ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

M. TECH. NANOSCIENCE AND TECHNOLOGY

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, 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 skills to use synthesis, ,processing and imaging equipments to analyze samples.
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 for life-long learning.

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

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			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 and Applications of Nanomaterials		✓								
		Nanostructures in Biological Systems							✓	✓		
		Computation and Simulation			✓							
		Material Synthesis (Practicals)	✓						✓		✓	
	SEM 2	Photonics for Nanotechnology	✓					✓				
		Processing and properties of Nanostructured Materials				✓	✓					
		Physicochemical methods for characterization of Nanomaterials		✓				✓				
		Imaging techniques for Nanotechnology		✓			✓	✓				
		Nanotechnology in Health Care							✓	✓		
		Lithography and Nanofabrication			✓							
		MEMS and Bio MEMS				✓						
		Nanometrology (Practicals)	✓					✓				
YEAR 2	SEM 3	Professional Elective I							✓	✓	✓	
		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

M. TECH. NANO SCIENCE AND TECHNOLOGY

SEMESTER – I

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
THEORY								
1.	NT7101	Mathematical Modeling and Simulation	FC	3	3	1	0	4
2.	NT7102	Nanostructures in Biological Systems	FC	3	3	0	0	3
3.	NT7103	Physics and Chemistry of Materials	FC	3	3	0	0	3
4.	NT7104	Quantum Mechanics	FC	3	3	0	0	3
5.	NT7105	Synthesis and Applications of Nanomaterials	FC	3	3	0	0	3
LABORATORY								
6.	NT7111	Computation and Simulation	FC	4	0	0	4	2
7.	NT7112	Material Synthesis	FC	4	0	0	4	2
			TOTAL	**23**	**15**	**1**	**8**	**20**

SEMESTER – II

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
THEORY								
1.	NT7201	Imaging techniques for Nanotechnology	PC	3	3	0	0	3
2.	NT7202	Lithography and Nanofabrication	PC	3	3	0	0	3
3.	NT7203	Nanotechnology in Health Care	PC	3	3	0	0	3
4.	NT7204	Photonics for Nanotechnology	PC	3	3	0	0	3
5.	NT7205	Physicochemical methods for characterization of Nanomaterials	PC	3	3	0	0	3
6.	NT7206	Processing and properties of Nanostructured Materials	PC	3	3	0	0	3
LABORATORY								
7.	NT7211	Nanometrology	PC	4	0	0	4	2
			TOTAL	**22**	**18**	**0**	**4**	**20**

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SEMESTER – III

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
THEORY								
1.	NT7301	MEMS and Bio MEMS	PC	3	3	0	0	3
2.		Elective I	PE	3	3	0	0	3
3.		Elective II	PE	3	3	0	0	3
4.		Elective III	PE	3	3	0	0	3
LABORATORY								
5.	NT7311	Project Work Phase - I	EEC	12	0	0	12	6
			TOTAL	**20**	**12**	**0**	**12**	**18**

SEMESTER – IV

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
LABORATORY								
1.	NT7411	Project Work Phase - II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL CREDITS : 70

Foundation Courses (FC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Mathematical Modeling and Simulation	FC	3	3	1	0	4
2.		Quantum Mechanics	FC	3	3	0	0	3
3.		Physics and Chemistry of Materials	FC	3	3	0	0	3
4.		Synthesis and Applications of Nanomaterials	FC	3	3	0	0	3
5.		Nanostructures in Biological Systems	FC	3	3	0	0	3
6.		Computation and Simulation	FC	4	0	0	4	2
7.		Material Synthesis	FC	4	0	0	4	2

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Professional Core (PC)

S.No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Photonics for Nanotechnology	PC	3	3	0	0	3
2.		Processing and properties of Nanostructured Materials	PC	3	3	0	0	3
3.		Physicochemical methods for characterization of Nanomaterials	PC	3	3	0	0	3
4.		Imaging techniques for Nanotechnology	PC	3	3	0	0	3
5.		Nanotechnology in Health Care	PC	3	3	0	0	3
6.		Lithography and Nanofabrication	PC	3	3	0	0	3
7.		MEMS and Bio MEMS	PC	3	3	0	0	3
8.		Nanometrology	PC	4	0	0	4	2

Professional Electives (PE)

S.No	COURSE CODE	COURSE TITLE	CATEGO RY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	NT7001	Advanced Drug Delivery Systems	PE	3	3	0	0	3
2.	NT7002	Advanced Nanocomposites	PE	3	3	0	0	3
3.	NT7003	Biophotonics	PE	3	3	0	0	3
4.	NT7004	Biosensors	PE	3	3	0	0	3
5.	NT7005	Bottom up synthesis of Nanostructures	PE	3	3	0	0	3
6.	NT7006	Nanoelectronics and Sensors	PE	3	3	0	0	3
7.	NT7007	Nanomaterials for Energy and Environment	PE	3	3	0	0	3
8.	NT7008	Nanotoxicology	PE	3	3	0	0	3
9.	NT7009	Research Methodology	PE	3	3	0	0	3
10.	NT7010	Semiconductor nanostructures and nanoparticles	PE	3	3	0	0	3
11.	NT7011	Top down manufacturing methods	PE	3	3	0	0	3

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Employability Enhancement Courses (EEC)

S.No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.		Product design, management techniques and entrepreneurship	EEC	3	3	0	0	3
2.		Project Phase - I	EEC	12	0	0	12	6
3.		Project Phase - II	EEC	24	0	0	24	12

NT7101 MATHEMATICAL MODELING AND SIMULATION L T P C
3 1 0 4

OBJECTIVES:

- To gain knowledge on Numerical methods and scientific computing.
- To know more about modeling equations and their applications.
- To learn about data processing and simulation.

UNIT I NUMERICAL METHODS AND SCIENTIFIC COMPUTING 12

Mathematical problems and analytic solutions- Numerical analysis and numerical methods - Approximations of functions – Taylor's series applications – Error analysis- Numerical Algorithms and examples- Evaluation of functions- Newton-Raphson method Numerical Differentiation - Numerical integration – Numerical linear algebra – Solving systems of equations-Eigen value of matrices –

UNIT II MATHEMATICAL MODELING 12

Mathematical modeling – Physical variables, parameters - stages of mathematical modeling and life cycle - Advantages of modeling and limitations – ODE modeling equations and examples – Numerical solutions of ODE (single step only) - Euler's method – Taylor series method – Runge - Kutta 2 nd and 4 th order methods.

UNIT III PDE MODEL EQUATIONS AND THEIR APPLICATIONS 12

Classification of second order PDEs – Equations of mathematical physics – boundary values- Finite difference approximations to partial derivatives - Solution of one dimensional heat conduction equation - Laplace equation using standard five point formula - Solving of Poisson equation.

UNIT IV DATA PROCESSING AND SIMULATION 12

Data formats, Data manipulation – Curve fitting and interpolation techniques – Structural and material properties – Material databases - Basic concepts of simulation- Model descriptors **-**Three dimensional models examples -. Molecular dynamics (MD) simulation - Trajectory, coordinates and acceleration - Newton's equation - Energy conservation – MD Applications

UNIT V MONTE CARLO METHODS AND FIRST PRINCIPLE METHODS 12

Basics of the Monte Carlo method-Algorithms for Monte Carlo simulation-Applications to systems of classical particles-modified Monte Carlo techniques-percolation system-variation Monte Carlo method-diffusion Monte Carlo method - Quantum Monte Carlo method.

TOTAL : 60 PERIODS

OUTCOME:

- Gaining knowledge of numerical methods and scientific computing, learnt about modeling equations, data processing, simulation and their applications.

REFERENCES

1. S.C. Chapra and R.P.Canale, "Numerical methods for Engineers", Tata McGraw Hill,New Delhi, 2002.
2. Erwin Kreyzig, "Advanced Engineering Mathematics", John Wiley & Sons, 2004.
3. R.J. Schilling and S.L. Harris, "Applied Numerical Methods for Engineers using MATLAB and C", Thomson publishers, New Delhi, 2004.
4. F R Giordano, W P Fox, S B Horton and M D Weir, "Mathematical Modeling Principles and Applications", CENGAGE Learning, New Delhi, 2009
5. D. Frenkel and B. Smith, "Understanding molecular simulation from algorithm to applications", Kluwar Academic Press, 1999.
6. A.R. Leach Molecular Modeling – Principles and Applications, Pearson Edition, 2001
7. K. Ohno, K. Esfarjani and Y. Kawazoe, "Introduction to Computational Materials Science from ab initio to Monte Carlo Methods", Springer-Verlag, 1999.

NT7102 NANOSTRUCTURES IN BIOLOGICAL SYSTEMS

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. R. Cantor, P.R.Samuel, “Biophysical Chemistry”, W.H., Freeman & Co., 1985.
2. 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.
3. 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.
4. Branden, Carl-Ivar, and John Tooze. Introduction to Protein Structure. 2nd ed. New York: Garland Pub., 1991.
5. Creighton, E, Thomas, “Proteins: Structures and Molecular Properties”, 2nd Ed. New York: W.H. Freeman, 1992.
6. B.Lewin, “Genes IX”, International Edition. Sudbury: Jones & Bartlett, 2007.

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NT7103 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. K.W. Kolasinski, “Surface Science: Foundations of Catalysis and Nanoscience”, Wiley, 2002.
2. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications , Imperial College Press, 2004.
3. Joel I. Gersten, “The Physics and Chemistry of Materials”, Wiley, 2001.
4. A. S. Edelstein and R. C. Cammarata, “Nanomaterials: Synthesis, Properties and Applications”, Institute of Physics Pub., 1998.
5. S.Yang and P.Shen: “Physics and Chemistry of Nanostructured Materials”, Taylor & Francis, 2000.
6. G.A. Ozin and A.C. Arsenault, “Nanochemistry : A chemical approach to nanomaterials”, Royal Society of Chemistry, 2005.
7. Physical Chemistry – Atkins Peter, Paula Julio

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NT7104 **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. Quantum Mechanics - Bransden and Joachen 2nd edition 2000.
3. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, 2nd Edition by Eisberg, Robert; Resnick, Robert, 1985
4. Quantum Physics – Theory and application, Ajoy Ghatak, Springer 2004.
5. Principles of Quantum Mechanics 2nd ed. - R. Shankar 2000.
6. Quantum Mechanics - Vol 1&2 - Cohen-Tannoudji,1997

NT7105 SYNTHESIS AND APPLICATIONS 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 APPLICATION OF NANOMATERIALS 9

Overview of nanomaterials properties and their applications, nano painting, nano coating, nanomaterials for renewable energy, Molecular Electronics and Nanoelectronics – Nanobots- Biological Applications.

TOTAL : 45 PERIODS

OUTCOME:

- Knowledge on synthesis of Nano materials and their applications.

REFERENCE:

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

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NT7111 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

OUTCOME:

- Knowledge on modeling and simulation of equations using MATLAB.

NT7112 MATERIAL 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

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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

OUTCOME:

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

NT7201 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.

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NT7202 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. M. Baker et al., "Lithographic pattern formation via metastable state rare gas atomic beams", Nanotechnology 15, 1356 (2004).
3. H. Schift et al., "Fabrication of polymer photonic crystals using nanoimprint lithography", Nanotechnology 16, 261, (2005).
4. R.D. Piner, "Dip-Pen" Nanolithography, Science 283, 661 (1999).

NT7203 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. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester; 2002.
2. Biosensors and modern biospecific analytical techniques, Wilson & Wilson's Comprehensive Analytical Chemistry; Ed. L Gorton; Elsevier, Amsterdam, London; 2005.
3. The Immunoassay Handbook; Ed. David Wild; 3rd ed.; Amsterdam: Elsevier; 2005.
4. Electrochemical Methods: Fundamentals and Applications; Allen J Bard and Larry R Faulkner; Wiley, New York, Chichester : 2nd ed.; 2001.
5. Ultrathin Electrochemical Chemo- and Biosensors: Technology and Performance in Springer Series on Chemical Sensors and Biosensors; Volume Two; Ed. Vladimir M. Mirsky; Springer, Berlin; 2004

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NT7204 PHOTONICS FOR NANOTECHNOLOGY

L T P C
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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. H.Masuhara, S.Kawata and F.Tokunaga, Nano Biophotonics, Elsevier Science, 2007.
2. V.M. Shalaev and S.Kawata, Nanophotonics with Surface Plasmons (Advances in Nano-Optics and Nano-Photonics), 2007.
3. B.E.A. Saleh and A.C.Teich, Fundamentals of Photonics, John-Weiley & Sons, New York, 1993.
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. J.D.Joannopoulos, R.D.Meade and J.N.Winn, Photonic Crystals, Princeton University Press, Princeton, 1995.

NT7205 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. M. H.Loretto, “Electron Beam Analysis of Materials”, Chapman and Hall, 1984.
3. R.M.Rose, L.A.Shepard and J.Wulff, “The Structure and Properties of Materials”, Wiley Eastern Ltd, 1996.
4. B.W.Mott, “Micro-Indentation Hardness Testing”, Butterworths, London, 1956.

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NT7206 PROCESSING AND PROPERTIES OF NANOSTRUCTURED MATERIALS

L T P C
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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. H. Cottrell “The Mechanical Properties of Matter”, John Wiley, New York-London,1964.
2. R. Asthana, A. Kumar and N. Dahotre “Materials Science in Manufacturing” Butterworth-Heinemann, Elsevier 2006.
3. G. E. Dieter, adapted by D Bacon, “Mechanical Metallurgy”, SI Metric edition, McGraw Hill, Singapore, 1988.
4. K. A. Padmanabhan, “Mechanical Properties of Nanostructured Materials”, Materials

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5. Science and Engineering, A 304-306 (2001) 200-205.
6. H. Gleiter, “Nanocrystalline Materials”, Progress in Materials Science Vol. 33, pp. 223
7. 315, 1989
8. C. Koch, “Nanostructured Materials: Processing, Properties and Applications”, 2nd Edition, Ed.: 2007

NT7211 NANOMETROLOGY L T P C
0 0 4 2

OBJECTIVES

1. To learn techniques to study structural morphology of nanomaterials.
2. To develop skills to synthesize nanomaterials.
3. 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

OUTCOME

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

NT7301 **MEMS AND BIO MEMS** **L T P C**
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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. Marc Madou, Fundamentals of Microfabrication, CRC Press 1997.
2. MEMS and Microsystems design and manufacture, Tai-Ran Hsu,Tata Mc Graw Hill 2011.
3. Sergey Edward Lyshevski, Nano- and Microelectromechanical Systems, CRC Press 2000.
4. Vijay Varadan, Xiaoning Jiang, and Vasundara Varadan, Microstereolithography *and* other Fabrication Techniques for 3D MEMS*,* Wiley 2001.
5. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw-Hill 2001.
6. Ken Gilleo. MEMS/MOEMS Packaging: Concepts, Designs, Materials and Processes. McGraw-Hill, 2005.

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NT7001 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: Engineering Principles for Drug Therapy, M. Salzman, Oxford University Press, 2001.
2. Drug Delivery and Targeting, A.M. Hillery, CRC Press, 2002.
3. Drug Delivery: Principles and Applications, B. Wang, Wiley Intersceince, 2005.
4. Nanoparticle Technology for Drug Delivery, Ram B. Gupta, Uday B. Kompella Taylor & Francis, 2006

NT7002 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. Introduction to Nanocomposite Materials. Properties, Processing, Characterization-Thomas E. Twardowski. 2007. DEStech Publications. USA.
2. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun 2006.
3. Physical Properties of Carbon Nanotubes- R. Saito 1998.
4. Carbon Nanotubes (Carbon , Vol 33) - M. Endo, S. Iijima, M.S. Dresselhaus 1997.
5. The search for novel, superhard materials- Stan Vepr¡ek (Review Article) JVST A, 1999
6. Electromagnetic and magnetic properties of multi component metal oxides, hetero
7. Nanometer versus micrometer-sized particles-Christian Brosseau,Jamal BeN Youssef, Philippe Talbot, Anne-Marie Konn, (Review Article) J. Appl. Phys, Vol 93, 2003
8. Diblock Copolymer, - Aviram (Review Article), Nature, 2002

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NT7003 **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. Laser Tweezers in Cell Biology in Methods in Cell Biology, Vol.55, Michael P. Sheetz (Ed.), Academic Press 1997.
2. P.N. Prasad, Introduction to Biophotonics, John-Wiley, 2003.
3. G. Marriot & I. Parker, Methods in Enzymology, Vol.360,2003.
4. G. Marriot & I. Parker, Methods in Enzymology, Vol.361,2003.

NT7004 **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 enzyme nano particles – nano tubes microporus silica – protein based nano crystalline. 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.

NT7005 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 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. W.T.S. Huck, “Nanoscale Assembly: Chemical Techniques (Nanostructure Science and Technology)”2005.
3. “Handbook of Nanoscience, Engineering and Technology”, Kluwer publishers, 2002.

NT7006 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.

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

NT7007 NANOMATERIALS FOR ENERGY AND ENVIRONMENT

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. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.
2. Hydrogen from Renewable Energy Sources by D. Infield 2004.
3. Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures by R.A. Shatwell 1996.
4. Fuel cell technology handbook. Hoogers. CRC Press, 2003.
5. Handbook of fuel cells: Fuel cell technology and applications by Vielstich. Wiley, CRC Press, 2003.

NT7008 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. John H. Duffus, Howard G. J. Worth, 'Fundamental Toxicology', The Royal Society of Chemistry 2006.
2. Nancy A. Monteiro-Riviere, C. Lang Tran., 'Nanotoxicology: Characterization, Dosing and Health Effects',Informa Healthcare publishers, 2007.
3. Lucio G. Costa, Ernest Hodgson, David A. Lawrence, Donald J. Reed,William F. Greenlee, 'Current Protocols in Toxicology', John Wiley & Sons, Inc. 2005.
4. Shayne C. Gad, 'Animal models in toxicology', Taylor & Francis Group, LLC 2007.
5. P. Houdy, M. Lahmani, F. Marano, 'Nanoethics and Nanotoxicology', Springer-Verlag Berlin Heidelberg 2011.
6. A Reference handbook of nanotoxicology by M.ZafarNyamadzi 2008.
7. Andreas Luch, 'Molecular, Clinical and Environmental Toxicology Volume 2: Clinical Toxicology', BirkhauserVerlag AG 2010.

NT7009 RESEARCH METHODOLOGY

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

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

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. Donald R. Cooper and Ramela S. Schindler, Business Research Methods, Tata McGraw- Hill Publishing Company Limited, New Delhi, 2000
1. Uma Sekaran, Research Methods for Business, John Wiley and Sons Inc., New York, 2000.
2. C.R.Kothari, Research Methodology, Wishva Prakashan, New Delhi, 2001.
3. Donald H.McBurney, Research Methods, Thomson Asia Pvt. Ltd. Singapore, 2002.
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.

NT7010 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. Springer Handbook of Nanotechnology - Bharat Bhusan, 2004.
3. Handbook of Semiconductor Nanostructures and Nanodevices Vol 1-5- A. A. Balandin, K. L. Wang 2006.
4. Nanostructures and Nanomaterials - Synthesis, Properties and Applications - Cao, Guozhong, 2011.

NT7011 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. M. J. Jackson, "Micro fabrication and Nanomanufacturing", CRC Press, 2005.
2. P.Rai-Choudhury, "Handbook of Micro lithography, Micro machining, and Micro fabrication", Vol. 2, SPIE Press, 1997.
3. M. Madou, "Fundamentals of Microfabrication," CRC Press, 1997.
4. G.Timp, "Nanotechnology", AIP press, Springer-Verlag, New York, 1999.

Attested

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Centre For Academic Courses
Anna University, Chennai-600 025.