOGIES – VLSI TO NANOSCALE	L	T	P	C
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OVERVIEW OF ULTRA-DIP SUBMICRON TECHNOLOGIES

Basic concepts of MOSFET devices- Schematic diagram, classification and functional issues, Scaling of CMOS technologies, Evaluation of different technology nodes - with Moore's law, down scaling and device performance

DIFFERENT KIND OF SUBSTRATE

Si, strained SiGe, Strained Si, SiC, SiGeC, SOI, fabrication steps, physics of strained – misfit dislocations, Physical and chemical characteristics of different substrates

ALTERNATIVE GATE DIELECTRICS: INTEGRATION ISSUES

Issues due to scaling of Gate dielectrics thickness, motivation for switching to alternative dielectrics, Properties of ultra-thin-SiO₂ layers; Quantum-mechanical tunneling leakage current versus oxide thickness; concepts of equivalent oxide thickness (EOT), candidate materials for alternative dielectrics: different categories, Alternative dielectric film-deposition techniques, Nitridation and interface preparation, Process integration challenges of alternative dielectrics: different kinds of defects, interface issues, Annealing effect, Current status and future prospects for alternative materials in gate-stack applications

COMPATIBILITY OF METAL GATE ELECTRODES

Conventional Poly-Si gate, Difficulties: boron penetration of thin gate-dielectric layers in PMOSFETs, poly-Si depletion effects, Fermi-level-pinning in Poly-Si /dielectrics gate stacks; Extraction of metal work function for PMOS and NMOS devices, Candidate gate electrode materials: mid-band gap metals (TiN, TaN); Fully-Silicided Gate Materials (NiSi FUSI); Dual-metal gates; Tunable Work-Function Metal Gates: Doping FUSI; Bi-Metal Layers (Ru-Ta Alloys), deposition techniques of different gate electrode materials, chemical and physical characterization of gate materials, compatibility with underlying gate dielectrics

RELIABILITY ISSUES

Reliability: Thermal, electrical, environmental, Challenges to implement the alternative gate dielectrics and gate electrodes in 45 nm technology nodes and beyond.

TEXT BOOK

1.Kelsall, R, Hamley,I.W and Geoghegan, M. Nanoscale Science and Technology, Wiley, 2005

REFERENCES

1. Chang.C.Y and S.M.Sze,ULSI Technology, McGraw-Hill Companies Inc., Singapore, 1996.
2. Wolf. S. Silicon processing for the VLSI era, Vol-1 to 4, Lattice Press.2005
3. Ghandhi, S.K VLSI fabrication principles: Silicon and Gallium Arsenide, 2nd Edition, Wiley-Interscience, 1994

MNT6005	NANOMATERIALS AND NANOMEDICINE	L	T	P	C
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BIOLOGICAL MATERIALS

Structure property relationship of Biological Materials: tissues, bones and teeth, collagen rich tissues, elastic tissues, nanostructured collagen mimics in tissue engineering. Biopolymers: Preparation of nanobiomaterials – Polymeric scaffolds collagen, Elastins: Mucopolysaccharides, proteoglycans, cellulose and derivatives; Dextrans; Alginates; Pectins; Chitin.

NANOMATERIALS FOR BIOLOGICAL APPLICATIONS

Cardiovascular implants: Role of nanoparticles and nanodevices in Blood clotting; Blood rheology; Blood vessels; Geometry of blood circulation; Vascular implants; Cardiac pacemakers; Blood substitutes; Biomembranes.

BIOLOGICAL SUBSTITUTE MATERIALS

Polymeric implant materials: Polyolefin; polyamides (nylon); Acrylic polymers (bone cement) and hydrogels; Fluorocarbon polymers; Natural and synthetic rubbers, silicone rubbers; High strength thermoplastics; Deterioration of polymers. Biomaterials for Ophthalmology: Contact lenses; Optical implants for glaucoma; adhesives.

IMPLANT MATERIALS

Metallic and ceramic implant materials: Bone regeneration, Nano crystalline structures of Bone and Calcium phosphate cements. Cobalt-based alloys; Titanium and its alloys, Nanoparticles relating to Aluminium oxides; Hydroxyapatite; Glass ceramics; ceramic implants; Carbon implants. Nano dental materials.

DRUG DELIVERY SYSTEM

Synthesis of nanodrugs – metal nanoparticles and drug delivery vehicles – Nanoshells – Tectodentrimers Nanoparticle drug systems – Diagnostic applications of nanotechnology.

TEXT BOOK

1. Challa S.S.R.Kumar, Joseph Hormes, Carola Leuschmal, Nanofabrication towards biomedical applications Wiley –VCH Verlag GmbH & CO,2007

REFERENCES

1. Bhat,SV. Biomaterials (2nd Edition), Narosa Publishing House, New Delhi-2005.
2. Park,JB. Biomaterials Science and Engineering, Plenum Press, New York, 1984
3. Kewal K.Jain, The Handbook of Nanomedicine, Humanapress, 2008

MNT6006	INDUSTRIAL NANOTECHNOLOGY	L	T	P	C
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SEMICONDUCTOR PHYSICS

Semiconductor physics, fabrication techniques, electronic structure and physical processes in semiconductor nanostructures, principles and performance of semiconductor nanostructure based electronic and electro-optical devices.

NANOMAGNETIC MATERIALS

Revision of magnetism in solids, property- nanostructure relationships, fabrication and properties of nanostructured magnets - probes of nanomagnetic properties, electronic magneto-transport, micromagnetic modeling.

SENSOR MATERIALS

Micro and Nano-Electromechanical systems - fabrication process- choice of materials, calculations - the performance of different structures - advantages and disadvantages of different approaches, thermal radiation, magnetic, chemical, and mechanical sensors, Microactuators.

DISPLAY MATERIALS

Hybridisation, conjugation, excitations, molecular crystals, conducting vs semi conducting polymers, Organic electroluminescent displays injection, transport, Exciton formation, light emission, Influence of supramolecular order:excimers, H- and J-aggregates, liquid crystallinity.

INDUSTRIAL IMPORTANT NANOMATERIALS

Nanoparticles and Micro-organism, Nano-materials in bone substitutes & Dentistry, Food and Cosmetic applications, Textiles, Paints, Catalysis, Drug delivery and its applications.

TEXT BOOK

1. Mark A. Ratner and Daniel, Nanotechnology: A Gentle Introduction to the Next Big Idea, Pearson Education, 2003,

REFERENCES

1. John C. Miller, The Handbook of Nanotechnology: Business, Policy, and Intellectual Property Law, Wiley, 2004
2. Verdeyen. J, Laser Electronics, II Edition, Prentice Hall, 1990
3. Yariv. A, Principles of Optical Electronics, John Wiley, New York, 1984
4. M C Petty, M R Bryce, D Bloor (eds.), Introduction to Molecular Electronics, Edward Arnold, London, 1995 (ISBN 0-340-58009-7)
5. G Hadziioannou, P F van Hutten, Semiconducting Polymers: Chemistry, Physics, and Engineering', Wiley-VCH, 2000 (ISBN 3-527-29507-0)
6. D D C Bradley, Current Opinion in Solid State & Materials Science Vol.1, 789, 1996

MNT6007	NANOBIOTECHNOLOGY	L	T	P	C
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BASICS OF NANOBIOTECHNOLOGY

Interdisciplinary areas of Biotech and Nanoscience Cells, Cellular components, Nucleic acids and proteins refinement and application of instruments – to generate and manipulate nanostructured materials to basic and applied studies.

BIO-COMPATIBLE DEVICES

Interphase systems pertaining to biocompatible inorganic devices for medical implants – microfluidic systems – microelectronic silicon substrates.

BIOELECTRONIC DEVICES

Protein based nanostructures building blocks and templates – Proteins as transducers and amplifiers of biomolecular recognition events – nanobioelectronic devices and polymer nanocontainers – microbial production of inorganic nanoparticles – magnetosomes.

DNA BASED DEVICES

DNA based nanostructures – Topographic and Electrostatic properties of DNA and proteins – Hybrid conjugates of gold nanoparticles – DNA oligomers – use of DNA molecules in nanomechanics and Computing

NANOPARTICLES

Semiconductor (metal) nanoparticles, nucleic acid and protein based recognition groups – application in optical detection methods – Nanoparticles as carrier for genetic material

TEXT BOOK

1. Nano: The Essentials: T.Pradeep. McGraw – Hill – 2007.

REFERENCES

1. CM, Niemeyer, C.A. Mirkin. Nanobiotechnology – Concepts, Applications and Perspectives Wiley – VCH, 2004
2. Challa, S.S.R. Kumar, Josef Hormes, Carola Leuschaer. Nanofabrication towards Biomedical Applications, Techniques, Tools, Applications and impact. Wiley – VCH, 2005
3. Nicholas A. Kotov, Nanoparticle Assemblies and Superstructures. CRC Press, 2006

MNT6008	NANOTECHNOLOGY AND ENVIRONMENT	L	T	P	C
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EARTH ENERGY SYSTEMS

Origin of the earth-Earth's temperature and atmosphere-Sun as the source of energy Biological processes-photosynthesis-food chains-Energy sources-classification of energy sources, quality and concentration of energy sources-Overview of world energy scenario;

Fossil fuel reserves - estimates, duration, overview of India's energy scenario, energy and development linkage.

ENERGY SYSTEMS AND ENVIRONMENT

Environmental effects of energy extraction, conversion and use-Sources of pollution; primary and secondary pollutants; Consequence of pollution growth; Air, water, soil, thermal, noise pollution- cause and effect; Causes of global, regional and local climate change; Pollution control methods; Environmental laws on pollution control.

SUSTAINABILITY

Global warming; Green House Gas emissions, impacts, mitigation; Sustainability; Externalities; Future Energy Systems; Clean energy technologies; United Nations Framework Convention on Climate Change (UNFCCC)-Sustainable development-Kyoto Protocol; Conference of Parties (COP)-Clean Development Mechanism (CDM); Prototype Carbon Fund (PCF).

GREEN CHEMISTRY

Principles of green chemistry- green synthesis in a chemical laboratory-solvent free process-solvent free techniques-microwave synthesis: Introduction – characteristics of microwave heating – interaction of microwave radiation with the materials-difference between microwave heating and conventional heating-Sonochemical synthesis

NANOMATERIALS-ENVIRONMENTAL APPLICATIONS

Zerovalent iron nanoparticles- titanium dioxide-silver nanoparticles-nanomembrane process-nanosorbants-mesoporous silica-ground water remediation-airpurifier-nano photocatalysis-nanocoating-corrosion prevention-nanosolar thermal absorber-nanobased environmental treatment.

TEXT BOOKS

1. E H Thorndike, Energy & Environment: A Primer for Scientists and Engineers, Addison-Wesley Publishing Company
2. Mark Wiesner and Jean-Yves Bottero, Environmental Nanotechnology, McGraw-Hill, 2007

REFERENCES

1. K.R.Desai, - Green chemistry (Microwave synthesis), Himalaya Publishing House, Mumbai, 2005
2. Energy and the Challenge of Sustainability, World Energy assessment, UNDP, New York, 2000.
3. Ravindranath N.H., Usha Rao K., Natarajan B., Monga P., Renewable Energy and Environment – A Policy Analysis for India, Tata McGraw Hill, 2000.
4. Fowler, J.M., Energy and the Environment, 2nd Ed. ,McGraw Hill, New York, 1984