Solapur University, Solapur

NAAC Accredited-2015
'B'Grade(CGPA-2.62)

Syllabus

of

M.Sc. Part -II Nanotechnology

Choice Based Credit System-CBCS
W.E.F 2017-18

M. SC. PART -II NANOTECHNOLOGY

CHOICE BASED CREDIT SYSTEM (CBCS)

W. E. F JUNE 2017-18

Semester	Code	Title of the paper	Semester exam			L	T	P	Credits
Third		**Hard core**	**UA**	**IA**	**Total**				
NT	**HCT 3.1**	Nanotechnology and Health-care	70	30	100	4		-	4
	HCT 3.2	Application of Nanotechnology in Everyday Life	70	30	100	4		-	4
		Soft core (Any one)							
	SCT 3.1	Nanotechnology in Environment/Ecosystem	70	30	100	4		-	4
	SCT 3.2	Organic Semiconductors, Polymers & Molecular Electronics	70	30	100	4		-	
		Open elective (Any one)							
	OET 3.1	Organometallic Chemistry	70	30	100	4		-	4
	OET 3.2	Computational Structural Biology and Drug design	70	30	100	4		-	
		Tutorial			25		1	-	1
		Practical							
	HCP 3.1	Applications of Nanotechnology	35	15	50	-	-	2	2
	HCP 3.2	Nanotechnology in Electronics	35	15	50	-	-	2	2
		Open elective (Any one)							
	SCP 3.1	Nanotechnology in Environment Application	35	15	50	-	-	2	2
	SCP 3. 2	Molecular Electronics	35	15	50	-	-	2	2
		Open elective (Any one)							
	OEP 3.1	Nanomaterials Synthesis	35	15	50	-	-	2	2
	OEP 3.2	Computational Structural Biology and Drug design	35	15	50	-	-	2	
		Total for third semester	**420**	**180**	**625**				**25**
Four		**Hard core**							
NT	**HCT 4.1**	Polymers & Nanocomposites	70	30	100	4		-	4
	HCT 4.2	Industrial Nanotechnology	70	30	100	4		-	4
	HCT 4.3	Thin film Technology	70	30	100	4		-	4
		Soft core (Any one)						-	4
	SCT 4.1	Nano devices and Nano Sensors	70	30	100	4		-	
	SCT 4.2	Animal Biotechnology	70	30	100	4		-	
		Tutorial			25		1	-	1
	MP 4.1	**Research Project**	**140**	**60**	**200**	**-**	**-**	**-**	**8**
		Total for fourth semesters	**420**	**180**	**625**				**25**
						Total Credits			**100**

L = Lecture T = Tutorials P = Practical IA=Internal Assessment

4 Credits of Theory = 4 Hours of teaching per week

2 Credits of Practical = 4 hours per week

HCT = Hard Core Theory

SCT = Soft Core Theory

HCP = Hard Core Practical

SCP = Soft Core Practical

OET = Open Elective Theory

OEP = Open Elective Practical

MP = Major Project

M. Sc. Nanotechnology Part - II SEMESTER III

HCT 3.1 NANOTECHNOLOGY & HEALTH-CARE

60 Hrs
Total marks: 100
(Credits-4)

Unit-I: Applications of Nanotechnology in biology (10)

Bio-Tribology – Tribology in the human body, artificial organs and medical devices, natural human synovial joints and Total joint replacements, wind turbine Tribology, Biorefining, coating application - sliding bearings, rolling contact bearings, gears, erosion and scratch resistant, magnetic recording devices, micro components.

Unit – II: Nanomaterials for Medical applications (15)

Gold nanorods for sensing Biocompatibility of Traditional Medical Implants, Nanorobot Immunoreactivity, Nanobiotechnology in Tissue Engineering - Nanobiotechnology for Organ Replacement, Nanoparticles as Imaging Platform in Biomedicine USPIOS, SPIONS, MPIOS for imaging- Magnetic nanosensors-radio labeled nanoparticles. Drug delivery to CNS - Nanowires for Monitoring Brain Activity - Drug Delivery across BBB – Neurodegeneration – Nano neurosurgery. Nanobone Implants and Scaffolds - Nanocarriers for Nanotechnology-Based Products for Skin Disorders -Nanoparticle Drug Formulations for Spray Inhalation - Wound Healing –Nanogeriatrics – Orthodontal application

Unit – III: Nanotechnology in Health-care/Pharmaceutical Applications (20)

Protein and peptide based compounds for cancer, diabetes, infectious diseases and organ transplant- focused pharmaceutical delivery systems. Understanding of antibody based diagnostic techniques (immunoassay) - micro and nano immunosensors - use of magnets, gold, DNA and antibodies - therapies and diagnostics for cancer and central nervous system disorders.

Diagnostic products and techniques for the detection of tumors, plaque, genetic defects and other disease states; Diagnostic Equipment's: Biosensors, Nano-robots, Nano-tweezers, Potential Nano-scale devices based on the membrane protein F-1 ATPase.

Nanobot medical devices; medical implants - artificial organs and implants- artificial scaffolds or biosynthetic coatings - retinal, cochlear and neural implants - repair of damaged nerve cells and replacements of damaged skin, tissue, or bone. Cantilever Sensors - Targeted Drug Delivery - Magnetic Nanoparticles - Cancer cell targeting - Stem Cell Scaffolds

Unit-IV: Activities at Nano-bio scale (15)

Self-assembly of bio molecules in nanotechnology; Tailoring nanometer scale object to mimic and interact with natural materials; Biological nanostructures and biomimetic machinery; Molecular motors: natural molecular motors like kinesin, dynein, flagella, RNA and DNA helicases, topoisomerases; Ion channels as molecular switches; patch clamp technique; Photoreceptors as single photon optical detector; Manipulating redox systems application in nanotechnology; Micro fabricated devices in biotechnology e.g. micro reactors; Protein array technology; Exploiting enzymes in bio-nanotechnology; Nano scale devices for biosensors, Bio-degradable nanoparticles for drug & gene delivery to cells and tissues

Reference books:

1. Tuan Vo Dinh, Nanotechnology in Biology and Medicine: Method, Devices and Applications, CRC Press 2007
2. Vijay. K. Varadan, Linfeng Chen, Sivathanupillai, Nanotechnology Engineering in Nano and Biomedicine, John Wiley & Sons, 2010.
3. C.M. Niemeyer and C.A. Mirkin, Nanobiotechnology, Concepts, Applications and perspectives, WILEY-VCH, 2004.
4. David. S. Goodsell, Bionanotechnology: concepts, Lessons from Nature, Wiley-Liss, 2004
5. Sandra J Rosenthal, David W Wright, Nanobiotechnology Protocols, Humana Press Inc, 2005
6. R.S. Greco, F.B. Prinz and R.L.Smith, Nanoscale Technology in Biological Systems, CRC press, 2005.
7. Tuan Vo-Dinh, Protein Nanotechnology -Protocols, Instrumentation and Applications, Humana Press Inc, 2005.
8. Challa S.S.R. Kumar, Josef Hormes, Carola Leuschaer, Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact, Wiley VCH, (2005).
9. Kewal K. Jain , The Handbook of Nanomedicine, Humana Press, (2008).
10. Zhang, ||Nanomedicine: A Systems Engineering Approach, 1st Ed., Pan Stanford Publishing, (2005).
11. Robert A. Freitas Jr., Nanomedicine Volume IIA: Biocompatibility, Landes Bioscience Publishers, (2003).
12. Bharat Bhushan, NanoTribology and Nanomechanics: An Introduction, Springer
13. Hsu and Ying, Nano Tribology, Springer
14. Prasanta Sahoo,Engineering Tribology, PH

HCT 3.2 APPLICATION OF NANOTECHNOLOGY IN EVERYDAY LIFE

60 Hrs
Total marks: 100
(Credits-4)

Unit-I: Nanotechnology in Agriculture (15)

Nano-Sensor and their need in Agriculture, Biosensors and Diagnostics - DNA-Based Biosensors and Diagnostics - Integrated Nanosensor Networks: Detection and Response Surface Plasmon Resonance Spectroscopy. Nano fertilizer and foliar nutrient & drug delivery

Unit-II: Nanotechnology in Food processing (15)

Applications of Nanotechnology in Foods : Sensing, Packaging, Encapsulation, Engineering Food Ingredients to Improve Bioavailability - Nanocrystalline Food Ingredients - Nano-Emulsions - Nano-Engineered Protein Fibrils as Ingredient Building Blocks - Preparation of Food Matrices. Antimicrobial Functionality - Visual Indicators – Quality Assessment - Food Safety Indication - Product Properties

Unit – III: Nanotechnology in Cosmetics (15)

Introduction of Cosmetics : Cosmetics and cosmeceuticals. Classification of Cosmetics Quality characteristics – Quality Assurance Development Process of Cosmetics - Scientific background technology and its future. Oily Materials: Introduction, Oils and Fats, Wax, Hydrocarbons, Higher Fatty Acids, Higher Alcohols, Esters, Silicones -Surface Active Agents: Introduction Anionic Surfactant, Cationic, Surfactants, Amphoteric Surfactant, Non-ionic, Surfactant. Other Surfactants - Humectants : Introduction, Choice of Humectants - Unusual Humectants, Special Uses of Humectants. Antioxidants : Introduction, General Oxidative theory, Measurement of Oxidation and Assessment of Oxidant efficiency, Choice of Antioxidant. Polymers in Hair Coloring – Conditioning Polymers: Silicon's – Emulsions Multiple Emulsions as Novel Delivery Systems - Silicones and Beyond - Silicones in Shampoo: Without Undesirable Side Effects

Synthesis and Characterization of Dual Nano-delivery Systems Containing Vitamin E for Cosmetics; Preparation & Characterization of Keratin Coatings for Orthopedic Implant Titanium Rods; Contact Lenses beyond Vision Correction. Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly & its manipulation) –Sun-screen dispersions for UV protection using TiO_2 Colour cosmetics

Unit – IV: Nanotechnology in Textiles (15)

NANO FIBRE production by Electro spinning, Continuous yarns from electrospun nanofibers, Controlling the morphologies of electrospun nanofibers for tissue engineering.

CNT+ polymer nanocomposites for industrial applications
IMPROVED FUNCTIONALITY of nanopolymers with cyclodextrins, Dyeable polypropylene via nanotechnology. Polyolefin/clay nanocomposites.

NANOCOATINGS & SURFACE MODIFICATION of Textiles - Electrostatic self-assembled nanolayer films for cotton fibers - Nanofabrication of thin polymer films - Hybrid polymer nanolayers for surface modification of fibers - Structure–property relationships of polypropylene nanocomposite fibers.

NANO FINISHING IN TEXTILES: UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes, stain & crease free fabrics.

Reference books:

1. Tachowiak and Batchelor, Engineering Tribology, Elsevier
2. Brian R.Eggins, Chemical Sensors and Biosensors, John Wiley & Sons, 2002
3. P. J. Brown and K, Stevens, Nanofibers and Nanotechnology in Textiles, CRC Press, 2007.
4. Seeram Ramakrishna, An introduction to electro spinning and Nano fibers, World Scientific Publishing Co, 2005
5. Carl C. Koch, Nanostructured Materials: Processing, Properties and Potential Applications, Noyes Publications, William Andrew Publishing Norwich, New York, U.S.A (2002).
6. M. Niemeyer and C.A. Mirkin, Nanobiotechnology, Concepts, Applications and perspectives, WILEY-VCH, 2004.

SCT 3.1 NANOTECHNOLOGY IN ENVIRONMENT/ECOSYSTEM **60 Hrs**
Total marks: 100
(Credits-4)

Unit – I: Possible Health Impact of Nanomaterials (15)

Sources of Nanoparticles; Epidemiological Evidence; Entry Routes into the Human Body – Lung, Intestinal Tract, Skin*;* Nano particle Size - Surface and Body Distribution; Effect of Size and Surface Charges; Nanoparticles, Thrombosis and Lung Inflammation ;Nanoparticles and Cellular Uptake; Nanoparticles and the Blood-Brain Barrier

Unit – II: Nanomaterials for Environmental Remediation (15)

Introduction- Nanoparticle-based Remediation Materials - Acid-Base Chemistry - Redox Chemistry - Field Deployments of ZVI - Absorption Chemistry - Hybrid Nanostructured Remediation Materials - Self-assembled Monolayers on Mesoporous Supports (SAMMS) - CNTs, Antimicrobial activity & water purification.

Unit–III: Biotoxicity of Metal Oxide nanoparticles & CNT (15)

Introduction; Nanoparticles in the Environment; Nanoparticles in Mammalian Systems; Health Threats; Nanomaterials and Biotoxicity; Iron Oxide; Titanium Dioxide; Dark Studies; UV Irradiation Studies;Other Metal Oxides; Toxicological Studies and Toxicity of Manufactured CNTs- case study; Toxicity of CNTs and Occupational Exposure Risk; Toxicity of MWCNTs/SWCNTs and Impact on Environmental Health

Unit – IV:Toxicology of Nanoparticles in Environmental Pollution and Dosimetry, Epidemiology & Toxicology of Nanoparticles (15)

Air Pollution; Introduction to Air Pollution Particles; Adverse Effects of PM in Epidemiological Studies; Role of Nanoparticles in Mediating the Adverse Pulmonary Effects of PM; Effects of Nanoparticles on the Cardiovascular System; Nanoparticles Translocation and Direct Vascular Effects; Endothelial Dysfunction and Endogenous Fibrinolysis; Coagulation and Thrombosis; Cardiac Autonomies Dysfunction; Effects of Nanoparticles on the Liver and Gastrointestinal Tract; Effects of NP on the Nervous System

Reference books:

1. Kourosh Kalantar – Zadeh, Benjamin Fry, Nanotechnology- Enabled Sensors, Springer , 2008
2. Mark. R. Weisner and Jean-Yves Bottero ―Environmental Nanotechnology applications and impact of nanomaterial‖, The McGraw-Hill Companies (2007).
3. Geoffrey Hunt and Michael D. Mehta, Nanotechnology: Risk, Ethics and Law‖, Earthscan/James & James publication (2006).

4. Challa S. S. R. Kumar, Nanomaterials - Toxicity, Health and Environmental Issues, Wiley-VCH publisher (2006).
5. Nancy A. Monteiro-Riviere, C. Lang Tran, Nanotoxicology: Characterization, Dosing and Health Effects, Informa healthcare (2007).
6. D. Drobne, Nanotoxicology for safe and Sustainable Nanotechnology, Dominant publisher (2007).
7. M. Zafar Nyamadzi, A Reference handbook of nanotoxicology, Dominant publisher (2008)
8. Kathleen S, Christopher M, Lynn L. Bergeson, Nanotechnology and the Enviroment, CRC press (2009).
9. R. E. Hester, R. M. Harrison, Electronic Waste Management‖, RSC publishing (2009)
10. Darcy J. Gentleman, Nano and the Environment: Boon o Bane? Environmental Science and technology, Vol. 43, (2009).

SCT 3.2 ORGANIC SEMICONDUCTORS, POLYMERS AND MOLECULAR ELECTRONICS **60 Hrs**

Total marks: 100

(Credits-4)

Unit I: Organic semiconductors (15)

Organic semiconducting (small) molecules; orbitals and conjugation; Excitations: excitons and polarons; Exciton spin: singlets and triplets; Synopsis electronic and optical processes; Optical properties: a few examples EG (Energy Gap) vs. molecular weight Electron-phonon coupling: vibrational structure and thermochromism, Förster transfer and Site selective spectroscopy; Summary of optical properties.

Unit II: Organic Light emitting devices (OLED) (15)

OLED principle - HOMO and LUMO levels - Organic p-n junction-Factors affecting OLED performance - Energy level diagram-radiative and non-radiative recombination decay of excitons. White light emitting device (WOLED). Fabrication technology: the advantage of solution processability; thermal evaporation - Spin-coating, Ink-jet printing (IJP); Screen-printing and other examples; State of the art devices and future prospects.

Unit II: Polymer-based photovoltaic diodes (PVDs) (15)

Fundamental process; Exciton absorption; Exciton dissociation; Charge collection; Characterization of PVDs; Relevant performance parameters; Examples of polymer-based PVDs; Polymer-polymer heterojunctions; Enhanced dissociation at type II heterojunctions; Preparation methods: polymer blends and spontaneous phase separation; C60-polymer structures; Heterojunctions with nanocrystals, nanorods, etc; State of the art devices and future properties.

Unit IV: Organic Field Effect Transistors (15)

Polymer-based field-effect transistors, FETs Structure Fundamental processes; Channel formation; Charge transport Characterization; Relevant performance parameters; Examples of successful strategies.

Molecular Electronics :

Overview - organic vs inorganic devices-Rectifiers- Molecular wires-Molecular switches-Data storage –molecular engineering of doped polymers for optoelectronics - Fabrication process of OFETs –operation and characteristics - organic thin film transistors (OTFTs)

Reference books:

1. G. Cumberti and G. Fagas, *Introducing molecular electronics*, Spinger, 2005.
2. S.C. Levshevski, *Nano and molecular electronics hand book*, CRC press, 2007.
3. Wolfgang Brütting, *Physics of Organic Semiconductors,* Wiley - VCH, 2006.

4. Jiri George Drobny *Polymers for Electricity and Electronics: Materials, Properties, and Applications.*

OET 3.1 ORGANOMETALLIC CHEMISTRY **60 Hrs**
Total marks: 100
(Credits-4)

UNIT-I Methyl Derivatives of Metals **(15)**

Structures, bonding, classification of methyl derivatives of metals, cleavage of metal carbon bonds, thermochemical consideration. Catalytic processes: Carbonylation, hydrogenation, isomerisation of olefins, olefin oxidation, oligomerization, polymerization.

UNIT-II Organometallic Synthesis **(20)**

Radicals + metals, carbonyls, olefins complexes, addition of metal hydrides to unsaturated carbons, addition of metal alkyls to unsaturated hydrocarbons, substitution reactions, Hydrocarbons + metal Organometallic + metal, mettalation, metal halogen exchange reactions, Mercuration & related covalent metallation reactions of Organometallic compounds with metal salts, reactions of bimetallic compounds and halides, ligand exchange reactions of diazoalkanes with metal hydrides and halides, addition of M-OR to C=C, electrolyte reduction using metal cathode, decarboxylation.

UNIT-III Properties of Reactions of Organometallic Compounds **(15)**

Complex formation, reactions with active oxygen compounds, reactions with halogen, reactions with alkyl halides, acid halides, reactions with oxygen, carbonyls and others.

Metal carbonyls, Isocyanides and Acetylides:

Preparation, structure, reactions of metal carbonyls with alkyl halides, reactions of metal carbonyls with metal alkyls, cyanides and isocyanides complexes, acetalynide complex adduct formation. Complexes:2,3,4,5,6 and 7 electron donor carbametallic compounds, aromaticity of cyclopentadienyls.

UNIT-IV

Techniques of Organometallic Chemistry **(10)**

Methods of synthetic chemistry, vacuum techniques, inert atmosphere, non-aqueous media, handling and hazards of organ metallic.

Reference Books:

1. Paulson, Organometallic Chemistry -Arnold.
2. Rochow, Organometallic Chemistry - Reinhold.
3. Zeiss, Organometallic Chemistry - Reinhold.
4. Advances in Organometallic Chemistry A.P.
5. Organometallic Chemistry R. C. Mehrotra

OET 3.2 COMPUTATIONAL STRUCTURE BIOLOGY AND DRUG DESIGNING

60 Hrs
Total marks: 100
(Credits-4)

Unit -I: Introduction to Structural and Pathway Databases (15)
structural data, exploring the structural databases such as Protein Data Bank (PDB) at RCSB, Catalytic Site Atlas (CSA), Homology Derived Structures of Proteins (HSSP), Protein Data Bank Europe (PDBe), PDBeChem, PDBeFold, PDBeMotiff, PDBeNMR, PDBSum, SCOP and CATH. Introduction to biological Pathway Databases.

Unit -II: Structure Prediction Methods (20)
Statistical methods of Chou-Fasman, Garnier-Osguthorpe-Robson method, Neural network method, Position specific scoring matrices, Motifs and domains, folds and protein folding.
Molecular interaction:
Molecular interaction; protein-protein, protein-DNA, Protein-Lipid, Protein- Ligand, Protein-arbohydrate, DNA-Drug interaction, Metalloproteins, Pi … Pi interactions,C-H…Pi interactions.

Unit -III: Homology Modeling: (10)
Introduction to homology modeling, Fold recognition and Threading, RNA structure prediction, architectures and topologies of protein and DNA using molecular visualization software, Structure validation.

Unit -V: Drug Discovery and Drug designing: (15)
Natural products, drugs, principles of drug development, Drug discovery, mutation in drug targets, automated drug design, structure based and ligand based drug design methods, combinatorial chemistry, high throughput screening (HTS), *in silico* ADMET properties, QSAR, developing lead library, DOCKING; introduction to docking method to generate new structure, tools and molecular docking programs-AUTODOCK, HEX, Drug metabolism; Cytochrome p450, pharmacodynamics and pharmacokinetics, clinical trials, FDA approval.

Reference books:

1. Wilkins, M.R., Williams, K.L., Appel, R.D., Hochstrasser, D.F. (Editors) 1997
2. Proteome Research: New Frontiers in Functional Genomics. Springer Verlag Berlin Heidelberg.
3. Baxevanis, A.D. and Francis Ouellette, B.F. 2004 Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Second Edition, Wiley.
4. Graur, D. and Li, W-H. 2000 Fundamentals of Molecular Evolution. Sinauer Ass.,USA.
5. Essential Bioinformatics, Jin Xiong
6. Rastogi S. C., Mendiratta. N., Rastogi. P. 2005 Bioinformatics methods and application, Genomics, Proteomics, and Drug Discovery.

M.Sc. Part-II Sem III Nanotechnology

Practicals

HCP 3.1 APPLICATION OF NANO-TECHNOLOGY

60 Hrs
Total marks: 50
(Credits-2)

I. Hydrogen fuel cell studies using carbon nanomaterials.

i. Preparation of ceramic porous electrode
ii. Deposition of conducting carbon over porous ceramic electrode
iii. Deposition of different type of metals (Pt, Ni. Ag) on ceramic electrode
iv. Hydrogen oxidation and oxygen reduction in alkaline and acidic media and faradic efficiency calculation.
v. Influence of deposition of various types of carbon nanomaterials on faradic efficiency.

II. Measurement of hydrogen storage

i. In different types of CNM, using pressure technique.
ii. Measurement of absorbed hydrogen by CNM, using electrochemical method
iii. Measurement of hydrogen storage by gravimetric method.
iv. Measurement of hydrogen storage by electrical conduction measurement technique.

III. Nano-biotechnology-

i. Anti-bacterial activity of CNM: Microbial culture, Co-culture of microbes and CNM, survival observation s.
ii. Anti-fungal activity of CNM.: Fungal culture, Co-culture of microbes and CNM, survival observation.

HCP 3.2: NANO-TECHNOLOGY IN ELECTRONICS

60 Hrs
Total marks: 50
(Credits-2)

I. Super-Capacitor studies of Nano-materials

i. Fabricate an electrochemical cell with different type of carbon in alkaline and acidic media and
ii. Study potentiostatistically their current-voltage characteristics
iii. Calculate capacitance by charging/discharging process, using different carbon nanomaterials (CNM, CNF & CNB).

II. Electron Field Emission studies.

i. Deposit carbon nanomaterials (CNM, CNF & CNB) over alumina plate and
ii. Study its electron field emission.

III. Evaluation of semiconducting properties of CNM (CNM, CNF & CNB) deposited on alumina plate by.

i. Electrical method And

ii. Optical method

SCP 3.1: Nanotechnology in Environment Applications

60 Hrs
Total marks: 50
(Credits-2)

i. Review of Literature
ii. In this course, the students are expected to read and present research papers on current topics in Nanotechnology leading to environmental application
iii. Each student is expected to present minimum of 10 lectures of 30 min each followed by questions and discussion.
iv. Background knowledge related to the topic would be considered as the part of the presentation.
v. Marks distributions: Internal- 15 Marks, Seminar presentation-20 Marks, Record book write up -10 Marks and Viva -05 Marks

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SCP 3.2: Molecular Electronics **60 Hrs**

Total marks: 50
(Credits-2)

i) To determine energy-gap of PN-junction.

ii) To Study the characteristics of Optocoupler IC's.

iii) To Study the characteristics of polymer based photovoltaic diodes.

iv) To Study the characteristics of Field Effect Transistor (FET).

v) To determine temperature co-efficient resistance (TCR) of resistance temperature detector (RTD).

vi) To Study the characteristics of transistor.

vii) Study the characteristics of a photodiode and use as a light sensor (LDR).

OEP 3.1: Nanomaterials Synthesis **60 Hrs**

Total marks: 50
(Credits-2)

i) Synthesis & Characterizations of Pt nanocomposite

ii) Synthesis & Characterizations of TiO_2 nanocomposite

iii) Synthesis & Characterizations of Ti nanocomposite

iv) Synthesis & Characterizations of metal oxides nanocomposites

v) Synthesis & Characterizations of nanoceramics (Ferrites)

vi) Synthesis & Characterizations of nanoceramics (Mn ferrite)

vii) Synthesis & Characterizations of nanoceramics (Zn ferrite)

viii) Synthesis of organometallic synthesis

OEP 3.2: Computational structural biology and drug design **60 Hrs**

Total marks: 50
(Credits-2)

i. Review of Literature
ii. In this course, the students are expected to read and present research papers on current topics in Nanotechnology leading to Computational structural biology and drug design
iii. Each student is expected to present minimum of 10 lectures of 30 min each followed by questions and discussion.
iv. Background knowledge related to the topic would be considered as the part of the presentation.
v. Marks distributions: Internal- 15 Marks, Seminar presentation-20 Marks, Record book write up -10 Marks and Viva -05 Marks

M. Sc. Nanotechnology Part – II

SEMESTER IV

HCT 4.1 POLYMERS AND NANO-COMPOSITES **60 Hrs**
Total marks: 100
(Credits-4)

Unit – I: Introduction to Polymers (15)

Fundamentals of polymers - Importance of polymers, Classification of polymers. Applications- Chain Structure and configuration. Homo and hetero polymers – Copolymers - Chemistry of polymerization. Properties, Glass transition temperature (Tg) and melting point (Tm) – Factors affecting Tg and Tm, Importance of Tg. Molecular weights & degree of polymerization- Reactions and kinetics of polymerization

Unit –II: Polymeric Nanostructures (15)

The formation of ordered polymer structures at interfaces- Block copolymers for ordered polymeric nanostructures- Surface micelles and surface induced, Nano patterns- Surface nano and micro structuring with organo-metallic polymers, Conducting polymers. Applications of Nanocomposites: in propellants, Nano-composite magnets & Hydrophobic and hydrophilic polymers for drug delivery.

Unit – III: Polymer Matrix Nanocomposites (15)

Polymer/ clay nanocomposites- polypropylene layered silicate nanocomposites biodegradable polymer/layered silicate nanocomposites- poly(ethyl acrylate)/bentonitenanocomposites- poly(butylene terephthlate) (PBT) based nanocomposites - polymer/calcium carbonate nanocomposites. Carbon impregnated polymers: vapor grown carbon fiber composites & resin-carbon composite

Unit – IV: Metal Matrix & Ceramic matrix nanocomposites (15)

Metal-containing polymers: cryo-chemical synthesis, structure, and Physicochemical properties- nano-structured polymeric nano-reactors for metal nanoparticles formation- optical extinction of metal nanoparticles synthesized in polymer by ion implantation-optically anisotropic metal polymer. Nano-phase ceramic composites- Processing- micro-structural control of metal reinforced ceramic matrix nanocomposites- Machineable nano-composite ceramics-Silicon nitride and silicon carbide based ceramics- Functionally graded ceramics clay nanocomposites. Bullet proof composites

Reference books:

1. W.N. Chang, Nanofibres fabrication, performance and applications, Nova Science Publishers Inc, 2009.
2. Joseph H. Koo, Polymer Nanocomposites, Processing, characterization and Applications, McGraw-Hill, 2006.
3. C. F. Candau and R. H. Ottewill, ―*An introduction to polymer colloids*‖, Springer Berlin Heidelberg, New York, (2005).

HCT 4.2 : INDUSTRIAL NANOTECHNOLOGY **60 Hrs**
Total marks: 100
(Credits-4)

Unit-I Semiconductors and Magnetic Nanostructures (20)

Semiconductor fabrication techniques. Electronic structure and properties of semiconductor nanostructures. Principles and performance of semiconductor nanostructures based electronic and electro-optical devices.
Magnetism in solids-magnetic domains. Nanomagnetic properties of materials-nanostructure relationships. Fabrication and properties of nanostructured magnets. Photoinduced magnetism and spintronics. Nanomagnetic probes. Electronic magneto transport and micro magnetic modeling.

Unit-II Nanosensors and Actuators (15)

Micro and nano electromechanical systems-fabrication process, choice of materials, calculations, performance of different nanostructures, advantages and limitations of various approaches. Applications-thermal, radiation magnetic, chemical and mechanical nanosensors and micro actuators.

Unit-III Molecular electronics (15)

Conducting and semiconducting polymers-hybridization, conjugation and excitations. Molecular crystals. Organic electroluminescent displays-injection, transport, exciton formation and light emission. Influence of supramolecular order- excimers, H and J aggregates. Liquid crystal display.

Unit-IV Industrial Applications (10)

Nanomaterials in bone substitutes & dentistry. Antimicrobial applications of nanomaterials. Food and cosmetic applications of nanomaterials. Application of nanomaterials in textiles, paints, catalysis, lubricants, fuel cells and batteries.

Reference books:

1. J. Verdeyen, “Laser Electronics”, II Edition, Prentice Hall, 1990.
2 C.W. Turner, T. Van Duzer, “Principles of Superconductive Devices and Circuits”, 1981
3 Reynolds, M.Pomeranty, “Electro responsive molecules and polymeric systems”, Skotheim T. Marcel Dekker New York, 1991.
4 A . Yariv, “Principles of Optical Electronics”, John Wiley, New York, 1984
5 M C Petty, M R Bryce, D Bloor (eds.), 'Introduction to Molecular Electronics', Edward Arnold, London, 1995 (ISBN 0-340-58009-7)
6 G Hadziioannou, P F van Hutten, 'Semiconducting Polymers: Chemistry, Physics, and Engineering', Wiley-VCH, 2000 (ISBN 3-527-29507-0)
7 D. D. C Bradley, Current Opinion in Solid State & Materials Science Vol. 1, 789 (1996)

HCT 4.3: THIN FILM TECHNOLOGY **60 Hrs**

Total marks: 100

(Credits-4)

Unit- I Definition of thin films **(10)**

Environment (gas phase and plasma) for thin film deposition; requirement for substrate; substrate cleaning; deposition parameters and their effects on film growth ,nanocrystalline thin film.

Structure of thin films:

Formation of thin films (sticking coefficient, formation of thermodynamically stable cluster-nucleation); microstructure, surface roughness; density; stress in thin films; adhesion; stoichiometry; metastable structure.

Unit -II Physical parameters for evaluation of thin film **(10)**

Mechanical, electrical, thermal, chemical, optical.

VACCUME TECHNOLOGY: Concept of different vaccum pumps; rotary, diffusion,turbo molecular pump, cryogenic pump, ti-sublimation pump, gas kinetics; concept of different gauges : pirani, penning, pressure control.

Unit -III Physical vapour deposition (PVD) techniques **(15)**

Thermal evaporation, resistance evaporation; electron beam evaporation; laser ablation; ion vapor evaporation and cathodic arc deposition. Electrical discharges used in thin film deposition: Sputtering; glow discharge Sputtering; magnetron Sputtering; ion beam Sputtering; ion plating; oxidizing and nitriding.

Unit -IV Atomic layer deposition (ALD) **(25)**

Importance of ALD technique, atomic layer growth: physics and technology. Chemical vapor deposition techniques: Advantages and disadvantages of Chemical vapor deposition techniques (CVD) over PVD techniques, reaction types, boundaries and flow, different kinds of CVD techniques: metalorganic (MO) CVD, photo assisted CVD, thermally activated CVD, plasma enhanced(RF, wave) CVD, low pressure(LP) CVD, atmospheric pressure(AP) CVD and Pulsed laser deposition technique.

Processing technologies:

Pattern transfer: reactive ion etching, ion milling, ion beam dry itching, Molecular beam epitaxy.

Applications: Thin Film Photo voltaic cells, Thin film Batteries.

Reference books:

1. Chopra K.L., "Thin film phenomenon", Tata McGraw-Hill, 1968.
2. Chang C.Y. and Sze S.M., 'VLSI technology' Tata McGraw-Hill,1996.
3. Ghandhi S.K. , VLSI fabrication principles; silicon and gallium arsenide, 2nd Edition, John Wiley and Sons, 1994.
4. G.L. and Carlson R.W. "Methods of experimental physics" vol 14.' 3.Vaccume physics and technology'J.F.O'Hanlon." A Users guide
to vaccume technology "John Wiley and Sons, 1989.
5. Roth A., "Vaccume Technology" north-holland, 1990.
6. Delchar T.A., "vaccum physics and techniques", Chapman and hall, 1993.

SCT 4.1 NANODEVICES AND NANOSENSORS **60 Hrs**

Total marks: 100 (Credits-4)

Unit-I Quantum devices **(15)**

Quantum Electronic devices – Electrons in mesoscopic structures – Short channel, MOS Transistor – split Gate Transistor – Electron wave transistor – Electron spin transistor – Quantum Dot array – Quantum computer- Bit and Qubit. Carbon Nanotube based logic gates, optical devices. . Connection with quantum dots, quantum wires, and quantum wells

Unit-II Superconducting devices and photonics **(15)**

Basics - Macroscopic model- Super conducting switching Devices – Cryotron- Josephson Tunneling Devices- Elementary circuits – Associative or Content – Addressable Memory - SQUID – Flux Quantum device –LC –Gate – Magnetic Flux Quantum – Quantum cellular Automata- Quantum computer with Single Flux devices – SFQD- RSFQD – Application of superconducting devices

Unit-III Nanosensors -I **(15)**

Micro and nano-sensors, Fundamentals of sensors, biosensor, micro fluids, Packaging and characterization of sensors, Method of packaging at zero level, dye level and first level. Sensors for aerospace and defense: Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers, nano-cutting tools, Integration of sensor with actuators and electronic circuitry.

Nanosensors- II:

Sensor for bio-medical applications: Cardiology, Neurology and as diagnostic tool, For other civil applications: metrology, bridges etc. Biosensors. Clinical Diagnostics, generation of biosensors, immobilization, characteristics, applications, conducting Polymer based sensor, DNA Biosensors, optical sensors. Biochips. Metal Insulator Semiconductor devices, molecular electronics, information storage, molecular switching, Schottky devices,

Unit-IV Nanolithography **(15)**

Basics of lithography, optical, micro, ion beam lithography, lithographic tools, nanoimprint lithography – polymeric nanofiber templates – focused ion beam doping wet chemical etching – stencil lithography and sacrificial etching – large scale integration – future challenges - applications

Reference books:

1. K. Goser, P. Glosekotter and J. Dienstuhl, “Nanoelectronics and Nanosystems-From Transistors to Molecular Quantum Devices” , Springer, 2004.
2. Herve Rigneault, Jean-Michel Lourtioz, Claude Delalande, Ariel Levenson,“Nanophotonics”, ISTE.
3. W.R.Fahrner, “Nanotechnology and Nanoelectronics – Materials, Devices and Measurement Techniques” Springer, 2006
4. Sensors: Micro & Nanosensors, Sensor Market trends (Part 1&2) by H. Meixner.
5. Nanoscience & Technology: Novel structure and phenomea by Ping Sheng (Editor)
6. Nano Engineering in Science & Technology : An introduction to the world of nano design by Michael Rieth.
7. Tai –Ran Hsu, “MEMS & Microsystems Design and Manufacture”, Tata McGraw-Hill publication, 2001.
8. P. Rai-Choudhury, “MEMS and MOEMS technology and applications”, PHI learning private Ltd, 2009.
9. Mohamed Gad-el-Hak, “The MEMS Handbook”, CRC Press, 2002.

SCT 4.2 ANIMAL BIOTECHNOLOGY **60 Hrs**

Total marks: 100

(Credits-4)

Unit - I Tissue Culture Laboratory (15)

Introduction of animal cells & Tissue Culture Laboratory, Equipments and Materials for animal Cell Culture Technology, Design of Tissue Culture Laboratory, Equipments: Laminar Flow Hoods, CO_2 incubator, Open and closed cultures, Microscopes, centrifuge, Refrigerators and Freezers, pipetting aids, Miscellaneous small items of Equipment's, Materials, filters, Miscellaneous Items. Basic Aseptic Techniques, Storage, shipping and safety.

Unit - II Introduction to Tissue Culture Techniques (15)

Definition, principle and significance of tissue culture. Maintenance of sterility and use of antibiotics, Mycoplasma and viral contaminants. Various systems of tissue culture – their distinguishing features advantages and limitations. Culture medium: Logic of formulation (natural media, synthetic media, and sera). Methodology: i. Primary culture: Behaviour of cells, properties, utility. ii Explant culture. iii. Suspension culture.

Unit - III Animal Cell & Organ Culture (20)

Cell lines: Definition, development, maintenance and management and Cell adaptation. Established cell lines: Their characteristic features and utility, Cross contamination hazards. Characteristics of cells in culture. Contact inhibition, anchorage dependence & independence, cell-cell communication etc, Cell senescence. Cell and tissue response to tropic factors, Culturing of different cells. Designing of an experiment in tissue culture and response assessment. Significance of various controls. Growth studies: Cell proliferation, cell cycle, mitosis in growing cells. Organ culture: Methods, behavior of organ explant, and utility of organ culture. Organ transplants. Freeze storing of cells and transport of cultures. Mass production of biologically important compounds. Harvesting of products, purification and assays. Propagation of viruses (viral sensitivity of cell lines). Cell cloning and cell synchronization. Separation of cell types: Various methods: advantages and limitations; Flow cytometry. Nuclear transplantation, Cell hybridization, Transfection studies.

Unit - IV Applications of Tissue Culture (10)

Commercial applications of animal tissue culture: Tissue culture as a screening system. Cytotoxicity and diagnostic tests. Development and preparation of vaccines against infecting organisms, mammalian cloning. Establishment of cell lines from tissues of genetic diseases. Workings of a commercial laboratory (Design, aseptic techniques and control of contamination, quarantine, pathological indexing, packaging, cost analysis, marketing).

Transgenic Animals & Applications :

Introduction to transgenic animals, Method of production, Examples of transgenic animals and their commercial applications, ethical issues of transgenic animals.

Reference books:

1. Kuchler, R.J., Biochemical Methods in cell culture and Virology, Dowden, Huchinson and Ross,Inc. Strausberg, USA, 1977.
2. Morgan, S.I.Animal cell culture, 1993,Bio Scientific Publishers Ltd, Oxford.
3. Freshney,R.I.Culture of Animal cells:A Manual of Basic Technique, 1994, John Wiley and Sons Inc. Publication, USA.
4. Butler, M.Mammalian, cell Biotechnology: A Practical Approach (1991), IRL Press, Oxford.
5. Jenni P.Mather and David Barnes, eds; Animal cell culture Methods, Methods in cell Biology, vol.57, Academic Press.
6. Cell Culture: Methods in enzymology,Vol-58,Academic Press 1979 or recent

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MP 4.1 RESEARCH PROJECT

Total marks: 200
(Credits-8)

- Each student will begin research project during 3rd semester & submit at the end of 4th semester.
- Projects will be related to Nanotechnology.
- Research out-put will be presented in the form of a dissertation. At the end of semesters students have to present their research out come in the form of oral presentation during practical examinations. Weightage will be given on the basis of Aims & objectives, Review of literature, methodology, Research results, discussion & Summary & Conclusion.