ANNA UNIVERSITY:: CHENNAI 600 025
AFFILIATED INSTITUTIONS
M.TECH. NANOSCIENCE AND TECHNOLOGY
REGULATIONS – 2017
CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. To prepare students to outshine in academics and research in different motifs of Nanoscience and Nanotechnology through post graduate education.
II. To provide students with a solid foundation in Synthesis and Characterization of novel nanomaterials with multiple applications.
III. To train students with good theoretical and practical knowledge so as to comprehend, Analyze, design, and create novel products and solutions for the real life problems.
IV. To coach students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate nanotechnology to address environmental issues.
V. To provide students with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career

PROGRAMME OUTCOMES (POs):

On successful completion of the M.Tech Nanoscience and technology programme:

1. The Post Graduates will demonstrate knowledge on the physics, chemistry, biology, quantum confinement and photonics of nanomaterials.
2. Post Graduates will demonstrate an ability to synthesis and characterize the nanomaterials.
3. Post Graduate will project their skill in modeling and simulation, Lithography and nanofabrication.
4. Post Graduates will have expertise in processing of nanomaterials, MEMS and bio MEMS as per needs and specifications.
5. Post Graduates will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks including nanometrology, material science, physics, chemistry and nanobiotechnology.
6. Post Graduates will demonstrate their skills for synthesis, processing and handle imaging equipments to analyze nanomaterials.
7. Post Graduates will be able to propagate their knowledge to address problems of social relevance such as energy, environment and medicine through their specific electives.
8. Post Graduates will show the understanding of impact of nanomaterials on the society including environment, health and ecosystem.
9. Post graduates will be able to plan and execute their own innovative ideas in the form of projects, product design and development.
10. Post Graduates will develop confidence for self-education and ability to teach others and life-long learning.

Programme Educational Objectives	Programme Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
I	✓									
II		✓			✓					
III			✓	✓	✓					
IV							✓	✓	✓	
V									✓	✓

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
YEAR 1	SEM 1	Mathematical Modeling and Simulation			✓							
		Quantum Mechanics	✓									
		Physics and Chemistry of Materials	✓									
		Synthesis of Nanomaterials		✓								
		Physicochemical methods for characterization of Nanomaterials					✓					
		Computation and Simulation			✓							
		Nanomaterial Synthesis (Practicals)	✓						✓		✓	
	SEM 2	Photonics for Nanotechnology	✓					✓				
		Processing and properties of Nanostructured Materials				✓	✓					
		Imaging techniques for Nanotechnology		✓			✓	✓				
		Nanotechnology in Health Care							✓	✓		
		Lithography and Nanofabrication			✓							
		MEMS and Bio MEMS				✓						
		Nanometrology (Practicals)	✓					✓				
	SEM 3	Professional Elective I							✓	✓	✓	
YEAR 2		Professional Elective II							✓	✓	✓	
		Professional Elective III							✓	✓	✓	
		Project Work Phase I	✓	✓				✓	✓	✓	✓	✓
	SEM 4	Project Work Phase II	✓	✓				✓			✓	✓

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I TO IV SEMESTERS CURRICULUM AND SYLLABUS

SEMESTER I

Sl. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	MA5162	Mathematical Modeling and Simulation	FC	4	4	0	0	4
2	NT5101	Cellular Biochemistry	FC	3	3	0	0	3
3	NT5102	Physics and Chemistry of Materials	FC	3	3	0	0	3
4	NT5103	Quantum Mechanics	FC	3	3	0	0	3
5	NT5104	Synthesis of Nanomaterials	FC	3	3	0	0	3
6	NT5105	Physicochemical Methods for Characterization of Nanomaterials	FC	3	3	0	0	3
PRACTICAL								
7	NT5111	Computation and Simulation	FC	4	0	0	4	2
8	NT5112	Nanomaterial Synthesis	FC	4	0	0	4	2
			TOTAL	**27**	**19**	**0**	**8**	**23**

SEMESTER II

Sl. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	NT5201	Imaging Techniques for Nanotechnology	PC	3	3	0	0	3
2	NT5202	Lithography and Nanofabrication	PC	3	3	0	0	3
3	NT5203	Photonics for Nanotechnology	PC	3	3	0	0	3
4	NT5204	Processing and Properties of Nanostructured Materials	PC	3	3	0	0	3
5		Professional Elective I	PE	3	3	0	0	3
6		Professional Elective II	PE	3	3	0	0	3
PRACTICAL								
7	NT5211	Nanometrology	PC	4	0	0	4	2
			TOTAL	**22**	**18**	**0**	**4**	**20**

SEMESTER – III

Sl. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	NT5301	MEMS and Bio MEMS	PC	3	3	0	0	3
2		Professional Elective III	PE	3	3	0	0	3
3		Professional Elective IV	PE	3	3	0	0	3
PRACTICAL								
4	NT5311	Project Work (Phase I)	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER – IV

Sl. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
PROJECT								
1	NT5411	Project Work (Phase II)	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL CREDITS : 70

SEMESTER – II, PROFESSIONAL ELECTIVES I

Sl. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	NT5001	Advanced Drug Delivery Systems	PE	3	3	0	0	3
2	NT5002	Advanced Nanocomposites	PE	3	3	0	0	3
3	NT5003	Biophotonics	PE	3	3	0	0	3
4	NT5004	Bottom up Synthesis of Nanostructures	PE	3	3	0	0	3

SEMESTER – II, PROFESSIONAL ELECTIVES II

Sl. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	NT5005	Biosensors	PE	3	3	0	0	3
2	NT5006	Nanoelectronics and Sensors	PE	3	3	0	0	3
3	NT5007	Nanomaterials for Energy and Environmental	PE	3	3	0	0	3
4	NT5008	Nanotoxicology	PE	3	3	0	0	3

SEMESTER – III, PROFESSIONAL ELECTIVES III

Sl. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	NT5009	Research Methodology in Nanotechnology	PE	3	3	0	0	3
2	BO5091	Tissue Engineering and Regenerative Medicine	PE	3	3	0	0	3
3	NT5010	Optical Properties of Nano Materials	PE	3	3	0	0	3
4	NT5011	Application of Nanotechnology in Food Industries	PE	3	3	0	0	3

SEMESTER – III, PROFESSIONAL ELECTIVES IV

Sl. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	NT5012	Semiconductor Nanostructures and nanoparticles	PE	3	3	0	0	3
2	NT5013	Top down Manufacturing Methods	PE	3	3	0	0	3
3	NT5014	Nanotechnology in Health Care	PE	3	3	0	0	3
4	BO5092	Biomaterials	PE	3	3	0	0	3

Foundation Courses (FC)

Sl. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	MA5162	Mathematical Modeling and Simulation	FC	3	3	0	0	3
2	NT5103	Quantum Mechanics	FC	3	3	0	0	3
3	NT5102	Physics and Chemistry of Materials	FC	3	3	0	0	3
4	NT5104	Synthesis of Nanomaterials	FC	3	3	0	0	3
5	NT5101	Cellular Biochemistry	FC	3	3	0	0	3
6	NT5105	Physicochemical Methods for Characteraization of Nanomaterials	FC	3	3	0	0	3
7	NT5111	Computation and Simulation	FC	3	3	0	0	3
8	NT5112	Nanomaterial Synthesis	FC	3	3	0	0	3

Professional Core (PC)

Sl. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	NT5203	Photonics for Nanotechnology	PC	3	3	0	0	3
2	NT5204	Processing and Properties of Nanostructured Materials	PC	3	3	0	0	3
3	NT5201	Imaging Techniques for Nanotechnology	PC	3	3	0	0	3
5	NT5202	Lithography and Nanofabrication	PC	3	3	0	0	3
6	NT5301	MEMS and Bio MEMS	PC	3	3	0	0	3
7	NT5211	Nanometrology	PC	3	3	0	0	3

Employability Enhancement Courses (EEC)

S.No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	NT5311	Project Work (Phase I)	EEC	12	0	0	12	6
2.	NT5411	Project Work (Phase II)	EEC	24	0	0	24	12

MA5162 MATHEMATICAL MODELING AND SIMULATION L T P C
4 0 0 4

OBJECTIVES :

- The main objective of this course is to provide the student with a repertoire of mathematical methods that are essential to the solution of advanced problems encountered in the field of nanoscience and technology. This course covers a broad spectrum of mathematical techniques including matrix theory, approximation of functions using polynomial interpolation, numerical differentiation and integration, numerical solution of differential equations and partial differential equations and simulation and Monte - Carlo methods.

UNIT I MATRICES AND LINEAR SYSTEMS OF EQUATIONS 12

Solution of Linear Systems : Cramer's Rule - Gaussian elimination and Gauss Jordon methods - Cholesky decomposition method – Gauss Seidel iteration method - Eigenvalue problems : Power method with deflation for both symmetric and non symmetric matrices and Jacobi method for symmetric matrices.

UNIT II INTERPOLATION, DIFFERENTIATION AND INTEGRATION 12

Lagrange's interpolation - Newton's divided differences - Hermite's interpolation – Newton's forward and backward differences – Numerical differentiation – Numerical integration : Trapezoidal and Simpson's $\frac{1}{3}$ rules - Gaussian quadrature : 2 and 3 point rules.

UNIT III DIFFERENTIAL EQUATIONS 12

Initial value problems for first and second order ODEs : Single step methods - Taylor's series method – Euler's and modified Euler's methods - Runge - Kutta method of fourth order - Multi step methods : Milne's and Adam Bashforth methods - Boundary value problems : Finite difference approximations to derivatives - Finite difference method of solving second order ODEs .

UNIT IV PARTIAL DIFFERENTIAL EQUATIONS 12

Classification of second order PDE's - Finite difference approximations to partial derivatives - Elliptic equations : Solution of Laplace and Poisson equations - One dimensional parabolic equation - Bender Schmidt method - Hyperbolic equation : One dimensional wave equation.

UNIT V SIMULATION AND MONTE CARLO METHODS 12

Random numbers : Random number algorithms and generators – Estimation of areas and volumes by Monte Carlo techniques - Numerical integration - Computing volumes – Simulation : Loaded Die Problem - Birthday problem - Buffon's needle problem - Two dice problem and Neutron shielding problem.

TOTAL: 60 PERIODS

OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Solve an algebraic or transcendental equation and linear system of equations using an appropriate numerical method.
- Approximation of functions using polynomial interpolation, numerical differentiation and integration using interpolating polynomials.
- Numerical solution of differential equations by single and multistep methods.
- Solution of boundary value problems and initial boundary value problems in partial differential equations using finite differences.
- Simulation and Monte-Carlo methods and their applications.

REFERENCES:

1. Burden, R.L. and Faires, J.D. "Numerical Analysis", 9th Edition, Cengage Learning, Delhi, 2016.
2. Cheney, W and Kincaid D., "Numerical Mathematics and Computing", 7th Edition, Cengage Learning , Delhi, 2014.
3. Jain, M.K., Iyengar, S.R.K. and Jain R.K. "Numerical Methods for Scientific and Engineering Computation", 5th Edition, New Age International Pvt. Ltd., Delhi, 2010.
4. Landau, D.P. and Binder, K., "A Guide to Monte - Carlo Simulations in Statistical Physics", 3rd Edition, Cambridge University Press, Cambridge, 2009.
5. Maki, D P and Thompson, M., "Mathematical Modelling with Computer Simulation", Cengage Learning, Delhi , 2011.
6. Sastry, S.S., "Introductory Methods of Numerical Analysis", 5th Edition, PHI Learning Pvt. Ltd., Delhi, 2015.
7. Taha, H.A. "Operations Research", 9th Edition, Pearson Education India, Delhi, 2016.

NT5101 CELLULAR BIOCHEMISTRY L T P C
3 0 0 3

OBJECTIVES:

- To acquire knowledge on cell biology, nucleic acids, amino acids, carbohydrates, lipids and proteins.
- To know about their metabolisms and energy production.

UNIT I CELL BIOLOGY 9

Eukaryotic and Prokaryotic cells-Structure and functions, Principle of membrane organization. Cytoskeletal proteins, Types of cell division- mitosis and meiosis, Cell cycle and and its regulation. Screening of microbes using nanofluidic chips.

UNIT II NUCLEIC ACIDS 9

Genome structure and organization in prokaryotes and eukaryotes. Structure and function of nucleic acids. Replication, transcription and translation- mechanism, enzymology and regulation. Central Dogma of life. Two case studies on DNA nanotechnology.

UNIT III AMINO ACIDS AND PROTEINS 9

Structure and properties of amino acids. Peptide bond. Proteins-Classification and functions of proteins. Primary, secondary, super secondary, tertiary, quaternary structures and bonding interactions.Enzymes- properties, structure, assay and inhibition. Synzymes, ribozymes.

UNIT IV CARBOHYDRATES AND LIPIDS 9

Classification, Nomenclature, Structure, Function of carbohydrates and lipids. Membrane transport.

UNIT V METABOLISM AND ENERGY PRODUCTION 9

Integrative Metabolism of biomolecules, Electron transport chain, oxidative phosphorylation, energy production.

TOTAL : 45 PERIODS

OUTCOME:

- Deep knowledge on biomolecules, their metabolisms and energy production.

REFERENCES:

1. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell. 4th ed. New York: Garland Science, 2002.
2. B.Lewin, “Genes IX”, International Edition. Sudbury: Jones & Bartlett, 2007.
3. Branden, Carl-Ivar, and John Tooze. Introduction to Protein Structure. 2nd ed. New York: Garland Pub., 1991.
4. Creighton, E, Thomas, “Proteins: Structures and Molecular Properties”, 2nd Ed. New York: W.H. Freeman, 1992.
5. R. Cantor, P.R.Samuel, “Biophysical Chemistry”, W.H., Freeman & Co., 1985.
6. Watson, James, T.Baker, S.Bell, A.Gann, M.Levine, and R.Losick. “Molecular Biology of the Gene”, 5th ed., San Francisco: Addison-Wesley, 2000.

NT5102 PHYSICS AND CHEMISTRY OF MATERIALS L T P C

3 0 0 3

OBJECTIVES:

- To gain knowledge on Physical and chemical aspects of Nano materials.
- To know about diffusion and surface defects, nanostructures and Nano systems.

UNIT I PHYSICS ASPECTS 9

Size effect on thermal, electrical, electronic, mechanical, optical and magnetic properties of nanomaterials- surface area and aspect ratio- band gap energy- quantum confinement size effect.

UNIT II CHEMISTRY ASPECTS 9

Photochemistry and Electrochemistry of nanomaterials –Ionic properties of nanomaterials- Nanocatalysis - Nanoscale heat transfer - Electron transport in transition metals and

semiconducting nanostructures.

UNIT III DIFFUSION AND SURFACE DEFECTS 9

Fick's Law-mechanisms of diffusion - influence of pressure and temperature- Kirkendall effect - surface defects in nanomaterials - effect of microstructure on surface defects - interfacial energy.

UNIT IV NANOSTRUCTURES 9

Classifications of nanomaterials - Zero dimensional, one-dimensional and two dimensional nanostructures- Kinetics in nanostructured materials- multilayer thin films and superlattice-clusters of metals, semiconductors and nanocomposites.

UNIT V NANOSYSTEMS 9

Nanoparticles through homogeneous and heterogeneous nucleation-Growth controlled by surface and diffusion process- Oswald ripening process - influence of reducing agents-solid state phase segregation- Mechanisms of phase transformation- grain growth and sintering-precipitation in solid solution- hume rothery rule.

TOTAL : 45 PERIODS

OUTCOME:

- knowledge on physical and chemical aspects of Nano materials, diffusion surface defects and Nano systems.

REFERENCES

1. A. S. Edelstein and R. C. Cammarata, “Nanomaterials: Synthesis, Properties and Applications”, Institute of Physics Pub., 1998.
2. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications , Imperial College Press, 2004.
3. G.A. Ozin and A.C. Arsenault, “Nanochemistry : A chemical approach to nanomaterials”, Royal Society of Chemistry, 2005.
4. Joel I. Gersten, “The Physics and Chemistry of Materials”, Wiley, 2001.
5. K.W. Kolasinski, “Surface Science: Foundations of Catalysis and Nanoscience”, Wiley, 2002.
6. Physical Chemistry – Atkins Peter, Paula Julio
7. S.Yang and P.Shen: “Physics and Chemistry of Nanostructured Materials”, Taylor & Francis, 2000.

NT5103 QUANTUM MECHANICS L T P C

3 0 0 3

OBJECTIVES:

- To learn basics of Quantum mechanics.
- To know more about approximation methods, time dependent and independent schrodinger equation.

- To know the concept of Quantum computation

UNIT I BASICS OF QUANTUM MECHANICS 9

Wave-particle duality, group velocity, Phase velocity, De-Broglie wavelength, Uncertainty principle and Schrödinger equation.

UNIT II TIME DEPENDENT SCHRÖDINGER EQUATION 9

Solutions of the one-dimensional Schrödinger equation for free particle, particle in a box, particle in a infinitely deep well potential, linear harmonic oscillator. Reflection and transmission by a potential step.

UNIT III TIME INDEPENDENT SCHRÖDINGER EQUATION 9

Particle in a three dimensional box, linear harmonic oscillator and its solution, density of states, free electron theory of metals. The angular momentum problem. The spin half problem and properties of Pauli spin matrices.

UNIT IV APPROXIMATE METHODS 9

Time independent and time dependent perturbation theory for non-degenerate and degenerate energy levels, the variational method, WKB approximation, adiabatic approximation, sudden approximation

UNIT V QUANTUM COMPUTATION 9

Concept of quantum computation, Quantum Qbits, Introduction to nuclear spin, quantum confinement, quantum devices, single electron devices.

TOTAL : 45 PERIODS

OUTCOME:

- Basics of Quantum mechanics, Quantum computation and approximation methods would be learned.

REFERENCES

1. Modern Physics – Beiser 6th edition 2009.
2. Principles of Quantum Mechanics 2nd ed. - R. Shankar 2000.
3. Quantum Mechanics - Bransden and Joachen 2nd edition 2000.
4. Quantum Mechanics - Vol 1&2 - Cohen-Tannoudji,1997
5. Quantum Physics – Theory and application, Ajoy Ghatak, Springer 2004.
6. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, 2nd Edition by Eisberg, Robert; Resnick, Robert, 1985

NT5104 SYNTHESIS OF NANOMATERIALS L T P C

3 0 0 3

OBJECTIVES:

- To learn about bulk synthesis of Nano materials.
- To know about Physical and chemical approaches of Nano material synthesis.

- To learn about Nano porous materials and application of Nano materials.

UNIT I BULK SYNTHESIS 9

Top down and bottom up approaches–Mechanical alloying and mechanical ball milling-Mechano chemical process, Inert gas condensation technique – Arc plasma and laser ablation.

UNIT II CHEMICAL APPROACHES 9

Sol gel processing-Solvothermal, hydrothermal, precipitation, Spray pyrolysis, Electro spraying and spin coating routes, Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, micro emulsion polymerization- templated synthesis, pulsed electrochemical deposition.

UNIT III PHYSICAL APPROACHES 9

Vapor deposition and different types of epitaxial growth techniques (CVD,MOCVD, MBE,ALD)-pulsed laser deposition, Magnetron sputtering - lithography :Photo/UV/EB/FIB techniques, Dip pen nanolithography, Etching process :Dry and Wet etching, micro contact printing.

UNIT IV NANOPOROUS MATERIALS 9

Zeolites, mesoporous materials, nanomembranes - Carbon nanotubes and graphene - Core shell and hybrid nanocomposites.

UNIT V BIOLOGICAL NANOMATERIALS 9

Overview of biological nanomaterials, Ferritins and Related Protiens – Superparamagnetic model systems – Native forms – Magnetoferritin, Magnetotactic Bacteria – Magnetic direction finding – Magnetosomes, Molluscan Teeth – Biomineralization.

TOTAL : 45 PERIODS

OUTCOME:

- Knowledge on synthesis of Nano materials and their applications.

REFERENCE:

1. A S Edelstien, RC Cammarata, Nanomaterials: Synthesis, Properties and Application; Taylor & Francis. 1996.
2. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties &Applications , Imperial College Press, 2004.
3. J.George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.
4. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.
5. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
6. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002.

NT5105 PHYSICOCHEMICAL METHODS FOR CHARACTERIZATION OF NANOMATERIALS **L T P C 3 0 0 3**

OBJECTIVES

1. To learn advanced analytical method used to study nanomaterials.
2. To know about qualitative and quantitative analysis techniques employed for studying nanomaterials.
3. To understand the mechanical analytical techniques used to study nanomaterials.

UNIT I 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; NMR Spectroscopy; Dynamic Nuclear Magnetic Resonance; Dynamic light scattering (DLS), Double Resonance Technique.

UNIT II DIFFRACTION METHODS **9**

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

UNIT III THERMAL ANALYSIS METHODS **9**

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

UNIT IV QUALITATIVE AND QUANTITATIVE ANALYSIS **9**

Electron Energy Loss Spectroscopy; High Resolution Imaging Techniques, Atom probe field ion microscopy-X-Ray Photoelectron Spectroscopy - X-ray fluorescence (XRF) - EDAX and WDA analysis – EPMA – ZAP corrections.

UNIT V NANOMECHANICAL ANALYSIS **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- BET analysis.

TOTAL : 45 PERIODS

OUTCOME

- Getting of knowledge on Techniques used for analysis and characterization of nanomaterials were learned

REFERENCES:

1. B. D.Cullity, “Elements of X-ray Diffraction”, 4th Edition, Addison Wiley, 1978.
2. B.W.Mott, “Micro-Indentation Hardness Testing”, Butterworths, London
3. M. H.Loretto, “Electron Beam Analysis of Materials”, Chapman and Hall, 1984.

4. R.M.Rose, L.A.Shepard and J.Wulff, “The Structure and Properties of Materials”, Wiley Eastern Ltd, 1996.

NT5111 COMPUTATION AND SIMULATION L T P C
0 0 4 2

OBJECTIVES:

- To learn about programming on modeling and simulation of mathematical equations.

1. Numerical programme to plot the first four Eigen functions of a one - dimensional rectangular potential well with infinite potential barrier.
2. Numerical solution of the Schrodinger wave equation for a rectangular potential well with infinite potential barrier using numerical programme.
3. Toy model in molecular electronics: IV characteristics of a single level molecule
4. To determine the lattice constant and lattice angles for atomically resolved STM image of HOPG (Highly Oriented Pyrolytic Graphite using offline Scanning Probe Imaging Processor (SPIP) Software.
5. To determine the surface roughness of raw and processed AFM images of glass, silicon and films made by different methods using offline SPIP software.
6. Simulation of I-V Characteristics for a single Junction circuit with a single quantum Dot using MOSES 1.2 Simulator.
7. Study of Single Electron Transistor using MOSES1.2 Simulator.

TOTAL : 60 PERIODS

LIST OF EQUIPMENTS

1. Magentic Stirrer
2. Hot Air Oven
3. Ultrasonicator
4. Autoclave
5. Chemical Vapor Deposition (CVD)
6. Spin Coating Unit
7. Box Furnace (with Max. Temp 1000C)
8. Centrifuge Machine
9. Ball Milling
10. Glove Box
11. Vaccum Oven
12. Deep Freezer

13. Refrigerator
14. Weighing Balance
15. Microwave Furnace

OUTCOME:

- Knowledge on modeling and simulation of equations using MATLAB.

NT5112 **NANOMATERIAL SYNTHESIS** **L T P C**
0 0 4 2

OBJECTIVES:

- To synthesize Nano materials by various chemical and physical methods.

1. Chemical synthesis of Ag nanoparticles; UV-Visible absorption of the colloidal sol; Mie formalism; Estimation of size by curve fitting
2. Chemical synthesis of CdS nanoparticles; Optical absorption spectra; Band gap estimation from the band edge
3. Aqueous to organic phase transfer of Ag and CdS nanoparticles; Confirmation by UV-Visible absorption
4. Microwave assisted polymerization synthesis of ZnO nanowires
5. Sol gel synthesis of metal oxide (ZnO, TiO, CdO) nanoparticles:
6. Sol-gel spin coating route to SnO_2 nanothin films: surface roughness measurement by AFM
7. Electro spraying route to carbon nanofibers: surface morphology by SEM
8. Hydrothermal synthesis of ZnS Nanorods: Nanorods formation by SEM analysis
9. Mechanical ball milling technique to oxide ceramics preparation: crystallite size measurement by XRD

TOTAL : 60 PERIODS

LIST OF EQUIPMENTS

1. Magentic Stirrer
2. Hot Air Oven
3. Ultrasonicator
4. Autoclave
5. Chemical Vapor Deposition (CVD)
6. Spin Coating Unit
7. Box Furnace (with Max. Temp 1000C)
8. Centrifuge Machine

9. Ball Milling
10. Glove Box
11. Vaccum Oven
12. Deep Freezer
13. Refrigerator
14. Weighing Balance
15. Microwave Furnace

OUTCOME:

- Thorough hands on training and knowledge and skills on Nano materials synthesis using various chemical and physical methods

NT5201 IMAGING TECHNIQUES FOR NANOTECHNOLOGY L T P C

3 0 0 3

OBJECTIVES

- To learn noninvasive microscopic techniques such as optical and electron microscopy.
- To learn invasive microscopic techniques such as atomic microscopy. To understand the principles and working of various microscopes.

UNIT I OPTICAL MICROSCOPY 9

Optical microscopy- Use of polarized light microscopy – Phase contrast microcopy – Interference Microscopy – hot stage microscopy - surface morphology – confocal microscopy.

UNIT II CANNING ELECTRON MICROSCOPY 9

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 9

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

TOTAL : 45 PERIODS

OUTCOMES

- Getiing ideas about n Various microscopic techniques used for studying nanomaterials was understood.

REFERENCES

1. J.Goldstein, D.E.Newbury, D.C.Joy, and C.E.Lym, " Scanning Electron Microscopy and X-Ray Microanalysis", 2003
2. P.J. Good hew, J.Humphreys, R.Beanland, "Electron Microscopy and Analysis, 2001.
3. R.Haynes, D.P.Woodruff and T.A.Talchar, " Opitcal Microscopy of Materials". Cambridge University Press, 1986
4. S.L.Flegler, J.W.Heckman and K.L.Klomparens, " Scanning and Transmission Electron Microscopy. A Introduction", W.H.Freeman & Co, 1993

NT5202 LITHOGRAPHY AND NANOFABRICATION L T P C
3 0 0 3

OBJECTIVES

- To learn lithographic techniques.
- To obtain knowledge on nanofabrication of devices using lithography.

UNIT I SEMICONDUCTOR PROCESSING AND MICROFABRICATION 9

Introduction to semiconductor device processing - Necessity and different types of clean rooms-construction and maintenance of a clean room – Microfabrication process flow diagram – Chip cleaning, coating of photoresists, patterning, etching, inspection – Process integration - Etching techniques- Reactive Ion etching- RIE reactive ion etching-Magnetically enhanced RIE-IBE Ion beam etching.

UNIT II PHOTOLITHOGRAPHY AND PATTERNING OF THIN FILMS 9

Lithography -Optical lithography - different modes - Optical projection lithography - Multistage scanners – resolution and limits of photolithography – Resolution enhancement techniques - 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

UNIT III DIRECT WRITING METHODS - MASKLESS OPTICAL LITHOGRAPHY 9

Maskless optical projection lithography – types, Advantages and Limitations – required components - Zone plate array lithography - Extreme ultraviolet lithography – Light sources - Optics and materials issues

UNIT IV ELECTRON BEAM LITHOGRAPHY (EBL), X-RAY AND ION BEAM LITHOGRAPHY 9

Scanning electron-beam lithography- Electron sources, and electron optics system mask less EBL- parallel direct-write e-beam systems-electron beam projection lithography - Scattering with angular limitation projection e-beam lithography (SCALPEL) - Projection reduction exposure with variable axis immersion lenses. XRPP - Ion beam lithography-Focusing ion beam lithography - Ion projection lithography.

UNIT V NANOIMPRINT LITHOGRAPHY AND SOFT LITHOGRAPHY 9

Nanoimprint lithography (NIL)- NIL - hot embossing - UV-NIL- Soft Lithography-Moulding/Replica moulding: PDMS stamps - Printing with soft stamps- Edge lithography - Dip-Pen Lithography-set up and working principle – Self-assembly – LB films – Rapid prototyping

TOTAL : 45 PERIODS

OUTCOME

- Different lithographic techniques used for nanofabrication will be learnt.

REFERENCES:

1. Chris Mack, Fundamental Principles of Optical Lithography: The Science of Microfabrication, Wiley, 2008.
2. D. S. Dhaliwal et al., PREVAIL –"Electron projection technology approach for next generation lithography", IBM Journal Res. & Dev. 45, 615 (2001).
3. H. Schift et al., "Fabrication of polymer photonic crystals using nanoimprint lithography", Nanotechnology 16, 261, (2005).
3. M. Baker et al., "Lithographic pattern formation via metastable state rare gas atomic beams", Nanotechnology 15, 1356 (2004).
4. R.D. Piner, "Dip-Pen" Nanolithography, Science 283, 661 (1999).

NT5203 PHOTONICS FOR NANOTECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

- To understand the nature of materials in nanosize and nano-structures.
- To learn plasmonics and photonics to enable students to take up research towards optoelectronics.
- To understand the mechanism of bio-photonic systems

UNIT I QUANTUM CONFINED MATERIALS 9

Quantum structures – optical transitions – absorption-inter-band transitions-quantum confinement intraband transitions-fluorescence/ luminescence–photoluminescence /fluorescence optically excited emission, time resolved PL – 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 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- Surface enhanced Raman spectroscopy (SERS).

UNIT IV 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.

UNIT V 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.

TOTAL : 45 PERIODS

OUTCOME:

- Knowledge on plasmonics and photonics for developing various applications such as optoelectronics gained

REFERENCES:

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

NT5204 PROCESSING AND PROPERTIES OF NANOSTRUCTURED MATERIALS

L T P C
3 0 0 3

OBJECTIVES

- To learn basic material science with special emphasize on nanomaterials
- To know about processes in handling polymers and nanostructured materials.
- To understand various forms of nanomaterials and polymers for special applications.

UNIT I DEFORMATION PROCESSING AND METAL FORMING 9

Classification of engineering materials - Tensile testing – Stress strain curve – Flow stress - Mechanical properties – Formability - Deformation processes - Mechanics of metal working – Metal forming - forging, rolling, extrusion, wire drawing – Superplastic forming – Bulk nanostructured materials by Severe Plastic Deformation (SPD) - Comparison of processes.

UNIT II MICROSTRUCTURAL PROPERTIES 9

Defects in solids – classifications of defects – Microstructure – grain size, grain boundary, effects of processing and defects – Processing, microstructure, properties correlations – Mechanical Properties and processing - grain size evolution and grain size control; HallPetch relation- strengthening mechanisms; work hardening - grain boundary strengthening – solid solution strengthening – precipitation hardening - effects of diffusion on strength and flow of materials .

UNIT III PROCESSING OF POLYMERS 9

Engineering plastics – Pellets and sheets – Glass transition temperature of polymers – Melt flow index – Polymer processing tools and process conditions - injection moulding, thermoforming, vacuum and pressure assisted forming.

UNIT IV PROCESSING OF POWDERS OF METALS AND CERAMICS 9

Metal/Ceramic Powder synthesis - Selection and characterization of powders – compacting and sintering - Production of Porous and Dense Composite Components: Advanced composite materials - Metal- polymer- and ceramic- based composites and their properties – Fabrication of composite materials.

UNIT V PROCESSING OF FUNCTIONAL NANOMATERIALS 9

Properties of nanocrystalline materials required for structural, energy, environmental, textile and catalytic applications; processing techniques; techniques for retaining the nanocrystalline structure in service. Pervoskite structures, catalytic applications.

TOTAL : 45 PERIODS

OUTCOME

- knowledge on concepts of Material science and material handling aspects of nanomaterials and polymers learned

REFERENCES

1. A. Padmanabhan, “Mechanical Properties of Nanostructured Materials”, Materials Science and Engineering, A 304-306 (2001) 200-205.
2. C. Koch, “Nanostructured Materials: Processing, Properties and Applications”, 2nd Edition, Ed.: 2007
3. G. E. Dieter, adapted by D Bacon, “Mechanical Metallurgy”, SI Metric edition, McGraw Hill, Singapore, 1988.
4. H. Cottrell “The Mechanical Properties of Matter”, John Wiley, New York-London,1964.
5. H. Gleiter, “Nanocrystalline Materials”, Progress in Materials Science Vol. 33, pp. 223 - 315, 1989
6. R. Asthana, A. Kumar and N. Dahotre “Materials Science in Manufacturing” Butterworth-Heinemann, Elsevier 2006.

NT5211 NANOMETROLOGY L T P C

0 0 4 2

OBJECTIVES

- To learn techniques to study structural morphology of nanomaterials.
- To develop skills to synthesize nanomaterials.
- To develop skills in fabrication and nanolithography.

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 TiN film using AFM; thickness across a step.

4. Surface topography of a SiO_2 film 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

LIST OF EQUIPMENTS

1. Magentic Stirrer
2. Hot Air Oven
3. Ultrasonicator
4. Autoclave
5. Chemical Vapor Deposition (CVD)
6. Spin Coating Unit
7. Box Furnace (with Max. Temp 1000C)
8. Centrifuge Machine
9. Ball Milling
10. Glove Box
11. Vaccum Oven
12. Deep Freezer
13. Refrigerator
14. Weighing Balance
15. Microwave Furnace

OUTCOME

- Techniques and skills required to synthesize and characterize the nano fabricated device will be developed.

NT5301 MEMS AND BIO MEMS L T P C

3 0 0 3

OBJECTIVES:

- To learn about Micro fabrication and scaling of MEMS
- To study the Microsystem and materials used in MEMS Technology To learn about Biological MEMS Technology

UNIT I MEMS MICROFABRICATION 10

Historical Development of Microelectronics, Evolution of Microsensors, Evolution of MEMS, Emergence of Micromachines, Modeling - Finite Element Analysis, CAD for MEMS, Fabrication – ALD, Lithography Micromachining, LIGA and Micromolding, Saw-IDT Microsensor Fabrication, Packaging – Challenges, Types, Materials and Processes.

UNIT II SCALING OF MEMS 9

Introduction to Scaling Issues, Scaling effects on a cantilever beam, Scaling of electrostatic actuators, Scaling of thermal actuator, Scaling of Thermal Sensors, mechanics and electrostatistics. Influence of scaling on material properties.

UNIT III MICROSYSTEMS 10

Microsensors, microaccelerometer, microfluidics, Mechanics for Microsystems design-Thermomechanics, fracture mechanics, thin film mechanics. Microfluid mechanics.

UNIT IV MATERIALS FOR MEMS 8

Materials for mems and pro mems-silicon-metals and polymers-Substrate Materials for MEMS-Silicon-quartz-ceramics-Bulk metallic glasses-Sharp Memory alloys, Carbon based MEMS

UNIT V COMMERCIAL AND TECHNOLOGICAL TRENDS 8

Commercial trends in miniaturization – High density chip analysis- Microaccelerometers-microresonators-lab-in-chip for DNA and protein analysis – Nano HPLC system-nanopatches

TOTAL : 45 PERIODS

OUTCOMES:

- Students would gain knowledge in area microfabrication techniques and scaling process
- Students would acquire information about recent trends in MEMS and BioMEMS techniques.

REFERENCES:

1. Ken Gilleo. MEMS/MOEMS Packaging: Concepts, Designs, Materials and Processes. McGraw-Hill, 2005.
2. Marc Madou, Fundamentals of Microfabrication, CRC Press 1997.
3. MEMS and Microsystems design and manufacture, Tai-Ran Hsu,Tata Mc Graw Hill 2011.
4. Sergey Edward Lyshevski, Nano- and Microelectromechanical Systems, CRC Press 2000.
5. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw-Hill 2001.
6. Vijay Varadan, Xiaoning Jiang, and Vasundara Varadan, Microstereolithography *and* other Fabrication Techniques for 3D MEMS*,* Wiley 2001.

NT5001 ADVANCED DRUG DELIVERY SYSTEMS L T P C

3 0 0 3

OBJECTIVES:

- To learn about Fundamentals of drug delivery systems
- To study the materials and techniques used in Delivery systems
- To learn about Recent development in the area of devices and therapy.

UNIT I THEORY OF ADVANCED DRUG DELIVERY 9

Fundamentals of Nanocarriers - Size, Surface, Magnetic and Optical Properties, Pharmacokinetics and Pharmacodynamics of Nano drug carriers. Critical Factors in drug delivery. Transport of Nanoparticles - In Vitro and Ex Vivo Models.

UNIT II POLYMERS 9

Dendrimers- Synthesis -Nanoscale containers- Dendritic Nanoscafold systems-Biocompatibility of Dendrimers, Gene transfection. pH based targeted delivery- chitosan and alginate. Copolymers in targeted drug delivery- PCL,PLA, PLGA.

UNIT III LIPID BASED NANOCARRIERS 9

Liposomes, niosomes and solid lipid nanoparticles. Ligand based delivery by liposomes. Cubosomes.

UNIT IV MICROBES AND ANTIBODY BASED NANOCARRIERS 9

Bacterial dependent delivery of vaccines. Drug delivery and subcellular targeting by virus, Drug packaging and drug loading. Delivery of therapeutics by antibodies and antibody-bioconjugates.

UNIT V DEVICES FOR DRUG DELIVERY 9

Fabrication and Applications of Microneedles, Micropumps, microvalves. Implantable microchips.

TOTAL : 45 PERIODS

OUTCOMES:

- Students will gain knowledge in basics of drug delivery systems
- Students will gather idea about materials and techniques used for drug coating and delivery.
- Students will acquire information about recent trends equipments and delivery systems.

REFERENCES:

1. Drug Delivery and Targeting, A.M. Hillery, CRC Press, 2002.
2. Drug Delivery: Engineering Principles for Drug Therapy, M. Salzman, Oxford University Press, 2001.
3. Drug Delivery: Principles and Applications, B. Wang, Wiley Intersceince, 2005.
4. Nanoparticle Technology for Drug Delivery, Ram B. Gupta, Uday B. Kompella Taylor & Francis, 2006

NT5002 ADVANCED NANOCOMPOSITES L T P C

3 0 0 3

OBJECTIVES:

- To learn about Fundamentals of nanocoposites
- To study the materials and techniques used preparation of composites To learn about Recent development and commerical application .

UNIT I BASICS OF NANOCOMPOSITES 9

Nomenclature. Properties, features and processing of nanocomposites.Sample Preparation and Characterization of Structure and Physical properties.Designing, stability and mechanical properties and applications of Super hard nanocomposites.

UNIT II METAL BASED NANOCOMPOSITES 9

Metal-metal nanocomposites, some simple preparation techniques and their properties. Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Fractal based glass-metal nanocomposites, its designing and fractal dimension analysis. Electrical property of fractal based nanocomposites. Core-Shell structured nanocomposites

UNIT III POLYMER BASED NANOCOMPOSITES 9

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

UNIT IV NANOCOMPOSITE FROM BIOMATERIALS 9

Natural nanocomposite systems - 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 V NANOCIRCUITRY 9

Protein based nanocuitry. DNA based nanocircuitry Nanocomposite membrane structures- Preparation and applications.

TOTAL : 45 PERIODS

OUTCOMES:

- Students will gain knowledge in basics of nanocomposites
- Students will gather idea about materials and techniques used preparation of composites.
- Students will acquire information about recent trends of nanocomposites application and various fields.

REFERENCES

1. Carbon Nanotubes (Carbon , Vol 33) - M. Endo, S. Iijima, M.S. Dresselhaus 1997.
2. Diblock Copolymer, - Aviram (Review Article), Nature, 2002
3. Electromagnetic and magnetic properties of multi component metal oxides, hetero
4. Introduction to Nanocomposite Materials. Properties, Processing, Characterization-Thomas E. Twardowski. 2007. DEStech Publications. USA.
5. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun 2006.
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. Physical Properties of Carbon Nanotubes- R. Saito 1998.
8. The search for novel, superhard materials- Stan Vepr¡ek (Review Article) JVST A, 1999

NT5003 **BIOPHOTONICS** **L T P C**

3 0 0 3

OBJECTIVES:

- To learn about Fundamentals of light and optics
- To study the concepts of optical based imaging techniques. To learn about Recent development in optical sensors.

UNIT I BASICS OF LIGHT AND OPTICS 9

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

UNIT II IMAGING TECHNIQUES 9

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 SINGLE MOLECULE SPECTROSCOPY 9

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 OPTICAL FORCE SPECTROSCOPY 9

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 SENSORS AND OPTICAL TECHNIQUES 9

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

TOTAL : 45 PERIODS

OUTCOMES:

- Students will gain knowledge in basics of optics
- Students will gather idea about imaging techniques.
- Students will acquire information about Biophotonics and advanced optical sensors.

REFERENCES:

1. G. Marriot & I. Parker, Methods in Enzymology, Vol.360,2003.
2. G. Marriot & I. Parker, Methods in Enzymology, Vol.361,2003.
3. Laser Tweezers in Cell Biology in Methods in Cell Biology, Vol.55, Michael P. Sheetz (Ed.), Academic Press 1997.
4. P.N. Prasad, Introduction to Biophotonics, John-Wiley, 2003.

NT5004 BOTTOM UP SYNTHESIS OF NANOSTRUCTURES L T P C
3 0 0 3

OBJECTIVES:

- To learn about Fundamentals bottom up synthesis.
- To study the different approaches used for bottom up synthesis
- To learn about Recent development and advancement of printing techniques.

UNIT I THIN FILM TECHNOLOGIES 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- Sputter technologies- DC sputtering-RF Magnetron sputtering.

UNIT II 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 III WET-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 IV PRESSURE AND TEMPERATURE BASED SYNTHESIS METHODS 9

Hydrothermal synthesis- Solvothermal synthesis -Microwave assisted synthesis - Sonochemical synthesis - Spray pyrolysis - Chemical bath deposition.

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

OUTCOMES:

- Students gained knowledge about bottom up synthesis
- Students gathered idea about wet and dry chemical methods of bottom up approach.
- Students acquired information about advanced methods and printing techniques for fabrication.

REFERENCES:

1. G. Cao, “Nanostructures & Nanomaterials: Synthesis, Properties &Applications” Imperial College Press, 2004.
2. "Handbook of Nanoscience, Engineering and Technology”, Kluwer publishers, 2002.
3. W.T.S. Huck, “Nanoscale Assembly: Chemical Techniques (Nanostructure Science and Technology)”2005.

NT5005 **BIOSENSORS** **L T P C**
3 0 0 3

OBJECTIVES:

- To learn about principles, components and fabrication of biosensors To study about various types of biosensors
- To learn about recent development and application of biosensor.

UNIT I ESSENTIALS OF BIOSENSORS 9

General principle, component, characteristics. Types- Calorimetric Biosensor, Potentiometric Biosensor, Amperometric Biosensor, Optical Biosensor, Piezo-electric Biosensor. Detection systems. Techniques used for microfabrication -microfabrication of electrodes-on chip analysis.

UNIT II PROTEIN BASED BIOSENSORS 9

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

UNIT III DNA BASED BIOSENSOR 9

Heavy metal complexing with DNA and its determination. sensing in water and food samples – DNA zymo Biosensors.

UNIT IV SENSING OF CELLS AND PATHOGENS 9

Nanoscale biosensors. Nanobiosensors for cellular biosensing and sensing of rare cells. Detection of pathogens in food and water samples.

UNIT V APPLICATIONS OF BIOSENSORS 9

Designed protein pores and protein cages -as components of biosensors. Biosensors for pharma and medicine, bioremediation, defense and food technology. wearable biosensor.

TOTAL : 45 PERIODS

OUTCOMES:

- Students will acquire knowledge in basics of Biosensors.
- Students will gain idea about fabrication techniques of biosensors.
- Students will gain information about recent trends in nanobiosensors and application in various fields.

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.

NT5006 **NANOELECTRONICS AND SENSORS** **L T P C**
3 0 0 3

OBJECTIVES:

- To learn about overview of nanoelectronics.

- To study the basic components of electronic systems. To learn about sensor fabrication and applications.

UNIT I OVERVIEW OF NANO-ELECTRONICS 9

Nano-scale electronics; Foundation of nano-electronics – low dimension transport, quantum confinement, Coulomb blockade and quantum dot; Ballistic transport and Quantum interferences; Landauer formula, quantization of conductance, example of Quantum point contact.

UNIT II TWO-TERMINAL JUNCTION TRANSISTORS 9

Basic CMOS process flow; MOS scaling theory; Issues in scaling MOS transistors; Requirements for non-classical MOS transistor; PMOS versus NMOS; Design and construction of MOS capacitor; Integration issues of high-k MOS – interface states, bulk charge, band offset, stability, reliability; MOS transistor and capacitor characteristics.

UNIT III GATE TRANSISTORS 9

Metal gate transistors – motivation, basics and requirements; quantum transport in nano MOSFET; Ultrathin body silicon on insulator (SOI) – double gate transistors; Vertical transistors – FinFET and surround gate FET; compound semiconductor MOSFET – Hetero-structures MOSFET.

UNIT IV SENSORS AND ACTUATOR CHARACTERISTICS 9

Basics: types and working principles of sensors and actuators; ***Characteristic features***: Range, Resolution, Sensitivity, Error, Repeatability, Linearity and Accuracy, Impedance, Nonlinearities, Static and Coulomb Friction, Eccentricity, Backlash, Saturation, Dead-band, System Response, First Order System Response, Under-damped Second Order System Response, Frequency Response.

UNIT V MEMORY DEVICES AND SENSORS 9

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

TOTAL : 45 PERIODS

OUTCOMES:

- Students will gain knowledge in basics of nanoelctronics
- Students will gather idea about materials and techniques used for sensor components.
- Students will acquire information about fabrication of different sensors.

REFERENCES

1. K.E. Drexler, “Nano systems”, Wiley, (1992).
2. M.C. Petty, “Introduction to Molecular Electronics”1995.
3. W. Ranier, “Nano Electronics and Information Technology”, Wiley, (2003).

NT5007 NANOMATERIALS FOR ENERGY AND ENVIRONMENTAL L T P C
3 0 0 3

OBJECTIVES:

- To be aware of the challenges and demand for Energy
- To study about the nanomaterials used in Energy applications
- To enhance our knowledge on the nanomaterials employed for Environmental remediation

UNIT I INTRODUCTION 9

Sustainable energy - Materials for energy - Green house effect - CO_2 emission - Energy demand and challenges.

UNIT II RENEWABLE ENERGY TECHNOLOGY 9

Development and implementation of renewable energy technologies. Nano, micro and meso scale phenomena and devices. Energy conversion, transport and storage. High efficiency Photovoltaic solar cells. High performance thermoelectric systems - Integration and performance of DSSC- Quantum dots based solar cells.

UNIT III NANOMATERIALS IN FUEL CELL AND STORAGE 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 - Supercapacitors - Specific energy- charging/discharging - EIS analysis.

UNIT IV HYDROGEN STORAGE AND PHOTOCATALYSIS 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 - multiple catalytic effects - degradation of the dye - nanomaterials based photocatalyst design - kinetics of degradation.

UNIT V EMERGING TECHNOLOGIES FOR ENVIRONMENTAL REMEDIATION 9

Use of nanoparticles for environmental remediation and water treatment- Role of dendrimer-single enzyme-nanoparticle and metalloprotein. Case studies and Regulatory needs.

TOTAL : 45 PERIODS

OUTCOMES:

- Students will gain familiarity with renewable energy technologies updated with nano devices
- They will get knowledge of different fabrication methodologies
- Kinetic studies of dye degradation using nanophotocatalysts will be learned

REFERENCES:

1. Fuel cell technology handbook. Hoogers. CRC Press, 2003.
2. Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures by R.A. Shatwell

1996.
3. Handbook of fuel cells: Fuel cell technology and applications by Vielstich. Wiley, CRC Press, 2003.
4. Hydrogen from Renewable Energy Sources by D. Infield 2004.
5. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.

NT5008 NANOTOXICOLOGY L T P C
3 0 0 3

OBJECTIVES:

- To make students learn various concepts of toxicity, and its effects.
- To help them gain knowledge about the toxicity in Nanoscience, and their effects on Human.
- To enhance knowledge on the nanotoxicology - prevention and remedies.

UNIT I INTRODUCTION TO TOXICOLOGY 9

Concept of Toxicology-Types of toxicity based on route of entry, nature of the toxin. Toxicodynamics–Dose vs Toxicity Relationships. Toxicokinetics – ADME, LADMET hypothesis. Genotoxicity and carcinogenicity – Mechanisms and Tests. Organ toxicity – Respiratory**,** dermal, hepato, neuro and nephro.

UNIT II NANOTOXICOLOGY 9

Characteristics of Nanoparticles that determine Potential Toxicity. Bio-distribution of nanoparticles. Interation of Nanoparticles with Biomembrane and genes. Evaluation of Nanoparticle transfer using placental models. Nanomaterial toxicity – Pulmonary**,** dermal, hepato, neuro, ocular and nephro; Estimation of Nanoparticle Dose in Humans.
In vitro toxicity studies of ultrafine diesel exhaust particles; Toxicity studies of carbon nanotubes

UNIT III PROTOCOLS IN TOXICOLOGY STUDIES 9

Methods for toxicity assessment – Cyto, Geno, hepato, neuro, nephrotoxicity. Assessment of toxicokinetics. Assessment of oxidative stress and antioxidant status.

UNIT IV ANIMAL MODELS 9

Types, species and strains of animals used in toxicity studies. Dosing profile for animal models. Studies on toxicology, pathology and metabolism in mouse and rat. Laws and Regulations Governing Animal Care and Use in Research.

UNIT V RISK ASSESSMENT AND EXECUTION 9

SRisk assessment of Nanoparticle exposure. Prevention and control of nanopaticles exposure. Regulation and recommendations.

TOTAL : 45 PERIODS

OUTCOMES:

- Students wiil get knowledge on nanotoxicology and their effects on human and animals.
- They will acquire knowledge about various prevention methods.
  Students will gain knowledge on remedies.

REFERENCES:

1. A Reference handbook of nanotoxicology by M.ZafarNyamadzi 2008.
2. Andreas Luch, 'Molecular, Clinical and Environmental Toxicology Volume 2: Clinical Toxicology', BirkhauserVerlag AG 2010.
3. John H. Duffus, Howard G. J. Worth, 'Fundamental Toxicology', The Royal Society of Chemistry 2006.
4. Lucio G. Costa, Ernest Hodgson, David A. Lawrence, Donald J. Reed,William F. Greenlee, 'Current Protocols in Toxicology', John Wiley & Sons, Inc. 2005.
5. Nancy A. Monteiro-Riviere, C. Lang Tran., 'Nanotoxicology: Characterization, Dosing and Health Effects',Informa Healthcare publishers, 2007.
6. P. Houdy, M. Lahmani, F. Marano, 'Nanoethics and Nanotoxicology', Springer-Verlag Berlin Heidelberg 2011.
7. Shayne C. Gad, 'Animal models in toxicology', Taylor & Francis Group, LLC 2007.

NT5009 RESEARCH METHODOLOGY IN NANOTECHNOLOGY L T P C
3 0 0 3

OBJECTIVES:

- To create an exposure about the need for research work
- To build a knowledge & know the current scenario
- To develop research ideas & create novel projects

UNIT I INTRODUCTION TO RESEARCH 9

The hallmarks of scientific research – Building blocks of science in research – Concept of Applied and Basic research – Quantitative and Qualitative Research Techniques – Need for theoretical frame work – Hypothesis development – Hypothesis testing with quantitative data. Research design – Purpose of the study: Exploratory, Descriptive, Hypothesis Testing.

UNIT II EXPERIMENTAL DESIGN 9

Laboratory and the Field Experiment – Internal and External Validity – Factors affecting Internal validity. Measurement of variables – Scales and measurements of variables. Developing scales – Rating scale and attitudinal scales – Validity testing of scales – Reliability concept in scales being developed – Stability Measures.

UNIT III DATA COLLECTION METHODS 9

Interviewing, Questionnaires, etc. Secondary sources of data collection. Guidelines for Questionnaire Design – Electronic Questionnaire Design and Surveys. Special Data Sources:

Focus Groups, Static and Dynamic panels. Review of Advantages and Disadvantages of various Data-Collection Methods and their utility. Sampling Techniques – Probabilistic and non-probabilistic samples. Issues of Precision and Confidence in determining Sample Size. Hypothesis testing, Determination of Optimal sample size.

UNIT IV MULTIVARIATE STATISTICAL TECHNIQUES 9

Data Analysis – Factor Analysis – Cluster Analysis – Discriminant Analysis – Multiple Regression and Correlation – Canonical Correlation – Application of Statistical (SPSS) Software Package in Research.

UNIT V RESEARCH REPORT 9

Purpose of the written report – Concept of audience – Basics of written reports. Integral parts of a report – Title of a report, Table of contents, Abstract, Synopsis, Introduction, Body of a report – Experimental, Results and Discussion – Recommendations and Implementation section – Conclusions and Scope for future work.

TOTAL : 45 PERIODS

OUTCOMES:

- The basics of writing reports will be learned
- They will acquire the principles of carrying out a good research

REFERENCES

1. C.R.Kothari, Research Methodology, Wishva Prakashan, New Delhi, 2001.
2. Donald H.McBurney, Research Methods, Thomson Asia Pvt. Ltd. Singapore, 2002.
3. Donald R. Cooper and Ramela S. Schindler, Business Research Methods, Tata McGraw- Hill Publishing Company Limited, New Delhi, 2000
4. G.W.Ticehurst and A.J.Veal, Business Research Methods, Longman, 1999.
5. Ranjit Kumar, Research Methodology, Sage Publications, London, New Delhi, 1999.
6. Raymond-Alain Thie'tart, *et.al.,* Doing Management Research, Sage Publications, London, 1999.
7. Uma Sekaran, Research Methods for Business, John Wiley and Sons Inc., New York, 2000.

BO5091 TISSUE ENGINEERING AND REGENERATIVE MEDICINE L T P C

3 0 0 3

OBJECTIVES

- The course intends to give advanced theoretical knowledge on tissue engineering, Stemcells and its biological applications

UNIT I INTRODUCTION 9

Introduction to tissue engineering: Basic definition; current scope of development; use intherapeutics, cells as therapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology, number viability, motility and functions. Measurement of tissue

characteristics, appearance, cellular component, ECM component, mechanical measurements and physical properties.

UNIT II TISSUE ARCHITECTURE 9

Tissue types and Tissue components, Tissue repair, Basic wound healing events, Applications of growth factors: Role of VEGF. Angiogenesis, Basic properties, Cell-Matrix & Cell-Cell Interactions, Control of cell migration in tissue engineering.

UNIT III BIOMATERIALS 9

Biomaterials: Properties of Biomaterials, Surface, bulk, mechanical and biological properties. Scaffolds & tissue engineering, Types of Biomaterials, biological and synthetic materials, Biopolymers, Applications of biomaterials, Modifications of Biomaterials, Role of Nanotechnology.

UNIT IV BASIC BIOLOGY OF STEM CELLS 9

Stem Cells : Introduction, Types & sources of stem cell with characteristics: hematopoietic differentiation pathway, Potency and plasticity of stem cells, sources, embryonic stemcells, hematopoietic and mesenchymal stem cells, Stem Cell markers, FACS analysis, Differentiation, Stem cell systems- Liver, neuronal stem cells, cancer stem cells, induced pluripotent stem cells.

UNIT V CLINICAL APPLICATIONS 9

Stem cell therapy, Molecular therapy, *In-vitro* organogenesis, Neurodegenrative diseases,spinal cord injury, heart disease, diabetes, burns and skin ulcers, muscular dystrophy, orthopedic applications, Stem cells and Gene therapy, Physiological models, tissue engineering therapies, product characterization, components, safety, efficacy. Preservation – freezing and drying. Patent protection and regulation of tissue-engineered products, ethical issues.

TOTAL: 45 PERIODS

OUTCOME

- The students will acquire knowledge in advanced methods to carry out cutting edge academic and industrial research.

REFERENCES

1. Artech House, Inc Publications Naggy N.Habib, M.Y. Levicar, , L. G. Jiao,and N. Fisk, “Stem Cell Repair And Regeneration, Volume-2,Imperial College Press.2007
2. Bernard N. Kennedy (Editor). Stem “CellTransplantation, Tissue Engineering, and Cancer Applications”New York: Nova Science Publishers, 2008.
3. Bernhard O.Palsson,Sangeeta N.Bhatia,“Tissue Engineering” Pearson Publishers 2009.
4. J. J. Mao, G. Vunjak-Novakovic et al (Eds), “Translational Approaches In TissueEngineering & Regenrative Medicine” 2008,
5. Meyer, U.; Meyer, Th.; Handschel, J.; Wiesmann, H.P.Fundamentals of TissueEngineering and Regenerative Medicine.2009.

6. R. Lanza, I. Weissman, J. Thomson, and R. Pedersen, “Handbook Of Stem Cells, Two-Volume, Volume 1-2: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal StemCells”, Academic Press,2004.
7. R. Lanza, J. Gearhart etal (Eds),” Essential of Stem Cell Biology”,ElsevierAcademic Press.2006.
8. Raphael Gorodetsky, Richard Schäfer..”Stem CellbasedTissue Repair”Cambridge: Rsc Publishing, 2011.

NT5010 OPTICAL PROPERTIES OF NANOMATERIALS 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. Encyclopedia of Nanotechnology- Hari Singh Nalwa 2004.

2. Nanoplasmonics, From fundamentals to Applications vol 1 & 2- S. Kawata & H Masuhara 2006.
3. Nanotechnology for Microelectronics and Optoelectronics - J. M. Martinez-Duart,Raúl J. Martín-Palma, Fernando Agullo-Rueda 2006
4. Springer Handbook of Nanotechnology by Bharat Bhushan 2004.
5. The Handbook of Photonics By Mool Chand Gupta, John Ballato 2007

NT5011 APPLICATION OF NANOTECHNOLOGY IN FOOD INDUSTRIES **L T P C 3 0 0 3**

OBJECTIVES:

- To expose the students the effect of nanotechnology in food processing and Preservation.

UNIT I INTRODUCTION **9**

Water relationships in foods; Chemistry of oils and fats, free radical chemistry, reactive oxygen, photosensitized oxidation, metal catalyzed reactions, Antioxidants: chemistry and mechanisms of action, techniques of evaluation of antioxidant activity, uses - INS numbering - JECFA and Food Chemical Codex standards- permissible levels under Indian food laws.

UNIT II NANOTECHNOLOGY IN FOOD PROCESSING **9**

Nano encapsulation and emulsion in Flavors, aromas, Lipids, enzymes; Nano in Agriculture and food processing; Nano pesticides, UV protective and anti microbial nanomaterials for food processing; Anti-caking; Nano carriers.

UNIT III NANO SENSORS IN FOOD TECHNOLOGY **9**

Nano biosensors; type of sensors; sensitivity and selectivity of biosensors; Pathogen detection in food; Detection of contaminants in Food- pesticides, heavy metals and other Toxins; Food quality monitoring; detection of allergen in food.

UNIT IV NANOTECHNOLOGY IN FOOD PACKAGING **9**

Packaging– Concepts, definition, Significance, classification; Packaging of foods –fresh and processed; Basic packaging materials, types of packaging, packaging for different types of foods. Nanomaterials for food packaging - Gas barrier plastics; Food adulteration monitoring;

UNIT V NANOTECHNOLOGY FOR CONTROLING FOOD SPOILAGE **9**

Types of micro-organism normally associated with food-mold, yeast and bacteria; Controlling and sensing of microbial growth in food by Nanotechnology: intrinsic, extrinsic and implicit factors; Micro-organism in natural food products and their control; Controlling the deterioration of various types of food products by Nanotechnology; Nanotechnology in preservatives.

OUTCOME

- Deep knowledge on the nanotechnology based food processing and preservations. Familiarize with the recent methods of nanotechnology based processing of food and understand the materials and types of packaging for food.

REFERENCES

1. GopalaRao, "Essentials of Food Processing Engineering", BS Publications, 2006
2. Khetarpaul, N. "Food Processing and Preservation", Daya Publications, 2005

NT5012 SEMICONDUCTOR NANOSTRUCTURES AND NANOPARTICLES L T P C
3 0 0 3

OBJECTIVES:

- To gain knowledge about basic semiconductor metals & its characteristics
- To know the physical & quantum aspects of semiconductor
- To obtain a basic idea about energizing material & its effects

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 SYNTHESIS 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 9

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 9

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

TOTAL : 45 PERIODS

OUTCOMES:

- Overall the reader will get idea about basic and advanced concepts in electronics and

quantum physics

- Students will acquire the ideas about optics

REFERENCES:

1. Encyclopedia of Nanoscience and Nanotechnology- Hari Singh Nalwa, 2004.
2. Handbook of Semiconductor Nanostructures and Nanodevices Vol 1-5- A. A. Balandin, K. L. Wang 2006.
3. Nanostructures and Nanomaterials - Synthesis, Properties and Applications - Cao, Guozhong, 2011.
4. Springer Handbook of Nanotechnology - Bharat Bhusan, 2004.

NT5013 TOP DOWN MANUFACTURING METHODS L T P C
3 0 0 3

OBJECTIVES:

- To know about the various synthesis of nanomaterials using top down approaches
- To study how bulk materials are being converted into nano particles by employing lithography and milling process
- To learn about the different types of etching techniques

UNIT I INTRODUCTION 9

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 9

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 - Soft lithography- Dip-Pen lithography.

UNIT III ETCHING TECHNIQUES 9

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 9

Nanopowders produced using micro reactors; Nanocrystalline ceramics by mechanical activation; Formation of nanostructured polymers; types and characteristics of balls; wet milling and dry milling.

UNIT V MACHINING PROCESSES 9

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

OUTCOMES:

- Students will get knowledge on the wide classification of lithographic techniques and the methodology used in each one of them
- They will gain access to in-depth information on the milling and micromachining process

REFERENCES:

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

NT5014 NANOTECHNOLOGY IN HEALTH CARE L T P C

3 0 0 3

OBJECTIVES

- To be introduced to recent advancements in nano medicine. To learn about nano diagnostics.
- To learn developments in nanostructured materials used for medical implants.

UNIT I TRENDS IN NANOBIOTECHNOLOGY 9

Nanotechnology in gene therapy. Stem Cell technology. PCR, ELISA, DNA Profiling and Blotting techniques-Nanoprobes.

UNIT II NANOIMMUNOTECHNOLOGY 9

Nanoimmunoassay and nano-immunosensors- Bio-Barcode Assay- use of magnets, gold, DNA and antibodies. Immunodiagnostics for cancer and central nervous system disorders.

UNIT III NANOTECHNOLOGY BASED MEDICAL DIAGNOSTICS 9

Improved diagnosis by i*n vivo* imaging - detection of tumors, plaque and genetic defects. Nanobot medical devices. Cantilever Sensors.

UNIT IV PROSTHETIC AND MEDICAL IMPLANTS 9

Prosthesis and implants. neural, ocular, cochlear, dental implants. implants and prosthesis of skin, limb, bone. Artficial organ and Organ transplant. Nanofibre scaffold technology.

UNIT V BIOMEDICAL APPLICATIONS OF NANOTECHNOLOGY 9

Nano-bioconjugates and their significance. Nanoscaffolds. Magnetic Nanoparticles. Multifunctional Inorganic and organic nanoparticles and their biomedical applications.

TOTAL : 45 PERIODS

OUTCOME

- Complete knowledge in the field of nanomedicine including diagnosis, therapy and sensing.

REFERENCES:

1. Biosensors and modern biospecific analytical techniques, Wilson & Wilson's
2. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester; 2002.
   Comprehensive Analytical Chemistry; Ed. L Gorton; Elsevier, Amsterdam,
3. Electrochemical Methods: Fundamentals and Applications; Allen J Bard and Larry R Faulkner; Wiley, New York, Chichester : 2nd ed.; 2001.
   London; 2005.
4. The Immunoassay Handbook; Ed. David Wild; 3rd ed.; Amsterdam: Elsevier; 2005.
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

BO5092 BIOMATERIALS L T P C
3 0 0 3

OBJECTIVES

- To know the classification of biomaterial, their bulk and surface properties and characterization to prepare the students to find a place in biomedical field .To learn the various biological responses to the materials and biomechanics .To have an exposure on the clinical context of their use, manufacturing processes and testing, cost, sterilization, packaging and regulatory issues.

UNIT I INTRODUCTION AND CLASSIFICATION 9

Introduction and classifications; Metals: different types, properties and interaction with the tissue, Polymers: classification and properties, Ceramics: Types, properties and interactions with the tissue, Composites: matrix and reinforcing agents/fillers and properties, Cell adhesion, host- tissue reactions. Tissue derived biomaterials: Structure and properties of collagen and collagen-rich tissues, Biotechnology of collagen, design of resorbable collagen-based medical implants soft.

UNIT II BULK AND SURFACE CHARACTERIZATION 9

Bulk Characterization: XRD, FT-IR, SEM, energy dispersive X-ray (EDX), DSC, TGA, dielectric analysis (DEA); Surface analysis: XPS, SIMS, AES, surface enhances Raman spectroscopy (SERS), AFM/STM; Structural properties of tissues-bone, teeth and elastic tissues, Effects of sterilization on material properties.

UNIT III TESTING 9

Biocompatibility: blood and tissue compatibility; degradation of biomaterials in biological environment, toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests; In vitro

and In vivo testing, implant associated infections, biocompatibility enhancement using carona discharge and plasma processes, surface coatings; Ethical considerations, good manufacturing practice, standards, Regulatory issues.

UNIT IV TISSUE REPLACEMENT IMPLANTS WITH BIOMATERIALS 9

Tissue replacements, sutures, surgical tapes, adhesive, percutaneous and skin implants, maxillofacial augmentation, blood interfacing implants, hard tissue replacement implants, internal fracture fixation devices, Joint replacements.

UNIT V ARTIFICIAL ORGANS WITH BIOMATERIALS 9

Artificial heart, prosthetic cardiac valves, limb prosthesis, externally powered limb prosthesis, Dental implants.

TOTAL: 45 PERIODS

OUTCOME

- To select biomaterial for organ replacement and temporary body implant Design, analytical, problem solving, technical judgment skills

REFERENCES:

1. D. Shi , Ed., “Biomaterials and Tissue Engineering”, Berlin, New York: Springer, 2004.
2. Joon Park, D.B. Joseph and Boca Ration, “Biomaterials: Principles and Applications”, CRC, Press, 2003.
3. Kay C. Dee, David A. Puleo and Rena Bizios, “An Introduction to Tissue-Biomaterial Interactions”, John wiley, 2002.
4. L. Hench and J. Jones, “Biomaterials, Artificial Organs and Tissue Engineering”, Woodhead Publishing in Materials, 2002.
5. Ratner, B. D., et al, (eds.), “Biomaterials Science: An Introduction to Materials in Medicine”, Academic Press, 2004
6. Saltzman W M, “Tissue Engineering: Engineering Principles for the Design of Replacement Organs and Tissues”, Oxford University Press, 2004.