LIST OF SUBJECTS

Code No.	Subject Name	Credit
NT301	Introduction to Nanostructured Materials	4:0:0
NT302	Synthetic Methodologies for Nanomaterials	4:0:0
NT303	Biology for Nanotechnology	4:0:0
NT304	Engineering Principles for Nanotechnology	4:0:0
NT305	Synthesis of Nanomaterials	0:0:4
NT306	Fabrication and Imaging Techniques for Nanotechnology	4:0:0
NT307	Thermodynamics and Quantum Mechanics for Nanoscale systems	4:0:0
NT308	Nanobiotechnology	4:0:0
NT309	Nano Electronics	4:0:0
NT310	Advanced Experiments & Simulation Techniques for Nanoparticle Charaterization	0:0:4
NT311	Nanolithography	4:0:0
NT312	Nanotechnolgy for Advanced Drug Delivery Systems	4:0:0
NT313	Experimental Techniques for Nanobiotechnology.	0:0:4
NT314	Nanobiomaterials	4:0:0
NT315	Chemical Principles of Self Assembly Systems	4:0:0
NT316	Nanosensors and Transducers	4:0:0
NT317	Industrial Nanotechnology	4:0:0
NT318	Nanocomposites	4:0:0
NT319	Molecular Photonics	4:0:0

NT301 INTRODUCTION TO NANOSTRUCTURED MATERIALS

Credit 4:0:0

Unit I - Introductory Aspects

Free electron theory and its features, Idea of band structure – Metals, Insulators and Semiconductors. Density of state in bands and its variation with energy, Effect of crystal size on density of states and band gap – Electronic structure of nanoparticles

Unit II - Bulk Nanostructured Materials

Solid disordered Nanostructures – Nanostructured crystals – Nanostructured Ferromagnetism; optical and vibrational spectroscopy; Infrared frequency range – Luminescence – Quantum wells, wires and Dots – Size ad dimensionality effects – Excitons – Single electron tunneling – Applications – Superconductivity; Self assembly and catalysis

Unit III - General Characterization Techniques

UV – Vis- NIR - absorption and reflectance Spectroscopy, X- Ray Diffraction studies – Bragg's law – particle size – Scherrer's equation – Photoluminescence (PL) studies –Fourier Transform Infrared Spectroscopy(FTIR) – FT Raman studies –Surface Enhanced Infrared spectroscopy, Resonance Raman Spectroscopy.

Unit IV - Luminescence of Semiconducting Nanoparticles
Fluorescence of semiconducting nanoparticles – Photoluminescence of doped semiconductor nanoparticles – Shift in photoluminescence peaks - Electro luminescence – Nanoparticle LED – Thermo luminescence –Cathode luminescence – Magneto luminescence

Unit – V - Nano Devices
Background – Quantization of resistance - Single electron transistors – Esaki and resonant tunneling diodes – Magnetic Nanodevices – Magneto resistance – Spintronics – MEMS and NEMS

Reference Books

1. Introduction to Nanotechnology, Charles P.Poole, Jr. and Frank J.Owens, Wiley, 2003
2. Silicon VLSI Technologies, J.D.Plummer, M.D.Deal and P.B. Griffin, Prentice Hall, 2000
3. Introduction to Solid State Physics, C.Kittel, a chapter about Nanotechnology, Wiley, 2004
4. Nanotechnology - Molecularly Designed Materials – G.M.Chow and K.E.Gonslaves (American chemical society)
5. Physics of semiconductor Nanostructures: K.P.Jain, Narosa Publishers, 1997
6. Quantum dot heterostructures – B.Bimerg, M.Grundmann and N.N.Ledentsov – John Wiley & Sons, 1999
7. Nanoparticles and Nanostructured films – preparation, characterization and application – J.H.Fendler – John Wiley & Sons 1998
8. Encyclopedia of NSNT Volume 4 - Hari Singh Nalwa, American Scientific Publishers, 2004 (for Unit IV)

NT302 SYNTHETIC METHODOLOGIES FOR NANOMATERIALS

Credit 4:0:0

Unit I - Chemical methods
Sol-gel technique – control of grain size – co-precipitation hydrolysis – sonochemical method combustion technique – colloidal precipitation – template process – growth of nanorods – solid-state sintering – grain growth.

Unit II - Carbon and related materials
Arc method – carbon nanotube – other nanotubes and nanorods – nanosprings – rings – chemical routes for nanotubes and nanorods – Ion beam induced nanostructures.

Unit III - Mechanical methods
Grinding – high energy ball milling – types of balls – WC and ZrO_2 – material-ball ratio – medium for grinding – limitations in getting required grain size for low melting point materials – typical systems – severe plastic deformation –melt quenching and annealing

Unit IV - Ultra high vacuum system

Ultra high vacuum systems – design – Joule heating – evaporation boats – cold finger – role of inert gases – powder collection –making a pellet – prevention of contamination from air – limitations of Joule heating – laser ablation - RF/DC magnetron sputtering – microwave plasma evaporation – control of grain size – scale-up process.

Unit V - Nanopolymers

Nanopolymers – Preparation and characterization of diblock Copolymer based nanocomposites, Nanoparticles polymer ensembles; Assembly of polymer – Nanoparticles composite material; Fabrication of polymer-mediated organized Nanoparticles assemblies; Applications of Nanopolymers in Catalysis.

Reference Books

1. Vacuum Technology & Coating, 2000, Cowan & Co
2. Vacuum Technology: Practice for Scientific Instruments, Nagamitsu Yoshimura,2007, Gardners books
3. Progress in Materials Science Research, Antonio C. Venetti, 2007, Nova Science Publishers
4. The Chemistry of Nanomaterials: Synthesis, Properties and Applications. C. N. R. Rao, A. Muller, A. K. Cheetham (Eds.), (2004) WILEY-VCH Verlag GmbH & Co., Weinheim
5. Nanostructured Materials, Jackie Yi-Ru Ying, 2001, Academamic press
6. Nanostructured materials, Philippe Knauth, Joop Schoonman, 2002, Springer
7. Nanostructured materials, C. C. Koch, 2006, William Andrew Inc
8. Polymer – clay Nanocomposite – T.J. Pinnayain, G.W. Beall, Wiley, New York 2001.
9. Block Co-polymers in Nanoscience – Massimo Lazzari, Guojun Liu, Sebastien Lecommandoux, Wiley, New York 2007
10. Recent Advances in the liquid –phase synthesis in inorganic nanoparticles. Brain L. Cushing, Vladimir L. Kolesnichenko, Charles J.O'Connor, Chem Rev. 104 (2004) 3893-3946
11. Preparation of thin films. J.George, Marcel Dekker, Inc., New York. 2005

NT303 BIOLOGY FOR NANOTECHNOLOGY

Credit 4:0:0

Unit I

Structure and organization of prokaryotic and eukaryotic cell (Animal cell & plant cell), tissues and organs, Cell and Tissue Culture – Application of plant Transformation for Productivity and performance - Green House and Green House Technology. Animal Cell Culture Technology – Applications of Animal Cell Culture-Stem Cell Culture, Artificial organ synthesis,

Unit II

Introduction Gene- protein-central dogma of cell-molecular targets- estimation of RNA, estimation of DNA, Protein Estimation.

Unit III

Recombinant DNA technology, Scope and Milestones in Genetic Engineering -Molecular tools used in Genetic Engineering - Gene cloning – Ethical issues – Merits and Demerits of cloning – Transgenic organisms. Genomics and Functional Genomics- Whole genome analysis – Human Genome Project, Gene therapy, Gene delivery.

Unit IV

Basic Immunology and immune system – Antigen, antibody structure and its types, humoral immunity, Cell mediated immunity, introduction, to complement system- MHC & graft transplantation and graft rejection.

Unit V

Biosynthesis of Nanoparticles, Microbial Nanoparticle production Biomineralization, Magnetosomes, Nanoscale magnetic iron minerals in bacteria, virus & fungi. DNA based Nano structures. Protein based Nano structures.

Reference Books

1. Kuby J, Immunology, WH Freeman & Co., 2000
2. Tizard, Immunology., 4th Edition.
3. Stanir R.Y. Ingraham J.L. Wheelis M.L. Painter R.R. General Microbiology, McMillan Publications, 1989.
4. Foster C.F. John ware D.A. Environmental Biotechnology, Ellis, Honwood Ltd. 1987
5. Pelczar MJ, Chan ECS And Krein NR, Microbiology, Tata McGraw Hill Edition, New Delhi, India; 2001
6. V Nano bio-technology: Concepts, Applications and Perspectives, Christ of M. Niemeyer, Wiley, 2004
7. Robert.W.Kelsall, Ian.W.Hamley, Mark Geoghegan, Nano Scale Science And Technology, John Wiley and son, ltd., 2005 H.Fujita (Ed), Micromachines As Tools For Nanotechnology, Springer, 2003
8. Mick Wilson Kamali Kannangara , Geooff Smith Michelle Simmons, Urkhard Raguse , Nano Technology, Overseas India private Ltd., 2005.
9. Gunter Schmid (Ed), Nano Particles , Jhon wiley and sons limited, 2004
10. K.K.Jain, Nano Biotechnology, Horizions Biosciences, 2006
11. "From Genes to Clones" by Ernat-.L.Winnacker, Panima Publishing Corporation, India, 2003.
12. "Biotechnology : Fundamentals and Applications" by S.S. Purohit , Agrobios(Ind), Jodhpur, 2002
13. Principles of cloning by Jose Cibelli,Robert P.Lanza, Keith H.S. Campbell, Michael D.West, Academic Press, 2002.
14. Bojwani, S.S. 1990. Plant Tissue Culture : Applications and Limitations.
15. Elsevier,Amsterdam
16. Old RW, Primrose SB, "Principles Of Gene Manipulation, An Introduction To Genetic Engineering ", Blackwell Science Publications, 1993.

NT304 ENGINEERING PRINCIPLES FOR NANOTECHNOLOGY

Credit 4:0:0

Unit I - Thin Film Technology
Electro plating, Electroless plating, Langmuir- Blodget films,Thermal growth, Chemical vapour deposition, sputtering deposition, molecular beam epitaxy atomistic nucleation process, cluster coalescence and deposition, grain structure of films and coatings, amorphous thin films.

Unit II - Analysis of Thin films
Mehanical, electrical, magnetic and optical properties of Thin film , Analysis of thin films.

Unit III - Vacuumed Technology
Pump selection and exhaust handling , rotary oil pumps, roots pump, diffusion pumps, turbo molecular pump, cryo pump, sputter-ion pump, pressure measurements, thermodynamics of evaporation, evaporation rate, alloys, compounds, sources, transport and deposition monitoring.

Unit IV - MEMS
MEMS and Microsystems – Evolution of Micro Fabrication – Micro Systems and Microelectronics. Application of MEMS in Various Fields. Introduction – Substrate and Wafer, Active Substrate Material. Silicon as a substrate material, MEMS packaging. Case study on pressure sensor with packaging.

Unit V - Silicon Technology
Semiconductor as base material- band diagram of semiconductor- band diagram of inhomogeneous semiconductor- different types of components in semiconductor, different types of transistor integration- technological processes for microminiaturization- methods and limits of microminiaturization in silicon.

Reference Books

1. Tai-Ran Hsu, "MEMS & Microsystems – Design and Manufacture," Tata McGraw Hill, 2002
2. Karl glosekotter, "Nanoelectronics and Nanosystems",.Springer, 2004
3. M.Ohring The material science of thin films, Academic press, Boston, 1991

NT305 SYNTHESIS OF NANOMATERIALS

Credit 0:0:4

12 experiments will be notified by the HOD from time to time

NT306 FABRICATION AND IMAGING TECHNIQUES FOR NANOTECHNOLOGY

Credit: 4:0:0

Unit I

Si processing methods – Cleaning/etching – Oxidation-oxides – Gettering –doping – Epitaxy. Top-down techniques – Photolithography – Other optical lithography's (EUV, X-ray, LIL) – Particle beam lithographies (e-beam, FIB, shadow mask evaporation) – Probe lithography's. Processing of III-V semiconductors including nitrides

Unit II

Molecular-beam epitaxy – Chemical beam epitaxy – Metal-organic CVD (MOCVD) – Bottom-up techniques – Self-assembly – Self-assembled monolayers – Directed assembly – Layer-by-layer assembly – Combinations of top-down and bottom-up techniques – Current state of the art

Unit III

Spectroscopy of Semiconductors – excitons – infrared surface spectroscopy – raman Spectroscopy – Brillouin spectroscopy – Dynamic Light Scattering (DLS) – NMR Spectroscopy – ESR Spectroscopy –photo electron spectroscopy(XPS)-SEM,TEM,STM,Atomic force microscopy(AFM).

Unit IV

Mechanical Characterization – modulus and load carrying capability of nano region/ compression micro hardness – fatigue – abrasion and wear resitance – superplasticity – nanoindentation.

Nanotribology – Nanotribometre – Surface Force apparatus – Quartz Crystal microbalance – Friction force microscope.

Unit V

Neutron and X- ray diffraction – Debye Scherrer formula – dislocation density – microstrain macromolecular crystallography using synchrotron radiation – role for neutron scattering in nanoscience. Optical absorption and emission spectroscopy – photoluminescence – Thermoluminescence – X – ray absorption Fine Structure (XAFS) – extended X- ray absorption fine structure (EXAFS) – electron scattering for chemical Analysis (ESCA)

Reference books

1. T. Tsakalakos, I. Ovid'ko and A.K. Vasudevan (eds.), "Synthesis, Functional Properties and Applications of Nanostructures", Kluwer Academic Publishers, Dordrecht, 2003
2. Richard Xylen, "Physics of Amorphous Solids"
3. Gang Moog Chow, "Nanostructured Films & Coatings"
4. H.A. Willard and L.L. Merrit, J.A. Dean, "Instrumental methods of Analysis", Van Nonstrand, New York, 1986
5. R.M. Silverstein, G.C. Bassler, T.C. Morril, "Spectrometric Identification of Organic Compounds", John Wiley, New York, 1991
6. Michael Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons and Burkhard Raguse, "Nanotechnology – Basic Science and Emergin Technologies", Chapman & Hall (CRC), 2004
7. Nano: The Essentials, T. Pradeep. Tata McGraw Hill, New Delhi, 2007
8. Introduction to Nanotechnology, Charles P Poole Jr and Frank J Ownes, John Wiley Sons, Inc., 2003

9. Nanocomposite Science and Technology, Pulickel m.Ajayan, Linda S.Schadler, Paul V.Braun, Wiley – VCH Verlag, weiheim, 2003
10. Nanotechnology: Basic sciences and emerging technologies, Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkar Raguse, Overseas Press, 2005.
11. H.A. Willard and L.L. Merrit, J.A. Dean, "Instrumental methods of Analysis", Van Nonstrand, New York, 1986
12. Ewing G, "Instrumental Methods for Chemical Analysis", 5th edition, New york: McGraw Hill, 1985

NT307 THERMODYNAMICS AND QUANTUM MECHANICS FOR NANO SCALE SYSTEMS

Credit 4:0:0

Unit I - Review of the Laws of Thermodynamics and their Consequences

Energy and the first law of thermodynamics – Heat content and Heat capacity – Specific heat – Entrophy and the second law of thermodynamics – Thermodynamic potentials and the reciprocity relations – Maxwell's relations – Deductions – Properties of thermodynamic relations – Gibb's – Helmholtz relation – Thermodynamic equilibrium – Nernst's Heat Theorem and third law – Consequences of third law – Nernst's - Gibb's phase rule – Chemical potential.

Unit II - Statistical Description of Systems of Particles

Statistical formulation of the state system – phase space – Ensemble – average value – density of distribution in phase space – Liouville Theorem – Equation of motion and Liouville theorem – Equal apriori probability – Statistical equilibrium – Ensemble representations of situations of physical interest – isolated system – Systems in contact.

Unit III - Quantum mechanics

Quantum Mechanics -Review of classical mechanics -de Broglie's hypothesis -Heisenberg uncertainty principle -Pauli exclusion principle -Schrödinger's equation -Properties of the wave function -Application: quantum well, wire, dot -Quantum cryptography

Unit IV - Electrical and magnetic properties

Electronic and electrical properties-One dimensional systems-Metallic nanowires and quantum conductance - dependence on chirality -Quantum dots -Two dimensional systems - Quantum wells and modulation doping -Resonant tunnelling -4.Magnetic properties Transport in a magnetic field -Quantum Hall effect. -Spin valves -Spin-tunnelling junctions - Domain pinning at constricted geometries -Magnetic vortices

Unit V - Mechanical and Optical Properties

Mechanical properties -Individual nanostructures - Bulk nanostructured materials-Ways of measuring-Optical properties-Two dimensional systems (quantum wells)-Absorption spectra -Excitons -Coupled wells and superlattices - Quantum confined Stark effect

Reference Books

1. Fundamentals of Statistical and Thermal Physics – Federick Reif.
2. Statistical Mechanics – Bipin K. Agarwal and Melvin Einsner
3. Statistical Thermodynamics – M.C. Gupta.
4. Introduction to Nanotechnology, Charles P.Poole, Jr. and Frank J.Owens, Wiley, 2003
5. Silicon VLSI Technology, J.D.Plummer, M.D.Deal and P.B. Griffin, Prentice Hall, 2000
6. Introduction to Solid State Physics, C.Kittel, a chapter about Nanotechnology, Wiley, 2004

NT308 NANOBIOTECHNOLOGY

Credit 4:0:0

Unit – I

Biology inspired concepts – biological networks-biological neurons- the function of neuronal cell- biological neuronal cells on silicon modelling of neuronal cells by NLSI circuits – bioelectronics- molecular processor – DNA analyzer as biochip – molecular electronics

Unit – II

Nano biometrics – Introduction – lipids as nanobricks and mortar: self assembled nanolayers- the bits that do think – proteins- three dimensional structures using a 20 aminoacid-biological computing – a protein based 3D optical memory using DNA to build nano cubes and hinges – DNA as smart glue – DNA as wire template – DNA computers

Unit – III

Natural Nanocomposites – Introduction – natural nano composite materials- biologically synthesized nanostructures- biologically derived synthetic nanocomposites- protein based nanostructure formation – biologically inspired nanocomposites – nanotechnology in Agriculture (Fertilizers and pesticides)

Unit – IV

Nano analytics – quantum dot biolabeling – nanoparticle molecular labels – analysis of biomolecular structure by AFM and molecular pulling- force spectroscopy – biofunctionalized nanoparticles for Surface Enhanced Raman Scattering and Surface Plasmon Resonance

Unit – V

Molecular Manufacturing – Nano simulation; Is nanotechnology bad or good? – Implications of nanotechnology: Health and safety implications from nanoparticles: Health issues – Environmental issues – Need for regulation – Societal implications: Possible military applications – Potential benefits and risks for developing countries – Intellectual property issues – Criticism of Nanotechnology – Studies on the implications of Nanotechnology

Reference Books

1. Nanobiotecholog : Concepts, Applications and perspectives, Christ of M.Neimeyer, Chad.A.Mirkin (eds.,) Wiley VCH Weinheim (2004)
2. Bionanotechnology: concepts, Lessons from Nature, by David.S.Goodsell, Wiley-Liss (2004)

3. Nanobiotechnology Protocols, Sandra J Rosethal, David W Wright, Series Methods in Molecular Biology (2005)
4. R.S. Greco, F.B.Prinz and R.L.Smith, Nanoscale Technology in Biological Systems, CRC press, 2005.
5. Protein Nanotechnology Protocols, Instrumentation and Application, Tuan Vo-Dinh, Series ; Methods in Molecular Biology (2005)

NT309 NANOELECTRONICS

Credit 4:0:0

Unit I

Basics of nanoelectronics – capabilities of nano electronics – physical fundamentals of nano electronics – basics of information theory – the tools for micro and nano fabrication – basics of lithographic techniques for nanoelectronics

Unit II

Quantum electron devices – from classical to quantum physics: upcoming electronic devices – electrons in mesoscopic structure – short channel MOS transistor – split gate transistor – electron wave transistor – electron spin transistor – quantum cellular automate – quantum dot array – Principles of Single Electron Transistor (SET) – SET circuit design – comparison between FET and SET circuit design

Unit III

Nanoelectronics with tunneling devices and superconducting devices – tunneling element technology - RTD: circuit design based RTD – Defect tolerant circuits.
Molecualr electronics – elementary circuits – flux quantum devices – application of superconducting devices – Nanotubes based sensors, fluid flow , gas temperature; Strain – oxide nanowire, gas sensing (ZnO,TiO_2,SnO_2,WO_3), LPG sensor (SnO_2 powder)- Nano designs and Nanocontacts – metallic nanostructures

Unit IV

A survey about the limits – Replacement Technologies – Energy and Heat dissipation – Parameter spread as Limiting Effect – Limits due to thermal particle motion – Reliability as limiting factor – Physical limits – Final objectives of integrated chip and systems

Unit V

Memory devices and sensors – 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

Reference Books

1. Nanoelectronics and Nanosystems, Karl Goser, Peter Glosekotter, Jan Dienstuhl., Springer, 2004
2. Nanoelectronics and information technology : Advanced electronic materials and novel devices (2^{nd} edition) Rainer Waser (ed.) Wiley VCH Verlag Weiheim (2005)

3. Nanotechnology: basic science and emerging technologies – Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005)

NT310 ADVANCED EXPERIMENTS AND SIMULATION TECHNIQUES FOR NANOPARTICLE CHARACTERIZATION

Credit 0:0: 4

12 experiments will be notified by the HOD from time to time

NT311 NANOLITHOGRAPHY

Credit 4:0:0

Unit I

Lithography – Printing – chemical process – refinements – The modern process – optical, micro, nanolithography – Lithography in artistic medium – nanometer design for electronic circuits.

Unit II

Optical lithography – Light sources – photo mask and alignment, Resolution in projection systems – positive and negative photo resists – ultraviolet lithography – X-ray lithography – Synchrotron radiation – Ion beam lithography.

Unit III

Microlithography – Microchips – Electron beam lithography – Ion beam lithography – Maskless lithography – immersion lithography – Semiconductor processing – MEMS design.

Unit IV

Nanolithography, Nanosphere lithography – Molecular self-assembly Nanoimprint lithography, Dip-pen nanolithography, soft lithography, Stereo-lithography, nanoscale 3D shapes – NEMS design.

Unit V

Tools for nanolithography, molecular manipulation by STM and AFM - LB flim resists - nanopattern synthesis – Nano scratching.

Reference Books

1. Microlithography Sciences and Technology – Sheats J.R and Amith B.W.Marcel Dekker Inc. New York 1998.
2. Nanolithography: A Borderland between STM, EB, IB, and X-Ray Lithographies – M.Gentili (Ed) Carlo Giovannella Stefano Selci, Springer; I edition (1994)
3. Handbook of Microlithography, Micromachining, and Microfabrication (4 vols.0 – P Rai – Choudhury – 1997 – Bellingham, Wash., USA: SPIE Optical Engineering Press; London.

NT312 NANOTECHNOLGY FOR ADVANCED DRUG DELIVERY SYSTEMS

Credit : 4:0:0

Unit I :Principles of drug delivery systems: modes of drug delivery, ADME hypothesis – controlled drug delivery, site specific drugs , barriers for drug targeting, passive and active targeting, Strategies for site specific, time and rate controlled delivery of drugs, antibody-based and metabolism-based targeting

Unit II : Targetted Nanoparticles for drug delivery: Nanoparticles surface modification, bioconjugation, pegylation, antibodies, cell-specific targeting and controlled drug release, Multi-Functional Gold Nanoparticles for Drug Delivery: Virus Based-nanoparticles

Unit III : Dendrimers as Nanoparticular Drug Carriers: – Synthesis – Nanoscale containers — Naoscafold systems – Gene transfection, Biocompatibility Polymer Micelles as Drug Carriers, Polymers nanotubes- Magnetic Nanoparticles as Drug Carriers

Unit IV : Liposomes for drug delivery and targeting: classification and preparation of liposomal nanoparticles. Liposomes for pharmaceutical and cosmetic applications, Liposomal Drug Carriers in Cancer Therapy, lipid-DNA complexes, viral gene transfection systems, Lipid based drug delivery systems for peptide and protein drug delivery, Liposomal anticancer and antifungal agents

Unit V : Nanoparticle and targeted systems for cancer diagnosis and therapy: Targeted delivery through enhanced permeability and retention. Folate receptors, Targeting through angiogenesis, Targeting to specific organs or tumor types, Tumor-specific targeting: Breast cancer, Liver, Targeting tumor vasculature for Imaging, Delivery of specific anticancer agents: such as Paclitaxel, Doxorubicin,5-Fluorouracil etc

References

1. Drug Delivery and Targetting, A.M.Hillery, CRC Press, 2002.
2. NANOTHERAPEUTICS: Drug Delivery Concepts in Nanoscience edited by Alf Lamprecht ISBN 978-981-4241-02-1 981-4241-02-4
3. Nanoparticulate Drug Delivery Systems Deepak Thassu, Michel Deleers (Editor), Yashwant Pathak (Editor) ISBN-10: 0849390737 ISBN-13: 9780849390739
4. Bio-Applications of Nanoparticles **Warren C.W. Chan** ISBN: 978-0-387-76712-3
5. Lisa Brannon-Peppas, James O. Blanchette Nanoparticle and targeted systems for cancer therapy Advanced Drug Delivery Reviews 56 (2004) 1649– 1659
6. Irene Brigger, Catherine Dubernet, Patrick Couvreur Nanoparticles in cancer therapy and diagnosis Advanced Drug Delivery Reviews 54 (2002) 631–651

NT313 EXPERIMENTAL TECHNIQUES FOR NANOBIOTECHNOLOGY

Credit 0:0:4

12 experiments will be notified by the HOD from time to time

NT314 NANO BIOMATERIALS

Credit 4:0:0

Unit I

Polymeric implant materials: Polyolefin; polyamides (nylon); Acrylic polymers (bone cement) and hydrogels; Fluorocarbon polymers; Natural and synthetic rubbers, silicone rubbers; High strength thermoplastics; Deterioration of polymers- applications of nano biomaterial

Unit II

Bio ceramics for implant coating: calcium phosphates - hydroxy epilates Ti_6Al_4V and other biomedical alloys - implant tissue interfacing -biomimetic and solution based processing – osteo porosis – osteo plaste – regeneration of bones by using bio compactable ceramics – biointeractive hydro gels – PEG coating and surface modifications – PEG hyrogels patterned on surfaces – PEG based hyrogels

Unit III

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

Unit IV

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

Unit V

Tissue Engineering: Engineering biomaterial to control cell function – building structure into engineered tissues – fibrous proteins and tissue engineering- scaffolds for tissue fabrications – materials for scaffolds – materials for hydrogel scaffolds – scaffolds fabrications technologies— nano-featured and bioactive scaffolds – nano-fiber scaffolds – nanocomposite scaffolds – bioactive scaffolds – scaffolds for stem cells – micro and nanopatterned scaffolds - scaffolds and stem cells.

Reference Books

1. SV Bhat, Biomaterials (2nd Edition), Narosa Publishing House, New Delhi-2005.
2. JB Park, Biomaterials Science and Engineering, Plenum Press, New York, 1984 Challa S.S.R.Kumar, Joseph Hormes, Carola Leuschmal.
3. Nanofabrication towards biomedical applications wiley –VCHVerlag GmbH & CO, KGaA.
4. Robert.W.Kelsall, Ian.W.Hamley, Mark Geoghegan (Ed), Nano Scale Science And Technology, John Wiley and son, ltd., 2005
5. H.Fujita (Ed), Micromachines As Tools For Nanotechnology, Springer, 2003
6. Mick Wilson Kamali Kannangara Geooff Smith Michelle, Simmons Urkhard Raguse, Nano Technology, Overseas India private Ltd., 2005.

7. Gunter Schmid , Nano Particles, Jhon wiley and sons limited, 2004
8. K.K.Jain, Nano Biotechnology, Horizions Biosciences, 2006

NT315 CHEMICAL PRINCIPLES OF SELF-ASSEMBLY SYSTEMS

Credit 4:0:0

Unit I- Fundamentals of Self-assembly and Nanochemistry
What is nanochemistry? – molecular vs. materials self assembly – directing self-assembly – supramolecular vision – genealogy of self-assembling materials – two-dimensional assemblies – bottom-up nanotechnology and the role of chemistry in bottom-up approach - Review of the experimental techniques Transmission electron microscopy, X-ray diffraction, neutron diffraction X-Ray fluorescence spectroscopy, Mass spectrometry, and Photoelectron spectroscopy as applied to the study of self-assembly of various types

Unit II - Monolayer self-assembly
Principle of soft lithography – self assembled monolayers (SAMs) – alkanethiolates on gold – polymethylsiloxane (PDMS) patterned elastomers – polyurethane hemispheres as microlens arrays – electrically contacting self-assembled monolayers – patterning by photocatalysis – chemical reactions on self-assembled monolayers – applications of self-assembled monolayers in chemistry and biology

Unit III - Layer-by-layer self-assembly
Layer-by-layer self-assembly - Electrostatic superlattices – organic polyelectrolyte multilayers – polyelectrolyte-colloid multilayers – imaging polyelectrolyte multilayers – LbL Micro-electromechanical systems – patterned multilayers – non-electrostatic layer-by-layer self-assembly – low-pressure layers

Unit IV - Nanocluster self-assembly
Terminologies as nanocrystals, nanoparticles, and nanoclusters – synthesis of capped semiconductor nanoclusters – nanocluster phase transformations – alkanethiolate capped nanoclusters – water soluble nanoclusters – soft-lithography of capped nanoclusters – electroluminescent semiconductor nanoclusters – capped semiconductor nanoclusters and biomolecules – carbon nanoclusters – building nanodevices with bucky-balls

Unit V - Bio-inspiration in nanochemistry
Nature's siliceous sculptures – ancient to modern synthetic morphology – biomimicry – biomineralization and biomimicry analogies – learning from nature – viral cage directed synthesis of nanoclusters – polynucleotide directed nanocluster assembly – DNA coded nanocluster chains – bacteria directed materials self-assembly – protein S layers – morphosynthesis – better bones through chemistry - biomolecular motors – kinesin – bioinspiration

Reference Books
1. Nano: TheEessentials, T. Pradeep, McGraw Hill Publishers

2. Core Concepts on Supramolecular Chemistry and Nanochemistry, Jonathan Steed *and Jerry Atwood*
3. http://www.uaf.chem/rfk/nano.html
4. The Physics and Chemistry of Nanosolids, Frank J.Owens and Charles P.Poole Jr., Wiley Interscience Publishers
5. Encyclopedia of Nanochemistry, R.Thomson, Anmol Publishers
6. Nanoscale Technology in Biological Systems, Ralph G. Grew, Fritz B. Prinz, and R. Lane Smith, CRC Press
7. Nanoscale Materials, Parag Diwan and Ashish Paradwaj, Pentagon Publishers

NT316 NANOSENSORS AND TRANSDUCERS

Credit:4:0:0

Unit I : Transducers

Conductometric and capacitive transducers – optical waveguide based transducers – optical fiber based transducers – Interferometric optical transducers – surface plasmon resonance transducers – electrochemical transducers – soild state transducers – pn diodes or bipolar junction based transducers – schottky diode based transducers – MOS capacitor based transducers – FET based transducers – Acoustic wave transducers – Quartz crystal microbalance – Film Bulk acoustic wave resonator)BAW transducer) – Interdigitally launched surface acoustic wave transducer (SAW transducer) – Cantilever based tansducers.

Unit II : Sensor Characteristics and Physical effects:

Active and Passive sensors – Static characteristic:- Accuracy, offset and linearity – Dynamic characteristic:- First and second order sensors – Physical effects involved in signal transduction:- Photoelectric effect – photodielectric effect – Photoluminescence effect – electroluminescence effect – chemiluminescence effect – Doppler effect – Barkhausen effect – Hal effect – nernst / Ettinshausen effect – Thermoelectric effect – Peizoresistive effect – piezoelectric effect – pyroelectric effect – magneto-mechanical effect (magnetostriction) – Magnetoresistive effect – Faraday-Henry Law – magneto optice Kerr effect – Kerrand Pockels effect.

Unit III: Nano based Inorganic sensors

Density of states (DOS) – DOS of 3D, 2D, 1D and 0D materials – one dimensional gas sensors:- gas sensing with nanostructured thin films – absorption on surfaces – metal oxide modifications by additives – surface modifications – Nano optical sensors – nano mechanical sensors – plasmon resonance sensors with nano particles – AMR, Giant and colossal magnetoresistors – magnetic tunnelling junctions.

Unit IV : Organic / Biosensors

Structure of Protein – role of protein in nanotechnology – using protein in nanodevices – antibodies in sensing – antibody in nano particle conjugates – enzymes in sensing – enzyme nanoparticle hybrid sensors – Motor proteins in sensing – transmembrane sensors – Nanosensors based on Nucleotides and DNA – Structure of DNA – DNA decoders and microarrays – DNA protein conjugate based sensors – Bioelectronic sensors – DNA sequencing with nanopores – sensors based on molecules with dendritic architectures – biomagnetic sensors.

Unit V: Signal conditioning and data acquisition

Earthing and grounding – series and common mode noise – errors due to common mode interference – specification of common mode rejection ratio- instrumentation amplifiers – isolation amplifiers – charge amplifiers – filters – integrators and differentiators – phase sensitive detectors (PSD:- Linear switching PSD – Multiplying PSD – Digital PSD – Edge triggered PSD – Phase locked loop.

Reference Books

1. Nanotechnology enabled sensors by Kouroush Kalantar – Zadeh, Benjamin Fry, Springer Verlag New York, (2007) ISBN-13: 9780387324739
2. Data acquisition for sensor systems (sensor physics and technology 5) by H.Rosemary Taylor (1997) Chapman and Hall, London, UKISBN 0 412 785609
3. Biosensing: International Research and Development, Jerome Schultz, Milar Mrksich, Sangeeta N. Bhatia, David J. Brady, Antionio J. Ricco, David R. Walt, Charles L. Wilkins, Springer 2006 ISBN 10 14020 40571, ISBN 13 978 1 4020 4057 3 (e-book available)
4. Sensors and signal conditioning, 2nd edition Ramon Pallas-Areny, John G. Webster John Wiley & Sons (2001) ISBN 0 471 33232 1.

NT317 INDUSTRIAL NANOTECHNOLOGY

Credit 4:0:0

Unit I - Overview of Information Storage and Nanotechnology

Different types of information storage materials and devices: solid state memory, optical memory, magnetic recording, emerging technologies, role of nanotechnology in data storage.

Unit II - Optical Data Storage

Write and read techniques (signal modulation, disk format, data reproduction), read and write principles (read-only, write-once, phase-change, magnetooptic disks), optical pickup heads (key components, diffraction-limited laser spot, focusing and tracking error signals, servo-loop design, actuator), optical media, near field optical recording, holographic data storage.

Unit III – Energy Devices

Solar cells - Thin film Si solar cells - Chemical semiconductor solar cells - Dye sensitized solar cells - Polymer solar cells - Nano quantum dot solar cells - Hybrid nano-polymer solar cells

Fuel Cells – principle of working – basic thermodynamics and electrochemical principle – Fuel cell classification – Fuel cell Electrodes and Carbon nano tubes – application of power and transportation.

Unit IV – Nano pharmaceuticals

Generation and significance of Nano pharmaceuticals like nanosuspensions, nanogels, nanocarrier systems - Nano formulation – Nano incapsulation – Enhancement of drug therapy epitaxy

Unit V - Industrial applications of nanomaterials

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

Reference Books

1. Black Hole Computers, Scientific American Magazine, November 2004, by Seth Lloyd and Y. Jack Ng.
2. Information in the Holographic Universe, Scientific American Magazine, August 2003, Jacob D. Bekenstein.
3. Wu YH, "Nano Spintronics for Data Storage", Encyclopedia for Nanoscience and Nanotechnology, vol.7, American Scientific Publishers, 2003.
4. Optical Data Storage, Erwin R. Meinders , Matthias Wuttig, Liesbeth Van Pieterson, Andrei V.Mijiritskii, 2006, Springer.
5. A. A. Balandin, K. L. Wang "Handbook of Semiconductor Nanostructures and Nanodevices" Vol 1-5
6. F. Kreith and J.F. Kreider, "Principles of Solar Engineering, McGra-Hill (1978)
7. S.P. Sukhtame, "Solar Energy: Principles of Thermal Collection and Storage", Tata-McGraw-Hill (1984)
8. D D C Bradley, Current Opinion in Solid State & Materials Science Vol. 1, 789 (1996)
9. Rainer Waser, Nano Electronics And Information Technology, John Wiely and sons publication, 2003
10. Narayan R and B Viswanathan, "Chemical and Electrochemical Energy Systems", University press (India) Ltd., 1998
11. A.B. Hart and G. J. Womack, "Fuel Cells: Theory & Applications", Prentice Hall, NY
12. A. J. Domb, Y. Tabata, M. N. V. Ravi Kumar, and S. Farber, "Nanoparticles for Pharmaceutical Applications" American Scientific publishers, 2007
13. Dr.Parag Diwan And Ashish Bharadwaj, Nano Electronics, Pentagen press, 2006
14. K.Goser, P.Glose Kotter, J.Dienstuhl, Nanoelectronics And Nano Systems, Springer International Edition, 2004
15. Bingzhou, Sophie Herman And Gabor. A.Somorjai, Nanotechnology In Catalysis, Kluwer academic/Plenum Publishers New York (volum1 and 2), 2004.
16. Dr.Parag Diwan And Ashish Bharadwaj, Nano Robotics, Pentagon press, 2005.

NT318 NANOCOMPOSITES

Credit 4:0:0

Unit I - Introduction of nanocomposites

Nanocomposites – Definition – Nanocomposites past and present – Nomenclature – Solids - Atomic and molecular solids – Role of statistics in materials – Primary, secondary and tertiary structure – Transitions

Unit II - Properties and features of nanocomposites

Physics of modulus – Continuum measurements – Yield – Fracture – Rubbery elasticity and viscoelasticity – Composites and nanocomposites – Surface mechanical properties – Diffusion and permeability – Features of nanocomposites – basics of polymer nano composites - Nanoreinforcements – Matrix materials – Hazards of particles

Unit III - Processing of nanocomposites

Viscosity - Types of flow – Viscosity - Experimental viscosity - Non-newtonian Ffow - Low-viscosity processing - Solvent processing - Particle behavior - In situ polymerization - Post-Forming - Hazards of solvent Processing - Melt, high -shear, and direct processing - Melting and softening - Melt processes with small shears or Low-shear rates flow - Melt processes with large deformations or high-shear rates - Thermo-kinetic processes

Unit IV - Characterization of nanocomposites

Introduction to characterization – Experiment design – Sample preparation – Imaging – Structural characterization – Scales in nanocomposites – Texture – Electromagnetic energy – Visualization – Physicochemical analysis – Characterization of physical properties – Identification – Mechanical – Surface mechanical – Exposure – Barrier properties – Recipes and standards

Unit V: Applications of nanocomposites

Nanocomposites – Optical, structural applications – Nanoparticulate systems with organic matrices – Applications – Biodegradable protein nanocomposites - Applications Polypropylene nanocomposites – Application as exterior automatic components – Hybrid nanocomposite materials – Application for corrosion protection

Reference books

1. Thomas E. Twardowski, Introduction to Nanocomposite Materials – Properties, Processing, Characterization, DesTech Publications, April 2007
2. Klaus Friedrich, Stoyko Fakivov, Zhony Shang, Polymer Composites from Nano – to Macro – scale, Springer, USA, 2005
3. Sumio Sakka, Sol-gel Science and Technology – Topics in fundamental research and applications, Volume 3 – Sol-gel prepared organic – inorganic hybrids and nanocomposites, Kluwer academic publishers, Springer, 2002
4. Ray Smith, Biodegradable polymers for Industrial Applications, CRC Press, 2005
5. Manas Chandar and Salil K. Roy, Plastics technology handbook, CRC Press, 2006
6. Yiu-Wing Mai and Zhong-Zhen Yu. Polymer nanocomposites CRC Press Boca Raton
7. Boston New york Washing ton, DC. and Woodhead publishing ltd, England, 2006.
8. Parag Diwan and Ashish Bharadwaj. Nanocomposites Pentagon Press
9. Nanocomposite Science and Technology Pulickel M. Ajayan , Linda S. Schadler , Paul V. Braun, 2006, Wiley-VCH

NT319 MOLECULAR PHOTONICS

Credit 4:0:0

Unit I - Concept of Polarization

Molecule/material interaction with electromagnetic waves as described by Maxwell equations**. Wave** optics, ray optics, beam optics, polarization, Snell laws and lens formula, Lambert-Beer law, excited states and molecular orbitals, the influence of π-electron system expansion on the absorption spectrum, the Jablonski diagram

Unit II - Fundamentals of Fluorescence

Excited states, fluorescence and phosphorescence, emission yield, polarization, lifetime, quenching**. Applications** -molecular orientation and dynamics studied by energy transfer and quenching; Stern-Volmer model, FRET, Dexter and Förster mechanisms, excitonic interaction, J and H aggregates

Unit III - Experimental Methods of Fluorescence Spectroscopy

Biological fluorophores and molecular probes, steady-state emission and excitation spectra, time-correlated single photon counting, up-conversion, **Light Scattering** -determining molecular size and characterizing intermolecular interactions from Rayleigh scattering data, explaining Raman effect

Unit IV- Nonlinear Optical Effects

Second-order and third-order, electrooptics (Mach-Zehnder switch), photo refractivity, Two Photon Absorption and Optical Switching -physical description, applications in TP fluorescence spectroscopy and optical computing, study of Surfaces and Interfaces 2^{nd} harmonics at surfaces, 3^{rd} and higher order methods to study dynamics, photon echoes, optical Kerr effect

Unit V - Electron Transfer

Marcus model and applications to molecular systems- Photoconductivity and Photovoltaics inorganic nanocrystalline solar cells, organic polymer photoconductors, ectroluminescencent materials. Photochemistry -photoisomerization, photoacids, photochromism] Photons as Medicine and Diagnostics Tools-singlet oxygen photochemistry, photodynamic therapy, tetrapyrroles as photosensitizes for PDT, measuring tissue oxygenation, optical tomography

Reference Books

1. K. Horie, H. Ushiki, F. M. Winnik, Molecular Photonics, 2000, Wiley VCH.
2. S. Mukamel, Principles of Nonlinear Optical Spectroscopy, 1999, Oxford University Press
3. J. R. Lakowicz, Principles of Fluorescence Spectroscopy, 2^{nd} edition, 1999, Kluwer Academic/Plenum Publishers
4. G. R. Van Hecke, K. K. Karukstis, A Guide to Lasers in Chemistry, 1988, Jones and Bartlett Publishers
5. P. P. Prasad, D. J. Williams, Introduction to Nonlinear Optical Effects in Molecules and Polymers, 1991, John Wiley and Sons
6. P. P. Prasad, Biophotonics, 2003, John Wiley Interscience, especially for 6.

ADDITIONAL SUBJECTS

Code	Name of the Subject	Credit
09NT320	Introduction to Nanostructured Materials	4 : 0 : 0
09NT321	Biology for Nanotechnology	4 : 0 : 0
09NT322	Fabrication and Imaging Techniques for Nanotechnology	4 : 0 : 0
09NT323	Nanobiotechnology	4 : 0 : 0
09NT324	Nanobiomaterials	4 : 0 : 0
09NT325	Nano Toxicology	4 : 0 : 0

09NT320 - INTRODUCTION TO NANOSTRUCTURED MATERIALS

Credit 4:0:0

Objectives:

1. To acquire the fundamental knowledge about nanostructured materials
2. To understand about the characterization techniques used for characterizing nanomaterials
3. To understand the theory of luminescence of semiconducting nanoparticles
4. To acquire the basic understanding about nanodevices

UNIT I: INTRODUCTORY ASPECTS

Free electron theory and its features, Idea of band structure – Metals, Insulators and Semiconductors - Density of state in bands and its variation with energy, Effect of crystal size on density of states and band gap – Electronic structure of nanoparticles

UNIT II: BULK NANOSTRUCTURED MATERIALS

Solid disordered Nanostructures – Nanostructured crystals – Luminescence – Quantum wells, wires and Dots – Size and dimensionality effects – Excitons – Superconductivity; Self assembly and catalysis

UNIT III: GENERAL CHARACTERIZATION TECHNIQUES

UV – Vis- IR - absorption Spectroscopy, X- Ray Diffraction studies –Bragg's law – particle size – Scherrer's equation, –FT-IR – FT- Raman studies - Surface Resonance

UNIT IV: LUMINESCENCE OF SEMICONDUCTING NANOPARTICLES

Theory of photoluminescence, Fluorescence of semiconducting nanoparticles – Photoluminescence of doped semiconductor nanoparticles – Shift in photo luminescence peaks - Electroluminescence– Thermo luminescence –Cathode luminescence – Magneto luminescence

UNIT – V: NANO DEVICES

Background – Quantization of resistance - Single electron transistors – Esaki and resonant tunneling diodes – Magnetic Nanodevices – Magneto resistance – Spintronics

Reference Books

1. C. Kittel, 'Introduction to Solid State Physics', Wiley, 2004
2. J.D. Plummer, M.D. Deal and P.B.Griffin, 'Silicon VLSI Technology, Fundamentals, Practice, and Modeling', Prentice-Hall, 2002
3. Redattori V. S. Muralidharan, A. Subramania, 'Nanotechnology: Materials, Fabrication, Particles, and Characterization', CRC Press, November 2008
4. Hari Singh Nalwa, 'Encyclopedia of Nanoscience and Nanotechnology (Vol. 10)', American Scientific Publishers, 2004
5. Bimberg, M. Grundmann, and N. N. Ledentsov, 'Quantum Dot Heterostructures', John Wiley & Sons Ltd, 1999

09NT321 - BIOLOGY FOR NANOTECHNOLOGY

Credit 4:0:0

Objectives:

1. To acquire the basic knowledge about animal and plant cells
2. To understand about molecular targets
3. To know the chemistry of genetic engineering
4. To understand the concept of biosynthesis of nanoparticles

Unit I

Structure and organization of prokaryotic and eukaryotic cell (Animal cell & plant cell), tissues and organs, Cell and Tissue Culture – Application of plant Transformation for Productivity and performance - Animal Cell Culture Technology – Applications of Animal Cell Culture-Stem Cell Culture, Artificial organ synthesis,

Unit II

Introduction Gene- protein-central dogma of cell-molecular targets- estimation of RNA, estimation of DNA, Protein Estimation.

Unit III

Recombinant DNA technology, Scope and Milestones in Genetic Engineering -Molecular tools used in Genetic Engineering - Gene cloning – Transgenic organisms. Genomics and Functional Genomics- Whole genome analysis – Human Genome Project, Gene therapy, Gene delivery.

Unit IV

Cells and organs of immunity, Types of Innate and acquired immune system – Antigen, antibody structure and its types, humoral immunity, Cell mediated immunity, introduction, to complement system- MHC & graft transplantation and graft rejection.

Unit V

Biosynthesis of Nanoparticles, Microbial Nanoparticle production Biomineralization, Magnetosomes, Nanoscale magnetic iron minerals in bacteria, virus & fungi. DNA based Nano structures. Protein based Nano structures.

Reference Books

1. C.M. Niemeyer and C.A. Mirkin, 'Nanobiotechnology: Concepts, Applications and Perspectives', Wiley-VCH, 2004
2. K. K. Jain, 'Nanobiotechnology Molecular Diagnostics: Current Techniques and Applications (Horizon Bioscience)', Taylor & Francis, 2006
3. Mick Wilson and Kamali Kannangara, 'Nanotechnology – Basic Science and Emerging Technologies', Overseas Press India Private Ltd., 2005
4. S.S. Purohit, 'Biotechnology: Fundamentals and Applications', Agrobios, Jodhpur, 2002
5. R.W. Old, & S.B.Primrose, 'Principles of Gene Manipulations: An introduction to genetic engineering (5^{th} edition)', Blackwell Science Ltd, Australia, 1994

09NT322 - FABRICATION AND IMAGING TECHNIQUES FOR NANOTECHNOLOGY

Credit 4:0:0

Objectives:

1. To acquire knowledge about general nanofabrication techniques
2. To understand the concepts of spectroscopy techniques
3. To know the mechanical methods of characterizing nanomaterials
4. To study the x-ray related techniques used for characterizing the nanomaterials

Unit I: General Fabrication Techniques

Key challenges and barriers for nanocharacterization - Photolithography – Cleaning / etching – Oxidation - oxides – Gettering – doping – Epitaxy. Top-down techniques – Other optical lithographies (EUV, X-ray, LIL) – Particle beam lithographies (e-beam, FIB, shadow mask evaporation) – Probe lithographies. – Ball milling – Chemical routes – Chemical Vapour Deposition, wet chemical routes

Unit II: Spectroscopic techniques

Spectroscopy of Semiconductors – excitons – Brillouin spectroscopy – Dynamic Light Scattering (DLS) – NMR Spectroscopy – ESR Spectroscopy – X-ray photo electron spectroscopy (XPS) - electron spectroscopy for chemical Analysis (ESCA) - Principles and applications of the above methods

Unit III: Probing techniques and magnetometry

Scanning electron microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), Atomic force microscopy (AFM), Near field optical scanning microscopy (NSOM) - Vibrating sample magnetometry (VSM)

Unit IV: Mechanical characterization

Mechanical Characterization – modulus and load carrying capability of nano region/ compression micro hardness – fatigue – abrasion and wear resitance – superplasticity – nanoindentation. Nanotribology – Nanotribometre – Surface Force apparatus – Quartz Crystal microbalance – Friction force microscope.

Unit V: Neutron and X-ray diffraction and crystallography

Neutron and X- ray diffraction – Debye Scherrer formula – dislocation density – micro-strain macromolecular crystallography using synchrotron radiation – role for neutron scattering in nanoscience.– X – ray absorption Fine Structure (XAFS) – extended X- ray absorption fine structure (EXAFS) – Small angle X-ray scattering and Wide angle X-ray scattering

Reference Books

1. T. Tsakalakos, I. Ovid'ko and A.K. Vasudevan, 'Synthesis, Functional Properties and Applications of Nanostructures', Kluwer Academic Publishers, Dordrecht, 2003
2. H.A. Willard and L.L. Merrit, J.A. Dean, 'Instrumental methods of Analysis', Van Nonstrand, New York, 1986
3. R. M. Silverstein, G. C. Bassler, and T. C. Morrill, 'Spectrometric Identification of Organic Compounds', John Wiley & Sons, New York, NY, USA, 7th edition, 2005
4. Pulickel .Ajayan, Linda S. Schadler, Paul V.Braun, 'Nanocomposite Science and Technology, Wiley – VCH, 2003
5. Charles P Poole Jr and Frank J Ownes, 'Introduction to Nanotechnology', John Wiley Sons, Inc., 2003

09NT323 - NANOBIOTECHNOLOGY

Credit: 4:0:0

Objectives:

1. To acquire knowledge about biochips and molecular electronics
2. To understand the concepts of biological computing techniques
3. To know the fundamentals about natural nanocomposites
4. To know about molecular manufacturing and nano simulation techniques

Unit: I

Biology inspired concepts-biological networks-biological neurons-the function of neuronal cell-biological neuronal cells on silicon modeling of neuronal cells by NLSI circuits-bioelectronics-molecular processor-DNA analyzer as biochip-molecular electronics.

Unit: II

Nanobiomectrics - introduction-lipids as nanobricks and mortar, self assembled nanolayers-the bits that do think-proteins-three dimensional structures using a 20 aminoacid-biological computing-a protein based 3D optical memory using DNA to build nano cubes and hinges-DNA as smart glue-DNA as wire template-DNA computers.

Unit: III

Natural nanocomposites-introduction-natural nano composite materials-biologically synthesized nanostructures-biologically derived synthetic nanocomposites-protein based nanostructure formation-biologically inspired nanocomposites-nanotechnology in Agriculture [Fertilizers and Pesticides].

Unit: IV

Nano analytics-quantum dot biolabeling-nanoparticle molecular labels-analysis of biomolecular structure by AFM and molecular pulling-force spectroscopy-biofunctionalized nanoparticles for surface enhanced raman scattering and surface Plasmon resonance.

Unit: V

Molecular Manufacturing-Nano simulation, implications of nanotechnology, health and safety implications from nanoparticles. Health issues-Environmental issues-need for regulation-social implications, possible military applications-potential benefits and risks for developing countries-studies on the implications of nanotechnology.

Reference Books

1. C.M. Niemeyer and C.A. Mirkin, 'Nanobiotechnology: Concepts, Applications and Perspectives', Wiley-VCH, 2004
2. David.S.Goodsell, 'Bionanotechnology: concepts, Lessons from Nature', Wiley-Liss, 2004
3. Sandra J. Rosenthal, David W. Wright, 'Nanobiotechnology Protocols', Humana Press, 2005
4. R.S. Greco, F.B.Prinz and R.L.Smith, 'Nanoscale Technology in Biological Systems', CRC Press, 2005
5. Tuan Vo-Dinh, 'Protein Nanotechnology - Protocols, Instrumentation and Applications , Humana Press, 2005

09NT324 - NANO BIOMATERIALS

Credit 4:0:0

Objectives:

1. To acquire knowledge about polymeric implant materials
2. To know the role of biomaterials for implant coating
3. To understand the concepts of cardiovascular implants
4. To know the basics of biopolymers and tissue engineering

Unit I

Polymeric implant materials: Classification of biomaterials, Polyolefin; polyamides (nylon); Acrylic polymers (bone cement) and hydrogels; Fluorocarbon polymers; Natural and synthetic rubbers, silicone rubbers.

Unit II

Bio materials for implant coating: calcium phosphates, Ti_6Al_4V and biomedical alloys - implant tissue interfacing -biomimetic and solution based processing – osteo porosis – osteo plaste – regeneration of bones by using bio compactable ceramics – biointeractive hydro gels.

Unit III

Cardiovascular implants: Role of nanoparticles and nanodevices in Blood clotting; Blood rhelogy; Blood vessels; Geometry of blood circulation; Vascular implants; Cardiac pacemakers; Blood substitutes; Biomembranes, Opthomological applications of nano biomaterial.

Unit IV

Structure property relationship of Biological Materials: tissues, bones and teeth, collagen rich tissues, elastic tissues - Biopolymers: Preparation of nanobiomaterials – Polymeric scaffolds collagen, Elastins: Mucopolysaccharides, proteoglycans, cellulose and derivates Dextrans, Alginates, Pectins, Chitin.

Unit V

Tissue Engineering: Engineering biomaterial to control cell function - nanostructured collagen mimics in tissue Engineering – building structure into engineered tissues – fibrous proteins and tissue engineering- scaffolds for tissue fabrications – materials for scaffolds – materials for hydrogel scaffolds – scaffolds fabrications technologies—nanocomposite scaffolds – bioactive scaffolds – scaffolds for stem cells – micro and nanopatterned scaffolds.

Reference Books

1. S.V Bhat, 'Biomaterials (2nd Edition)', Narosa Publishing House, New Delhi, 2005.
2. Robert.W.Kelsall and Ian.W.Hamley, Mark Geoghegan, Nano Scale Science and Technology, John Wiley, 2005
3. Challa S.S.R. Kumar, Josef Hormes and Carola Leuschner, 'Nanofabrication Towards Biiomedical Applications – Techniques, Tools, Applications and Impact', Wiley – VCH, 2005
4. Paul K. Chu and Xuanyong, 'Biomaterials fabrication and processing handbook', CRC / Taylor & Francis, 2008
5. K. K. Jain, 'Nanobiotechnology Molecular Diagnostics: Current Techniques and Applications (Horizon Bioscience)', Taylor & Francis, 2006

09NT325 - NANO TOXICOLOGY

Credit 4:0:0

Objectives:

1. To acquire the basic knowledge about nanotoxicology
2. To know the mechanism of nanosized particle toxicity
3. To know about nanopollution
4. To understand the human exposure to nanosized materials and risk assessment

Unit I: Introduction

Concept of Nanotoxicology - Laboratory rodent studies - Ecotoxicologic studies - Methodology for Nanotoxicology - *toxicity testing*

Unit II: Mechanism

Mechanism of nanosize particle toxicity - Reactive oxygen species mechanisms of NSP toxicity - Interactions between Nanoparticles and Living Organisms: Mechanisms and Health Effects - Interactions of Nanoparticles with Cells and their Cellular Nanotoxicology - Cytotoxicity of Ultrafine Particles - Cytotoxicity and Potential Mechanism of Nanomaterials

Unit III: Pollution

Nanopollution – Nanomaterials in Environment - Toxicology of Airborne - Manufactured nanomaterials in the environment

Unit IV: Human exposure to Nanosized Materials

Biological Activities of Nanomaterials and Nanoparticles - Respiratory Tract - Efficient deposition of inhaled NSPs. - Disposition of NSPs in the respiratory - Disposition of NSPs in the respiratory -Epithelial translocation - Translocation to the circulatory system - Neuronal uptake and translocation -Translocation of NSPs in the blood circulation to bone marrow in mice - Studies of neuronal translocation of UFPs from respiratory tract -Exposure via GI Tract and Skin

Unit V: Risk Assessment and Execution

Portals of entry and target tissue – Risk assessment – Ethical – Legal and Social Implications - Nanoparticle Toxicology and Ecotoxicology, The Role of Oxidative Stress – Development of Test Protocols for Nanomaterials – Regulation of Engineered Nanomaterials in Europe and USA

Reference Books

1. E P. Widmaier, H. Raff, K.T. Strang, Vander, Sherman and Luciano, 'Human Physiology: The Mechanisms of Body. Functions', 9th edition, McGraw Hill, New York, 2004
2. Yuliang Zhao and Hari Singh Nalwa, 'Nanotoxicology: Interactions of Nanomaterials with Biological Systems, American Scientific Publishers, 2007
3. Gunter Oberdörster, Eva Oberdorster and Jan Oberdorster, *Environmental Health Perspectives*, Volume 113 Number 7 , July 2005
4. D. Drobne, 'Nanotoxicology for safe and Sustainable Nanotechnology', Nanotoxicology for safe and sustainable Nanotechnology , 58, pp. 471-478, December 2007
5. Monteiro-Riv, 'Nanotoxicology: Characterization, Dosing and Health Effects', Informa Healthcare publishers, 2007

DEPARTMENT OF NANOTECHNOLOGY

LIST OF NEW SUBJECTS

Code	Subject Name	Credit
10NT201	Principles of Organic Chemistry	3:0:0
10NT202	Qualitative Analysis and Inorganic Preparations Lab	0:0:2
10NT203	Organic Reactions and Mechanisms	4:0:0
10NT204	Biochemistry	3:0:0
10NT205	Organic Qualitative Analysis Lab	0:0:2
10NT206	Materials Chemistry	4:0:0
10NT207	Introductory Nanotechnology	4:0:0
10NT208	Characterization and Instrumental Techniques	4:0:0
10NT209	Titrimetric Analysis and Gravimetric Analysis Lab	0:0:2
10NT210	Inorganic and Co-ordination Chemistry	4:0:0
10NT211	Physical Chemistry	4:0:0
10NT212	Medicinal Chemistry	4:0:0
10NT213	Physical Chemistry Lab	0:0:2
10NT214	Analytical Chemistry and Spectroscopy	4:0:0
10NT215	Nanotechnology, Green Chemistry and Environmental Health	4:0:0
10NT216	Molecular and Materials Self-assembly	4:0:0
10NT217	Cheminformatics	4:0:0
10NT218	Molecular Machines and Materials	4:0:0
10NT219	Synthesis of Organic Compounds and Chromatography Lab	0:0:2
10NT301	Chemical Approach to Nanomaterials	4:0:0
10NT302	Nano-toxicology and Ethics	4:0:0
10NT303	Nanotechnology in Fuel Cells and Energy Storage	4:0:0
10NT304	Supra-molecular Chemistry	4:0:0
10NT305	Bioinformatics & Drug Designing	4:0:0
10NT306	Synthesis of Nanomaterials and Characterization Lab	0:0:4
10NT307	Nanocomposites and Quantum Computation	4:0:0
10NT308	Applications of Nanotechnology	4:0:0
10NT309	Nanoelectrochemistry and Nanoscale thermodynamics	4:0:0
10NT310	Nanotechnology & Environmental Issues	4:0:0
10NT311	Biological Nanostructures	4:0:0
10NT312	Nanobiotechnology	4:0:0
10NT313	Advanced Experiments & Simulations Techniques for Nanoparticle Characterization (Lab)	0:0:3
10NT314	Experimental Techniques for Nanobiotechnology (Lab)	0:0:3

10NT201 PRINCIPLES OF ORGANIC CHEMISTRY

Credits: 3:0:0

Objectives:

- The student will get rudimentary ideas on chemical structure and formula of organic molecules

- The student will understand the influence of stereoisomerism and conformation in chemical structure and properties of molecules
- The student will be exposed to ideas about natural products, their structure, and function

Outcome:

The students will get knowledge on the structural basics of organic compounds

Unit I: Introduction to organic chemistry

Classification of organic compounds – Functional groups –Nomenclature of organic compounds – nomenclature of heterocyclic compounds – fission of bonds – electrophiles and nucleophiles (definition, discussion on the conditions these are formed) – carbocation and carbanion, Free radicals, arynes (structure and reaction only; methods to identify these species are not required)

Unit II: Electronic effects; types of reactions

Inductive effect and field effect – electron delocalization and resonance, rules of resonance – steric inhibition of resonance and steric enhancement of resonance (with only one example for each) – hyperconjugation - tautomerism

Types of reactions: substitution reactions (types and examples), addition reactions (types and examples), elimination reactions (types and examples), rearrangement reactions (types and examples) – thermodynamic and kinetic requirements of a reaction – kinetic and thermodynamic control – the Hammond postulate

Unit III: Stereochemistry I

Stereoisomerism – cis-trans isomerism (definition and examples only) – E, Z nomenclature (rules and examples only) – optical isomerism – cause of optical activity – racemization – resolution methods – absolute configuration – R, S nomenclature – Cahn, Ingold, Prelog nomenclature - Atropisomerism (biphenyls only) – Asymmetric synthesis

Difference between conformation and configuration – conformation of ethane, substituted ethanes – conformation of cyclohexanes, mono, and di-substituted cyclohexanes – saw-horse, staggered, skew, gauche forms

Unit IV: Stereochemistry II

Dynamic stereochemistry – Stereo-selectivity and stereo-specificity – Curtin-Hammett principle – enantioselective, diastereoselective synthesis – enzymatic and kinetic methods – effect of conformation on reactivity in acyclic compounds and cyclohexanes

Unit V: Natural products

Nomenclature, classifications, general methods of structure determination of alkaloids, terpenoids, steroids, and flavonoids (structure determination of any specific natural product is not required)

Text Books:

1. P.S. Kalsi, Stereo Chemistry Conformation and Mechanism, New Age Publishing Ltd., New Delhi, 2002

2. O.D. Tyagi, M. Yadav, A Text Book of Organic Chemistry, Anmol Publishing Ltd., New Delhi, 2002

References:

1. Jerry March, Advanced Organic Chemistry, Willey, 4th Edition, Newyork, 1992
2. I.L. Finar, Organic Chemistry, Pearson Education Pvt. Ltd., Vol. I & II, 5th Edition, Singapore, 1975
3. R.T. Morrison & R.N. Boyd, Organic Chemistry, 6th Edition, Pearson Education Pvt Ltd., Singapore, 2003
4. Gurdeep and Chatwal, Organic Chemistry of natural products, Vol. I & II, 3rd edition, 2000
5. Nasipuri, stereochemistry of organic compounds, New Age International publishers, 3rd edition, 1999

10NT202 QUALITATIVE ANALYSIS AND INORGANIC PREPARATIONS LAB

Credit: 0:0: 2

Qualitative Analysis and Inorganic Preparations:

Analysis of mixtures containing one anion and one cation from the following:
Anions: Carbonate, sulfide, sulphate, chloride, bromide, iodide, acetate, nitrate, oxalate, tartrate, borate, phosphate, arsenate and chromate.

Cations: Lead, copper, bismuth, cadmium, tin, antimony, iron, aluminum, zinc, manganese, nickel, cobalt, calcium, strontium, barium, potassium and ammonium.

Preparations: Any three of the following inorganic preparations:

1. Ferrous ammonium sulphate
2. Tetrammine copper (II) sulphate
3. Potassium trisoxalato chromate (III)
4. Potash alum $KAl(SO_4)_2.2H_2O$
5. Hexammine cobalt (III) chloride.
6. Manganous sulphate
7. Microcosmic salt
8. Sodium thiosulphate

12 experiments will be notified by HOD from time to time

Reference:

1. G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denney, "Vogel's text book of quantitative chemical analysis", ELBS, 5th Edn. Longman, Singapore publishers, Singapore, 1996
2. I.M. Kolthoff and E.B. Sandell, "Quantitative Chemical Analysis" MacMillan, Chenai, 1980
3. G.Svehla, "Vogel's Qualitative Inorganic Analysis", 6th Edn., Orient Longman, New Delhi, 1987
4. V. Ramanujan, "Inorganic Semi-micro Qualitative Analysis", 3rd Edn., National Publishing Company, Chennai, 1990

5. K. Manivasakam, "Physico-chemical Examination of Water Sewage and Industrial Effluents", 3rd Edn., Pragati Prakashan, Meerut, 1996

10NT203 ORGANIC REACTIONS AND MECHANISMS

Credits: 4:0:0

Objectives:

- Chemical reactions, which are mostly used to synthesize compounds of various types, and their mechanism are discussed.
- Distinguishing the types of reactions and their mechanism will give an idea of the structural requirements of reactions of a particular type.
- The student will be able to write a reaction by explaining which bonds are broken and in what order.

Outcome:

The students will get a thorough knowledge on reactions of organic compounds in different types mechanisms which he will use in synthesis of nanoscale materials. He will understand how classical chemistry is related to nanochemistry in terms of synthesis.

Unit I: Aromatic and aliphatic nucleophilic substitutions

The S_NAr mechanism – S_N1 mechanism – benzyne mechanism – reactivity – effect of substrate structure, leaving group, attacking nucleophile – Bucherer reaction – Ulmann reaction – Chichibabin reaction

S_N1 and S_N2 mechanisms – neighboring group participation – non-classical carbocations – effect of substrate structure, attacking nucleophile, leaving group, and reaction medium on nucleophilic substitution – ambident nucleophiles and regioselectivity

Unit II: Aromatic and aliphatic electrophilic substitutions

Arenium ion mechanism – orientation and reactivity in mono-substituted aromatic rings – quantitative treatment – Hammett equation – effect of leaving group – nitration, diazonium coupling, nitrosation, amination,– mechanisms S_E2 mechanism – S_E1 mechanism – reactivity – aliphatic diazonium coupling – acylation at an aliphatic carbon – the Stork-enamine reaction

Unit III: Addition and elimination reactions

Addition reactions - Electrophilic, nucleophilic, and free-radical addition to double and triple bonds – hydration, hydroxylation, Michael addition, hydroboration, and epoxidation – Addition to carbonyl compounds – Mannich reaction

Elimination reactions – mechanism – E_1, E_2 mechanisms, Hofmann, Saytzeff rules, Bredt's rule – Chugaev reaction, Hofmann degradation

Unit IV: Common organic reactions

Aldol, Perkin, Stobbe, Dieckman condensations – Reimer-Tiemann, Reformatsky and Grignard reactions – Gattermann reaction, Kolbe-Schmitt reaction - Friedel-Crafts reaction, Wittig reaction, and Robinson annulation – functional group transformations and inter-

conversion of simple functionalities – Clemmensen, Wolff-Kishner, Meerwein-Pondorf-Verley, and Birch reductions

Unit V: Molecular rearrangements

Baeyer-Villiger rearrangement– Fries, Benzidine, and Stevens rearrangements – Benzil-benzilic acid rearrangement – Favorski rearrangement– Curtius, Lossen, Schmidt rearrangements – the von Ritcher reaction – Sommlett-Hauser rearrangement – Hoffmann rearrangement

Text Books

1. S. H. Pine, Organic Chemistry, 5th edn., McGraw-Hill, 1987
2. J. March. Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 4th edn., Wiley Student Edition, John Wiley & Sons Asia Pvt. Ltd., 2005
3. P. S. Kalsi, Stereochemistry, Conformation and Mechanism 3rd edn., John Wiley, 1995

Reference Books

1. F. A. Carey & R. J. Sundberg. Advanced Organic Chemistry, Part A and B, 3rd edn. 1990
2. Wamser & Harris, Fundamentals of Organic Reaction Mechanisms, John Wiley (1990).
3. R.T.Morrison & R.N.Boyd, Organic Chemistry, 6th Edition, Pearson Education Pvt Ltd., Singapore, 2003
4. Gurdeep and Chatwal, Organic Chemistry of natural products, Vol. I & II, 3rd edition, 2000

10NT204 BIOCHEMISTRY

Credits: 3:0:0

Objectives:

- The student will get ideas on biomolecular structure and their functional role
- The student will understand the influence of biomolecules in bodily processes
- The student will be exposed to ideas about separation and classification of large molecules

Outcome:

The students will get knowledge about the structure, properties, and action of biomolecules

Unit I: Proteins and nucleic Acids

Amino acids and proteins: Definition, General Properties - Primary Secondary, Tertiary, Quaternary and 3-D Structures of Proteins - Chemical Synthesis of Poly peptides. Nucleic acids: Definition, composition, structures of purines, pyrimidines, Phosphodiester bonds and Sugars - Classification of Nucleic acids, Differences between DNA and RNA - Solid Phase synthesis of DNA (Sanger's method)

Separation and Purification of Amino acids and Proteins: Paper, Gel Filtration Chromatography, Gel Electrophoresis, Western blotting

Unit II: Carbohydrates and lipids

Carbohydrate – Definition, classification, conformation of furanose and pyranose rings, general Properties – glycoproteins, proteoglycans: Structure and functions - Fatty acids: Structure, and function - Membrane lipids: classification as phospholipids, sulfolipids, spingolipids and glycolipids, their importance - lipoproteins, diffusion of proteins into the plane of membrane proteins

Unit III: Enzymes: mechanism and kinetics

Enzymes – definition, IUB classification, nomenclature - Enzymes as specific catalyst, Lock & key and induced fit theories, Inhibitors for enzyme reactions - Free energy and transition state changes - Michaelis-Menten and Linewiever-Burk plot - Proteases: facilitators of specific reactions, Protease inhibitors as drugs - Hemoglobin–oxygen binding

Unit IV: Metabolism and bioenergetics

Metabolism – definition, coupled and interconnecting reactions - Meatbolic pathways with recurring motifs - Cellular energy: Oxidation of carbon fuels - Role of hormones and signal transduction in the metabolic pathways

Unit V:

Trans-membrane and intracellular receptors - calcium as ubiquitous cytosolic messenger - Glycolysis, HMP-shunt pathway, glycogenesis, glycogenolysis, glyconeogenesis, TCA cycle and mitochondrial Electron transport chain - An overview of amino acid metabolism

Text books:

1. H.F. Gilbert, Basic concepts in biochemistry, McGraw Hill, Ed. 2, 2002
2. Lehninger, Principles of biochemistry, David L. Nelson, Michael M. Cox, Ed. 4, 2002

Reference books:

1. J.M. Berg, J.L. Tymoczko, L. Stryer, Biochemistry, Ed. 5, W.H. Freeman & Co., 2004
2. Lynne B. Jorde, Biochemistry notes, Kaplan Inc., 2002
3. G. N. Wilson, Biochemistry, McGraw Hill co., 2002

10NT205 ORGANIC QUALITATIVE ANALYSIS LAB

Credit: 0:0: 2

Organic Qualitative Analysis:

i. Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives

[Detection of elements (N, S and halogens) and functional groups (phenolic, carboxylic, carbonyl, esters, carbohydrates, amines, amides, nitro and aniline) in simple organic compounds]

ii. Separation of two component mixtures

1) Aniline + Naphthalene 2) Benzoic acid + Benzophenone 3) p-Cresol + Chlorobenzene.

12 experiments will be notified by HOD from time to time

Reference:

1. A.I. Vogel – "Text book of practical organic chemistry", 5th Ed. ELBS, London, 1989
2. B.B. Dey and M.V. Sitharaman, "Laboratory manual of Organic Chemistry" Revised by T.R. Govindachari, Allied Publishers Ltd., New Delhi, 4th Revised edition, 1992
3. Daniel R. Palleros, "Experimental Organic Chemistry" John Wiley & Sons, Inc., New York, 2000
4. B.S. Fumiss, A.J. Hannaford, V. Rogers, P.W.G. Smith and A.R. Tatchell, "Text book of Practical Organic Chemistry", LBS, Singapore, 1994
5. S.M. Khopar, "Basic concepts of Analytical Chemistry", John Wiley & Sons, 1984

10NT206 MATERIALS CHEMISTRY

Credits: 4:0:0

Objectives:

- Since atoms are the building blocks of materials and life, the student will learn the theories behind atomic structure
- The student will learn the types of materials and their bonding features
- The student will be able to distinguish between the chemical and physical nature of various categories of materials

Outcome:

The students will get knowledge on the building blocks of materials, the bonding involved, and their function

Unit I: Atomic structure

Structure of atom – defects of Rutherford's model - Bohr's model of an atom – Sommerfield's extension of atomic structure – electronic configuration and quantum numbers – s, p and d orbitals - Pauli's exclusion principle – Hund's rule of maximum multiplicity – Aufbau principle – ionic radius, ionization potential, electron affinity, electronegativity (definitions with examples only; trend in group and period not required) – sigma and pi bonds – hydrogen bonding – Van der Waals' forces - bond lengths and bond angles (with reference to single and multiple bonds) – Particles: leptons, quarks, gauge bosons, fermions (brief discussion on their charge, physical existence only)

Unit II: Solid state

Crystal structure – crystal symmetry – unit cell – the seven crystal systems – the 14 Bravais lattices – the 32 point groups – space groups – reciprocal lattice - defects in crystals – point defects, line defects, planar defects – dislocations – edge dislocations, screw dislocations – slip and plasticity

Unit III: Metals

Metallic bonding – ductility and conductivity – alloys – classification as base metals, ferrous metals, noble metals and precious metal – structure of metals: 12 coordination, 8 coordination, crystal grains – properties of metals – thermal spray, case hardening, plating – metal testing: nondestructive testing – metallography

Unit IV: Polymers

Classification of polymers – polymer morphology: crystallinity, tensile strength, Young's modulus – phase behavior: glass transition temperature, mixing behavior, inclusion of plasticizers – types of polymerization – mechanisms – important polymers (preparations and uses only): polyethylene, polyvinyl chloride, bakelite, rubber, silicones – polymer degradation

Unit V: Ceramics and composites

Ceramics: introduction – types of ceramic products – types of ceramic materials: crystalline and non-crystalline – properties ceramics: mechanical, electrical, and optical properties – applications.

Composites: introduction – moulding methods – properties composites: mechanics, resins – polymer composites – fiber glass – fiber formation – glass reinforced plastic – uses – optical filter – optical fiber communication.

Text books:

1. Brian S. Mitchell, An introduction to materials engineering and science for chemical and material engineers, Wiley Inter-science, 2004
2. William D. Callister, Fundamentals of materials science and engineering, Ed. 5, John Wiley & sons, 2001

Reference books:

1. Robert E. Newnham, Properties of materials, Oxford university press, 2005
2. Deborah D.L. Chung, Applied materials science, CRC Press, Chapman and Hall, 2001
3. Wole Soboyejo, Mechanical properties of engineered materials, Marcel Dekker Inc., 2002

10NT207 INTRODUCTORY NANOTECHNOLOGY

Credits: 4:0:0

Objectives:

- As the students have known the basic principles of chemical science he/she will now get introduced to the concept of nanochemistry
- A knowledge on the conceptual origin of nanotechnology and the unique techniques of nanosynthesis as opposed to traditional synthesis will be given
- The student will be exposed to ideas on the conditions to manipulate nanostructures with ease

Outcome:

Elementary ideas of origin, and newer chemistry which deals with nanoobjects and the unconventional catalysis using nanoparticles will be given to students

Unit I: Introduction to nanochemistry

History of nanotechnology – conceptual origins – experimental advances – role of Richard Feynman, Eric Drexler and Maxwell – prefixing nano before disciplines – nanochemistry - size effects in nanochemistry – brief explanation on top-down and bottom-up approaches – classification as dry and wet nanotechnology

Unit II: Cryochemistry of metal atoms and nanoparticles

Cryochemistry – definition and explanation – cryochemical synthesis - reactions of Mg particles – activation of small molecules – size-induced peculiarities of cryochemical reactions – stabilization of silver metal particles by polymers (eg: p-xylene polymer) – reactions of silver particles of various sizes and shapes – reactions at superlow temperatures – selectivity – reactions of magnesium oxide nanocrystals with aldehydes, ketones, and alcohols – general scheme of the synthesis of solvated metal particles in organic media

Unit III: Catalysis on nanoparticles

Catalysis on nanoparticles – oxide reactions – semiconducting nanoparticles in heterogeneous nanocatalysis – photoreaction involving n-dodecanethiol – covered silver nanoparticles – formation of assemblies of biomolecules on the surface of inorganic materials – operation of electronic switches – reduction of bipyridyl group on gold electrode

Unit IV: Chemical methods in preparation of nanomaterials

Sol – gel technique – co-precipitation hydrolysis – sonochemical method – combustion technique – colloidal precipitation – template process

Unit V: Other methods in preparation of nanomaterials

Solid-state sintering – grain growth – arc method – ion-beam induced nanostructures – grinding – high energy ball milling – material-ball ratio – control of grain size in the above methods

Text books:

1. Bruno Pignataro, Tomorrow's chemistry today–Concepts in nanoscience, organic materials, and environmental chemistry, Wiley-VCH, Royal chemical society, 2008
2. G.B. Sergeyev, Nanochemistry, Elsevier, 2007

References:

1. T. Pradeep, Nano: The essentials, McGraw Hill Publishers, 2007
2. Jonathan Steed, Core Concepts on supramolecular chemistry and nanochemistry, Wiley Eastern Publishers, 2006
3. Frank J. Owens and Charles P. Poole Jr., The physics and chemistry of nanosolids, Wiley Interscience Publishers, 2006
4. Parag Diwan and Ashish Paradwaj, Nanoscale materials, Pentagon Publishers, 2007
5. H.S. Nalwa, Encyclopedia of nanoscience and nanotechnology, Vol. 1, American scientific publishers, 2004

10NT208 CHARACTERIZATION AND INSTRUMENTAL TECHNIQUES

Credits: 4:0:0

Objectives:

- Since nanotechnology had its origin on the technological advancements of probing structures a study in combination of classical and modern techniques is required

- The student will understand the ways of identifying molecules and materials based on spectral and microscopic techniques
- The student will be able to distinguish between light scattering, absorption, and emission spectral techniques and those do not involve light sources

Outcome:

The students will get knowledge on analyzing the structure of molecules and materials

Unit I: Microscopy; XRD

Scanning electron microscopy (SEM) – scanning tunneling microscopy (STM) – transmission electron microscopy (TEM) – X-ray diffraction (XRD) – extended X-ray absorption fine structure (EXAFS) (physical principles and instrumentation only to be discussed for all the techniques)

Unit II: Diffraction and scattering techniques

Neutron diffraction – low energy electron diffraction (LEED) – reflection high energy electron diffraction (RHEED) – electron energy loss spectroscopy (EELS) - reflected electron energy loss spectroscopy (REELS) - Dynamic light scattering (DLS) (physical principles and instrumentation only to be discussed for all the techniques)

Unit III: Vibrational spectroscopy

Introduction to spectroscopy – spectroscopic regions and classifications - the vibrating diatomic molecule – vibrational transitions - selection rule – simple harmonic oscillator – anharmonic oscillator – the diatomic rotor – vibrations of polyatomic molecule – factors influencing vibrational frequencies – identification of functional groups – finger print region – application to organic compounds – instrumentation

Unit IV: Ultraviolet and visible spectroscopy

Electronic spectra of diatomic molecules – physical principles – laws of absorption – absorption transitions – chromophores and auxochromes – effects of conjugation – Woodward-Fieser rules for α,β-unsaturated carbonyl compounds and dienes – aromatic systems with extended conjugation – application to organic and inorganic compounds – instrumentation

Unit V: Nanotribology; Photoelectron spectroscopy

Nanotribology – nanotribometer – surface force apparatus – quartz crystal microbalance – friction force microscope – X-ray photoelectron spectroscopy (XPS) – electron spectroscopy for chemical analysis (ESCA) – ultraviolet photoelectron spectroscopy (UPS) (physical principles and instrumentation only to be discussed for all the techniques)

Text Books:

1. C.N.R. Rao, A. Muller, A.K. Cheetham, The chemistry of nanomaterials, Wiley VCH, 2004
2. Charles P Poole Jr., and Frank J. Ownes, Introduction to Nanotechnology, John Wiley Sons, Inc., 2003
3. Colin N. Banwell & Elaine M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edition, McGraw-Hill, New Delhi, 2004

References:

1. T. Tsakalakos, I. Ovid'ko and A.K. Vasudevan (eds.), Synthesis, Functional Properties and Applications of Nanostructures, Kluwer Academic Publishers, Dordrecht, 2003
2. H.A. Willard and L.L. Merrit, J.A. Dean, Van Nonstrand, Instrumental methods of Analysis, New York, 1986
3. T. Pradeep, Nano: The Essentials, Tata McGraw Hill, New Delhi, 2007
4. Jag Mohan, Organic Spectroscopy Principles and Applications, Narosa Publishing House, New Delhi, 2001
5. D.N. Satyanarayana, Vibrational Spectroscopy Theory and Applications, New Age International Publishers, New Delhi, 2004

10NT209 TITRIMETRIC ANALYSIS AND GRAVIMETRIC ANALYSIS LAB

Credit: 0:0: 2

I. Titrimetric analysis:

a) Acidimetry

1. Estimation of sodium hydroxide – standard sodium carbonate
2. Estimation of borax – standard sodium carbonate
3. Estimation of bicarbonate and carbonate in a mixture

b) Permanganometry

1. Estimation of oxalic acid - standard - Mohrs salt or ferrous sulphate.
2. Estimation of calcium
3. Estimation of sodium nitrite - standard - Oxalic acid
4. Estimation of ferric ion
5. Estimation of percentage of manganese in pyrolusite

c) Iodometry

1. Estimation of arsenious oxide
2. Estimation of copper – standard potassium dichromate
3. Estimation of potassium dichromate – standard copper sulphate

e) Complexometry

1. Estimation of zinc or magnesium using EDTA
2. Estimation of zinc using potassium ferrocyanide
3. Estimation of temporary and permanent hardness of water

f) Dichrometry

1. Estimation of ferrous ion using diphenyamine I N-.Phenyl anthramlic acid as indicator.
2. Precipitation titration - Estimation of chloride in neutral medium

II. Gravimetric analysis

1. Determination of barium as barium sulphate
2. Determination of sulphate as barium sulphate
3. Determination of lead as lead chromate
4. Determination of nickel as Ni-DMG complex
5. Determination of magnesium as magnesium pyrophosphate.

12 experiments will be notified by HOD from time to time

Reference:

1. G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denney, "Vogel's text book of quantitative chemical analysis", ELBS, 5th Edn. Longman, Singapore publishers, Singapore, 1996
2. I.M. Kolthoff and E.B. Sandell, "Quantitative Chemical Analysis" MacMillan, Chenai, 1980
3. G.Svehla, "Vogel's Qualitative Inorganic Analysis", 6th Edn., Orient Longman, New Delhi, 1987
4. V. Ramanujan, "Inorganic Semi-micro Qualitative Analysis", 3rd Edn., National Publishing Company, Chennai, 1990
5. K. Manivasakam, "Physico-chemical Examination of Water Sewage and Industrial Effluents", 3rd Edn., Pragati Prakashan, Meerut, 1996

10NT210 INORGANIC AND COORDINATION CHEMISTRY

Credits: 4:0:0

Objectives:

- The student will get the rudimentary ideas on chemical structure and formula of inorganic and co-ordination compounds
- The student will understand the differences in bonding of organic molecules (learnt in first semester) with those of inorganic molecules
- The student will know the basic structure of molecules which are components of supramolecular structures (which he/she will learn in upcoming semesters)

Outcome:

The students will get knowledge on the structural and reaction basics of inorganic compounds

Unit I: Chemical Bonding; Acid-base concept

Covalent Bond – Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions - Valence shell electron pair repulsion (VSEPR) theory: postulates and applications - MO theory, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference - classification as hard and soft acids and bases - Pearson's HSAB concept - theoretical basis of hardness and softness - electronegativity and hardness and softness

Unit II: Transition elements and co-ordination compounds

Chemistry of elements of Second and Third transition Series: general characteristics - comparative treatment with their 3d analogues with respect to ionic radii, oxidation states - comparative treatment of elements of second and third transition series- magnetic behavior, spectral properties and stereochemistry - Werner's coordination theory and its experimental verification, effective atomic number (EAN) concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds

Unit III: Metal-ligand bonding in transition metal complexes and magnetic properties

An elementary idea of crystal field theory - Crystal field splitting in octahedral, tetrahedral and square-planner complexes - factors affecting the crystal field parameters - A brief out line of thermodynamic stability of metal complexes and factors affecting the stability of square planner complexes - types of magnetic behavior, spin (only formula) LS coupling, correlation of μ_s (spin only) and $\mu_{effective}$ values - orbital contribution to magnetic moments

Unit IV: Organometallic Compounds

Definition, nomenclature and classification of organometallic compounds – Organo magnesium compounds: the Grignard reagents - formation, structure and chemical reactions – Organo-zinc compounds: formation and chemical reactions – Organo-lithlum compounds: formation and chemical reactions – Organo-sulfur Compounds: Nomenclature, structural features, methods of formation and chemical reactions of thiols, sulphonamides and sulphaguanidine - nature of bonding in metal carbonyls

Unit V: Bio-inorganic chemistry

Metallo-porphyrins – hemoglobin – myoglobin – di-oxygen binding, transport and utilization- structure and function- ferredoxins and cytochromes – Blue copper proteins - chlorophyll- electron flow in photo-synthesis - Vitamin B_{12} – structure and function - Nitrogenase enzyme- *in vivo* nitrogen fixation

Text books:

1. K. Sarn, Co-Ordination Chemistry, Rajat Publications, New Delhi, 2005
2. R.C. Agarwal, Some Recent Aspects of Inorganic Chemistry, Kitab Mahal, Allahabad, 1998
3. R.L. Madan, G.D. Tuli, Inorganic Chemistry (Q&A), S. Chand and Co., New Delhi 2005
4. R.K. Bansal, Organic Reaction Mechanism, Tata McGraw Hill, New Delhi, 1995

Reference books:

1. J.E.Huheey, E.A.Keitler & R.L.Keitler, Inorganic Chemistry, Vol. IV, Pearson Education, Singapore, 2002
2. F.A.Cotton & G.Wilkinson, Advanced Inorganic Chemistry, John Wiley & Sons, New York, 2003
3. J.D. Lee, Concise Inorganic Chemistry, 5th Edition, Black Well Science, London, 2005
4. Alan G. Sharpe, Inorganic Chemistry, 3rd Edition, Addison Wesley, Harlow, England, 1999

10NT211 PHYSICAL CHEMISTRY

Credits: 4:0:0

Objectives:

- The speed of a reaction and the criteria for reactions to take place will be discussed
- The thermodynamic requirement for a chemical reaction to take place and the criteria for spontaneity and reversibility are to be discusses
- The energy of molecules and quantum chemical explanation given to physical and chemical phenomena will be explained

Outcome:

The students will explain chemical reactions on the basis of energetic considerations

Unit I: Chemical kinetics and catalysis

First order, second order, zero order, and pseudo-first order reactions – Theories of reaction rates: Simple collision theory, absolute reaction rate theory, Arrhenius theory – opposing, parallel and consecutive reactions – kinetic isotopic effect

Acid base catalysis – Bronsted catalysis law – Enzyme catalysis (single substrate reaction only) – Michaelis-Menton law - Surface phenomenon – Gibb's adsorption isotherm - Physisorption and chemisorption

Unit II: Thermodynamics

First law of thermodynamics, relation between C_p and C_v, enthalpies of physical and chemical changes – second law of thermodynamics, entropy, Gibbs-Helmholtz equation – third law of thermodynamics and calculation of entropy

Free energy and entropy of mixing, partial molar quantities, Gibbs-Duhem equation – equilibrium constant, temperature dependence of equilibrium constant

Unit III: Electrochemistry

Electrode potential – Measurement of electrode potential – Nernst equation for electrode potential – Electrochemical Series – Electrochemical cell or Voltaic cell – Concentration cell – Primary Cell– LeClanche cell - Secondary batteries – alkaline batteries – Lead acid and Li batteries – An introduction to Fuel Cell, $H_2 – O_2$ Fuel Cell – Applications – Types of corrosion – factors influencing corrosion – Corrosion control methods

Unit IV: Quantum chemistry I

Black body radiation - Planck's quantum theory – wave-particle duality – uncertainty principle – operators and commutation relations – postulates of quantum mechanics and Schrodinger equation – particle in one dimensional and three dimensional box - degeneracy - harmonic oscillator - rigid rotator – angular momentum

Unit V: Quantum chemistry II

Variation and perturbation theory – application to helium atom – anti-symmetry and exclusion principle – Slater determinants – term symbols – Born-Oppenheimer approximation – electron density and their role in chemical bonding – hybridization and

valence MOs of H_2O, and CH_4 – Huckel pi electron theory and its application to ethylene, butadiene, and benzene

Text books:

1. R.K. Prasad, Quantum Chemistry, 2nd New Age International Pvt. Ltd., New Delhi, 2002
2. K.L. Kapoor, Text Book of Physical Chemistry, Vol. I & II, Mac Millan India Ltd., New Delhi, 1994
3. J. Rajaram K.C. Kuriakose, Kinetics & Mechanisms of Chemical Transformations, Mac Millan, Chennai (1993)

Reference books:

1. N. Levine, Quantum Chemistry, Prentice–Hall of India Pvt. Ltd., New Delhi 2001
2. A.K. Chandra, Quantum Chemistry 4th Edition Tata McGraw – Hill Publishing Company Ltd., New Delhi (2002)
3. P.W. Atkins, Physical Chemistry, 7th Edition, Oxford University Press, Oxford (2002).
4. S. Glasstone, Thermodynamics for Chemists, Litton Edition Publishing, New York (2002).
5. K.J. Laidler, Chemical Kinetics, 3rd Edition, Pearson Education, Singapore (2004).
6. S. Glasstone, Introduction to Electrochemistry, Litton Educational Publishing, New Delhi (2002).

10NT212 MEDICINAL CHEMISTRY

Credits: 4:0:0

Objectives:

- The student will use his earlier knowledge on organic structures to design a drug
- The student will understand the mechanism of drug action and various phases of drug develeopment
- The student will be exposed to ideas about target-based drug design and clinical trial of drugs

Outcome:

A thorough idea of drug chemistry and the structure–action relationship will be given

Unit I: Basics of medicinal chemistry

Brief history of medicinal chemistry – classification of drugs – brief description of biological, chemical, computer revolutions in drug design – pro drugs and soft drugs – design of pro drug system – multiple pro drug formation – soft drug principle and applications

Unit II: Drug targets and drug solubility

Enzymes and enzyme inhibitors – competitive and non-competitive inhibitors – reversible and irreversible inhibitors – ligand-receptor theories – Clark's theory and Paton's rate theory – proteins, lipids, and nucleic acids as drug targets – effect of pH, pK_a, and polarity on drug solubility

Unit III: Pharmacokinetics and drug metabolism

Natural resources of lead compounds – absorption, distribution, metabolism, and elimination – oxidation and hydrolysis – testing drugs in vitro – high-throughput screening – testing drugs in vivo – therapeutic index and therapeutic ratio

Unit IV: Clinical testing and synthesis of drugs

Various phases in preclinical testing and clinical trials – designing organic synthesis – convergent synthesis – patenting and manufacture – complexes and chelating agents – metal clusters – detoxification – drug action and metal chelation

Unit V: Development of new drugs

Five classic steps in the design of a new drug – procedures in drug design – isolation of bioactive compounds – accidental discovery – examination of metabolites – interference with fundamental life processes – exploitation of side effects of drugs - random screening – synthesis of drugs ab initio – molecular modification of lead compounds – factors affecting drug development

Text Books:

1. David A. Williams, William O. Foye, Thomas L. Lemke; Foye's Principles of Medicinal Chemistry, 5th edition; Lippincott Williams & Wilkins: Philadelphia, 2002.
2. Delgado & Remers, Eds.; Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, 11th edition; Lippincott Williams & Wilkins: Philadelphia, 2004 ("W&G").

References:

1. D.J. Abraham, Ed., Burger's Medicinal Chemistry, 6th ed., Vol. 1-6; (RS403 .B8 2003 - vol.1-6)
2. Daniel Lednicer and Lester A. Mitscher Organic Chemistry of Drug Synthesis, Vol. I-6, (RS 403.L38-vol. 1-6)
3. Joel G. Hardman & Lee L. Limbird, Eds.; Goodman & Gilman's the Pharmacological Basis of Therapeutics, 10th ed., Alfred Gilman, Contrib. Ed (RM300 .G644 2001

10NT213 PHYSICAL CHEMISTRY LAB

Credit: 0:0: 2

Physical Chemistry Lab:

1. Chemical kinetics
   i. Determination of specific reaction rate of the hydrolysis of methyl acetate
   1. catalyzed by hydrogen ion at room temperature.
   ii. Determination of rate of decomposition of hydrogen peroxide.
   iii. Determination of overall order of saponification of ethyl acetate
2. Distribution law
   i. Determination of distribution coefficient of iodine between water and carbon Tetrachloride.
   ii. Determination of molecular status and partition coefficient of benzoic acid in Toluene and water.

3. Electrochemistry

i. Determination of concentration of HCl conductometrically using standard NaOH solution.

ii. Determination of concentration of acetic acid conductometrically using standard NaOH solution.

iii. Determination of dissociation constant (K_a) of acetic acid by conductivity measurements.

iv. Determination of solubility and solubility product of $BaSO_4$

v. Determination of redox potentials of $Fe^{2+}/Fe^{3+}$by potentiometric titration of ferrous ammonium sulphate vs. potassium dichromate.

4. pH metry

i. Preparation phosphate buffer solutions

ii. pH metric titration of weak acid, acetic acid with strong base NaOH and calculation of dissociation constant.

5. Colorimetry

i. Verification of Beer-Lambert law for $KMnO_4$, $K_2Cr_2O_7$ and determination of concentration of the given solution.

ii. Verification of Beer-Lambert law for $CuSO_4$ and determination of concentration of the given solution.

iii. Composition of complex of Cu^{2+} - EDTA disodium salt

6. Adsorption

i. Surface tension and viscosity of liquids.

ii. Adsorption of acetic acid on animal charcoal, verification of Freundlich isotherm.

12 experiments will be notified by HOD from time to time

Reference:

1. Willard – Dean – Merrit, "Instrumental methods of analysis", Affiliated East West pvt. Ltd., New Delhi, 1965
2. A.I. Vogel – "Text book of quantitative inorganic analysis", Long man group Ltd., 1978
3. D.P.Shoemaker,., C.W. Garland,, J.W. Nibbler, , "Experiments in Physical Chemistry" McGraw Hill 5th Edition, 1989
4. B.D. Khosala, A.Gulnti and V.C. Garg, "Senior practical physical chemistry" 7th edition, S. Chand & Co., New Delhi, 1994
5. D.R. Satiya, 'Practical Chemistry', 2nd edition, Allied publishers Ltd., Chennai, 1991

10NT214 ANALYTICAL CHEMISTRY AND SPECTROSCOPY

Credits: 4:0:0

Objectives:

- The separation methods of compounds and their purification will be discussed
- The student will understand the structure analysis using spectral techniques

- The student will distinguish between the principles of techniques which are used to study solution phase samples and to study solid samples

Outcome:

The students will know separation and structure analysis of molecules and materials

Unit I: Analytical techniques

Chromatography: theory, instrumentation, basic principles and applications of the following – column, thin layer, and ion-exchange chromatography – HPLC - applications in chemical analysis – gas chromatography

Principles of ORD and CD – Cotton effect – octant rule – axial haloketone rule – applications of ORD and CD in organic and bio-molecules

Unit II: NMR spectroscopy

Principle of NMR spectroscopy – instrumentation – factors affecting chemical shifts – chemical and magnetic equivalence – proton NMR – spin-spin coupling – FT NMR – C^{13} NMR – factors affecting chemical shifts – application of NMR to structure determination of organic compounds – Decoupling – Off-resonance decoupling

Unit III: Emission spectroscopy

Photoluminescence – fluorescence and phosphorescence – Jablonskii diagram – fluorescence polarization – fluorescence correlation spectroscopy (FCS) – fluorescence in-situ hybridization (FISH) – fluorescence confocal microscopy – fluorescence resonance energy transfer (FRET) - (physical principles, instrumentation and applications)

Unit IV: Mass spectrometry

Principles of mass spectrometry – nitrogen rule – meta-stable ions and peaks – molecular ion peak – fragmentation processes – even and odd electron ions – retro-Diels-Alder rearrangement – McLafferty rearrangement – fragmentation associated with functional groups – aldehydes and ketones, carboxylic acids, esters, amides and alcohols, thiols and amines, aromatic compounds

Unit V: Introduction to Crystallography

Introduction to X-ray crystallography – protein crystallography – problems associated with growing biomolecular crystals – isomorphous replacement in solving crystal structure – interpretation of derived electron density maps – land mark modules in crystallography (physical principles and instrumentation only to be discussed for all the techniques)

Text books:

1. G.W. Ewing, Instrumental Methods of Chemical Analysis, 5th Edition, 1978, McGraw Hill Books Co., New York.
2. P.S. Kalsi, Spectroscopy Of Organic Compounds, 6th Edition, New Age International Publishers, New Delhi, 2004
3. Y.R. Sharma, Elements Of Organic Spectroscopy, S. Chand & Company Ltd., New Delhi, 2004

Reference books:

1. D.A. Skoog, Principles of Instrumental Analysis, 5th Edition, 1998, Saunders College Publishing, Philadelphia, London
2. J.H. Kennedy, Analytical Chemistry: Principles, 2nd Edition, 1990, Saunders Holt, London.
3. Robert M. Silverstein & Francis X. Webster, Spectroscopy of Organic Compounds, 6th Edition, Wiley Publications, 1998
4. B.P. Straughan & S.Walker, Spectroscopy, John Wiley and Sons, New York (1976).
5. Charles Kittel, Introduction to solid state physics, John Wiley and sons, 1953

10NT215 NANOTECHNOLOGY, GREEN CHEMISTRY AND ENVIRONMENTAL HEALTH

Credits: 4:0:0

Objectives:

- The student will understand the risk and safety of nanotechnology
- The concept of green chemistry will be introduced to the students
- The role of nanotechnology in environmental health will be understood by the student

Outcome:

The environmental applications of nanotechnology and the concept of green chemistry will be learnt by the student

Unit I: Health, policy and energy issues

Issues in nanotechnology involving environmental health safety – nanotechnology policy implications – nanotechnology products of today – reactive applications of nanotechnology in environment – nanotechnology lifecycles – nanotechnology, human health, and medicine – routes of administration of nanomaterials – oxidative stress – what can we learn from diesel particles – persistent redox activity – risk benefit analysis – need for framework and leadership

Unit II: Risks and safe nanotechnology

Nano-objects – exposure routes to nano-objects – effects seen in animal studies – observations from epidemiological studies – hypothesis from animal and epidemiological studies – fire and explosion risk – risk of catalytic reactions – workplace exposures – sampling strategy

Unit III: Working with engineered nanomaterials

Potential for occupational exposure – factors affecting exposure to nanomaterials – elements of risk management programs – engineering controls, dust collection efficiency of filters, work practices, personal protective clothing, respirators, clean-up and disposal of nanomaterials

Unit IV: Introduction to green chemical principles

Definition, tools, and twelve principles of green chemistry, solvent-less reactions and reactions in water, microwaves and fluorous solvents, green resolution of racemic mixtures, materials for a sustainable economy, chemistry of longer wear, agrochemicals: problems and green alternate solutions, Atom efficient processes, evaluating chemical reagents according to their yield and atom efficiency, examples of efficient stoichiometric and catalytic processes, atom economy and homogeneous catalysis, halide-free synthesis and alternatives to Strecker synthesis

Unit V: Greener reagents and products

Greener solvents – the use of volatile organic compounds and the need for inoccuous replacements – use of ionic liquids – the use of supercritical CO_2 – solvent-less, solid-supported reagents, and aqueous systems as alternative solvents – greener reagents and products, avoidance of toxic functional groups, minimizing bioavailability and use of auxiliary materials, examples of greener reagents including replacement of phosgene, solid state polymerizations, alternative nitrile synthesis

Text books:

1. Lynn Goldman, Christine Coussens, Implications of nanotechnology for environmental health research, National Academic Press, Washington, 2007
2. Matlack, A. S. Introduction to Green Chemistry. Marcel Dekker: New York, 2001

References:

1. Anastas, P. T.; Warner, J. C. Green Chemistry: Theory and Practice. Oxford Univ. Press: Oxford, 1998.
2. http://www.chemicalstrategies.org/other_green.htm
3. Mukesh Doble, Green Chemistry and Engineering, Academic Press; 1 edition 2007
4. Approaches to safe nanotechnology, Department of health and human services, DHHS (NIOSH) publication, 2009
5. www.foresight.org/UTF/Unbound_LBW/

10NT216 MOLECULAR AND MATERIALS SELF-ASSEMBLY

Credits: 4:0:0

Objectives:

- The assembly of nanomaterials of different types will be discussed
- The student will get knowledge on the bottom-up approach in nanotechnology based on self-assembly
- The student will be able to distinguish molecular and materials self-assembly on the basis of the driving force needed for them to form

Outcome:

Self-assembly, which is the most basic of bottom-up building up of nanostructures will be learnt in detail by the student

Unit I: Fundamentals of self-assembly and self-assembled monolayers

Self-assembly: definition – molecular vs. materials self-assembly – hierarchical self-assembly – forms, patterns and functions – self-assembled monolayers (SAMs) – soft lithography – microlens arrays – transfer printing – electrically contacting SAMs – SAM crystal engineering - switching SAM function – chemical reactions on SAMs – applications of SAMs

Unit II: Layer–by–layer self assembly

Electrostatic superlattices – organic polyelectrolyte multilayers – assembling metallo-polymers – polyelectrolyte-colloid multilayers – graded composition LbL films – LbL MEMS – crystal engineering of oriented zeolite film – zeolite-ordered multi-crystal arrays – cross-linked crystal arrays – patterned multilayers – non-electrostatic LbL assembly – LbL self-limiting reactions

Unit III: Nanorod, nanowire self-assembly

Templating nanowires – modulated diameter gold nanorods – self-assembling nanorods – magnetic nanorods – magnetic nanorods and nanoclusters – hierarchically ordered nanorods – nanorod devices – nanotubes from nanoporous templates – VLS synthesis of nanowires – nanowire quantum size effects – manipulating nanowires – crossed semiconductor nanowire smallest LCD – nanowire sensors

Unit IV: Nanocluster self-assembly

Definitions for nanocrystal, nanoparticle, and nanocluster – synthesis of capped semiconductor nanoclusters – electrons and holes in nanocluster boxes – nanocrystal semiconductor alloys – nanocluster phase transition – capped gold nanoclusters – alkanethiolate capped nanocluster diagnostics – water soluble nanoclusters – alkanethiolate capped silver nanocluster superlattice – core-shell magnetic nanoclusters – nanocluster-polymer nanocomposites

Unit V: Self-assembling block copolymers

Block copolymer self-assembly – nanostructured ceramics – block copolymer thin films – electrical ordering – spatial confinement of block copolymers – block copolymer lithography – decorating block copolymers – nanowires from block copolymers – making micelles – harnessing rigid rods – block co-polypeptides – block copolymer bio-factories

Text books:

1. Bruno Pignataro, Tomorrow's chemistry today–Concepts in nanoscience, organic materials, and environmental chemistry, Wiley-VCH, Royal chemical society, 2008
2. G.B. Sergeyev, Nanochemistry, Elsevier, 2007

References:

1. T. Pradeep, Nano: The essentials, McGraw Hill Publishers, 2007
2. Jonathan Steed, Core Concepts on supramolecular chemistry and nanochemistry, Wiley Eastern Publishers, 2006
3. http://www.uaf.chem/rfk/nano.html
4. Frank J. Owens and Charles P. Poole Jr., The physics and chemistry of nanosolids, Wiley Interscience Publishers, 2006
5. R. Thomson, Encyclopedia of nanochemistry, Anmol Publishers, 2005

6. Ralph G. Grew, Fritz B. Prinz, and R. Lane Smith, Nanoscale technology in biological systems, CRC Press, 2007
7. Parag Diwan and Ashish Paradwaj, Nanoscale materials, Pentagon Publishers, 2007

10NT217 CHEMINFORMATICS

Credits: 4:0:0

Objectives:

- The learnt concepts of structure, medicinal properties of chemical species will be applied in describing them using computer
- The graphical way of representation of chemical structures will be discussed
- Choosing the best structure for drug design will be taught

Outcome:

The students gain knowledge on virtual screening methods in structure searching and design

Unit I: Representation of 2D molecular structures

Cheminformatics: definition and scope – use of cheminformatics – evolution of cheminformatics – computer representation of chemical structures – graph theoretic representation of chemical structures – connection tables and linear notions – canonical representations of molecular structures – structure searching, substructure searching – screening methods – reaction databases

Unit II: Representation of 3D molecular structures

Introduction to 3D representation – experimental 3D databases – 3D pharmacophores – theoretical 3D databases: structure generation programs, conformational search and analysis – random conformational search – methods to derive 3D pharmacophores, pharmacophore mapping using constrained systematic search – pharmacophore mapping using clique detection, maximum likelihood method for pharmacophore mapping – practical aspects of phamacophore mapping – applications of 3D pharmacophore mapping

Unit III: Molecular descriptors

Introduction – descriptors calculated from 2D structure: simple counts, physicochemical properties, molar refractivity – topological indices, kappa shape indices – electro-topological state indices – 2D finger prints – descriptors based on 3D representations – 3D fragment screens, pharmacophore keys – date verification and manipulation: data spread and distribution, scaling – correlations between descriptors – principal component analysis – reducing the dimensionality of a data set

Unit IV: Similarity methods

Introduction – similarity based on 2D finger prints – similarity coefficients – other 2D descriptor methods (Maximum common sub graph similarity) – 3D similarity – alignment independent methods – alignment methods: field based alignment – Gnomonic projection methods – finding the optical alignment – comparison and evaluation of similarity methods

Unit V: Analysis of high-throughput screening data; virtual screening

Introduction – data visualization – non linear mapping – data mining methods; sub structure analysis – discriminant analysis – neural networks – decision trees – introduction to virtual screening – drug likeness and compound filters – structure based virtual screening; protein-ligand docking – scoring functions for protein-ligand docking

Text books:

1. Andrew R. Leach, Valerie J. Gillet, An introduction to chemoinformatics, Springer, 2005
2. Richard G. Brereton, Chemometrics Data Analysis for the Laboratory and Chemical Plant, John Wiley & sons, 2003

Reference books:

1. Johann Gasteiger, Thomas Engel, Chemoinformatics, Wiley-VCH, 2003
2. Jure Zupan, Johann Gasteiger, Neural Networks in Chemistry and Drug Design, Wiley-VCH, 1999
3. H. Holtje, W. Sippl, D. Rognan, G. Folker, Molecular modeling, Wiley-VCH, 2003
4. B.A. Bunin, J. Bajorath, B. Siesel, G. Morales, Chemoinformatics: theory, practice, and products, Springer, 2007

10NT218 MOLECULAR MACHINES AND MATERIALS

Credits: 4:0:0

Objectives:

- Structure, function and classifications of specific nanomaterials will be discussed
- Distinguishing element-based function of nanostructures will be known to the students
- The student will know how these nano-sized materials work strange in suitable conditions

Outcome:

The applications of nanostructures in various fields, based on the structure and function of molecular machines, carbon nanostructures, and dendrimers, will be taught to the students

Unit I: Molecular machines

Historical basis for molecular machines – molecular nanotechnology - molecular motors: examples, modern insights – smart materials and nanosensors – replicating nanorobots – molecular propeller – molecular switches, rectifiers, wires – molecular shuttle – molecular tweezers – molecular logic gates – molecular assembler – Drexler and Smalley debate

Unit II: Fullerenes, graphenes

Allotropes of carbon – diamond and graphite; Fullerenes: nomenclature, bucky-balls, carbon nanobuds, solubility, safety and toxicity, fullerites, chemical properties of fullerenes, fullerene reactions – fullerenes as ligands – fullerene synthesis

Graphenes – hybridization in graphenes – epitaxial growth on silicon carbide – epitaxial growth on metal substrates – properties –electronic properties – thermal properties – mechanical properties – potential applications

Unit III: Dendrimers

Introduction –general structure – synthesis – click chemistry – classification as linear, cross-linked, branched, and dendrintic polymers - properties and applications – types of dendrimers as PAMAM, PAMAMOS, PPI, and Tacto dendrimers – Frechet type dendrimers – chiral dendrimers – divergent dendrimer growth – convergent dendrimer growth – mixed growth

Unit IV: Nanotubes

Nanotubes: carbon nanotubes – classification as single walled and multi walled – kinetic, thermal, and electrical properties – defects – synthesis of nanotubes – structural, electro-acoustic, electromagnetic applications of nanotubes – nanotubes in electrical circuits – selective chemistry of single-walled nanotubes

Unit V: Quantum dots chemistry

Quantum dots, quantum wires and wells – making quantum dots – colloidal synthesis – fabrication – viral assembly – electrochemical assembly – optical properties – applications in biology and computing – applications in photovoltaic devices and light emitting devices

Text books:

1. Frank J. Owens and Charles P. Poole Jr., The physics and chemistry of nanosolids, Wiley Interscience Publishers, 2006
2. C. Brechignac, P. Houdy, M. Lahmani, Nanomaterials and nanochemistry, Springer, 2006

Reference books:

1. Brian Cantor, Novel nanocrystalline alloys and magnetic nanomaterials: An Oxford–Kobe materials text, IoP publishing ltd., 2005
2. J.C. Miller, R.M. Serrato, J.M.R. Cardenas, G.A. Kundahl, The handbook of nanotechnology, John Wiley & sons, 2005
3. C.N.R. Rao, A.K. Cheetham, Materials science at the nanoscale Taylor & Francis group, 2006

10NT219 SYNTHESIS OF ORGANIC COMPOUNDS AND CHROMATOGRAPHY LAB

Credit: 0:0: 2

1. Synthesis of Organic Compounds

i. Aromatic electrophilic substitution Nitration: Preparation of nitro benzene and p-nitro acetanilide, Halogenation: Preparation of p-bromo acetanilide – preparation of 2,4,6-tribromo phenol.
ii. Diazotization and coupling: Preparation of pheyl azo β-napthol
iii. Oxidation: Preparation of benzoic acid from benzoyl chloride

iv. Reduction: Preparation of m-nitro aniline from m-dinitro benzene
v. Esterfication: Preparation of methyl p-nitro benzoate from p-nitro benzoic acid.
vi. Methylation: Preparation of β-napthyl methyl ether
vii. Condensation: Preparation of benzilidine aniline and Benzoyl aniline.

2. Thin layer Chromatography & Column Chromatography

i. Preparation of the TLC plates. Checking the purity of the compounds by TLC:
ii. Acetylation of salicyclic acid, aniline, Benzoylation of Aniline and Phenol
iii. Determination of Rf values and identification of organic compounds by TLC: preparation and separation of 2,4-dinitrophenyl hydrazones of acetone and 2-butanone using toluene and light petroleum(40:60)
iv. Separation of ortho & para nitro aniline mixture by column chromatography

3. Demonstration experiments:

1. Steam distillation experiment: separation of ortho and para nitro phenols
2. Microwave assisted Green synthesis, two examples:
    a. Hydrolysis of Benzamide
    b. Oxidation of Toluene

12 experiments will be notified by HOD from time to time

Reference:

1. A.I. Vogel – "Text book of practical organic chemistry", 5th Ed. ELBS, London, 1989
2. B.B. Dey and M.V. Sitharaman, "Laboratory manual of Organic Chemistry" Revised by T.R. Govindachari, Allied Publishers Ltd., New Delhi, 4th Revised edition, 1992
3. Daniel R. Palleros, "Experimental Organic Chemistry" John Wiley & Sons, Inc., New York, 2000
4. B.S. Fumiss, A.J. Hannaford, V. Rogers, P.W.G. Smith and A.R. Tatchell, "Text book of Practical Organic Chemistry", LBS, Singapore, 1994
5. S.M. Khopar, "Basic concepts of Analytical Chemistry", John Wiley & Sons, 1984

10NT301 CHEMICAL APPROACH TO NANOMATERIALS

Credits: 4:0:0

Objectives:

- Soft lithographic patterning on the basis of chemistry will be discussed
- The theory of materials preparation with soft building blocks and large building blocks will be taught to the students
- The question of how chemistry uses bioinspiration for material preparation will be addressed

Outcome:

The student will get a thorough knowledge of the chemical approach to patterning and synthesis of nanomaterials

Unit I: Nanocontact printing

Soft lithography – micro-contact printing – defect patterning – below 50 nm nanocontact printing – nanocontact writing – dip-pen nanolithography (DPN) – nanoscale writing on semiconductor nanowires – soft patterning of hard magnets – patterning bio-constructions – enzyme DPN – SPM Nano-electrochemistry – scanning probe contact printing (SP-CP) – nanoplotters

Unit II: Microspheres

Photonic crystals – microsphere building blocks – silica microspheres – multi-shell microspheres – microsphere self-assembly crystals and films – photonic crystal marbles – photonic crystal fibers – optical properties of colloidal crystals – synthesizing photonic band gap – internal light sources – photonic inks – color oscillator – photonic crystal sensors - liquid crystal photonic crystal

Unit III: Porous materials from soft building blocks

Modular self-assembly of microporous materials – hydrogen storage coordination frameworks – microporous materials – mesoscale building blocks – designing function into mesoporous materials – mesostructure and dimensionality – mesotexture – silica-polymer hybrids – guests in mesopores – organics in the backbone – films, interfaces, mesoepitaxy – mesomorphology

Unit IV: Large building blocks

Supra-micron shapes assembly – crystallizing micron-sized planar building blocks – polyhedra with patterned faces – large sphere building block assembly – magnetic self-assembly – dynamic self-assembly – autonomous assembly – synthetic life – large sphere building blocks and 3D crystals

Unit V: Biomaterials and bioinspiration

Nature's design of materials – mimicking nature – faux fossils – siliceous sculptures – synthetic morphology – biomimicry – biomineralization – learning from nature – viral cage directed synthesis of nanoclusters – polynucleotide directed nanoclusters – DNA coded nanoclusters – bacteria directed materials self-assembly – protein S-layers – better bones through chemistry

Text books:

1. Bruno Pignataro, Tomorrow's chemistry today–Concepts in nanoscience, organic materials, and environmental chemistry, Wiley-VCH, Royal chemical society, 2008
2. G.B. Sergeyev, Nanochemistry, Elsevier, 2007

Reference Books:

1. T. Pradeep, Nano: The essentials, McGraw Hill Publishers, 2007
2. Jonathan Steed, Core Concepts on supramolecular chemistry and nanochemistry, John Wiley Publishers, 2006
3. Frank J. Owens and Charles P. Poole Jr., The physics and chemistry of nanosolids, Wiley Interscience Publishers, 2006
4. R. Thomson, Encyclopedia of nanochemistry, Anmol Publishers, 2005

5. Ralph G. Grew, Fritz B. Prinz, and R. Lane Smith, Nanoscale technology in biological systems, CRC Press, 2007
6. Parag Diwan and Ashish Paradwaj, Nanoscale materials, Pentagon Publishers, 2007

10NT302 NANOTOXICOLOGY AND ETHICS

Credits: 4:0:0

Objectives:

- Awareness will be created on the toxicology of nanomaterials among students and the concept of sustainable nanotechnology will be introduced
- The adverse effect of nanoparticles interacting with biological membranes will be discussed
- The ethical agenda to be followed in nanotechnology will be emphasized

Outcome:

The student will understand the toxicology of nanomaterials and his/her responsibility when using nanotechnology

Unit I: Nanotoxicology and sustainable nanotechnology

Size-specific behavior of nanomaterials – nanotoxicology challenges – carbon nanotubes in practice – postproduction processing of carbon nanotubes – physicochemical properties of nanomaterials as mediators of toxicity – characterization of administered nanomaterials during toxicity studies – nanomaterial characterization after administration experiment

Unit II: Nanoparticle exposure

Physicochemical determinants in particle toxicology – nanoparticles vs. micron-size particles – nanoparticle toxicity comparison to larger counterparts – requirement for appropriate model particles – exposure assessment, exposure pathways and their significance – documenting the occurrence and nature of exposures – bio-distribution of nanoparticles – localization of particles in tissues – relevance of drug targeting to nanotoxicology

Unit III: Nanoparticle interaction with biological membranes

Interaction of nanoparticles with lipid bilayers – cell-level studies of nanoparticle-induced membrane permeability – internalization of cation nanoparticles into cells – placental biological barrier model for evaluation of nanoparticle transfer – transport across placental barrier – assessment of placental transfer - Biological mechanism of nanoparticle disposition – outline of gene-cellular interactions of nanomaterials – overview of dermal effects of nanomaterials – toxicity of nanoparticles in the eye

Unit IV: Approaching the Nano-age

scientists as moral agents – the business community and corporations as moral agents – policy makers and regulators as moral agents – ethical and societal implications – the public interface of science and human values – origins of the precautionary principle – the citizen as moral agent – the language of ethics – meta-ethics and normative ethics

Unit V: The ethical agenda for nanotechnology

The visions of nanotechnology – scenarios in the nanotech marketplace – clarifying purpose – the principle of respect for communities – the principle of the common good – the principle of social justice – utilitarian priorities
The pressing questions – the players – the funders – the thinkers – the communicators – the arenas combined – the role of fore-sighting – ethics applied to the practical – citizenship in the nano-age – the value of the skeptical optimist

Text Books:

1. A. Monterio-Rivierie, C. Lang Tran, Nanotoxicology, Informa health care, London, 2007
2. Lynn Goldman, Christine Coussens, Implications of nanotechnology for environmental health research, National Academic Press, Washington, 2007
3. Deb Bennett-Woods, Nanotechnology: Ethics and society, CRC Press, Taylor and Francis group, 2008

References:

1. Niosh, Approaches to Safe Nanotechnology, Department of health and human services, US, 2008
2. Hans-Joachim Jördening, Josef Winter, Environmental Biotechnology, Wiley-VCH, 2005
3. Patrick Lin and Fritz Allhoff, Nano-ethics: The Ethical and Social Implications of Nanotechnology, John Wiley & Sons, 2007

10NT303 NANOTECHNOLOGY IN FUEL CELLS AND ENERGY STORAGE

Credits: 4:0:0

Objectives:

- The application of nanotechnology in energy storage will be discussed
- The question of possibility of alternative energy will be met with on theoretical basis
- The materials in use for such energy storage will be introduced to the students

Outcome:

The student gets an exposure to the role of nanotechnology in meeting the energy needs of the future

Unit I: Nanostructured catalysts for low temperature fuel cells

Working principle of a fuel cell – electrode reactions at low temperature fuel cells – supported catalysts – catalyst preparation – impregnation method, colloidal method, micro-emulsion method – catalyst supports – nanostructured carbon – nanoporous carbon – mesoporous carbon – hierarchical pore structures

Unit II: Nanocrystalline solar cells

Dye-sensitized solar cells – cell operation, materials – semiconductor-sensitized solar cells (SSSC) – liquid junction SSSCs – recombination rates in semiconductors – back-transport of electrons from oxide to absorbing semiconductor – electron injection from oxide / substrate into electrolyte

Unit III: Oxides and solid-state SSSCs

Losses in semiconductor aggregates on oxides – multilayer semiconductors – other porous oxides – solid state semiconductor-sensitized solar cells (sSSSCs) – the ETA cell – two-component ETA cells - three-component ETA cells – built-in fields in SSSCs

Unit IV: Nano-scale materials for hydrogen and energy storage

Introduction – methods for energy storage – energy storage in super-capacitors and batteries – hydrogen storage in mobile applications – challenges in material development – physisorption materials – nanoporous inorganic materials for hydrogen storage – zeolite-based and transition metal-based structures

Unit V: Nano-porous organic materials for hydrogen storage

Nanoporous organic and carbon materials – activated carbon, carbon nanotubes, carbide-derived carbons – metal-organic framework – chemisorption materials – magnesium hydride, complex hydrides – reaction systems – experimental aspects – materials handling – synthesis methods – characterization of hydrogen storage materials – thermodynamic and kinetic properties of hydride systems

Text Book:

1. Gerard Wilde, Nanostructured materials, Elsevier, 2009
2. A.B. Hart and G. J. Womack, "Fuel Cells: Theory & Applications", Prentice Hall, NY, 1997
3. Narayan R and B Viswanathan, "Chemical and Electrochemical Energy Systems", University press (India) Ltd., 1998

References:

1. Stephen L. Gillett, Nanotechnology: clean energy resources for the future, Foresight institute, 2002
2. Jamelyn D. Holladay, Yong Wang, Evan Jones, Chemical Reviews 2004, 104, 4767 – 4790,

10NT304 SUPRAMOLECULAR CHEMISTRY

Credits: 4:0:0

Objectives:

- As the students have known the structural and functional basics of building blocks of supramolecular structures, he/she will now be taught how to build up such structures
- A knowledge on the driving forces of supramolecular structure formation will be given to the student
- The student will be exposed to ideas on the types of supramolecules based on structure and the chemistry behind host-guest assembly

Outcome:

The structure of supramolecules of various types in solution and solid state and their importance as materials and functional units will be learnt by the student

Unit I: Introduction to supramolecular chemistry

Introduction to supramolecular chemistry – selectivity – lock and key principle and induced fit model – complementarity – co-operativity and chelate effect – pre-organization – binding constants – kinetic and thermodynamic selectivity – optically active supra-molecules – self-assembly of intrinsically chiral molecular capsules – chiral induction in the formation of supra-molecular systems – chiral memory effect – chiral nanoparticles

Unit II: Solution host–guest chemistry

Introduction: guests in solution – macrocyclic vs. acyclic hosts – high-dilution synthesis – template synthesis – cation binding – crown ethers and cryptands – spherands – heterocrowns – biological ligands: ion channels – anion binding – charged receptors – neutral receptors – Lewis acid receptors – neutral molecule binding – calixarenes, cyclodextrins and dendrimers as catalysts

Unit III: Supramolecular structures

Ladders, polygons, and helices – self-assembly using metal templates – racks, ladders, and grids – helicates – molecular polygons

Rotaxanes, catenanes, and knots – topological connectivity – rotaxanes and catenanes as molecular devices – borromeates – knots (structure and function of the above species)

Unit IV: Solid state supramolecular chemistry

Introduction – zeolites: structure – zeolite composition – zeolites and catalysis – clathrates – urea/thiourea clathrates – trimesic acid clathrates – hydroquinone and Dianin's compound – clathrate hydrates (structure and function of the above species) –uses

Unit V: Self-assembling capsules

Self-assembling capsules – molecular containers – metal directed capsules – hydrogen bonded capsules – concepts in crystal engineering – the Cambridge structural database - crystal engineering with hydrogen bonds – pi interactions - solid state reactivity – metal-organic frameworks – guest properties of metal-organic frameworks

Text books:

1. Jean-Marie Lehn, Supramolecular Chemistry, RCS pubs., 2005
2. Jonathan Steed, David Turner, Carl Wallace, Core concepts in Supramolecular Chemistry and nanochemistry, John Wiley & sons, 2007
3. Katsuhiko Ariga · Toyoki Kunitake,Supramolecular chemistry –Fundamentals and applications advanced textbook, Springer-Verlag, 2000

Reference books:

1. http://www.uaf.edu/chem/rfk/nano.htm
2. T. Pradeep, Nano: The essentials, McGraw Hill Publishers, 2007
3. G.B. Sergeyev, Nanochemistry, Elsevier, 2007
4. C. Brechignac, P. Houdy, M. Lahmani, Nanomaterials and nanochemistry, Springer, 2006

10NT305 BIOINFORMATICS AND DRUG DESIGNING

Credits: 4:0:0

Objectives:

- The student will be able to distinguish between cheminformatics and bioinformatics
- A knowledge on the protein structure prediction and drug design will be given
- Receptor-based drug optimization will be discussed

Outcome:

The student will be in a ready-to-go state to design drugs in-vitro

Unit I: Introduction to bioinformatics

Introduction to bioinformatics – definition – need – differences between cheminformatics and bioinformatics – benefits of mathematical models – applications – target validation – proteomics, metabolomics, and lipomics: definitions, brief discussion with example – high throughput screening (HTS) and experimental medicine – brief explanation on microarray analysis – need for microarray analysis

Unit II: Force Fields

Force fields - bond stretching - angle bending - introduction to non-bonded interactions - electrostatic interactions - van der Waals interactions - hydrogen bonding in molecular mechanics - force field models for the simulation of liquid water

Unit III: Protein structure prediction and drug design

Protein Structure Prediction - introduction to comparative modeling - sequence Alignment - constructing and evaluating a comparative model - predicting protein structures by 'threading', molecular docking, AUTODOCK and HEX - structure based de novo ligand design

Unit IV: Computer–assisted drug design

Basic terms: retro-synthetic analysis, transforms, retrons, synthons – reaction center and reaction sub-structure – concepts for computer assisted organic synthesis: synthesis design systems, LHASA – SYNCHEM, SYNGEN – searching for building blocks, generating precursors – fields of applications of cheminformatics in drug design – ligand based drug design: a brief discussion – structure based drug design

Unit V: Receptor binding sites

Introduction – experimental characterization of binding sites – sequence based approaches to prediction of binding sites – structural approaches – experimental and theoretical determination of binding sites – analyzing and visualization of binding sites – virtual screening approach to receptor-ligand interactions

Text books:

1. Andrew R. Leach, Valerie J. Gillet, An introduction to chemoinformatics, Springer, 2005

2. Richard S. Larson, Bioinfromatics and drug discovery, Humana press, New Jersey, 2006
3. Creighton, T.E., Proteins: structure and molecular properties, Second edition, W.H. Freeman and Company, New York, USA, 1993

Reference books:

1. A.R.Leach, Molecular Modelling Principles and Application, Longman, 1996
2. Jure Zupan, Johann Gasteiger, Neural networks in chemistry and drug design, Wiley-VCH, 1999
3. H. Holtje, W. Sipple, D. Rognan, G. Folker, Molecular modeling, Wiley-VCH, 2003
4. B.A. Bunin, J. Bajorath, B. Siesel, G. Morales, Chemoinformatics: theory, practice, and products, Springer, 2007

10NT306 SYNTHESIS OF NANOMATERIALS AND CHARACTERIZATION LAB

Credit: 0:0: 4

1. Synthesis of nanomaterials

- Synthesis of Al_2O_3 nanoparticles
- Synthesis of strontium doped cerium oxide nanoparticles
- Synthesis of Magnetite nanoparticles (ferro fluid) by co-precipitation method
- Fabrication of nano silver coating on glass substrate
- Synthesis of NiO nanoparticles
- Synthesis of silver nanoparticles by chemical precipitation method
- Synthesis of gamma – ferric oxide (Meghemite) nanoparticles by simple low temperature route
- Synthesis of gold nanoparticles
- Synthesis of copper nanoparticles
- Preparation of CuO nanorods by wet chemical method

2. Characterization of nanoparticles

- XRD – crystalline structure, unit cell parameters, ystallite size & theoretical density measurements
- UV - comparison with standard data
- FTIR - comparison with standard data
- SEM - Microstructure determination
- TEM – Microstructure determination

12 experiments will be notified by HOD from time to time

10NT307 NANOCOMPOSITES AND QUANTUM COMPUTATION

Credits: 4:0:0

Objectives:

- The student will learn newer concepts and current technology related to nanoscience
- The student will get an enthusiasm on getting involved in science of current importance
- The influence of nanocomposites in newer materials becomes obvious to the students

Outcome:

The student will get updated in knowledge of the current status of nanotechnology and gain knowledge on nanocomposites

Unit I: Quantum computing

Turing machines, logic gates, and computers – reversible vs. irreversible computation – Landauer's principle and the Maxwell demon – natural phenomena as computing processes – physical limits of computation – Moore's law – quantum computation – historical development of quantum computation – quantum bits – quantum logic gates – graphical representation of gates and quantum circuits – quantum entanglement

Unit II: Pattern formation in chemical and biological systems

Pattern formation in biological systems – three mechanisms – diffusion – evoking an effect: thresholds – reaction diffusion – conditions for chemical pattern formation – pattern formation by lateral inhibition – random and non-random patterns – cellular automata – oscillating chemical reactions and chemical waves – spatial patterns – open reactors

Unit III: Introduction to nanocomposites

Nanocomposite – definition – nanocomposites: past and present – nomenclature – atomic and molecular solids – primary, secondary, and teritiary structure – transistions - Physics of modulus – continuum measurements – yield – fracture – rubbery elasticity and visco-elasticity – composites and nanocomposites – surface mechanical properties – diffusion and permeability – features of nanocomposites – nano-reinforcements

Unit IV: Processing of nanocomposites

Viscosity – types of flow – viscosity – experimental viscosity – non-Newtonian flow – low viscosity processing – solvent processing – particle behavior – in situ polymerization – post-forming – hazards of solvent processing – melt, high-shear, and direct processing – melting and softening – melt processes with small shears or low-shear rates flow – melt processes with large deformations or high-shear rates – thermo-kinetic processes

Unit V: Applications of nanocomposites

Nanocomposites – optical, structural applications – nanoparticulate systems with organic matrices – applications – biodegradable protein nanocomposites – applications polypropylene nanocomposites – applications as exterior automatic components – hybrid nanocomposite materials – application for corrosion protection

References:

1. Philip Kaye, Raymond Laflamme, and Michele Mosca, An introduction to quantum computing, Oxford University Press, 2007
3. Ch. Zander, J. Enderlein, and R.A. Keller,Single molecule detection in solution, Wiley-VCH, 2002

3. H.F. Nijhout, L. Nadel, D.L. Stein, Pattern formation in the physical and biological sciences, Lecture notes, Vol. V, Addison–Wesley publishers, 1997
4. Brechignani, Houdi, Lahmani, Nanomaterials and Nanochemistry, Springer, 2006
5. Pulickel M. Ajayan, Linda S. Schadler, and Paul V. Braun, Nanocomposite science and technology, Wiley-VCH, 2006
6. Thomas E. Twardowski, Introduction to Nanocomposite materials – properties, processing, characterization, DesTech publications, April 2007
7. Klaus Friedrich, Stoyko Fakivov, Zhony Shang, Polymer composites from nano to micro scale, Springer, USA, 2005

10NT308 APPLICATIONS OF NANOTECHNOLOGY

Credits: 4:0:0

Objectives:

- The student will learn the advanced applications of nanotechnology

Outcome:

- The student will get updated in knowledge of the current status of nanotechnology and its applications

Unit I: Nano based Inorganic sensors

Density of states (DOS) – DOS of 3D, 2D, 1D and 0D materials – one dimensional gas sensors:- gas sensing with nanostructured thin films – absorption on surfaces – metal oxide modifications by additives – surface modifications – Nano optical sensors – nano mechanical sensors – plasmon resonance sensors with nano particles – AMR, Giant and colossal magnetoresistors – magnetic tunnelling junctions

Unit II: Organic / Biosensors

Structure of Protein – role of protein in nanotechnology – using protein in nanodevices – antibodies in sensing – antibody in nano particle conjugates – enzymes in sensing – enzyme nanoparticle hybrid sensors – Motor proteins in sensing – transmembrane sensors – Nanosensors based on Nucleotides and DNA – Structure of DNA – DNA decoders and microarrays – DNA protein conjugate based sensors – Bioelectronic sensors – DNA sequencing with nanopores – sensors based on molecules with dendritic architectures – biomagnetic sensors.

Unit III: Optical Data Storage

Write and read techniques (signal modulation, disk format, data reproduction), read and write principles (read-only, write-once, phase-change, magnetooptic disks), optical pickup heads (key components, diffraction-limited laser spot, focusing and tracking error signals, servo-loop design, actuator), optical media, near field optical recording, holographic data storage.

Unit IV: Energy Devices

Solar cells - Thin film Si solar cells - Chemical semiconductor solar cells - Dye sensitized solar cells - Polymer solar cells - Nano quantum dot solar cells - Hybrid nano-polymer solar cells.

Fuel Cells – principle of working – basic thermodynamics and electrochemical principle – Fuel cell classification – Fuel cell Electrodes and Carbon nano tubes – application of power and transportation.

Unit V: Nano pharmaceuticals

Generation and significance of Nano pharmaceuticals like nanosuspensions, nanogels, nanocarrier systems - Nano formulation – Nano incapsulation – Enhancement of drug therapy epitaxy

Reference Books

1. Kouroush Kalantar – Zadeh, Benjamin Fry, Nanotechnology enabled sensors, Springer Verlag New York, (2007) ISBN-13: 9780387324739
2. H.Rosemary Taylor, Data acquisition for sensor systems (sensor physics and technology 5) (1997) Chapman and Hall, London, UKISBN 0 412 785609
3. Jerome Schultz, Milar Mrksich, Sangeeta N. Bhatia, David J. Brady, Antionio J. Ricco, David R. Walt, Charles L. Wilkins, Biosensing: International Research and Development, Springer 2006 ISBN 10 14020 40571, ISBN 13 978 1 4020 4057 3 (e-book available)
4. John G. Webster, Sensors and signal conditioning, 2nd edition Ramon Pallas-Areny, John Wiley & Sons (2001) ISBN 0 471 33232 1.
5. A. J. Domb, Y. Tabata, M. N. V. Ravi Kumar, and S. Farber, "Nanoparticles for Pharmaceutical Applications" American Scientific publishers, 2007

10NT309 NANOELECTROCHEMISTRY AND NANOSCALE THERMODYNAMICS

Credits: 4:0:0

Objectives:

- The student will know electrochemistry as applied to nanoscale science
- Electrode preparation (various types and methods) by principles of nanotechnology will be taught to the students
- The student will understand thermodynamics of nanoscale and the uncertainty in solid-liquid transition temperature in the nanoregime

Outcome:

The applications of nanostructures in various fields, based on the structure and function of molecular machines, carbon nanostructures, and dendrimers, will be taught to the students.

Unit I: Electrochemical techniques in nanostructured materials

Anodic synthesis – Electropolishing and Anodization – Porous anodic alumina – Porous anodic alumina as template – Porous anodic alumina to create nanodevices: Photonic crystals, electrochemical double layer capacitors, light emitting diodes – Medical applications

Cathodic synthesis – Nanowires, template procedures to prepare nanowires – magnetic nanowires – multilayers and superlattices

Unit II: Nanopatterned electrodes

Considerations for choosing a nano electrode fabrication strategy – Nanoelectrode fabrication using top down approaches – cyclic voltammograms recorded at nanopore electrodes: a brief discussion – nanogap electrodes – non high resolution techniques – applications of nanopatterned electrodes

Unit III: Template synthesis using electrochemistry

Reactions, diffusion and nucleation in the electrochemical deposition of cobalt nanowires – Theoretical considerations of spherical diffusion at a nano rod array – electrodeposition of magnetic multi layered nano wire arrays – template synthesis of Au/Co multilayered nanowire arrays – Physical properties of electrodeposited nanowires

Unit IV: Nanoelectrodes

Nanowires as nanoelectrodes – electrochemical aspects of nanoelectrodes – nanoelectrodes based on chemically modified surface – electrochemical step edge approach – the pre determinant mechanism – atomic metal wires from electrochemical etching – sensing molecular adsorption with quantized nano junction

Unit V: Thermodynamics and solid-liquid transitions in nanosystems

Introduction – size-dependence of the solid-liquid transition – macroscopic and microscopic theory of the solid-liquid transition – uncertainty in solid-liquid transition temperature – from nanoparticles to molecules – thermodynamics of very small systems – dynamically co-existing phases – stability of an isolated particle – theories of evaporation

References:

1. U. Heiz, U. Landman, Nano-catalysis, Springer, 2006
2. Brechignani, Houdi, Lahmani, Nanomaterials and Nanochemistry, Springer, 2006
3. Ali Eftekhari, Nanostructured materials in Electrochemistry, Wiley VCH, 2008

10NT310 NANOTECHNOLOGY AND ENVIRONMENTAL ISSUES

Credits: 4:0:0

Objectives:

- Analysis of samples in the environment for nanoparticles will be taught to the students
- The treatment of nanoparticles in waste water will be discussed
- The assessment of risks will be taught to the students

Outcome:

The student gets an idea of how to manage risks in the environment due to nanotechnology

Unit I: Over-viewing manufacturing processes

Introduction – a brief primer on manufacturing processes – ramifications of worker exposure and environmental issues for nanomanufacturing – four generations of nano-product development – the impact of "engineered" nanomaterials – integrating nanoparticles into nanoproducts

Unit II: Analyses of nanoparticles in the environment

Analytical methods – product characterization and air monitoring – the Brunauer Emmett Teller (BET) method – size distribution – workplace air monitoring – condensation particle counter (CPC) – surface area: total exposure – sampling and analysis of waters and soils for nanoparticles – nanotechnology measurement research and future directions

Unit III: Treatment of nanoparticles in waste water

Introduction – mass balance considerations – case study: silver care washing machine – case study: socks with nano-silver – treatment processes: sedimentation, coagulation and flocculation, activated sludge, sand filters, membrane separation, disinfection

Unit IV: Environmental fate and transport

Introduction – nature of nanomaterials in the environment – physical manifestation of nanomaterials: particle size distribution and formation of mobile suspensions – chemical forces acting on nanomaterials – implications of polymorphism – predicting the behavior of nanomaterials in the environment – predicting the temporal reaction rates: estimating particle affinities – nanoparticle affinity and inter-particle force fields

Unit V: Risk assessment

Risk assessment and nanomaterials – effects of steric hindrance, inflammatory and immune-based mechanisms – critical variables – exposure and effects through ingestion – diffusion – endocytosis – exposure and effects through dermal asorption – exposure and effects through inhalation – mechanism for adsorption and removal – pulmonary toxicology – known toxicity of nanomaterials

Text Book:

1. Kathleen sellers, Christopher Mackay, Lynn L. Bergeson, Stephen R. Clough, Marilyn Hoyt, Julie Chen, Kim Henry, Jane Hamblen, Nanotechnology and the environment –CRC Press, Taylor and Francis group, 2009

References:

1. Barbara Karn, Nanotechnology and the environment applications and implications, American Chemical Society, Oxford University Press (Washington, DC), 2005
2. Louis Theodre, Robert G. Kunz, Nanotechnology: Environmental implications and solutions –Wiley, 2007

10NT311 BIOLOGICAL NANOSTRUCTURES

Credits: 4:0:0

Objectives:

- Usage of biomaterials as nanostructures will be taught to the students
- The application of biological molecules in newer materials will be discussed
- The assessment of risks will be taught to the students

Outcome:

- The student gets an idea of how to make nanostructures from biological molecules and apply them in various fields

Unit I: Protein S-layers and nanopores

Chemistry and structure of protein S-layers - Secondary cell-wall polymers and Assembly of S-layers - Methods in diagnosis of S-layer and lipid chips - S-layers as templates for formation of regulatory arranged nanoparticles - Biological nanopores: Introduction and functions - Potential applications of nanopores - Alternative protein pores - Methods of using engineered nanopores - Keeping nanopores happy

Unit II: Programmed assembly and nanocontainers

Introduction, ordering from chaos - Monitoring enrichment - Quantification of binding and criteria for specificity - Microbial nanoparticle production - Polymer nanocontainers: Introduction and in therapy - Liposomes in biotechnology - Shell cross-linked Knedels (SCKs) - Block co-polymer hybrids - Stimuli responsive nanocapsules

Unit III: Biomolecular motors and assemblies

Introduction and overview of biomolecular motors - Methods in biomolecular motors – Biomaterial: nanoparticle for bioelectronic and biosensing applications - Biomaterial based nanocircuting - DNA as functional template for nanocircuting – Oligonucleotide-enzyme conjugates - Non-covalent DNA – Streptavidin conjugates - Multifunctional protein assemblies - DNA-Protein conjugates in micro array technologies - Methods in mucleic acid-protein assembly

Unit IV: DNA-templated electronics

Introduction to DNA-templated Electronics - Sequence-specific molecular lithography - DNA interaction into microelectronic arrays - DNA branching for network formation - Controlled cluster growth on DNA templates - Conductivity measurements on metallized DNA wires - DNA junctions - DNA metallization - DNA site specific attachment

Unit V: Biomimetic ferritins; DNA-nanoparticle conjugates

Introduction to Biomimetic Ferritins - High-density magnetic data storage by ferritins - DNA-gold nanoparticles conjugation - Nanoparticles based DNA and RNA detection assays - DNA nanoparticles detection of proteins - Methods and protocols: DNA nanoparticles conjugation - Applications and challenges ahead - Nanoparticles for drug and gene targeting - Non-viral nanomaterials in development and testing - Setbacks and strategies to improve specific cell uptake of non-viral systems

Text books:

1. Michael Stroscio, Mitra Dutta, Biological nanostructures and applications of nanostructures in biology, Kluwer academic publishers, 2004
2. Zhong Lin Wang, Nanomaterials for nanoscience and nanotechnology, Wiley-VCH, 2000

Reference books:

1. H. Fujita, Micromachines as tools for nanotechnology, Springer, 2003
2. JB Park, Biomaterials science and engineering, Ed. 2, Narosa publishers, New Delhi, 2005
3. R.W. Kelsall, I.W. Hamley, M. Geoghegan, Nanoscale science and technology, John Wiley & sons, 2005

10NT312 NANOBIOTECHNOLOGY

Credits: 4:0:0

Course Objectives:

- To know about biology inspired concepts, nanobiomectrics, natural nanocomposites, nano analytics and molecular manufacturing

Outcome

- Students acquire a good understanding on the basic principles and applications of nanobiotechnology

Unit I

Biology inspired concepts- Microbial production of inorganic nanoparticles-Extra cellular matrix and biomimic of ECM-preparation of nanofibers and its applications-bioelectronics-molecular processor-DNA analyzer as biochip-molecular electronics.

Unit II

Nano biomectrics-introduction-lipids as nanobricks and mortar, self assembled nanolayers-the bits that do think-proteins-three dimensional structures using a 20 aminoacid-biological computing-a protein based 3D optical memory using DNA to build nano cubes and hinges-DNA as smart glue-DNA as wire template-DNA computers.

Unit III

Natural nanocomposites-introduction-natural nano composite materials-biologically synthesized nanostructures-biologically derived synthetic nanocomposites-protein based nanostructure formation-biologically inspired nanocomposites-nanotechnology in Agriculture [Fertilizers and Pesticides].

Unit IV

Nano analytics-quantum dot biolabeling-nanoparticle molecular labels-analysis of biomolecular structure by AFM and molecular pulling-force spectroscopy-biofunctionalized nanoparticles for surface enhanced raman scattering and surface Plasmon resonance.

Unit V

Molecular Manufacturing-Nano simulation, implications of nanotechnology, health and safety implications from nanoparticles. Health issues-Environmental issues-need for regulation-social implications, possible military applications-potential benefits and risks for developing countries-studies on the implications of nanotechnology.

Reference Books:

1. Christ of M.Neimeyer, Chad.A.Mirkin (eds.,) Nanobiotechology : Concepts, Applications and perspectives, Wiley VCH Weinheim (2004)
2. David.S.Goodsell, Bionanotechnology: concepts, Lessons from Nature, Wiley-Liss (2004)
3. Sandra J Rosethal, David W Wright, Nanobiotechnology Protocols, Series Methods in Molecular Biology (2005)
4. R.S. Greco, F.B.Prinz and R.L.Smith, Nanoscale Technology in Biological Systems, CRC press, 2005.

5. Tuan Vo-Dinh, Protein Nanotechnology Protocols, Instrumentation and Application, Series ; Methods in Molecular Biology (2005)

10NT313 ADVANCED EXPERIMENTS & SIMULATIONS TECHNIQUES FOR NANOPARTICLE CHARACTERIZATION LAB

Credits: 0:0:3

Course Objectives:

- To characterize the nanoparticles by advanced characterization techniques such as UV Visible spectroscopy, XRD techniques, SEM, TEM, Electrochemical techniques, etc.

Outcome

- From this course, students can able to understand methods of characterizing nanomaterials

12 experiments will be notified by the HOD from time to time

10NT314 EXPERIMENTAL TECHNIQUES FOR NANOBIOTECHNOLOGY LAB

Credits: 0:0:3

Course Objectives:

- To synthesize nanoparticles by nanobiotechnological routes

Outcome

- Students acquire a good understanding on the methods of synthesizing nanomaterials by biotechnological based processes.

12 experiments will be notified by the HOD from time to time

NANOTECHNOLOGY

ADDITIONAL SUBJECT

Code	Subject Name	Credits
10NT220	Fundamentals of Nanotechnology	4:0:0

10NT220 – FUNDAMENTALS OF NANOTECHNOLOGY

Credits: 4:0:0

Course Objective: To study the basics and important applications of nanotechnology.

Course Outcome: The candidates will be familiar with the basics of nanotechnology, tools used for characterizing nanomaterials and specific applications of nanotechnology.

Unit I Basics of nanotechnology
Definition of nanotechnology - Living with nanoparticles - Nanotechnology, a Future trillion dollar business - Nanotechnology will develop in stages; Nanotechnology products and applications - Future applications of nanotechnology – Medical applications.

Unit II The science of nanotechnology
Matter - Properties of matter change at the nanoscale - Matter's smallest particles: Elements - Smallest part of an element: The atom - Inside the Atom: Subatomic particles - Models of the atoms - Atoms and molecules - Molecules and chemical bonding - Molecular self-Assembly and nanofabrication - Soap bubbles self-assemble - Using the self-assembly strategy to make products - Other applications of molecular self-assembly - Self-assembly in medicine.

Unit III The nanotechnology tool box
Optical microscopes - Scanning probe microscopes - Scanning tunneling microscopes - Atomic force microscopes - Magnetic force microscopes - Electron microscopes - A scanning electron microscope - The transmission electron microscope - Nanofabrication cleanroom facilities.

Unit IV Nanotechnology in medicine and health
Cardiovascular diseases - Cancer detection and diagnosis - Diabetes and nanotechnology - Implants and prosthetics - Nanotechnology and burn victims - Diagnosis and therapy - Drug delivery using nanoparticles - Nanotechnology fights infections - Pharmaceutical nanotechnology research.

Unit V The business of nanotechnology
Nanotechnologies in businesses - Sporting goods equipment - Chewing gum and nanocrystals - Apparel industry – Cosmetic – Appliances - Electronics and computers - Automobile/vehicle industry - Aircraft potential and metal rubber - Paint and other water resistance coatings - Removing windshield fog - Self-cleaning glass - Antibacterial cleansers - Medical bandages - Solar energy: Photovoltaic cells - working principle - Battery technology (Brief description only) – Fuel cells (Brief description only)

Text Books:

1. John Mongillo, Nanotechnology 101, Greenwood Press, 2007.
2. Lynn E. Foster, Nanotechnology: Science, Innovation and Opportunity, Prentice Hall, 2005.
3. The Opensource Handbook of Nanoscience and Nanotechnology, 2010.
4. Joe Anne Shatkin, 'Nanotechnology: Health and environmental risks', CRC press, 2008.

DEPARTMENT OF NANOTECHNOLOGY

ADDITIONAL SUBJECT

Subject Code	Subject Name	Credit
10NT220	Fundamentals of Nanotechnology	3:0:0

10NT220 – FUNDAMENTALS OF NANOTECHNOLOGY

Credit: 4:0:0

Course Objective: To study the basics and important applications of nanotechnology.

Course Outcome: The candidates will be familiar with the basics of nanotechnology, tools used for characterizing nanomaterials and specific applications of nanotechnology.

Unit-I: Basics of nanotechnology

Definition of nanotechnology - Living with nanoparticles - Nanotechnology, a Future trillion dollar business - Nanotechnology will develop in stages; Nanotechnology products and applications - Future applications of nanotechnology – Medical applications.

Unit-II: The science of nanotechnology

Matter - Properties of matter change at the nanoscale - Matter's smallest particles: Elements - Smallest part of an element: The atom - Inside the Atom: Subatomic particles - Models of the atoms - Atoms and molecules - Molecules and chemical bonding - Molecular self-Assembly and nanofabrication - Soap bubbles self-assemble - Using the self-assembly strategy to make products - Other applications of molecular self-assembly - Self-assembly in medicine.

Unit-III: The nanotechnology tool box

Optical microscopes - Scanning probe microscopes - Scanning tunneling microscopes - Atomic force microscopes - Magnetic force microscopes - Electron microscopes - A scanning electron microscope - The transmission electron microscope - Nanofabrication cleanroom facilities.

Unit-IV: Nanotechnology in medicine and health

Cardiovascular diseases - Cancer detection and diagnosis - Diabetes and nanotechnology - Implants and prosthetics - Nanotechnology and burn victims - Diagnosis and therapy - Drug delivery using nanoparticles - Nanotechnology fights infections - Pharmaceutical nanotechnology research.

Unit-V: The business of nanotechnology

Nanotechnologies in businesses - Sporting goods equipment - Chewing gum and nanocrystals - Apparel industry – Cosmetic – Appliances - Electronics and computers - Automobile/vehicle industry - Aircraft potential and metal rubber - Paint and other water resistance coatings - Removing windshield fog - Self-cleaning glass - Antibacterial cleansers - Medical bandages - Solar energy: Photovoltaic cells - working principle - Battery technology (Brief description only) – Fuel cells (Brief description only)

Text Books:

1. John Mongillo, Nanotechnology 101, Greenwood Press, 2007.
2. Lynn E. Foster, Nanotechnology: Science, Innovation and Opportunity, Prentice Hall, 2005.
3. The Opensource Handbook of Nanoscience and Nanotechnology, 2010.
4. Joe Anne Shatkin, 'Nanotechnology: Health and environmental risks', CRC press, 2008.

ADDITIONAL SUBJECTS

S.No	Sub. Code	Name of the Subject	Credits
1.	11NT301	Intermolecular And Surface Forces In Nanotechnology Applications.	4:0:0
2.	11NT302	Nanolithography	4:0:0
3.	11NT303	Synthetic Methodologies for Nanomaterials	4:0:0
4.	11NT304	Engineering Principles for Nano Technology	4:0:0
5.	11NT305	Synthesis of Nanomaterials	4:0:0
6.	11NT306	Thermodynamics and Quantum Mechanics for Nano Scale Systems	4:0:0
7.	11NT307	Nanoelectronics	4:0:0
8.	11NT308	Advanced Experiments and Simulation Techniques for Nanoparticle Characterization	0:0:4
9.	11NT309	Nanocomposites	4:0:0
10.	11NT310	Nanotechnology for Advanced Drug Delivery Systems	4:0:0
11.	11NT311	Experimental Techniques for Nanobiotechnology	0:0:4
12.	11NT312	Nanosensors and Transducers	4:0:0
13.	11NT313	Industrial Nanotechnology	4:0:0

11NT301 INTERMOLECULAR AND SURFACE FORCES IN NANOTECHNOLOGY APPLICATIONS.

Credits 4:0:0

Course Objective:

To learn the basic concepts of intermolecular forces, surface forces and contact forces and study advanced concepts of these forces in nanotechnology applications.

Course Outcome:

Students should be able to understand the concepts of intermolecular forces, surface forces and contact forces and analyze effects these forces in nanotechnology applications.

UNIT I: Overview of Molecular Forces

Intermolecular Force-Laws and Interaction Potentials-Lennard-Jones Potential- Long and short range forces- interaction energies of molecules-strong intermolecular forces: covalent and coulomb interactions-charge-charge interactions-self-energy-Born energy of an ion.

UNIT II: Forces between Atoms and Molecules

Interaction involving polar molecules: ion-dipole interaction- -Dipole-dipole interactions-rotating dipole and angle-averaged potentials- Interaction involving polarization of molecules-polarizability of atoms and molecules-polarizability of polar molecules-dipole-induced dipole interactions-van der Waal's forces (VDW): origin –VDW dispersion force between neutral molecules-London equation- VDW equation of state-VDW forces between polar molecules-general theory of VDW forces between molecules-induction force-orientation force-dispersion force-VDW forces in medium.

UNIT III: Forces between Particles and Surfaces

van der Waal's force between surfaces- Hamaker constant-molecule- surface, surface-surface for different geometries: sphere-sphere, sphere-plane, plane-plane, cylinder-cylinder- - Electrostatic forces between surfaces –electric double layer-Poisson-Boltzman (PB) equation- surface charge- electric field –counter ion concentration- PB Limitations-Debey length- DLVO forces. Non-DLVO forces-solvation-structural-hydration forces-hydrophobic-hydrophilic interactions-steric and fluctuation forces

UNIT IV: Force Measuring Techniques

Basic understanding of force measuring techniques- basic understanding of contact forces and model equations of Hertz, JKR and DMT-adhesion-surface energy- effect of capillary forces and humidity -contact angle-wetting- -Atomic Force Microscopy-Surface Force Apparatus,-Force-Distance curves- Nanoindentation Techniques, Load-Displacement Curves- Load-Deformation Curves.

UNIT V: Applications in Nanotechnology

Nanoparticles, problem of agglomeration and clusters in nanoparticles and Geeko Feet adhesion, NEMS- MEMS adhesion.

Text Books

1. Intermolecular and Surface Forces by J.N. Israelachvili, 2nd Edition, 2000, Academic Press Limited, London.
2. Contact, Adhesion, Rupture of Elastic Solids by D. Maugis, Springer, Springer-Verlag, 2000.

Reference Books

1. Springer Handbook of Nanotechnology: Volume 2, edited by Bharat Bhushan, Springer-Verlag. Second ed., 2007
2. Force-Distance Curves by atomic force microscope, by B.Cappella and G. Dietler, Surface Science Reports, 34, 1-104, (1999). Elsevier.

11NT302 NANOLITHOGRAPHY

Credits: 4:0:0

Course Objective:

To learn the basic concepts, methods, tools, applications and issues of lithography and study the advanced concepts and tools required for realizing and manipulating devices and nano-scale dimensions.

Course Outcome:

Students should be able to understand the concepts involved in lithography and design lithographic masks for a given micro- and nano- devices and circuits.

Unit I – Introduction to Lithography

Introduction to lithography – Lithography process steps; Mask making, wafer pre-heat, resist spinning, pre-bake, exposure, development & rinsing, post-bake, oxide etching and resist stripping - Alignment marks in mask plate – Optical lithography – Light sources – Contact, proximity and projection printing and their modulation transfer function - Resolution in projection systems – Resists - Positive and negative photo resists and their comparison in terms of various parameters – Lift-off profile

Unit II – Applications of Lithography

Application of lithography – Semiconductor IC fabrication – Fabrication of n-type/p-type MOSFETs using metal gate and self-aligned poly-gate with lithographic masks – Fabrication of CMOS FET using p-well and n-well process with lithographic masks – Fabrication of NPN and PNP BJT with lithographic masks – MEMS design flow - MEMS based pressure and acceleration sensor fabrication using lithographic masks – Advantages of scale-down approach in semiconductor ICs and MEMS sensors – Limitations of optical lithography.

Unit III – Next Generation Lithographic Techniques

Next generation lithographic techniques – Extreme ultraviolet lithography - X-ray lithography – X-ray resists - Synchrotron radiation – Merits and demerits of X-ray lithography – Geometrical effects in X-ray lithography – Mask making for X-ray lithography – E-beam lithography – E-beam resists - Merits and demerits – Inter- and intra-proximity effects - SCALPEL - Ion beam lithography - Limitations of micro-lithographic techniques and top-down approach for nano-scale pattern transfer.

Unit IV – Nanolithography

Nanolithography, Nano-sphere lithography – Molecular self-assembly – Nano-imprint lithography, Dip-pen nanolithography, soft lithography - Nano-scale 3D shapes and 3-D lithographic methods – Stereo-lithography and Holographic lithography.

Unit V – Tools for Nanolithography

Tools for nanolithography, molecular manipulation by STM and AFM – Very thin resist layers; LB flim resists – Nano-pattern synthesis – Nano scratching.

Text Books

1. Fundamentals of Microfabrication, Marc J. Madou, CRC Press, 2nd edition, 2002.
2. Handbook of Nanotechnology, Bharath Bhushan, Springer – Verlag, 2nd edition, 2006.

Reference Books

1. S. A. Campbell, The science and Engineering of Microelectronic Fabrication, 2nd Edition, Oxford University Press, 2001.
2. Microlithography Science and Technology – Sheats J.R and Smith B.W., CRC Press, New York, 2007.
3. Nanolithography: A Borderland between STM, EB, IB, and X-Ray Lithographies – M.Gentili (Ed) Carlo Giovannella Stefano Selci, Springer; 1st edition, 1994.

11NT303 SYNTHETIC METHODOLOGIES FOR NANOMATERIALS

Credits 4:0:0

Course Objective:

To learn and understand basic and advanced concepts of synthetic techniques and methodologies used for nanomaterials preparations.

Course Outcome:

The students should be able understand basic and advanced synthetic methodologies and techniques used for nanomaterials preparations.

Unit I - Chemical methods

Sol-gel technique – control of grain size – co-precipitation hydrolysis – sonochemical method combustion technique – colloidal precipitation – template process – growth of nanorods – solid-state sintering – grain growth.

Unit II - Carbon and related materials

Arc method – carbon nanotube – other nanotubes and nanorods – nanosprings – rings – chemical routes for nanotubes and nanorods – Ion beam induced nanostructures.

Unit III - Mechanical methods

Grinding – high energy ball milling – types of balls – WC and ZrO_2 – material-ball ratio – medium for grinding – limitations in getting required grain size for low melting point materials – typical systems – severe plastic deformation –melt quenching and annealing

Unit IV - Ultra high vacuum system

Ultra high vacuum systems – design – Joule heating – evaporation boats – cold finger – role of inert gases – powder collection –making a pellet – prevention of contamination from air – limitations of Joule heating – laser ablation - RF/DC magnetron sputtering – microwave plasma evaporation – control of grain size – scale-up process.

Unit V - Nanopolymers

Nanopolymers – Preparation and characterization of diblock Copolymer based nanocomposites, Nanoparticles polymer ensembles; Assembly of polymer – Nanoparticles composite material; Fabrication of polymer-mediated organized Nanoparticles assemblies; Applications of Nanopolymers in Catalysis.

Text Books

1. Vacuum Technology & Coating, 2000, Cowan & Co
2. Vacuum Technology: Practice for Scientific Instruments, Nagamitsu Yoshimura,2007, Gardners books
3. Progress in Materials Science Research, Antonio C. Venetti, 2007, Nova Science Publishers

Reference Books

1. The Chemistry of Nanomaterials: Synthesis, Properties and Applications. C. N. R. Rao, A. Muller, A. K. Cheetham (Eds.), (2004) WILEY-VCH Verlag GmbH & Co., Weinheim

2. Nanostructured Materials, Jackie Yi-Ru Ying, 2001, Academamic press
3. Nanostructured materials, Philippe Knauth, Joop Schoonman, 2002, Springer
4. Nanostructured materials, C. C. Koch, 2006, William Andrew Inc

11NT304 ENGINEERING PRINCIPLES FOR NANOTECHNOLOGY

Credits 4:0:0

Course Objective:

To learn and understand basic and advanced concepts of engineering principles for nanotechnology:

Course Outcome:

The students should be able to understand basic and advanced concepts engineering principles in nanotechnology applications.

Unit I - Thin Film Technology

Electro plating, Electroless plating, Langmuir- Blodget films,Thermal growth, Chemical vapour deposition, sputtering deposition, molecular beam epitaxy atomistic nucleation process, cluster coalescence and deposition, grain structure of films and coatings, amorphous thin films.

Unit II - Analysis of Thin films

Mechanical, electrical, magnetic and optical properties of thin films- Analysis of thin films.

Unit III - Vacuumed Technology

Pump selection and exhaust handling, rotary oil pumps, roots pump, diffusion pumps, turbo molecular pump, cryo pump, sputter-ion pump, pressure measurements, thermodynamics of evaporation, evaporation rate, alloys, compounds, sources, transport and deposition monitoring.

Unit IV - MEMS

MEMS and Microsystems – Evolution of Micro Fabrication – Micro Systems and Microelectronics. Application of MEMS in Various Fields. Introduction – Substrate and Wafer, Active Substrate Material. Silicon as a substrate material, MEMS packaging. Case study on pressure sensor with packaging.

Unit V - Silicon Technology

Semiconductor as base material- band diagram of semiconductor- band diagram of inhomogeneous semiconductor- different types of components in semiconductor, different types of transistor integration- technological processes for microminiaturization-methods and limits of microminiaturization in silicon.

Text Books

1. MEMS & Microsystems – Design and Manufacture, Tai-Ran Hsu, Tata McGraw Hill, 2002
2. Nanoelectronics and Nanosystems, Karl glosekotter,.Springer, 2004.

Reference Books

1. The science and Engineering of Microelectronic Fabrication, S. A. Campbell, 2nd Edition, Oxford University Press, 2001.
2. Microlithography Science and Technology – Sheats J.R and Smith B.W., CRC Press, New York, 2007.
3. The material science of thin films, M.Ohring, Academic press, Boston, 1991

11NT305 SYNTHESIS OF NANOMATERIALS

Credits 0:0:4

Course Objective:

To synthesize nanomaterials by various chemical and physical routes

Course Outcome:

The student will understand the methodology of synthesizing nanomaterials by different processes and techniques.

12 experiments will be notified by the HOD from time to time

Experiments List:

1. Synthesis of Alumina (Al_2O_3) nanoparticles
2. Synthesis of $MgAl_2O_4$ nanoparticles (Spinel)
3. Synthesis of Strontium doped cerium oxide (CeO_2) nanoparticles
4. Synthesis of nano $BaCeO_3$ powder
5. Synthesis of γ- $LiAlO_2$ nanoparticles
6. Synthesis of Magnetite Nanoparticles (Aqueous Ferrofluid)
7. Synthesis of Nickel Oxide nanoparticles by chemical precipitation method
8. Fabrication of nano silver coating on glass substrate
9. Synthesis of silver nanoparticles by chemical reduction method
10. Synthesis of γ - Fe_2O_3 (Maghemite) nanoparticles by simple low temperature route
11. Chemical Synthesis of MgO nanoparticles
12. Preparation of CuO nanorods by wet chemical method
13. Synthesis of Fe_2O_3 nanoparticles by new sol-gel method
14. Synthesis of cadmium sulphide nanocrystals
15. Preparation of Barium Sulphate nanocrystals by aqueous colloidal method
16. Preparation of CuO nanorods using Ultrasonic bath
17. Synthesis of gold nanoparticles
18. Preparation and characterization of PCL (Poly Capro Lactum) nanospheres for drug delivery application

11NT306 THERMODYNAMICS AND QUANTUM MECHANICS FOR NANO SCALE SYSTEMS

Credits 4:0:0

Course Objective:

To learn and understand basic and advanced concepts of thermodynamics, statistical mechanics and quantum mechanics in the perspective nanoscale systems.

Course Outcome:

The students should be able to understand the basic and advanced concepts to analyze the nanoscale systems

Unit I - Review of the Laws of Thermodynamics and their Consequences

Energy and the first law of thermodynamics – Heat content and Heat capacity – Specific heat – Entropy and the second law of thermodynamics – Thermodynamic potentials and the reciprocity relations – Maxwell's relations – Deductions – Properties of thermodynamic relations – Gibb's – Helmholtz relation – Thermodynamic equilibrium – Nernst's Heat Theorem and third law – Consequences of third law – Nernst's - Gibb's phase rule – Chemical potential.

Unit II - Statistical Description of Systems of Particles

Statistical formulation of the state system – phase space – Ensemble – average value – density of distribution in phase space – Liouville Theorem – Equation of motion and Liouville theorem – Equal apriori probability – Statistical equilibrium – Ensemble representations of situations of physical interest – isolated system – Systems in contact.

Unit III - Quantum mechanics

Quantum Mechanics -Review of classical mechanics -de Broglie's hypothesis - Heisenberg uncertainty principle -Pauli exclusion principle -Schrödinger's equation - Properties of the wave function -Application: quantum well, wire, dot -Quantum cryptography

Unit IV - Electrical and magnetic properties

Electronic and electrical properties-One dimensional systems-Metallic nanowires and quantum conductance - dependence on chirality -Quantum dots -Two dimensional systems -Quantum wells and modulation doping -Resonant tunnelling -Magnetic properties Transport in a magnetic field -Quantum Hall effect. -Spin valves -Spin-tunnelling junctions -Domain pinning at constricted geometries -Magnetic vortices

Unit V - Mechanical and Optical Properties

Mechanical properties -Individual nanostructures - Bulk nanostructured materials-Ways of measuring-Optical properties-Two dimensional systems (quantum wells)-Absorption spectra -Excitons -Coupled wells and superlattices - Quantum confined Stark effect

Text Books

1. Heat and thermodynamics and statistical physics – Brijla, N.Subramanyam, P.S. Hemne, S.Chand & Co Ltd, Delhi 2007.

2. Fundamentals of Statistical and Thermal Physics – Federick Reif (Reproduced 2008) McGraw-Hill New York.

Reference Books

1. Statistical Mechanics – Bipin K. Agarwal and Melvin Einsner
2. Statistical Thermodynamics – M.C. Gupta.
3. Introduction to Nanotechnology, Charles P.Poole, Jr. and Frank J.Owens, Wiley, 2003
4. Silicon VLSI Technology, J.D.Plummer, M.D.Deal and P.B. Griffin, Prentice Hall, 2000

5. Introduction to Solid State Physics, C.Kittel, a chapter about Nanotechnology, Wiley, 2004

11NT307 NANOELECTRONICS

Credits 4:0:0

Course Objective:

To learn and understand basic and advance concepts of nanoelectronics.

Course Outcome:

The students should be able to understand basic and advanced concepts of nanoelectronic devices, sensors and transducers and their applications in nanotechnology.

Unit I

Basics of nanoelectronics – capabilities of nanoelectronics – physical fundamentals of nanoelectronics – basics of information theory – the tools for micro and nano fabrication – basics of lithographic techniques for Nanoelectronics

Unit II

Quantum electron devices – from classical to quantum physics: upcoming electronic devices – electrons in mesoscopic structure – short channel MOS transistor – split gate transistor – electron wave transistor – electron spin transistor – quantum cellular automate – quantum dot array – Principles of Single Electron Transistor (SET) – SET circuit design – comparison between FET and SET circuit design

Unit III

Nanoelectronics with tunneling devices and superconducting devices – tunneling element technology - RTD: circuit design based RTD – Defect tolerant circuits. Molecular electronics – elementary circuits – flux quantum devices – application of superconducting devices – Nanotubes based sensors, fluid flow , gas temperature; Strain –oxide nanowire, gas sensing (ZnO,TiO_2,SnO_2,WO_3), LPG sensor (SnO_2 powder)- Nano designs and Nanocontacts – metallic nanostructures

Unit IV

A survey about the limits – Replacement Technologies – Energy and Heat dissipation – Parameter spread as Limiting Effect – Limits due to thermal particle motion – Reliability as limiting factor – Physical limits – Final objectives of integrated chip and systems

Unit V

Memory devices and sensors – 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.

Text Books

1. Nanoelectronics and Nanosystems, Karl Goser, Peter Glosekotter, Jan Dienstuhl.,

Springer, 2004

2. Nanotechnology: basic science and emerging technologies – Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005)

Reference Books

1. Nanoelectronics and information technology : Advanced electronic materials and novel devices (2^{nd} edition) Rainer Waser (ed.) Wiley VCH Verlag Weiheim (2005)
2. Nanoelectronics and Information Technology by Rainer Waser (edition, 2005) from John Wiley & Sons, Germany.
3. Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices by K. Goser (Edition, 2004), Springer. London

11NT308 ADVANCED EXPERIMENTS AND SIMULATION TECHNIQUES FOR NANOPARTICLE CHARACTERIZATION

Credits 0:0: 4

Course Objective:

To learn and have hand-on experience with advanced nanotechnology characterization techniques

Course Outcome:

The students should be able to handle the characterization tools independently and analyze the data using technical software.
12 experiments will be notified by the HOD from time to time

Experiment details

1. Green synthesis of nanoparticles and its characterization using UV-Vis Spectroscopy
2. Characterization of Fe_2O_3 and Al_2O_3 nanoparticles using X-ray Diffraction
3. Morphological study of nanomaterials using Scanning Electron Microscopy
4. Photoluminescence studies of nanomaterials
5. Analysis of nanoparticles and nano thin films by Atomic Force Microscopy
6. Synthesis and characterization of Zero Valent Ion nanoparticles
7. Synthesis of nanoparticles and its characterization using Particle Size Analyzer(DLS)
8. Preparation characterization of polymer nanocomposite membrane
9. Characterizations of Ball Milled nanoparticles
10. I-V studies of nanomaterials.
11. Molecular Simulation
12. Molecular Dynamic Simulation

CASE STUDY

Cyclic Voltametry study of nanomaterials
Chemical Vapor Deposition techniques
Physical Vapor Deposition techniques
Electro-spinning techniques

Viscosity studies of fluids

11NT309 NANOCOMPOSITES

Credits 4:0:0

Course Objective:

To learn and understand structure - property correlation of various nanocomposites.

Course Outcome:

The students should be able to understand the structure-property relations of various nanocomposites used for engineering and biomedical applications.

UNIT I - Introduction of nanocomposites

Nanocomposites – Definition – Nanocomposites past and present – Nomenclature – Solids - Atomic and molecular solids – Role of statistics in materials – Primary, secondary and tertiary structure – Transitions

UNIT II - Properties and features of nanocomposites

Physics of modulus – Continuum measurements – Yield – Fracture – Rubbery elasticity and visco-elasticity – Composites and nanocomposites – Surface mechanical properties – Diffusion and permeability – Features of nanocomposites – basics of polymer nanocomposites – Nano-reinforcements – Matrix materials – Hazards of particles

UNIT III - Processing of nanocomposites

Viscosity - Types of flow – Viscosity - Experimental viscosity - Non-newtonian Flow - Low-viscosity processing - Solvent processing - Particle behavior – In-situ polymerization - Post-Forming - Hazards of solvent Processing - Melt, high-shear, and direct processing - Melting and softening - Melt processes with small shears or low-shear rates flow - Melt processes with large deformations or high-shear rates - Thermo-kinetic processes

UNIT IV - Characterization of nanocomposites

Introduction to characterization – Experiment design – Sample preparation – Imaging – Structural characterization – Scales in nanocomposites – Texture – Electromagnetic energy – Visualization – Physicochemical analysis – Characterization of physical properties – Identification – Mechanical – Surface mechanical – Exposure – Barrier properties – Recipes and standards

UNIT V: Applications of nanocomposites

Nanocomposites – Optical, structural applications – Nanoparticulate systems with organic matrices – Applications – Biodegradable protein nanocomposites - Applications Polypropylene nanocomposites – Application as exterior automatic components – Hybrid nanocomposite materials – Application for corrosion protection

Text books

1. Introduction to Nanocomposite Materials – Properties, Processing, Characterization, Thomas E. Twardowski, DesTech Publications, April 2007

2. Polymer Composites from Nano – to Macro – scale, Klaus Friedrich, Stoyko Fakivov, Zhony Shang, Springer, USA, 2005

Reference books

1. Sol-gel Science and Technology – Topics in fundamental research and applications, Sumio Sakka, Volume 3 – Sol-gel prepared organic – inorganic hybrids and nanocomposites, Kluwer academic publishers, Springer, 2002
2. Biodegradable polymers for Industrial Applications, Ray Smith, CRC Press, 2005
3. Plastics technology handbook, Manas Chandar and Salil K. Roy, CRC Press, 2006
4. Polymer nanocomposites, Yiu-Wing Mai and Zhong-Zhen Yu, CRC Press Boca Raton Boston New york Washington, DC,and Woodhead publishing ltd, England, 2006.
5. Nanocomposites, Parag Diwan and Ashish Bharadwaj Pentagon Press
6. Nanocomposite Science and Technology Pulickel M. Ajayan , Linda S. Schadler , Paul V. Braun, 2006, Wiley-VCH

11NT310 NANOTECHNOLOGY FOR ADVANCED DRUG DELIVERY SYSTEMS

Credits: 4:0:0

Course Objective:

To learn and understand basic and advanced concepts of nanotechnological drug delivery systems.

Course Outcome:

The students should be able to understand various methods of nanotechnological drug delivery systems.

UNIT I Principles of drug delivery systems:

Modes of drug delivery, ADME hypothesis-controlled drug delivery, site specific drugs, barriers for drug targeting, passive and active targeting, Strategies for site specific, time and rate controlled delivery drugs, antibody -based and metabolism based targeting.

UNIT II : Targeted Nanoparticles for drug delievery:

Nanoparticle surface modification, bioconjugation, pegylation, antibodies cell- specific targeting and controlled drug release, Multi- Functional Gold Nanoparticles for Drug Delivery, Virus based nanoparticles.

UNIT III : Dentrimer as Nanoparticular Drug Carriers:

Synthesis- Nanoscale containers- Nanoscafoled-Gene transpection- Biocompatibility- Polymer Micelles as Drug carriers, Polymer Nanotubes-Magnetic Nanoparticles as Drug Carriers.

UNIT IV: Liposomes for drug delievery and targeting:

Classification and preparation of liposomal nanoparticles. Liposomes for pharmaceutical and cosmetic applications, Liposomal Drug Carriers in Cancer Therapy, Lipid-DNA

complexes, Viral gene transpection system, Lipid based drug delievery system for peptide and protein drug delivery, Liposomal anticancer and anti fungal agents.

UNIT V: Nanoparticle and targeted systems for cancer diagnosis and therapy:
Targetted delivery through enhanced permeability and retention. Folate receptors, Targeting through angiogenesis, Targeting to specific organs or tumour types, Tumour specific targeting: Breast cancer, Liver targeting tumour, vasculature for imaging, Delivery of specific anticancer agents: such as Paclitaxel, Doxorubicin, 5-Fluorouracil etc

Text Books

1. Drug Delivery and Targeting, A.M.Hillery, CRC Press, 2002.
2. Nanotherapeutics: Drug Delivery Concept in Nanoscience edited by Alf Lampert Pan Stanford Publishing, Singapore (2009).

Reference Books

1. Nanoparticulate Drug Delivery Systems, Deepak Thassu, Michel Deleers (Editor), Yashwant Pathak (Editor), Informa Healthcare USA , Newyork (2007).
2. Bio-Applications of Nanoparticles, Warren C. W. Chan, Springer Science + Business Media, LLC, Landes Bioscience (2010) Texas.

11NT311 EXPERIMENTAL TECHNIQUES FOR NANOBIOTECHNOLOGY

Credits 0:0:4

Course Objective:

To learn and have hand-on experience with the synthesis of nanobiomaterials and relevant characterization techniques.

Course Outcome:

The students should be able to handle the experiments tools independently and synthesize the nanobiomaterials.

12 experiments will be notified by the HOD from time to time

Experiments

1. Isolation of Genomic DNA from Plant Tissue
2. Isolation of Genomic DNA from Animal Tissue
3. Digestion of Plasmid DNA & Testing with Agarose gel Electophoresis
4. Ligation of fragmented Plasmid DNA
5. Liposomes for Drug Delivery
6. Antimicrobial Activity of Microdiscs
7. Antimicrobial Activity of Zero Valent Iron Nanoparticles
8. Sodium Alginate Nanospheres
9. Microspheres for Drug Delivery
10. Determination of Drug loading in Nanosphere
11. Separation and Identification of Proteins by SDS-PAGE Using Coomassie Brilliant Blue Stain.
12. PCR (Polymerase Chain Reaction) Amplification of DNA

11NT312 NANOSENSORS AND TRANSDUCERS

Credits 4:0:0

Course Objective:

To learn and understand basic and advanced concepts of nanosensors and transducers for nanotechnology applications:

Course Outcome:

The students should be able to understand nanosensors and transducers used in nanotechnology applications

Unit I: Transducers

Conductometric and capacitive transducers – optical waveguide based transducers – optical fiber based transducers – Interferometric optical transducers – surface plasmon resonance transducers – electrochemical transducers – soild state transducers – p-n diodes or bipolar junction based transducers – schottky diode based transducers – MOS capacitor based transducers – FET based transducers – Acoustic wave transducers – Quartz crystal microbalance – Film Bulk acoustic wave resonator (BAW transducer) – Interdigitally launched surface acoustic wave transducer (SAW transducer) – Cantilever based transducers.

Unit II: Sensor Characteristics and Physical effects:

Active and Passive sensors – Static characteristic:- Accuracy, offset and linearity – Dynamic characteristic:- First and second order sensors – Physical effects involved in signal transduction:- Photoelectric effect – photodielectric effect – Photoluminescence effect – electroluminescence effect – chemiluminescence effect – Doppler effect – Barkhausen effect – Hall effect – Nernst / Ettinshausen effect – Thermoelectric effect – Peizoresistive effect – piezoelectric effect – pyroelectric effect – magneto-mechanical effect (magnetostriction) – Magnetoresistive effect – Faraday-Henry Law – magneto optic Kerr effect – Kerrand Pockels effect.

Unit III: Nano based Inorganic sensors

Density of states (DOS) – DOS of 3D, 2D, 1D and 0D materials – one dimensional gas sensors:- gas sensing with nanostructured thin films – absorption on surfaces – metal oxide modifications by additives – surface modifications – Nano optical sensors – nanomechanical sensors – plasmon resonance sensors with nanoparticles – AMR, Giant and colossal magnetoresistors – magnetic tunnelling junctions.

Unit IV: Organic / Biosensors

Structure of Protein – role of protein in nanotechnology – using protein in nanodevices – antibodies in sensing – antibody in nano particle conjugates – enzymes in sensing – enzyme nanoparticle hybrid sensors – Motor proteins in sensing – transmembrane sensors – Nanosensors based on Nucleotides and DNA – Structure of DNA – DNA decoders and microarrays – DNA protein conjugate based sensors – Bioelectronic sensors – DNA sequencing with nanopores – sensors based on molecules with dendritic architectures – biomagnetic sensors.

Unit V: Signal conditioning and data acquisition

Earthing and grounding – series and common mode noise – errors due to common mode interference – specification of common mode rejection ratio- instrumentation amplifiers – isolation amplifiers – charge amplifiers – filters – integrators and differentiators – phase

sensitive detectors (PSD:- Linear switching PSD – Multiplying PSD – Digital PSD – Edge triggered PSD) – Phase locked loop.

Text Books

1. Nanotechnology enabled sensors by Kouroush Kalantar – Zadeh, Benjamin Fry, Springer Verlag New York, (2007).
2. Sensors and signal conditioning, Ramon Pallas-Areny, John G. Webster John, 2nd edition, Wiley & Sons (2001).

Reference Books

1. Data acquisition for sensor systems (sensor physics and technology 5) by H.Rosemary Taylor (1997) Chapman and Hall, London.
2. Biosensing: International Research and Development, Jerome Schultz, Milar Mrksich, Sangeeta N. Bhatia, David J. Brady, Antionio J. Ricco, David R. Walt, Charles L. Wilkins, Springer 2006.

11NT313 INDUSTRIAL NANOTECHNOLOGY

Credits 4:0:0

Course Objective:

To learn and understand basic and advanced concepts of industrial nanotechnology.

Course Outcome:

The students should be able to understand industrial nanotechnology devices, sensors and transducers and their applications

Unit I - Overview of Information Storage and Nanotechnology

Different types of information storage materials and devices: solid state memory, optical memory, magnetic recording, emerging technologies, role of nanotechnology in data storage.

Unit II - Optical Data Storage

Write and read techniques (signal modulation, disk format, data reproduction), read and write principles (read-only, write-once, phase-change, magneto-optic disks), optical pickup heads (key components, diffraction-limited laser spot, focusing and tracking error signals, servo-loop design, actuator), optical media, near field optical recording, holographic data storage.

Unit III – Energy Devices

Solar cells - Thin film Si solar cells - Chemical semiconductor solar cells - Dye sensitized solar cells - Polymer solar cells - Nano quantum dot solar cells - Hybrid nano-polymer solar cells. Fuel Cells – principle of working – basic thermodynamics and electrochemical principle – Fuel cell classification – Fuel cell Electrodes and Carbon nano tubes – application of power and transportation.

Unit IV – Nano pharmaceuticals

Generation and significance of Nano pharmaceuticals like nanosuspensions, nanogels, nanocarrier systems - Nano formulation – Nano incapsulation – Enhancement of drug therapy epitaxy

Unit V - Industrial applications of nanomaterials

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

Text Books

1. Optical Data Storage, Erwin R. Meinders , Andrei V.Mijiritskii, Liesbeth Van Pieterson, Matthias Wuttig, Springer (2006).
2. Handbook of Semiconductor Nanostructures and Nanodevices, A.A.Balandin, K.L.Wang Volume 1-5 American Scientific Publishers; 1st edition (2006) USA, New York.
3. Nanoelectronics and Information Technology, Rainer Waser, John Wiely and sons publication, 2003

Reference Books

1. Nanoparticles for Pharmaceutical Applications, A. J. Domb, Y. Tabata, M. N. V. Ravi Kumar, and S. Farber American Scientific publishers, 2007
2. Nanoelectronics, Dr.Parag Diwan and Ashish Bharadwaj, Pentagon press, 2006
3. Nanoelectronics and Nanosystems, K.Goser, P.Glose Kotter, J.Dienstuhl, Springer International Edition, 2004
4. Nanotechnology in Catalysis, Bingzhou, Sophie Herman and Gabor. A.Somorjai, Kluwer academic/Plenum Publishers New York (volume1 and 2), 2004.

DEPARTMENT OF NANOSCIENCES AND TECHNOLOGY

LIST OF SUBJECTS AND SYLLABI

Sub. Code	Name of the Subject	Credits
11NT201	Applications of Nanotechnology	3:0:0
12NT201	Introductory Nanotechnology	4:0:0
12NT202	Fundamentals of Nanotechnology	4:0:0
12NT203	Introduction to Molecular Simulations	4:0:0
12NT204	Molecular Simulation Lab	0:0:1
12NT205	Nanotechnology, Green Chemistry and Environmental Health	4:0:0
12NT206	Nanotoxicology and Ethics	4:0:0
12NT207	Applications of Nanotechnology	3:0:0
12NT301	Synthesis of Nanomaterials and Characterization Lab	0:0:4
12NT302	Nanoelectronics	4:0:0
12NT303	Nanolithography	4:0:0
12NT304	Nanocomposites and Quantum Computation	4:0:0
12NT305	Applications of Nanotechnology	4:0:0
12NT306	Introduction to Nanostructured Materials	4:0:0
12NT307	Synthetic Methodologies for Nanomaterials	4:0:0
12NT308	Biology for Nanotechnology	4:0:0
12NT309	Engineering Principles for Nanotechnology	4:0:0
12NT310	Synthesis of Nanomaterials (Lab)	0:0:4
12NT311	Fabrication and Imaging Techniques for Nanotechnology	4:0:0
12NT312	Thermodynamics and Quantum Mechanics for Nanoscale Systems	4:0:0
12NT314	Advanced Experiments and Simulation Techniques for Nanoparticle Characterization	0:0:4
12NT316	Nanotechnology for Advanced Drug Delivery Systems	4:0:0
12NT317	Experimental Techniques for Nano-biotechnology (Lab)	0:0:4
12NT318	Intermolocular and Surface Forces in Nanotechnology Applications	4:0:0
12NT319	Nanobiomaterials	4:0:0
12NT320	Nanobiotechnology	4:0:0
12NT321	Nanocomposites	4:0:0
12NT322	Nanosensors and Transducers	4:0:0
12NT323	Industrial Nanotechnology	4:0:0
12NS202	Elementary Mathematics	4:0:0
12NS203	Engineering Physics	4:0:0
12NS204	Basic Principles of Chemistry	4:0:0
12NS205	Elementary Biology	4:0:0
12NS206	Basic Electronics	4:0:0
12NS207	Solid State Physics	4:0:0
12NS208	Quantum Mechanics	4:0:0
12NS210	Solid State Chemistry	4:0:0
12NS211	Materials Science Engineering	4:0:0

12NS212	Laboratory Work for NSNT	0:0:4

11NT201 APPLICATIONS OF NANOTECHNOLOGY

Credits 3:0:0

Course Objective:

- To learn the basic concepts of nanosciences and nanotechnology and their applications in various fields of science and engineering

Course Outcome:

- Students should be able to understand the basic concepts of nanosciences and nanotechnology and their applications in various fields of science and engineering

Unit I

Overview of Nanotechnology: Basic of Nanotechnology- Applications of nanotechnology- state of art of nanotechnology- relevance of nanotechnology- impact on economy and future development.

Unit II

Nanotechnology in Everyday Life: Nanotechnology based products- daily usage- associated concepts-advantages of using nanotechnology products.

Unit III

Nanotechnology in Sciences: Advancement of nanotechnology in various branches of sciences-associated concepts-applications of nanotechnology in manipulation of physical-chemical-optical and mechanical properties of materials.

Unit IV

Nanotechnology in Engineering: Applications of nanotechnology in various fields of engineering-Development of sensors- devices-electronic devices- electromechanical devices-.optoelectronic devices-computer memory-CPU etc.

Unit V

Nanotechnology in Biology: Applications of nanotechnology in biomedical fields- drug development and delivery-biomedical sensors- devices- development of biomaterials for tissue and bone replacement.

Text Books:

1. Nanotechnology: A gentle introduction to the next big idea. Mark Ratner and Daniel Ratner, Pearson Education Inc., 2003, Printice Hall/PTR, New Jersy, USA
2. Video and Text Resources available in www.nanohub.org
3. Resources available in various national and international organizations.

References :

1. Springer Handbook of Nanotechnology: Volume 2, edited by Bharat Bhushan, Springer-Verlag. Second ed., 2007
2. www.nanohub.org
3. www.wikipedia.org
4. www.foresight.org/nano

12NT201 INTRODUCTORY NANOTECHNOLOGY

Credit: 4:0:0

Course Objective:

- To introduce the basic concepts of nanotechnology in which the various nanotechnology related concepts, nano materials, and various synthesis techniques.

Course Outcome:

- The student will be able to understand the nanotechnology concepts
- Students will get the knowledge on recent nano-materials and their advancement
- Student can learn in depth on various nanomaterial synthesis procedures.

Unit I

Introduction to Nanotechnology: History of nanotechnology – conceptual origins – experimental advances – role of Richard Feynman, Eric Drexler and Maxwell – prefixing nano before disciplines – nanochemistry - size effects in nanochemistry – brief explanation on top-down and bottom-up approaches – classification as dry and wet nanotechnology.

Unit II

Fullerenes, CNT and Graphene: Allotropies of Carbon, Types of CNT, Introduction on Fullerenes, CNT, Discovery and early years, Synthesis and purification of fullerenes, CNTs, Chemistry of fullerenes in the condensed phase, Endohedral chemistry of fullerenes, Pressure effects, conductivity and superconductivity in doped fullerenes, Ferromagnetism in C_{60}, Optical and other unusual properties. Graphene - introduction, their unusual properties, various synthesis methodologies, present and future applications.

Unit III

Semiconductor Quantum dots: Introduction, synthesis and Purification, filling of nanotubes, Mechanism of growth, electronic structure, Transport properties, Mechanical properties, Physical properties, Application of Nanotubes and other materials. Introduction on semiconducting Quantum dots, synthesis of quantum dots, Chemical synthesis using clusters, Modification of the surface of Nanocrystals, electronic structure of Nanocrystals, characterization techniques to study quantum dots (absorption and emission spectro photometry, X-ray diffraction, TEM) and Applications of quantum dots.

Unit IV

Preparation of Nanomaterials (Bottom up approach): Graphene oxide -Modified Hummer's method, Sol gel technique (ZnO, TiO_2, MgO nanoparticles) – Co-precipitation hydrolysis – sonochemical method – combustion technique – colloidal precipitation – template process**.**

Unit V

Preparation of Nanomaterials (Top down approach): Solid-state sintering – Grain growth – Electric Arc method – Ion-beam induced nanostructures – grinding – high energy ball milling – material-ball ratio – control of grain size.

Text Books

1. T. Pradeep, Nano: The essentials, McGraw Hill Publishers, 2007
2. J. Steed, Core Concepts on supramolecular chemistry and nanochemistry, Wiley Eastern Publishers, (2006).

References Books

1. F.J. Owens and C.P. Poole Jr., The Physics and Chemistry of Nanosolids, Wiley Interscience Publishers, (2006)
2. Mark Ratner, Daniel Ratner, Nanotechnology, (2003), Pearson Education Inc. ISBN: 978-81-7758-743-2
3. Charles P. Poole, Jr, and Frank J. Owens, Introduction to Nanotechnology, Wiley (2006)

12NT202 FUNDAMENTALS OF NANOTECHNOLOGY

Credits: 4:0:0

Course Objective:

- To study the basics and important applications of nanotechnology.

Course Outcome:

- The candidates will be familiar with the basics of nanotechnology, tools used for characterizing nanomaterials and specific applications of nanotechnology.

Unit I

Basics of Nanotechnology : Definition of nanotechnology - Living with nanoparticles - Nanotechnology, a Future trillion dollar business - Nanotechnology will develop in stages; Nanotechnology products and applications - Future applications of nanotechnology – Medical applications.

Unit II

The Science of Nanotechnology: Matter - Properties of matter change at the nanoscale - Matter's smallest particles: Elements - Smallest part of an element: The atom - Inside the Atom: Subatomic particles - Models of the atoms - Atoms and molecules - Molecules and chemical bonding - Molecular self-Assembly and nanofabrication - Soap bubbles self-assemble - Using the self-assembly strategy to make products - Other applications of molecular self-assembly - Self-assembly in medicine.

Unit III

The Nanotechnology Tool box : Optical microscopes - Scanning probe microscopes - Scanning tunneling microscopes - Atomic force microscopes - Magnetic force microscopes - Electron microscopes - A scanning electron microscope - The transmission electron microscope - Nanofabrication cleanroom facilities.

Unit IV

Nanotechnology in Medicine and Health: Cardiovascular diseases - Cancer detection and diagnosis - Diabetes and nanotechnology - Implants and prosthetics - Nanotechnology and burn

victims - Diagnosis and therapy - Drug delivery using nanoparticles - Nanotechnology fights infections - Pharmaceutical nanotechnology research.

Unit V

The Business of Nanotechnology : Nanotechnologies in businesses - Sporting goods equipment - Chewing gum and nanocrystals - Apparel industry – Cosmetic – Appliances - Electronics and computers - Automobile/vehicle industry - Aircraft potential and metal rubber - Paint and other water resistance coatings - Removing windshield fog - Self-cleaning glass - Antibacterial cleansers - Medical bandages - Solar energy: Photovoltaic cells - working principle - Battery technology (Brief description only) – Fuel cells (Brief description only)

Text Books:

1. John Mongillo, Nanotechnology 101, Greenwood Press, 2007.
2. Lynn E. Foster, Nanotechnology: Science, Innovation and Opportunity, Prentice Hall, 2005.

Reference Books:

1. The Open source Handbook of Nanoscience and Nanotechnology, 2010.
2. Joe Anne Shatkin, 'Nanotechnology: Health and environmental risks', CRC press, 2008.

12NT203 INTRODUCTION TO MOLECULAR SIMULATIONS

Credit: 4:0:0

Course Objectives:

- To introduce the molecular simulation techniques, with special focus on molecular dynamics and Monte Carlo.
- To develop their own codes and utilize the learned methods towards solving a problem of their interest in Nanotechnology Applications.

Course Outcome:

- To solve the Nanoscience and the technology problems using the molecular stimulation

Unit I

An Overview of Molecular Simulation: Introduction Molecular Simulations-Computer Experiments and Modelling-Examples of molecular simulations – Monte Carlo-Molecular Dynamics- Newton's equation of motion.

Unit II

Interaction potentials: Degrees of Freedom, Constraints, Lennard Jones Potentials, Short and Long Range Potentials, Force Fields, Bonded and Non-Bonded Interactions

Unit III

Statistical Mechanics for Molecular Simulations: Ensembles- Micro canonical Ensemble (NVE), Canonical ensemble (NVT), Isothermal-Isobaric Ensemble, Grand canonical ensemble, Observables-Temperature, Pressure, Thermostats, Barostats-Andersen- Berendsen, Nose-Hoover

implementations. Ensembles- Microcanonical Ensemble (NVE), Canonical ensemble (NVT), Isothermal-Isobaric Ensemble, Grand canonical ensemble, Observables-Temperature, Pressure, Thermostats, Barostats-Andersen- Berendsen, Nose-Hoover implementations.

Unit IV

Monte Carlo Simulations: Monte Carlo (MC) – formulation, MC – structural characterization, MC – applications, Random Number generation- Lattice-Crystal structure, Simple MC Open Source Simulations tools.

Unit V

Molecular Dynamics Simulations: Molecular dynamics (MD) – formulation, MD – dynamic information, MD – applications, Euler -Verlet algorithms, Analysis trajectories, Correlations functions, Autocorrelations function (ACF), Structure Correlations Function (SCF). MD-Open Source Simulations tools.

Text Books

1. D. Frenkel, B. Smit, Understanding Molecular Simulation: From Algorithms to Applications, Academic Press, 2002.
2. J. M. Haile, Molecular Dynamics Simulation: Elementary Methods. ISBN 0-471-18439-X,2001.

Reference Books

1. M.P.Allen, D.J. Tildesley, Computer Simulation of Liquids, Clarendon Press, Oxford, 1987
2. D.J. Evans, G.P. Morriss Statistical Mechanics of Nonequilibrium Liquids, Second Edition, Cambridge University Press, ISBN 978-0-521-85791-8 (2008)
3. D.C. Rapaport, The Art of Molecular Dynamics Simulations, 2nd Edition, Cambridge University Press, 2004

12NT204 MOLECULAR SIMULATION LAB

Credit: 0:0:1

Course Objective:

- To understand the molecular simulation for various materials structures

Course Outcome:

- Student will get knowledge in simulation software and expertise in molecular simulations

1. Hands on experience on Molecular Dynamics Virtual Simulation Tools
2. Molecular Dynamic Simulations – Lennard Jones Potentails- Energy Optimization
3. Molecular Dynamics Simulations – Physical Properties Calculation
4. Molecular Dynamics Simulations of higher order systems
5. Hands on experience on Monte Carlo virtual simulation tools
6. Monte Carlo Simulations Energy minimization
7. Monte Carlo Simulation (Ising Model)
8. Monte Carlo Simulation (Hard Sphere)

6 experiments will be notified by the HOD from time to time

12NT205 NANOTECHNOLOGY, GREEN CHEMISTRY AND ENVIRONMENTAL HEALTH

Credits: 4:0:0

Course Objective

- The student will understand the risk and safety of nanotechnology
- The concept of green chemistry will be introduced to the students
- The role of nanotechnology in environmental health will be understood by the student

Course Outcome

- The environmental applications of nanotechnology and the concept of green chemistry will be learnt by the student

Unit I

Health, Policy and Energy Issues: Issues in nanotechnology involving environmental health safety – nanotechnology policy implications – nanotechnology products of today – reactive applications of nanotechnology in environment – nanotechnology lifecycles – nanotechnology, human health, and medicine – routes of administration of nanomaterials – oxidative stress – what can we learn from diesel particles – persistent re-dox activity – risk benefit analysis – need for framework and leadership.

Unit II

Risks and Safe Nanotechnology: Nano-objects – exposure routes to nano-objects – effects seen in animal studies – observations from epidemiological studies – hypothesis from animal and epidemiological studies – fire and explosion risk – risk of catalytic reactions – workplace exposures – sampling strategy.

Unit III

Working with Engineered Nanomaterials: Potential for occupational exposure – factors affecting exposure to nanomaterials – elements of risk management programs – engineering controls, dust collection efficiency of filters, work practices, personal protective clothing, respirators, clean-up and disposal of nanomaterials.

Unit IV:

Introduction to Green Chemical Principles: Definition, tools, and twelve principles of green chemistry, solvent-less reactions and reactions in water, microwaves and fluorous solvents, green resolution of racemic mixtures, materials for a sustainable economy, chemistry of longer wear, agrochemicals: problems and green alternate solutions, Atom efficient processes, evaluating chemical reagents according to their yield and atom efficiency, examples of efficient stoichiometric and catalytic processes, atom economy and homogeneous catalysis, halide-free synthesis and alternatives to Strecker synthesis

Unit V

Greener Reagents and Products: Greener solvents – the use of volatile organic compounds and the need for inoccuous replacements – use of ionic liquids – the use of

supercritical CO_2 – solvent-less, solid- supported reagents, and aqueous systems as alternative solvents – greener reagents and products, avoidance of toxic functional groups, minimizing bioavailability and use of auxiliary materials, examples of greener reagents including replacement of phosgene, solid state polymerizations, alternative nitrile synthesis

Text books

1. Lynn Goldman, Christine Coussens, Implications of nanotechnology for environmental health research, National Academic Press, Washington, 2007
2. A.S. Matlack, Introduction to Green Chemistry. Marcel Dekker: New York, 2001

References

1. P.T. Anastas, J.C. Warner, Green Chemistry: Theory and Practice. Oxford Univ. Press: Oxford, 1998.
2. http://www.chemicalstrategies.org/other_green.htm
3. M. Doble, Green Chemistry and Engineering, Academic Press; 1 edition 2007
4. Approaches to safe nanotechnology, Department of health and human services, DHHS (NIOSH) publication, 2009
5. www.foresight.org/UTF/Unbound_LBW/

12NT206 NANOTOXICOLOGY AND ETHICS

Credits: 4:0:0

Objectives:

- Awareness will be created on the toxicology of nanomaterials among students and the concept of sustainable nanotechnology will be introduced
- The adverse effect of nanoparticles interacting with biological membranes will be discussed. The ethical agenda to be followed in nanotechnology will be emphasized

Outcome:

- The student will understand the toxicology of nanomaterials and his/her responsibility when using nanotechnology

Unit I

Nanotoxicology and Sustainable Nanotechnology: Size-specific behavior of nanomaterials – nanotoxicology challenges – carbon nanotubes in practice – postproduction processing of carbon nanotubes – physicochemical properties of nanomaterials as mediators of toxicity – characterization of administered nanomaterials during toxicity studies – nanomaterial characterization after administration experiment

Unit II

Nanoparticle Exposure : Physicochemical determinants in particle toxicology – nanoparticles vs. micron-size particles – nanoparticle toxicity comparison to larger counterparts – requirement for appropriate model particles – exposure assessment, exposure pathways and their significance – documenting the occurrence and nature of exposures – bio-distribution of nanoparticles – localization of particles in tissues – relevance of drug targeting to nanotoxicology

Unit III

Nanoparticle Interaction with Biological Membranes: Interaction of nanoparticles with lipid bilayers – cell-level studies of nanoparticle-induced membrane permeability – internalization of cation nanoparticles into cells – placental biological barrier model for evaluation of nanoparticle transfer – transport across placental barrier – assessment of placental transfer - Biological mechanism of nanoparticle disposition – outline of gene-cellular interactions of nanomaterials – overview of dermal effects of nanomaterials – toxicity of nanoparticles in the eye

Unit IV

Approaching the Nano-age Scientists as Moral Agents – the business community and corporations as moral agents – policy makers and regulators as moral agents – ethical and societal implications – the public interface of science and human values – origins of the precautionary principle – the citizen as moral agent – the language of ethics – meta-ethics and normative ethics

Unit V

The ethical agenda for nanotechnology: The visions of nanotechnology – scenarios in the nanotech marketplace – clarifying purpose – the principle of respect for communities – the principle of the common good – the principle of social justice – utilitarian priorities The pressing questions – the players – the funders – the thinkers – the communicators – the arenas combined – the role of fore-sighting – ethics applied to the practical – citizenship in the nano-age – the value of the skeptical optimist

Text Books:

1. A. Monterio-Rivierie, C. Lang Tran, Nanotoxicology, Informa health care, London, 2007
2. Lynn Goldman, Christine Coussens, Implications of nanotechnology for environmental health research, National Academic Press, Washington, 2007
3. Deb Bennett-Woods, Nanotechnology: Ethics and society, CRC Press, Taylor and Francis group, 2008

Reference Books:

1. Niosh, Approaches to Safe Nanotechnology, Department of health and human services, US, 2008
2. Hans-Joachim Jördening, Josef Winter, Environmental Biotechnology, Wiley-VCH, 2005
3. Patrick Lin and Fritz Allhoff, Nano-ethics: The Ethical and Social Implications of Nanotechnology, John Wiley & Sons, 2007

12NT207 APPLICATIONS OF NANOTECHNOLOGY

Credits 3:0:0

Course Objective:

- To learn the basic concepts of nanosciences and nanotechnology and their applications in various fields of science and engineering

Course Outcome:

- Students should be able to understand the basic concepts of nanosciences and nanotechnology and their applications in various fields of science and engineering

Unit I

Overview of Nanotechnology: Basic of Nanotechnology- Applications of nanotechnology- state of art of nanotechnology- relevance of nanotechnology- impact on economy and future development.

Unit II

Nanotechnology in Everyday Life: Nanotechnology based products- daily usage- associated concepts-advantages of using nanotechnology products.

Unit III

Nanotechnology in Sciences: Advancement of nanotechnology in various branches of sciences-associated concepts-applications of nanotechnology in manipulation of physical-chemical-optical and mechanical properties of materials.

Unit IV

Nanotechnology in Engineering: Applications of nanotechnology in various fields of engineering-Development of sensors- devices-electronic devices- electromechanical devices-.optoelectronic devices-computer memory-CPU etc.

Unit V

Nanotechnology in Biology: Applications of nanotechnology in biomedical fields- drug development and delivery-biomedical sensors- devices- development of biomaterials for tissue and bone replacement.

Text Books:

1. Mark Ratner and Daniel Ratner, Nanotechnology: A gentle introduction to the next big idea. Pearson Education Inc., 2003, Prentice Hall/PTR, New Jersy, USA
2. Manasi Karkare Nanotechnology: Fundamentals and Applications, I. K. International Publishing House Pvt. Ltd 2008.

References:

1. Springer Handbook of Nanotechnology: Volume 2, edited by Bharat Bhushan, Springer-Verlag. 2nd ed., 2007
2. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience and Nanotechnology, PHI Learning Ltd, New Delhi, 2009.
3. Resources available in various national and international organizations.
4. www.nanohub.org
5. www.wikipedia.org
6. www.foresight.org/nano

12NT301 SYNTHESIS OF NANOMATERIALS AND CHARACTERIZATION LAB

Credit: 0:0:4

1. Synthesis of nanomaterials

• Synthesis of Al2O3 nanoparticles

• Synthesis of strontium doped cerium oxide nanoparticles

• Synthesis of Magnetite nanoparticles (ferro fluid) by co-precipitation method

• Fabrication of nano silver coating on glass substrate

• Synthesis of NiO nanoparticles

• Synthesis of silver nanoparticles by chemical precipitation method

• Synthesis of gamma – ferric oxide (Meghemite) nanoparticles by simple low temperature route

• Synthesis of gold nanoparticles

• Synthesis of copper nanoparticles

• Preparation of CuO nanorods by wet chemical method

2. Characterization of nanoparticles

• XRD – crystalline structure, unit cell parameters, crystallite size & theoretical density measurements

• UV - comparison with standard data

• FTIR - comparison with standard data

• SEM - Microstructure determination

• TEM – Microstructure determination

12 experiments will be notified by HOD from time to time

12NT302 NANOELECTRONICS

Credits 4:0:0

Course Objective:

- To learn and understand basic and advance concepts of nanoelectronics.

Course Outcome:

- To understand basic and advanced concepts of nanoelectronic devices, sensors and transducers and their applications in nanotechnology.

Unit I

Basics of Nanoelectronics: Capabilities of nanoelectronics – physical fundamentals of nanoelectronics – basics of information theory – the tools for micro and nano fabrication – basics of lithographic techniques for Nanoelectronics.

Unit II

Quantum Electron Devices: From classical to quantum physics: upcoming electronic devices – electrons in mesoscopic structure – short channel MOS transistor – split gate transistor – electron wave transistor – electron spin transistor – quantum cellular automate – quantum dot

array – Principles of Single Electron Transistor (SET) – SET circuit design – comparison between FET and SET circuit design.

Unit III

Nanoelectronics with Tunneling Devices and Superconducting Devices: Tunneling element technology - RTD: circuit design based RTD – Defect tolerant circuits. Molecular electronics – elementary circuits – flux quantum devices – application of superconducting devices – Nanotubes based sensors, fluid flow, gas temperature; Strain –oxide nanowire, gas sensing (using ZnO,TiO_2,SnO_2,and WO_3), LPG sensor (using SnO_2 powder)- Nano designs and Nano contacts – metallic nanostructures.

Unit IV

A Survey about the Limits – Replacement Technologies: Energy and Heat dissipation – Parameter spread as Limiting Effect – Limits due to thermal particle motion – Reliability as limiting factor – Physical limits – Final objectives of integrated chip and systems.

Unit V

Memory Devices and Sensors : 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.

Text Books

1. K. Goser, G. Peter, Nanoelectronics and Nanosystems, Academic Information 8 Springer, (2004).
2. M Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse Nanotechnology: basic science and emerging technologies – Overseas Press (2005)

Reference Books

1. Nanoelectronics and information technology: Advanced electronic materials and novel devices, Wiley VCH Verlag Weiheim (2nd edition) Rainer Waser (ed.) (2005).
2. Rainer Waser, John Wiley & Sons, Germany. Nanoelectronics and Information Technology (edition, 2005)
3. K. Goser, Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices (Edition, 2004), Springer. London

12NT303 NANOLITHOGRAPHY

Credits: 4:0:0

Course Objective:

- To learn the basic concepts, methods, tools, applications and issues of lithography
- To study the advanced concepts and tools required for realizing and manipulating devices and nano-scale dimensions.

Course Outcome:

- Students should be able to understand the concepts involved in lithography and design lithographic masks for a given micro- and nano- devices and circuits.

Unit I

Introduction to Lithography: Introduction to lithography – Lithography process steps; Mask making, wafer pre-heat, resist spinning, pre-bake, exposure, development & rinsing, post-bake, oxide etching and resist stripping - Alignment marks in mask plate – Optical lithography – Light sources – Contact, proximity and projection printing and their modulation transfer function - Resolution in projection systems – Resists - Positive and negative photo resists and their comparison in terms of various parameters – Lift-off profile.

Unit II

Applications of Lithography: Application of lithography – Semiconductor IC fabrication – Fabrication of n-type/p-type MOSFETs using metal gate and self-aligned poly-gate with lithographic masks – Fabrication of CMOS FET using p-well and n-well process with lithographic masks – Fabrication of NPN and PNP BJT with lithographic masks – MEMS design flow - MEMS based pressure and acceleration sensor fabrication using lithographic masks – Advantages of scale-down approach in semiconductor ICs and MEMS sensors – Limitations of optical lithography.

Unit III

Next Generation Lithographic Techniques: Next generation lithographic techniques – Extreme ultraviolet lithography - X-ray lithography – X-ray resists - Synchrotron radiation – Merits and demerits of X-ray lithography – Geometrical effects in X-ray lithography – Mask making for X-ray lithography – E-beam lithography – E-beam resists - Merits and demerits – Inter- and intra-proximity effects - SCALPEL - Ion beam lithography - Limitations of micro-lithographic techniques and top-down approach for nano-scale pattern transfer.

Unit IV

Nanolithography: Nanolithography, Nano-sphere lithography – Molecular self-assembly – Nano-imprint lithography, Dip-pen nanolithography, soft lithography - Nano-scale 3D shapes and 3-D lithographic methods – Stereo-lithography and Holographic lithography.

Unit V

Tools for Nanolithography: Tools for nanolithography, molecular manipulation by STM and AFM – Very thin resist layers; LB film resists – Nano-pattern synthesis – Nano scratching.

Text Books

1. M J. Madou, Fundamentals of Microfabrication, CRC Press, 2nd edition, (2002).
2. B. Bhushan, Handbook of Nanotechnology, Springer – Verlag, 2nd edition, (2006).

Reference Books

1. S. A. Campbell, The Science and Engineering of Microelectronic Fabrication, 2nd Edition, Oxford University Press, (2001).
2. J.R. Sheats, and B. W. Smith, Microlithography Science and Technology – CRC Press, New York, (2007).
3. Nanolithography: A Borderland between STM, EB, IB, and X-Ray Lithographies – M. Gentili (ed.) Carlo Giovannella Stefano Selci,, Springer; 1st edition, (1994).

10NT304 NANOCOMPOSITES AND QUANTUM COMPUTATION

Credits: 4:0:0

Objectives:

- The student will learn newer concepts and current technology related to nanoscience
- The student will get an enthusiasm on getting involved in science of current importance.
- The influence of nanocomposites in newer materials becomes obvious to the students

Outcome:

- The student will get updated in knowledge of the current status of nanotechnology and gain knowledge on nanocomposites

Unit I

Quantum Computing : Turing machines, logic gates, and computers – reversible vs. irreversible computation – Landauer's principle and the Maxwell demon – natural phenomena as computing processes – physical limits of computation – Moore's law – quantum computation – historical development of quantum computation – quantum bits – quantum logic gates – graphical representation of gates and quantum circuits – quantum entanglement

Unit II

Pattern Formation in Chemical and Biological Systems: Pattern formation in biological systems – three mechanisms – diffusion – evoking an effect: thresholds – reaction diffusion – conditions for chemical pattern formation – pattern formation by lateral inhibition – random and non-random patterns – cellular automata – oscillating chemical reactions and chemical waves – spatial patterns – open reactors

Unit III

Introduction to Nanocomposites : Nanocomposite – definition – nanocomposites: past and present – nomenclature – atomic and molecular solids – primary, secondary, and teritiary structure – transitions - Physics of modulus – continuum measurements – yield – fracture – rubbery elasticity and visco-elasticity – composites and nanocomposites – surface mechanical properties – diffusion and permeability – features of nanocomposites – nano-reinforcements

Unit IV

Processing of Nanocomposites: Viscosity – types of flow – viscosity – experimental viscosity – non-Newtonian flow – low viscosity processing – solvent processing – particle behavior – in situ polymerization – post forming – hazards of solvent processing – melt, high-shear, and direct processing – melting and softening – melt processes with small shears or low-shear rates flow – melt processes with large deformations or high-shear rates – thermo-kinetic processes

Unit V

Applications of Nanocomposites : Nanocomposites – optical, structural applications – nanoparticulate systems with organic matrices – applications – biodegradable protein nanocomposites – applications polypropylene nanocomposites – applications as exterior automatic components – hybrid nanocomposite materials – application for corrosion protection

Text Books :

1. Thomas E. Twardowski, Introduction to Nanocomposite materials – properties, processing, characterization, DesTech publications, April 2007
2. Klaus Friedrich, Stoyko Fakivov, Zhony Shang, Polymer composites from nano to micro scale, Springer, USA, 2005

Reference Books:

1. Philip Kaye, Raymond Laflamme, and Michele Mosca, An introduction to quantum computing, Oxford University Press, 2007
2. Ch. Zander, J. Enderlein, and R.A. Keller,Single molecule detection in solution, Wiley-VCH, 2002

12NT305 APPLICATIONS OF NANOTECHNOLOGY

Credits: 4:0:0

Objectives:

- The student will learn the advanced applications of nanotechnology

Outcome:

- The student will get updated in knowledge of the current status of nanotechnology and its applications

Unit I

Nano based Inorganic Sensors : Density of states (DOS) – DOS of 3D, 2D, 1D and 0D materials – one dimensional gas sensors:- gas sensing with nanostructured thin films – absorption on surfaces – metal oxide modifications by additives – surface modifications – Nano optical sensors – nano mechanical sensors – plasmon resonance sensors with nano particles – AMR, Giant and colossal magnetoresistors – magnetic tunnelling junctions

Unit II

Organic / Biosensors : Structure of Protein – role of protein in nanotechnology – using protein in nanodevices – antibodies in sensing – antibody in nano particle conjugates – enzymes in sensing – enzyme nanoparticle hybrid sensors – Motor proteins in sensing – transmembrane sensors – Nanosensors based on Nucleotides and DNA – Structure of DNA – DNA decoders and microarrays – DNA protein conjugate based sensors – Bioelectronic sensors – DNA sequencing with nanopores – sensors based on molecules with dendritic architectures – biomagnetic sensors.

Unit III

Optical Data Storage : Write and read techniques (signal modulation, disk format, data reproduction), read and write principles (read-only, write-once, phase-change, magnetooptic

disks), optical pickup heads (key components, diffraction-limited laser spot, focusing and tracking error signals, servoloop design, actuator), optical media, near field optical recording, holographic data storage.

Unit IV

Energy Devices: Solar cells - Thin film Si solar cells - Chemical semiconductor solar cells - Dye sensitized solar cells - Polymer solar cells - Nano quantum dot solar cells - Hybrid nano-polymer solar cells.Fuel Cells – principle of working – basic thermodynamics and electrochemical principle – Fuel cell classification – Fuel cell Electrodes and Carbon nano tubes – application of power and transportation.

Unit V

Nano Pharmaceuticals: Generation and significance of Nano pharmaceuticals like nanosuspensions, nanogels, nanocarrier systems - Nano formulation – Nano incapsulation – Enhancement of drug therapy epitaxy

Text Books

1. A. J. Domb, Y. Tabata, M. N. V. Ravi Kumar, and S. Farber, "Nanoparticles for Pharmaceutical Applications" American Scientific publishers, 2007
2. Jerome Schultz, Milar Mrksich, Sangeeta N. Bhatia, David J. Brady, Antionio J. Ricco, David R. Walt, Charles L. Wilkins, Biosensing: International Research and Development, Springer 2006 ISBN 10 14020 40571, ISBN 13 978 1 4020 4057 3 (ebook available)

Reference Books

1. Kouroush Kalantar – Zadeh, Benjamin Fry, and Nanotechnology enabled sensors, Springer Verlag New York, (2007) ISBN-13: 9780387324739
2. H.Rosemary Taylor, Data acquisition for sensor systems (sensor physics and technology 5) (1997) Chapman and Hall, London, UKISBN 0 412 785609
3. John G. Webster, Sensors and signal conditioning, 2 nd edition Ramon Pallas-Areny, John Wiley & Sons (2001) ISBN 0 471 33232 1.

12NT306 INTRODUCTION TO NANOSTRUCTURED MATERIALS

Credit 4:0:0

Course Objective:

- To acquire the fundamental knowledge about nanostructured materials
- To understand about the characterization techniques used for characterizing the nanomaterials

Course Outcome:

- The students should be able understand basic and advanced synthetic methodologies
- The techniques used for nanomaterials preparations

Unit I

Introductory Aspects: Free electron theory and its features, Idea of band structure – Metals, Insulators and Semiconductors - Density of state in bands and its variation with energy, Effect of crystal size on density of states and band gap – Electronic structure of nanoparticles.

Unit II

Bulk Nanostructured Materials: Solid disordered Nanostructures – Nanostructured crystals – Luminescence – Quantum wells, wires and Dots – Size and dimensionality effects – Exitons – Superconductivity; Self assembly and catalysis.

Unit III

General Characterization Techniques: UV – Vis- IR - absorption Spectroscopy, X- Ray Diffraction studies –Bragg's law – particle size – Scherer's equation, –FT-IR – FT- Raman studies - Surface Resonance.

Unit IV:

Luminescence of Semiconducting Nanoparticles: Theory of photoluminescence, Fluorescence of semiconducting nanoparticles – Photoluminescence of doped semiconductor nanoparticles – Shift in photoluminescence peaks - Electroluminescence– Thermo luminescence –Cathodo luminescence – Magnetoluminescence.

Unit V

Nano Devices: Background – Quantization of resistance - Single electron transistors – Esaki and resonant tunneling diodes – Magnetic nanodevices – Magneto resistance – Spintronics.

Text Books

1. C. Kittel, 'Introduction to Solid State Physics', Wiley (2004).
2. J.D. Plummer, M.D. Deal and P.B. Griffin, 'Silicon VLSI Technology, Fundamentals, Practice, and Modeling', Prentice-Hall (2002).
3. M.B. Haney, Solid State Physics and Chemistry (Book).

Reference Books

1. H. S. Nalwa, 'Encyclopedia of Nanoscience and Nanotechnology (Vol. 10)', American Scientific Publishers (2004).
2. Bimberg, M. Grundmann, and N. N. Ledentsov, 'Quantum Dot Heterostructures', John Wiley & Sons Ltd, (1999).
3. V. S Redattori. Muralidharan, A. Subramania, 'Nanotechnology: Materials, Fabrication, Particles, and Characterization', CRC Press, November (2008)

12NT307 SYNTHETIC METHODOLOGIES FOR NANOMATERIALS

Credits 4:0:0

Course Objective:

- To learn and understand basic and advanced concepts Nanomaterials preparations
- To understand the various synthetic techniques and methodologies used for nanomaterials preparations.

Course Outcome:

- To understand the basic and advanced synthetic methodologies
- To study the techniques used for nanomaterials preparations.

Unit I

Chemical Routes for the Synthesis of Nanomaterials: Chemical reduction method - sol-gel technique – control of grain size – co-precipitation technique – sonochemical method – combustion technique – colloidal precipitation – template process – growth of nanorods – solid-state sintering – mechanisms of sintering – grain growth.

Unit II

CNTs and other Nanomaterials: Types of CNTs – preparation of CNTs – arc discharge method – laser ablation method – chemical vapour deposition process – nanotubes made up of metal (silver), metal nitride (SiN), ceramic oxides (ZrO_2, TiO_2) and metal chalcogenides (S, Se, Te systems) – electrospinning of polymers – nanorods made up of metal (Sn) and semiconductors (ZnO, CdS) – nanosprings – nanorings – ion beam induced nanostructures – atom beam sputtering.

Unit III

Mechanical Methods: Mechanical grinding – high energy ball milling – attrition ball mill – planetary ball mill – vibration ball mill – tumbling ball mill - types of balls – WC and ZrO_2 (preparation and properties) – ball to powder ratio (BPR) – medium for grinding – effect of temperature in getting required grain size for materials – severe plastic deformation – melt quenching – annealing

Unit IV

Ultra High Vacuum System: Ultra high vacuum systems (UHV) – significant features – typical uses of UHV – Joule heating – evaporation boats – cold finger – gas condensation synthesis – powder collection – making a pellet – prevention of contamination from air – RF/DC magnetron sputtering – reactive sputtering process – basics of microwave plasma evaporation – preparation of iron nanoparticles with microwave plasma evaporation technique.

Unit V

Polymer Nanocomposties: Polymer nanocomposites – properties of polymer nanocomposites – Preparation and characterization of di-block copolymer based nanocomposites – polystyrene-b-poly(ethylene oxide) nanocomposite – nanoparticle polymer ensembles – assembly of polymer – nanoparticles building blocks – polymer scaffolds – fabrication of polymer-mediated organized nanoparticle assemblies – organized polymer-nanoparticle assemblies on surfaces – applications of polymer nanocomposites.

Text Books

1. C. N. R. Rao, A. Muller, A. K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications. (Eds.), Wiley - VCH Verlag GmbH & Co., Weinheim, 2004.
2. N. Yoshimura, Vacuum Technology: Practice for Scientific Instruments, Gardners books, 2007.
3. Dirk M. Guldi and Nazario Martin, Carbon Nanotubes and Related Structures, Wiley-VCH, 2010.

Reference Books

1. Vacuum Technology & Coating, Cowan & Co, 2000.
2. Jackie Yi-Ru Ying, Nanostructured Materials, Academamic Press, 2001.
3. P. Knauth, J. Schoonman, Nanostructured Materials, Springer, 2002.
4. Rotello, Vincent M, Nanoparticles: Building Blocks for Nanotechnology, Springer, 2004
5. Zhonglin Wang, Yi Liu, Ze Zhang, Hand book of Nanophase Nanostructured Materials – Synthesis, Kluwer Academic/Plenum Publishers, 2002

12NT308 - BIOLOGY FOR NANOTECHNOLOGY

Credit 4:0:0

Course Objective:

- To acquire the basic knowledge about animal and plant cells
- To understand about molecular targets

Course Outcome:

- The students should be able understand basic biology
- Nanotechnology applications in biological systems

Unit I

Cell Biology & Tissue Culture

Structure and organization of prokaryotic and eukaryotic cell (animal cell & plant cell), tissues and organs, cell and tissue culture – application of plant transformation for productivity and performance, animal cell culture technology – applications of animal cell culture – stem cell culture, artificial organ synthesis

Unit II

Molecular Biology

Introduction to genes, protein, central dogma of molecular biology, molecular targets, estimation of RNA, estimation of DNA, protein estimation.

Unit III

Genetic Engineering

Recombinant DNA technology, scope and milestones in genetic engineering, molecular tools used in genetic engineering – gene cloning – transgenic organisms. Genomics and functional Genomics, whole genome analysis – Human Genome Project, gene therapy, gene delivery.

Unit IV

Immunology

Cells and organs of immunity, types of innate and acquired immunities, antigen, antibody structure and its types, humoral immunity, cell mediated immunity, introduction to complement system – MHC & graft transplantation and graft rejection.

Unit V

Nanoparticles in Biology

Biosynthesis of nanoparticles, microbial nanoparticle production, biomineralization, magnetosomes, nanoscale magnetic iron minerals in bacteria, virus & fungi. DNA based nanostructures, protein based nanostructures.

Text Books

1. C.M. Niemeyer and C.A. Mirkin, 'Nanobiotechnology: Concepts, Applications and Perspectives', Wiley-VCH, (2004).
2. K. K. Jain, 'Nanobiotechnology Molecular Diagnostics: Current Techniques and Applications (Horizon Bioscience)', Taylor & Francis, (2006).

Reference Books

1. M. Wilson and K. Kannangara, 'Nanotechnology – Basic Science and Emerging Technologies', Overseas Press India Private Ltd., (2005).
2. S.S. Purohit, 'Biotechnology: Fundamentals and Applications', Agrobios, Jodhpur, (2002).
3. R.W. Old, & S.B.Primrose, 'Principles of Gene Manipulations: An introduction to genetic engineering (5th edition)', Blackwell Science Ltd, Australia, (1994).

12NT309 ENGINEERING PRINCIPLES FOR NANOTECHNOLOGY

Credits 4:0:0

Course Objective:

- To learn and understand basic and advanced concepts of engineering principles for nanotechnology:

Course Outcome:

- The students should be able to understand basic and advanced concepts engineering principles in nanotechnology applications.

Unit I

Thin Film Coating: Electro plating, Electroless plating, Langmuir-Blodget (LB) films, Thermal growth, Chemical Vapour Deposition (CVD), Sputtering deposition, molecular beam epitaxy atomistic nucleation process, cluster coalescence and deposition, amorphous thin films.

Unit II

Thin film Characterization: Mechanical, Electrical, Magnetic and Optical properties method of thin films- Analysis of thin films - Grain structure of films and coatings.

Unit III

Vacuum Technology: Introduction- Pump selection and exhaust handling, rotary oil pumps, roots pump, diffusion pumps, turbo-molecular pump, cryo pump, sputter-ion pump, pressure measurements, thermodynamics of evaporation, evaporation rate, alloys, compounds, sources, transport and deposition monitoring.

Unit IV

MEMS: MEMS and NEMS – Evolution of Micro Fabrication – Micro Systems and Microelectronics. Application of MEMS in Various Fields. Introduction – Substrate and Wafer, Active Substrate Material. Silicon as a substrate material, MEMS packaging. Case study on pressure sensor with packaging.

Unit V

Silicon Technology: Semiconductor as base material- band diagram of semiconductor- band diagram of inhomogeneous semiconductor- different types of components in semiconductor, different types of transistor integration- technological processes for microminiaturization methods and limits of microminiaturization in silicon.

Text Books

1. Tai-Ran Hsu, Tata McGrawHill, MEMS & Microsystems – Design and Manufacture, (2002).
2. K. Glosekotter, Nanoelectronics and Nanosystems, Springer, (2004).

Reference Books

1. S. A. Campbell, The science and Engineering of Microelectronic Fabrication, 2nd Edition, Oxford University Press, (2001).
2. J. R. Sheats and B. W. Smith, Microlithography Science and Technology, CRC Press, New York, (2007).
3. M. Ohring, Material Science of thin films, Academic press, Boston, (1991).

12NT310 SYNTHESIS OF NANOMATERIALS (LAB)

Credits 0:0:4

Course Objective:

- To synthesize nanomaterials by various chemical and physical routes

Course Outcome:

- The student will understand the methodology of synthesizing nanomaterials by different processes and techniques.

12 experiments will be notified by the HOD from time to time

List of Experiments:

1. Synthesis of Alumina (Al_2O_3) nanoparticles
2. Synthesis of $MgAl_2O_4$ nanoparticles
3. Synthesis of $Ce_{1-x}Sr_xO_{2-\delta}$ nanoparticles
4. Synthesis of nano $BaCeO_3$ powder
5. Synthesis of γ- $LiAlO_2$ nanoparticles
6. Synthesis of Magnetite Nanoparticles (Aqueous Ferro fluid)
7. Synthesis of Nickel Oxide nanoparticles by chemical precipitation method
8. Synthesis of silver nanoparticles by chemical reduction method
9. Chemical Synthesis of MgO nanoparticles
10. Preparation of CuO nanomaterials by wet chemical method
11. Synthesis of Cadmium sulphide nanocrystals
12. Preparation of Barium Sulphate nanocrystals by aqueous colloidal method
13. Preparation of CuO nanorods using Ultrasonic bath
14. Synthesis of gold nanoparticles by simple chemical reduction method
15. Preparation of Fe_2O_3 nanoparticles by new sol-gel method
16. Preparation of polymeric nanofibers

12NT311 FABRICATION AND IMAGING TECHNIQUES FOR NANOTECHNOLOGY

Credit 4:0:0

Course Objective:

- To acquire knowledge about general nanofabrication techniques
- To understand the concepts of spectroscopy techniques
- To know the mechanical methods of characterizing nanomaterials
- To study the x-ray related techniques used for characterizing the nanomaterials

Course outcome:

- To understand the basics of image processing techniques
- Basic and advanced synthetic methodologies using imaging techniques

Unit I

General Fabrication Techniques: Key challenges and barriers for nanocharacterization - Photolithography – Cleaning / etching – Oxidation - oxides – Gettering – doping – Epitaxy. Top-down techniques – Other optical lithography's (UV, X-ray, and LIL) – Particle beam lithography's (e-beam, FIB, shadow mask evaporation) – Probe lithography. – Ball milling-Bottom up approach – Chemical routes –Wet chemical routes, Chemical Vapor Deposition (CVD), Chemical reduction process, metal oxide formation.

Unit II

Spectroscopic Techniques: Spectroscopy of Semiconductors – excitons – Brillouin spectroscopy – Dynamic Light Scattering (DLS) – NMR Spectroscopy – ESR Spectroscopy – X-ray Photo electron Spectroscopy (XPS) - Electron Spectroscopy for Chemical Analysis (ESCA) - Principles and applications of the above methods.

Unit III

Probing Techniques and Magnetometer: Scanning electron microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), Atomic force microscopy (AFM), Near field scanning optical microscopy (NSOM) - Vibrating sample magnetometry (VSM)., EPR, Mossbauer spectroscopy.

Unit IV

Mechanical Characterization: Mechanical characterization – modulus and load carrying capability of nano region/ compression micro hardness – fatigue – abrasion and wear resistance – super plasticity – nano indentation. Nanotribology – Nanotribometre – Surface Force apparatus – Quartz crystal microbalance – Friction force microscope.

Unit V

Neutron, X-ray Diffraction and Crystallography: Neutron and X- ray diffraction – Debye Scherer formula – dislocation density – micro-strain macromolecular crystallography using synchrotron radiation – role for neutron scattering in nanoscience.– X- ray Absorption fFine Structure (XAFS) – extended X – ray absorption fine structure (EXAFS) – Small angle X-ray scattering and Wide angle X-ray scattering

Text Books

1. T. Tsakalakos, I. Ovid'ko and A.K. Vasudevan, 'Synthesis, Functional Properties and Applications of Nanostructures', Kluwer Academic Publishers, Dordrecht, (2003).
2. H.A. Willard and L.L. Merrit, J.A. Dean, 'Instrumental Methods of Analysis', Van Nonstrand, New York, (1986).

Reference Books

1. Baneul and F. A. Cox, Spectroscopic techniques (2003).
2. P. Ajayan, L.S. Schadler, P. V. Braun, 'Nanocomposite Science and Technology, Wiley – VCH, (2003)
3. C.P. Poole Jr and F.J. Ownes, 'Introduction to Nanotechnology', John Wiley Sons, Inc., (2003)

12NT312 THERMODYNAMICS AND QUANTUM MECHANICS FOR NANO SCALE SYSTEMS

Credits 4:0:0

Course Objective:

- To learn and understand basic and advanced concepts of thermodynamics, statistical mechanics and quantum mechanics in the perspective nanoscale systems.

Course Outcome:

- The students should be able to understand the basic and advanced concepts to analyze the nanoscale systems

Unit I

Laws of Thermodynamics and their Consequences: Energy and the first law of thermodynamics – Zeroth law of thermodynamics - Heat content and Heat capacity – Specific heat – Entropy and the second law of thermodynamics – Thermodynamic potentials and the reciprocity relations – Maxwell's relations – Deductions – Properties of thermodynamic relations – Gibb's – Helmholtz relation – Thermodynamic equilibrium –Nernst's Heat Theorem and third law – Consequences of third law – Nernst's - Gibb's phase rule – Chemical potential.

Unit II

Statistical Description of Systems of Particles: Statistical formulation of the state system – phase space – Ensemble – average value –density of distribution in phase space – Liouville Theorem – Equation of motion and Liouville theorem – Equal apriori probability – Statistical equilibrium – Ensemble representations of situations of physical interest – isolated system – Systems in contact.

Unit III

Quantum Mechanics: Quantum Mechanics -Review of classical mechanics - de Broglie's hypothesis- Heisenberg uncertainty principle -Pauli exclusion principle -Schrödinger's equation - Properties of the wave function -Application: quantum well, wire, dot –Quantum cryptography.

Unit IV

Electrical and Magnetic Properties: Electronic and electrical properties-One dimensional systems-Metallic nanowires and quantum conductance - dependence on chirality -Quantum dots

-Two dimensional systems -Quantum wells and modulation doping -Resonant tunnelling – Magnetic properties Transport in a magnetic field -Quantum Hall effect. -Spin valves –Spin tunneling junctions -Domain pinning at constricted geometries -Magnetic vortices.

Unit V

Mechanical and Optical Properties: Mechanical properties -Individual nanostructures - Bulk nanostructured materials-Ways of measuring-Optical properties-Two dimensional systems (quantum wells)-Absorption spectra -Excitons -Coupled wells and superlattices - Quantum confined Stark effect.

Text Books

1. Brijlal, N.Subramanyam, P.S. Hemne, Heat and thermodynamics and statistical physics –, S.Chand & Co Ltd, Delhi (2007).
2. Federick Reif, Fundamentals of Statistical and Thermal Physics – (Reproduced 2008) McGraw-Hill New York.

Reference Books

1. Bipin K. Agarwal and Melvin Einsner, Statistical Mechanics.
2. M.C. Gupta, Statistical Thermodynamics.
3. P. Poole, Jr. and Frank J. Owens, Introduction to Nanotechnology, (2003) Wiley.

12NT314 ADVANCED EXPERIMENTS AND SIMULATION TECHNIQUES FOR NANOPARTICLE CHARACTERIZATION

Credits 0:0: 4

Course Objective:

- To learn and have hand-on experience with advanced nanotechnology characterization techniques

Course Outcome:

- The students should be able to handle the characterization tools independently and analyze the data using technical software.

Experiment details

1. Greener synthesis of nanoparticles and its optical characterization using UV-Vis Spectroscopy
2. Characterization of Magnetite and Alumina nanoparticles using X-ray Diffraction
3. Surface Morphological study of nanomaterials using SEM (Scanning Electron Microscope)
4. Photoluminescence studies of nanomaterials
5. Analysis of nanoparticles and nano thin films by Atomic Force Microscopy
6. Synthesis of Zero Valent Ion nanoparticles.
7. Synthesis of nanoparticles and its characterization using Particle Size Analyzer.
8. Preparation characterization of polymer nanocomposite membrane
9. Characterizations of Ball Milled nanoparticles
10. I-V studies of nanomaterials.
11. Molecular Simulation
12. Molecular Dynamic Simulation

12NT316 NANOTECHNOLOGY FOR ADVANCED DRUG DELIVERY SYSTEMS

Credits: 4:0:0

Course Objective:

- To learn and understand basic and advanced concepts of nanotechnological drug delivery systems.

Course Outcome:

- The students should be able to understand various methods of nanotechnological drug delivery systems.

Unit I

Principles of Drug Delivery Systems: Modes of drug delivery, ADME hypothesis-controlled drug delivery, site specific drugs, barriers for drug targeting, passive and active targeting, Strategies for site specific, time and rate controlled delivery drugs, antibody based and metabolism based targeting.

Unit II

Targeted Nanoparticles for Drug Delivery: Nanoparticle surface modification, bio conjugation, pegylation, antibodies cell- specific targeting and controlled drug release, Multi-Functional Gold Nanoparticles for Drug Delivery, Virus based nanoparticles.

Unit III

Dentrimer as Nanoparticular Drug Carriers: Synthesis- Nanoscale containers- Nano scafoled-Gene transpection- Biocompatibility- Polymer Micelles as Drug carriers, Polymer Nanotubes-Magnetic Nanoparticles as Drug Carriers.

Unit IV

Liposomes for Drug Delivery and Targeting: Classification and preparation of liposomal nanoparticles. Liposomes for pharmaceutical and cosmetic applications, Liposomal Drug Carriers in Cancer Therapy, Lipid-DNA complexes, Viral gene transpection system, Lipid based drug delivery system for peptide and protein drug delivery, Liposomal anticancer and anti fungal agents.

Unit V

Nanoparticle and Targeted Systems for Cancer Diagnosis and Therapy: Targeted delivery through enhanced permeability and retention, Folate receptors, Targeting through angiogenesis, Targeting to specific organs or tumour types, Tumour specific targeting: Breast cancer, Liver targeting tumour, vasculature for imaging, Delivery of specific anticancer agents: such as Paclitaxel, Doxorubicin, 5-Fluorouracil etc.

Text Books

1. A.M. Hillery Drug Delivery and Targeting, CRC Press, (2002).
2. Alf Lampert Pan, Nanotherapeutics: Drug Delivery Concept in Nanoscience, Stanford Publishing, Singapore (2009).

Reference Books

1. D. Thassu, M. Deleers, Y. Pathak, Nanoparticulate Drug Delivery Systems, Informa Healthcare USA , Newyork (2007).
2. C. Warren, W. Chan, Bio-Applications of Nanoparticles, , Springer Science Business Media, LLC, Landes Bioscience (2010) Texas.

12NT317 EXPERIMENTAL TECHNIQUES FOR NANOBIOTECHNOLOGY

Credits 0:0:4

Course Objective:

- To learn and have hand-on experience with the synthesis of nanobiomaterials and relevant characterization techniques.

Course Outcome:

- The students should be able to handle the experiments tools independently and synthesize the nanobiomaterials.

Experiments

1. Isolation of Genomic DNA from Plant Tissue
2. Isolation of Genomic DNA from Animal Tissue
3. Digestion of Plasmid DNA & Testing with Agarose gel Electophoresis
4. Ligation of fragmented Plasmid DNA
5. Liposomes for Drug Delivery
6. Antimicrobial Activity of Microdiscs
7. Antimicrobial Activity of Zero Valent Iron Nanoparticles
8. Sodium Alginate Nanospheres
9. Microspheres for Drug Delivery
10. Determination of Drug loading in Nanosphere
11. Separation and Identification of Proteins by SDS-PAGE Using Coomassie Brilliant Blue Stain.
12. PCR (Polymerase Chain Reaction) Amplification of DNA

12NT318 INTERMOLECULAR AND SURFACE FORCES IN NANOTECHNOLOGY APPLICATIONS

Credits 4:0:0

Course Objective:

- To learn the basic concepts of intermolecular forces, surface forces and contact forces
- To study advanced concepts of these forces in nanotechnology applications.

Course Outcome:

- Students should be able to understand the concepts of intermolecular forces, surface forces and contact forces and analyze effects these forces in nanotechnology applications.

Unit I:

Overview of Molecular Forces: Intermolecular Force-Laws and Interaction Potentials-Lennard-Jones Potential- Long and short range forces- interaction energies of molecules-strong

intermolecular forces: covalent and coulomb interactions-charge-charge interactions-self-energy-Born energy of an ion.

Unit II

Forces Between Atoms and Molecules: Interaction involving polar molecules: ion-dipole interaction- -Dipole-dipole interactions rotating dipole and angle-averaged potentials- Interaction involving polarization of molecules-polarizability of atoms and molecules-polarizability of polar molecules-dipole induced dipole interactions-Van der Waal's forces (VDW): origin –VDW dispersion force between neutral molecules-London equation- VDW equation of state-VDW forces between polar molecules-general theory of VDW forces between molecules-induction force-orientation force-dispersion force-VDW forces in medium.

Unit III

Forces between Particles and Surfaces: **V**an der Waal's force between surfaces- Hamaker constant-molecule-surface, surface surface for different geometries: sphere-sphere, sphere-plane, plane-plane, cylinder cylinder- Electrostatic forces between surfaces –electric double layer-Poisson-Boltzman (PB) equation- surface charge- electric field –counter ion concentration- PB Limitations- Debey length- DLVO forces. Non-DLVO forces-solvation-structural-hydration forces hydrophobic- hydrophilic interactions-steric and fluctuation forces

Unit IV

Force Measuring Techniques: Basic understanding of force measuring techniques- basic understanding of contact forces and model equations of Hertz, JKR and DMT-adhesion-surface energy- effect of capillary forces and humidity -contact angle-wetting- -Atomic Force Microscopy-Surface Force Apparatus,-Force-Distance curves- Nano indentation Techniques, Load- Displacement Curves- Load-Deformation Curves.

Unit V

Applications in Nanotechnology: Nanoparticles, problem of agglomeration and clusters in nanoparticles and Geeko Feet adhesion, NEMS- MEMS adhesion.

Text Books

1. J.N. Israelachvili, Intermolecular and Surface Forces, 2nd Edition, (2000), Academic Press Limited, London.
2. D. Maugis, "Contact, Adhesion, Rupture of Elastic Solids"- Springer, Springer- Verlag, (2000).

Reference Books

1. B.Bhushan , Springer Handbook of Nanotechnology: Volume 2, , Springer-Verlag. Second ed., (2007)
2. B. Cappella and G. Dietler, Force-Distance Curves by atomic force microscope, Surface Science Reports, 34, 1-104, (1999). Elsevier.

12NT319 NANO BIOMATERIALS

Credit 4:0:0

Objectives:

- To acquire knowledge about polymeric implant materials
- To know the role of biomaterials for implant coating

Outcome:

- To understand the concepts of cardiovascular implants
- To know the basics of biopolymers and tissue engineering

Unit I

Polymeric Implant Materials: Classification of biomaterials, Polyolefin; polyamides (nylon); Acrylic polymers (bone cement) and hydrogels; Fluorocarbon polymers; Natural and synthetic rubbers, silicone rubbers.

Unit II

Bio Materials for Implant Coating: calcium phosphates, Ti6Al4V and biomedical alloys - implant tissue interfacing -biomimetic and solution based processing – osteo porosis – osteo plaste –regeneration of bones by using bio compactable ceramics – biointeractive hydro gels.

Unit III

Cardiovascular Implants: Role of nanoparticles and nanodevices in Blood clotting; Blood rhelogy; Blood vessels; Geometry of blood circulation; Vascular implants; Cardiac pacemakers; Blood substitutes; Biomembranes, Opthomological applications of nano biomaterial.

Unit IV

Structure Property Relationship of Biological Materials: tissues, bones and teeth, collagen rich tissues, elastic tissues - Biopolymers: Preparation of nanobiomaterials – Polymeric scaffolds collagen, Elastins: Mucopolysaccharides, proteoglycans, cellulose and derivates Dextrans, Alginates, Pectins, Chitin.

Unit V

Tissue Engineering: Engineering biomaterial to control cell function - nanostructured collagen mimics in tissue Engineering – building structure into engineered tissues – fibrous proteins and tissue engineering- scaffolds for tissue fabrications – materials for scaffolds – materials for hydrogel scaffolds – scaffolds fabrications technologies—nanocomposite scaffolds – bioactive scaffolds – scaffolds for stem cells – micro and nanopatterned scaffolds.

Text Books

1.Paul K. Chu and Xuanyong, 'Biomaterials fabrication and processing handbook', CRC / Taylor & Francis, 2008

2.K. K. Jain, 'Nanobiotechnology Molecular Diagnostics: Current Techniques and Applications (Horizon Bioscience)', Taylor & Francis, 2006

Reference Books

1. S.V Bhat, 'Biomaterials (2nd Edition)', Narosa Publishing House, New Delhi, 2005.

2. Robert.W.Kelsall and Ian.W.Hamley, Mark Geoghegan, Nano Scale Science and Technology, John Wiley, 2005

3. Challa S.S.R. Kumar, Josef Hormes and Carola Leuschner, 'Nanofabrication Towards Biiomedical Applications – Techniques, Tools, Applications and Impact', Wiley – VCH, 2005

12NT320 NANOBIOTECHNOLOGY

Credits: 4:0:0

Course Objectives:

- To know about biology inspired concepts, nanobiomectrics, natural nanocomposites, nano analytics and molecular manufacturing

Outcome :

- Students acquire a good understanding on the basic principles and applications of nanobiotechnology

Unit I

Biology Inspired Concepts- Microbial production of inorganic nanoparticles-Extra cellular matrix and biomimic of ECM-preparation of nanofibers and its applications-bioelectronicsmolecular processor-DNA analyzer as biochip-molecular electronics.

Unit II

Nano Biomectrics-introduction-lipids as nanobricks and mortar, self assembled nanolayersthe bits that do think-proteins-three dimensional structures using a 20 aminoacid-biological computing-a protein based 3D optical memory using DNA to build nano cubes and hingesDNA as smart glue-DNA as wire template-DNA computers.

Unit III

Natural Nanocomposites-introduction-natural nano composite materials-biologically synthesized nanostructures-biologically derived synthetic nanocomposites-protein based nanostructure formation-biologically inspired nanocomposites-nanotechnology in Agriculture [Fertilizers and Pesticides].

Unit IV

Nano Analytics-quantum dot biolabeling-nanoparticle molecular labels-analysis of biomolecular structure by AFM and molecular pulling-force spectroscopy-biofunctionalized nanoparticles for surface enhanced raman scattering and surface Plasmon resonance.

Unit V

Molecular Manufacturing-Nano simulation, implications of nanotechnology, health and safety implications from nanoparticles. Health issues-Environmental issues-need for regulation-social implications, possible military applications-potential benefits and risks for developing countries-studies on the implications of nanotechnology

Text Books:

1. R.S. Greco, F.B.Prinz and R.L.Smith, Nanoscale Technology in Biological Systems, CRC press, 2005.
2. Tuan Vo-Dinh, Protein Nanotechnology Protocols, Instrumentation and Application, Series ; Methods in Molecular Biology (2005)

Reference Books:

1. Christ of M.Neimeyer, Chad.A.Mirkin (eds.,) Nanobiotechology : Concepts, Applications and perspectives, Wiley VCH Weinheim (2004)
2. David.S.Goodsell, Bionanotechnology: concepts, Lessons from Nature, Wiley-Liss (2004)
3. Sandra J Rosethal, David W Wright, Nanobiotechnology Protocols, Series Methods in Molecular Biology (2005)

12NT321 NANOCOMPOSITES

Credits 4:0:0

Course Objective:

- To learn and understand structure - property correlation of various nanocomposites.

Course Outcome:

- The students should be able to understand the structure-property relations of various nanocomposites used for engineering and biomedical applications.

Unit I

Introduction of Nanocomposites: Nanocomposites – Definition – Nanocomposites past and present – Nomenclature – Solids - Atomic and molecular solids – Role of statistics in materials – Primary, secondary and tertiary structure – Transitions.

Unit II

Properties and Features of Nanocomposites: Physics of modulus – Continuum measurements – Yield – Fracture – Rubbery elasticity and visco-elasticity – Composites and nanocomposites – Surface mechanical properties – Diffusion and permeability – Features of nanocomposites – basics of polymer nanocomposites – Nano-reinforcements – Matrix materials – Hazards of particles.

Unit III

Processing of Nanocomposites: Viscosity - Types of flow – Viscosity - Experimental viscosity – Non Newtonian Flow - Low-viscosity processing - Solvent processing - Particle behavior – In-situ polymerization - Post-Forming - Hazards of solvent Processing - Melt, high-shear, and direct processing - Melting and softening - Melt processes with small shears or low-shear rates flow - Melt processes with large deformations or high-shear rates - Thermo-kinetic processes.

Unit IV

Characterization of Nanocomposites: Introduction to characterization – Experiment design – Sample preparation – Imaging – Structural characterization – Scales in nanocomposites – Texture – Electromagnetic energy – Visualization – Physicochemical analysis – Characterization of physical properties – Identification – Mechanical – Surface mechanical – Exposure – Barrier properties – Recipes and standards.

Unit V

Applications of Nanocomposites; Nanocomposites – Optical, structural applications – Nanoparticulate systems with organic matrices – Applications – Biodegradable protein nanocomposites – Applications Polypropylene nanocomposites – Application as exterior automatic components – Hybrid nanocomposite materials – Application for corrosion protection.

Text books

1. Thomas. E. Twardowski, Introduction to Nanocomposite Materials – Properties, Processing, Characterization, Destech Publications, April (2007).
2. Klaus Friedrich, Stoyko Fakivov, Zhony Shang, Polymer Composites from Nano – to Macro – scale, Springer, USA (2005).

Reference books

1. Sumio Sakka, Sol-gel Science and Technology – Topics in fundamental research and applications, Volume 3 – Sol-gel prepared organic – inorganic hybrids and nanocomposites, Kluwer academic publishers, Springer, 2002
2. Ray Smith Biodegradable polymers for Industrial Applications, CRC Press, (2005)
3. Manas Chandar and Salil K. Roy Plastics technology handbook, CRC Press, (2006).

12NT322 NANOSENSORS AND TRANSDUCERS

Credits 4:0:0

Course Objective:

- To learn and understand basic and advanced concepts of nano-sensors and transducers for nanotechnology applications:

Course Outcome:

- The students should be able to understand nano-sensors and transducers used in nanotechnology applications.

Unit I

Transducers: Conductometric and capacitive transducers – optical waveguide based transducers – optical fiber based transducers – Interferometric optical transducers – surface Plasmon resonance transducers – electrochemical transducers – solid state transducers – p-n diodes or bipolar junction based transducers – Schottky diode based transducers – MOS capacitor based transducers – FET based transducers – Acoustic wave transducers – Quartz crystal microbalance – Film Bulk acoustic wave resonator (BAW transducer) – Interdigitally launched surface acoustic wave transducer (SAW transducer) – Cantilever based transducers.

Unit II

Sensor Characteristics and Physical Effects: Active and Passive sensors – Static characteristic:- Accuracy, offset and linearity – Dynamic characteristic:- First and second order sensors – Physical effects involved in signal transduction:- Photoelectric effect – photo dielectric effect – Photoluminescence effect – electroluminescence effect – chemiluminescence effect – Doppler effect – Barkhausen effect – Hall effect – Nernst / Ettinshausen effect – Thermoelectric effect – Peizo resistive effect – piezoelectric effect – pyroelectric effect – magneto-mechanical effect (magneto -striction) – Magnetoresistive effect – Faraday-Henry Law – magneto optic Kerr effect – Kerrand Pockels effect.

Unit III

Nano based Inorganic Sensors: Density of states (DOS) – DOS of 3D, 2D, 1D and 0D materials – one dimensional gas sensors:- gas sensing with nanostructured thin films – absorption on surfaces – metal oxide modifications by additives – surface modifications – Nano optical sensors – nano mechanical sensors – plasmon resonance sensors with nanoparticles – AMR, Giant and colossal magneto resistors – magnetic tunnelling junctions.

Unit IV

Organic / Biosensors: Structure of Protein – role of protein in nanotechnology – using protein in nanodevices – antibodies in sensing – antibody in nano particle conjugates – enzymes in sensing – enzyme nano particle hybrid sensors – Motor proteins in sensing – trans membrane sensors – Nanosensors based on Nucleotides and DNA – Structure of DNA – DNA decoders and microarrays – DNA protein conjugate based sensors – Bio electronic sensors – DNA sequencing with nanopores – sensors based on molecules with dendritic architectures – bio magnetic sensors.

Unit V:

Signal Conditioning and Data Acquisition: Earthing and grounding – series and common mode noise – errors due to common mode interference – specification of common mode rejection ratio- instrumentation amplifiers –Edge triggered PSD) – Phase locked loop.

Text Books

1. K. Kalantar – Zadeh, B. Fry, Springer-Verlag , Nanotechnology enabled sensors, New York, (2007).
2. R. Pallas-Areny, G. John Webster John, Sensors and signal conditioning, 2nd edition, Wiley & Sons (2001).

Reference Books

1. H. Rosemary Taylor, Data acquisition for sensor systems (sensor physics and technology) (1997) Chapman and Hall, London.
2. J. Schultz, M.Mrksich, S. N. Bhatia, D. J. Brady, A.J. Ricco, D.R.Walt, C.L. Wilkins Biosensing: International Research and Development, Springer (2006).

12NT323 INDUSTRIAL NANOTECHNOLOGY

Credits 4:0:0

Course Objective:

- To learn and understand basic and advanced concepts of industrial nanotechnology.

Course Outcome:

- The students should be able to understand industrial nanotechnology devices, sensors and transducers and their applications

Unit I

Overview of Information Storage and Nanotechnology: Different types of information storage materials and devices: solid state memory, optical memory, magnetic recording, emerging technologies, role of nanotechnology in data storage.

Unit II

Optical Data Storage: Write and read techniques (signal modulation, disk format, data reproduction), read and write principles (read-only, write-once, phase-change, magneto-optic disks), optical pickup heads (key components, diffraction-limited laser spot, focusing and tracking error signals, servo-loop design, actuator), optical media, near field optical recording, holographic data storage.

Unit III

Energy Devices: Solar cells - Thin film Si solar cells - Chemical semiconductor solar cells - Dye sensitized solar cells - Polymer solar cells - Nano quantum dot solar cells - Hybrid nano-polymer solar cells. Fuel Cells – principle of working – basic thermodynamics and electrochemical principle – Fuel cell classification – Fuel cell Electrodes and Carbon nano tubes – application of power and transportation.

Unit IV

Nano pharmaceuticals: Generation and significance of Nano-pharmaceuticals like nanosuspensions, nanogels, nanocarrier systems - Nano formulation – Nano incapsulation – Enhancement of drug therapy epitaxy.

Unit V

Industrial Applications of Nanomaterials: Nanoparticles and Micro–organism, Nano-materials in bone substitutes & Dentistry, Food and Cosmetic applications, Textiles, Paints, Catalysis, Drug delivery and its applications, Biochips- analytical devices, Biosensors.

Text Books

1. E. R. Meinders , A. V.Mijiritskii, L. V. Pieterson, M. Wuttig Optical Data Storage, , Springer (2006).
2.A.A.Balandin, K.L.Wang Handbook of Semiconductor Nanostructures and Nanodevices, Volume 1-5 American Scientific Publishers; 1st edition (2006) USA, New York.
3. R. Waser, Nanoelectronics and Information Technology, John Wiely and sons publication, 2003

Reference Books

1. A. J. Domb, Y. Tabata, M. N. V. Ravi Kumar, and S. Farber, Nanoparticles for Pharmaceutical Applications, American Scientific publishers, (2007).
2. P. Diwan, A. Bharadwaj, Nanoelectronics, Pentagon press, (2006).
3. K.Goser, P.Glose Kotter, J.Dienstuhl, Nanoelectronics and Nanosystems, Springer international Edition, (2004).
4. Bingzhou, Sophie Herman and Gabor. A. Somorjai, Kluwer, Nanotechnology in Catalysis, Academic/Plenum Publishers, New York (Vol. 1 and 2) (2004).

12NS202 ELEMENTARY MATHEMATICS

Credit: 4:0:0

Course Objective:

- To understand the general formulation of Mathematics
- To solve equations for specific physical problems

Course Outcome:

• To improve mathematical skills necessary to solve differential equations and Integral equations.

Unit I

Differential Calculus: Curvature in Cartesian coordinates and polar coordinates – circle of curvature – evolutes and envelopes – maxima and minima of functions of two variables (proof of theorems not included)

Unit II

Integral Calculus: Double integrals – change of order of integration – triple integrals (problems involving Jacobians are not included).

Unit III

Vector Calculus: Scalar and Vector functions – differentiation – gradient, divergence and curl – directional derivatives identities (without proof) – Irrotational and solenoidal fields – vector integration line, surface and volume integrals Green's theorem, Gauss Divergence theorem and Stoke's theorem (without proof). Simple applications involving rectangles and cuboids.

Unit IV

Differential Equation: First order linear differential equations – second and higher order linear differential equations with constant coefficients with RHS of the form e(ax), x(n), sin (ax), cos (ax), e(ax) f(x), x f(x) where f(x) is sin (ax) or cos (bx) – differential equations with variable coefficients (Euler's form) – Simultaneous equations – method of variation of parameters.

Unit V

Beta and Gamma Integrals: Beta and Gamma integrals – Relation between them – properties – evaluation of definite integrals in terms of beta and gamma functions simple application.

Text Books

1. P.Kandasamy, K. Thilagavathy and K. Gunavathy, "Engineering Mathematics Vol. I" S. Chand Chand & Co. New Delhi 1997.
2. V.Zaitsev, V.Ryzhkov, M.Skanavi. Elementary Mathematics. Moscow, the publishing house "Nauka", 1974.

Reference Books

1. B. S. Grewal, B.S. "Higher Engineering Mathematics" Khanna Publishers, 1997.
2. S. Belyavsky. All Course of Mathematics. Minsk, "Sovremenny literator", 2001.
3. M. Vygodsky. Reference Book of Elementary Mathematics. Moscow, the publishing house "Nauka", 1979.

12NS203 ENGINEERING PHYSICS

Credits: 4:0:0

Course Objective:

- To have a basic knowledge about physics and its fundamental concepts.

Course Outcome:

- Students would be able to understand the basic concepts of physics particularly about the band theory of solids, Electrostatics fundamentals, and gravitation principles. thermodynamics basics, and photoconductivity, photovoltaic principles and nuclear physics.
- This course will give the students the broad knowledge on various fields in physics.

Unit I

Band Theory of Solids: Origin of energy bands, Kronig-Penny model (qualitative), E-K diagrams, Brillouin Zones, concept of effective mass and holes. Classification of solids into metals, semiconductors and insulators. Fermi energy and its variation with temperature. Hall Effect and its applications.

Unit II

Electrostatics: Revision of electrostatics, Applications of Gauss law for various symmetric situation, electric potential equi-potential surfaces, dipole, potential calculation in simple cases. Ohmś Law, Biot-Savart Law, Ampere's law and its applications, Lorentz force, cyclotron motion, magnetic force on a current carrying wire, Torque on a current.

Unit III

Gravitation & Thermodynamic: Law of gravitation, Kepler's laws, Oscillatory motion, Free harmonic oscillations, damped harmonic motion, forced oscillations and resonance, Concept of temperature and its measurement, heat and work, First law of thermodynamics, Second law of thermodynamics Carnot engine and cycle, isothermal and adiabatic processes, enthalpy and concept of entropy.

Unit IV

Photoconductivity and Photovoltaics: Photo conductivity in insulating crystal, variation with illumination, effect of traps, application of photoconductivity, photovoltaic cells, solar cell and its characteristics.

Unit V

Nuclear Physics: Structure of Nucleus, Binding energy curves of various elements, fission, fusion, effects of nuclear radiation, optical, microwave radiation, absorption, penetration, energy density, biological half life, interaction of radiation with living matter, isotopes used in biology and medicines.

Text Books

1. F. W. Sears, University Physics, Twelfth Edition, Addison-Wesley Publishing Company, 2008
2. Haliday, Resnick,Walke, Fundamentals of Physics.

References Books

1. C. Kittel, Introduction to Solid State Physics, John Wiley, 8th edition
2. A. Ghatak, S. Loganathan, Quantum Mechanics, Kluwer Academic Press, Springer,2004
3. M.N. Avadhanulu, P.G. Kshirsagar, A Textbook of Engineering Physics, S.Chand, 2010.

12NS204 BASIC PRINCIPLES OF CHEMISTRY

Credit: 4:0:0

Course Objective:

- To understand the basic principles of chemistry
- To provide fundamental insight into the macroscopic world of materials**.**

Course Outcome:

- To acquaint students with these basic principles
- To help students learn to apply these principles broadly and effectively.

Unit I

Introduction to Elements and Compounds: Elements and compounds, Chemical Formulae and Reactions, Quantum numbers - Aufbau Principle, Pauli Exclusion Principle, and Hund's Rule, Stiochiometry, Reactions in the solution - Evolution of Atomic Theory: Bohr Model of Hydrogen, Bohr-Sommerfield Model and Multi-electron Systems, Atomic Spectra – Quantum mechanical model, Heisenberg, de Broglie, Schrödinger wave equation.

Unit II

Introduction to Bonding in Chemical compounds: Atomic structure, quantum mechanical model and bonding, Primary Bonding: Ionic, Covalent, Metallic, hydrogen, Van der Waals, Secondary Bonding: Dipole-dipole, Dipole-induced Dipole, London Dispersion, Quantum theory of chemical bonding, Molecular structure, Molecular orbital theory.

Unit III

Thermodynamics: Introduction – system and surroundings – properties of a system – thermodynamic equilibrium and non-equilibrium – types of processes – concept of heat and work – derivation of expression for pressure-volume work – work done in isothermal and reversible / irreversible expansion of an ideal gas – first law of thermodynamics – internal energy – mathematical formulation of first law of thermodynamics – enthalpy – relationship between ΔH and ΔE – heat capacity – limitations of first law of thermodynamics – second law of thermodynamics – spontaneity – entropy – entropy and spontaneity of a process – entropy changes – Gibbs free energy – Helmholtz energy – Gibbs Helmholtz equation - Van't Hoff's isotherm – Van't Hoff's equation – Clapeyron equation – Clapeyron-Clausius equation.

Unit IV

Dynamics of chemical processes: Chemical kinetics – Basic concepts – rate law – rate equation – Order, molecularity, kinetics of zero, first, second and third order reactions – Kinetics – composite reactions (complex reaction) – Opposing (reversible) reactions – Consecutive reactions – Chain reactions – Stationary chain reaction – Nonstationary chain reaction – Collision theory of bimolecular and unimolecular reactions – Arrhenius theory of reaction rates – Theory of absolute reaction rates – Thermodynamic treatment of reaction rate – Kinetics of fast reactions – Enzyme kinetics - Michaelis-Menten equation.

Unit V

Surface Chemistry: Adsorption of gases by solids – Langmuir, Freundlich and B-E-T isotherms – applicability to heterogeneous catalysis – determination of surface area of adsorbents – Electrokinetic phenomena – Donnan membrane equilibrium – emulsions. Catalysis: Acid – Base catalysis – general scheme and mechanism – Arrhenius complex – Vant Hoff's complex –

specific and general catalysis – catalytic constants – Bronsted relationship – Hammett acidity functions.

Text Books:

1. Puri, Sharma and Pathania, Principles of Physical Chemistry, Vishal Publishing Co., 2008
2. K.J. Laidler, Chemical Kinetics, Harper and Row, New York, 3rd Edition, 2008

Reference Books:

1. A.W. Adamson, Physical Chemistry of Surfaces, 5th Edition, Wiley, 1990
2. Jain and Jain, Engineering Chemistry, 15th Edition, Dhanpat Rai, 2007
3. H. C. Srivastava, Engineering Chemistry, Pragati Prakashan, 2003
4. Gordon M Barrow, Physical Chemistry, 5th Edition, Tata McGraw-Hill, 2008
5. Ira N Levine, Physical Chemistry, special edition, Tata McGraw-Hill, 2007

12NS205 ELEMENTARY BIOLOGY

Credit: 4:0:0

Course Objective:

- To understand the basic principles of biology
- To provide fundamental insight into the bio world of materials.

Course Outcome:

- To acquaint students with these basic principles
- To help students learn to apply these principles broadly and effectively.

Unit I

General Physiology–General introduction to major human organ systems: Introduction to skeletal system, structure, organization & composition of bone tissue. Dynamics of bone: absorption and resorption. Circulatory & Cardio-pulmonary system: Structure and working of the heart & lungs, arteries, veins, capillary. Respiratory unit, exchange and transport of respiratory gases in the body. Composition and function of blood; plasma and blood cells, structure and function of haemoglobin, blood coagulation – mechanism and regulation. Introduction to renal system, structure of nephron, composition of urine and mechanism of urine formation, glomerular filtration, tubular reabsorption of glucose, water and electrolytes, tubular secretion.

Unit II

Biochemistry–Acidity and alkalinity: pH and pKa values and their effects on cellular activities; Buffers. Carbohydrates: Occurrence, classification, structure, properties and biological importance of carbohydrates. Mucopolysaccharides and amino sugars. Proteins: Classification, structure and properties of amino acids, Primary, secondary, tertiary and quaternary structures of proteins; determination and biochemical applications of the structures of proteins. Lipids: Structure, distribution and biological importance of fats and fatty acids. Chemical properties and characterization of fats. Waxes, cerebrosides, gangliosides, phospholipids and proteolipids. Lipid membranes; Micelle, lipid bilayer & liposomes. Steroids, Prostaglandins and bile salts. Nucleic

acids: Structure of purines, pyrimidines, nucleosides and nucleotides. Structure, types and biological role of RNA and DNA.

Unit III

Cell Biology & Immunology–Structure of prokaryotic and eukaryotic cells, plasma membrane, cell wall and its composition. Structure and functions of the ribosomes, endoplasmic reticulum, golgi body, lysosomes, nucleus and nucleolus, cytoskeleton: microtubules, microfilaments and intermediary filaments, extracellular matrix. Transport of metabolites across the plasma membrane, non-mediated and mediated, passive and active transport. Structure and function of semi-autonomous cellular organelles: mitochondria and chloroplast, electron transport complexes, ATP synthase, chloroplast and mitochondrial DNA. Cellular protein nano-structures and nano-machines: Dynein, Kinesin, F1 ATP synthase & bacterial flagellum Immune response mechanisms: Humoral immunity and cell mediated immunity, innate & acquired, immunity, self vs non-self discrimination. Immunoglobulins: structure, types, distribution and function. Phagocytic cells: neutrophils, monocytes & macrophages. Reactive Oxygen Species (ROS) & antioxidants. Hypersensitivity reactions and types. MHC antigens in transplantation and HLA tissue typing. Immunological tolerance and suppression. Single and double immunodiffusion, Immuno fluorescence, Radioimmunoassay (RIA) and Enzyme Linked Immuno Sorbant Assay (ELISA)

Unit IV

Molecular Biology, Genetic Engineering and Biotechnology–Concept, definition & structure of the gene, complexity of the eukaryotic gene. DNA synthesis: mechanism of DNA replication in bacteria. The central dogma and reverse transcriptase. RNA synthesis: mechanism of transcription in bacteria, post transcriptional processing of RNA, role of ribozymes. Protein synthesis: Concept of the genetic code, translation machinery and translation in bacteria, post translational processing of proteins. Study of regulation of gene expression using Lac operon as a model. Basic principles of genetic engineering: Methods of creating recombinant DNA molecule: Construction of DNA library, genomic vs cDNA library, chemical synthesis of gene. Tools employed in recombinant DNA technology: cloning vectors, restriction endonucleases, ligases. Amplification of DNA by polymerase chain reaction (PCR). Gene transfer methods for bacteria; bacterial transformation, transduction, transfection (liposome mediated), electroporation and particle gun. Transgenic animals and transgenic plants. Application of genetic engineering in medicine and agriculture.

Unit V

Industrial Microbiology & Biotechnology – Identification and classification of bacteria. Handling and sterility maintenance in microbiological work Types of sterilization; wet dry, surface sterilization, radiation sterilization. Methods of isolation and pure culture techniques, culture media. Microbial nutrition, bacterial growth and its kinetics. Fermentation technology - primary and secondary metabolites, continuous and batch type culture techniques, types and design of fermentors. Application of microbes in food industry: single cell protein, dairy products and food preservation. Brief introduction to Plant tissue culture and animal cell culture, Vaccine technology and gene therapy.

Text Books

1. S. B. Primrose, R. Twyman, Principles of Gene Manipulation and Genomics, 7th edition, Wiley-Blackwell (2006).
2. Alberts, D. Bray, K. Hopkin, A. Johnson, J. Lewis, M. Raff, K.Roberts, P. Walter, Essential Cell Biology, 3rd edition, Bruce Garland Science (2009).

Reference Books

1. L. Nelson, M. M. Cox, Lehninger – Principles of Biochemistry, Fifth Edition, David, W. H. Freeman and Company (2008).
2. W. Levinson Review of Medical Microbiology and Immunology, Eleventh Edition (LANGE Basic Science), McGraw-Hill Medical (2010).

12NS206 BASIC ELECTRONICS

Credit: 4:0:0

Course Objective:

- To know the basics about semiconductor, integrated circuits and communication system.

Course Outcome:

- Students will get overview about the basics of electronics.

Unit I

Introduction to Semiconductor: Covalent bond – N type & P type semiconductor – conduction in semiconductor – semiconductor device: diode, transistor, FET, MOSFET, UJT.

Unit II

Integrated Circuits: IC: OP-amp – introduction-Ideal characteristics-inverting and non-inverting amplifier –adder subtractor-differentiator-integrator- Monolithic IC fabrication techniques.

Unit III

Digital Systems: Number system – Boolean algebra – logic gates –truth table - combinational circuit -4 x 1 multiplexer – 1 x 4 demultiplexer - digital computer principles.

Unit IV

Communication: Basic block of communication system – need for modulation – Derivation of AM and FM signal - Amplitude and Frequency Modulation (Balanced modulator and varactor diode modulator)- Demodulation(AM diode detector and balanced slope detector.

Unit V

Communication Systems: Block diagram of AM and FM transmitter - Superheterodyne receiver – satellite communication – Fibre optic communication

Text Books

1. R. Muthusubramanian , S. Salivahanan, K. Muraleedharan, "Basic Electrical Electronics & Computer Engineering " Tata McGraw Hill, 2005
2. V. K. Mehta, Electonics made simple, S. Chand & Company Ltd, 2008.

Reference Books

1. R. Boylestad, Electronic Devices & Circuit Theory, Fifth Edition, PHI, 2002.
2. A. Singh, Principles of Communication Engineering S.Chand Co., 2001
3. V.K. Metha. Principles of Electronics, S. Chand Publications, 2008.

12NS207 SOLID STATE PHYSICS

Credit: 4:0:0

Course Objective:

- Get knowledge on band theory of solids
- Understand theoretical aspects of dielectric magnetic and optical properties of solids
- Gain knowledge on the principle of super conductivity

Course Outcome:

- Students will be able to apply the theory of solids to solve practical problems

Unit I

Lattice Vibrations: Elastic vibration – Mono atomic lattice – Linear diatomic lattice – optic and acoustic modes – infrared absorption – localized vibration – quantization of lattice vibration – Phonon momentum.(photon-phonon interaction) Band Theory of Solids: Energy bands in solids – Nearly free electron model – Bloch's theorem – Kronig and Penny model – Tight bound approximation – Brillouin zone – Fermi surface – density of states – de Hass – Van Alphen effect.

Unit II

Dielectric and Ferroelectric Properties: Dielectric constant and polarisability – Local field – different types of polarization – Langevin function – Classius – Mosotti relation – Dipolar dispersion – Dipolar polarization in solids – Ionic Polarisability, Electronic Polarisability – Measurement of dielectric constant. Ferroelectricity – General properties – Dipole theory.

Unit III

Magnetic Properties: Quantum theory of Paramagnetism – Paramaganetism of ionic crystals – Rare earth ions – Ferromagnetism – Weiss theory – Temperature dependence of magnetism – Exchange interation – Ferromagnetic domains surfaces – Bloch Wall – Antiferromagnetism – Molecular field theory – Neel temperature – Ferrimagnetism.

Unit IV

Optical Properties: Point defects in crystals - Colour centres – Photoconductivity – Electronic Transitions in photoconductors – Trap capture, recominations centres – General mechanism – Luminescence – Excitation and emission – Decay mechanism – Thermo luminescence and glow curves – Electroluminescence.

Unit V

Superconductivity: Zero resistance – Behavior in magnetic field – Meissner effect – thermodynamics of super conductive materials – Electro dynamics – London equations – B.C.S. theory (qualitative) - Tunneling A.C. and D.C. Josephson effect – Type I and II superconductors – High Tc super conductors (basic ideas)

Text Books

1. C. Kittel, Introduction to Solid State Physics, John Wiley, 8th edition,2004
2. A. J. Dekker, Solid State Physics, Macmillan India Ltd. (2005).

Reference Books

1. S.O. Pillai, Solid State Physics, New Age Publications, 2002
2. M. Ali, Elementary Solid State Physics, Pearson Education, 2004
3. Sybil P. Parker, Solid-State Physics, The Mcgraw-Hill Science Reference Series.

12NS208 QUANTUM MECHANICS

Credit: 4:0:0

Course Objective:

- To understand the general formulation of quantum mechanics
- To solve Eigen value equations for specific physical problems
- To get knowledge on the theoretical aspects of perturbation of atoms due to electric and magnetic fields
- To understand the theory of many electron systems

Course Outcome:

- Improved mathematical skills necessary to solve differential equations and Eigen value problems using the operator formalism
- Quantum mechanical solution of simple systems such as the harmonic oscillator and a particle in a potential well.
- Solutions to perturbation problems and many electron systems

Unit I

General Formalism of Quantum Mechanics: Linear Vector Space- Linear Operator- Eigen Functions and Eigen Values- Hermitian Operator- Postulates of Quantum Mechanics- Simultaneous Measurability of Observables- General Uncertainty Relation- Dirac's Notation- Equations of Motion; Schrodinger, Heisenberg and Dirac representation- momentum representation.

Unit II

Energy Eigen Value Problems: Particle in a box – Linear Harmonic oscillator- Tunnelling through a barrier- particle moving in a spherically symmetric potential- System of two interacting particles-Rigid rotator- Hydrogen atom.

Unit III

Angular Momentum: Orbital angular momentum-Spin angular momentum-Total angular momentum operators-Commutation relations of total angular momentum with components-Ladder operators-Commutation relation of Jz with J+ and J- - Eigen values of J2, Jz- Matrix representation of J2, Jz, J+ and J- - Addition of angular momenta- Clebsch Gordon Coefficients – Properties.

Unit IV

Approximate Methods: Time Independent Perturbation Theory in Non-Degenerate Case-Ground State of Helium Atom-Degenerate Case-Stark Effect in Hydrogen – Spin-orbit interaction-Variation Method & its Application to Hydrogen Molecule- WKB Approximation.

Unit V

Many Electron Atoms: Indistinguishable particles – Pauli principle- Inclusion of spin – spin functions for two-electrons- The Helium Atom – Central Field Approximation - Thomas-Fermi model of the Atom - Hartree Equation- Hartree -Fock equation.

Text Books

1. P.M. Mathews & K. Venkatesan , A Text Book of Quantum Mechanics- - Tata McGraw Hill, 2007.
2. G. Aruldhas, Quantum Mechanics , Prentice Hall of India 2006

Reference Books

1. D. J.Griffiths ,Introduction to Quantum Mechanics, Pearson Prentice Hall 2005
2. L.I Schiff , Quantum Mechanics, McGraw Hill, 1968
3. SatyaPrakah, S. Saluja, Quantum mechanics, Kedar Nath, Ram Nath & Co, Meerut, 2007
4. R.Shankar, Principles of Quantum Mechanics-, Springer 2005.

12NS210 SOLID STATE CHEMISTRY

Credit: 4:0:0

Course Objective:

- To teaches basic principles of Solid state chemistry and physics
- To understand the how they apply in describing the behavior of the solid state.
- To study the relationship between electronic structure, chemical bonding, and crystal structure is developed.

Course Outcome:

- The student should be conversant with the Solid state of material
- To understand the Principles of characterization of the materials
- To understand the basic of bonding principles and formation process

Unit 1

Solid State Materials: Introduction – Classification of solids – Periodicity in crystals – Crystal structure – Geometry of space lattice – Unit cell – Bravis lattices - Crystallographic planes and miller indices - FCC, BCC, HCP Crystal systems – Crystal symmetry – The unit cell characteristics– Atomic packing – Characteristics of a HCP.

Unit II

Crystal Structure: Crystal structure: packing efficiency, Radius ratio rule, Relation between void radius and atom radius in close packing, Bragg's law, X –ray structure of crystals, Structure of some ionic solids, Structure based on FCC and other cubic lattices. Imperfections in Solids: Point (Schotsky and Frenkel), Line and Plane defects.

Unit III

Solid State Reactions: Types; sintering; nucleation; Factors influencing the reactivity of solids; Precursors to solid state reactions; Tammann and Hedvall mechanism; Wagner's diffusion theory of reaction; Material transport in solid state reaction—counter diffusion, Kirkendall effect;

Huttig's mechanism; Kinetic model: Reaction in powder compact, parabolic rate law, Jander's rate equation.

Unit IV

Chemical Kinetics and Phase diagram: Rate of reaction, Order and molecularity, integrated rate equation. Half life, Pseudo first order reaction, temperature dependence of rate of reactions, Theory of reaction rates: Collision theory, Arrhenius equation. Definition of terms: Phase, component, degree of freedom or varions, Phase rule: Advantages, limitations, Phase diagram, One component system: Water and Sulphur system, Two component styste: Solid – Liquid equilibrium, Eutectic and Eutectoid system.

Unit V

Liquids, Solution and Redox reaction; Solubility rules, Acids, Bases, pH, pK_a, pK_b, Buffers, concepts, Henderson equations, Oxidation reduction reaction.

Text Books

1. I. N. Levine. Quantum Chemistry, Prentice Hall India (2001).
2. D. A. McQuarrie. Quantum Chemistry, Viva Books Pvt Ltd (2003)
3. A. K. Chandra. Introductory Quantum Chemistry, Tata McGraw Hill (1994).
4. Y. Moroi. Micelles: Theoretical and Applied Aspects, Plenum (1992).
5. A. R. West. Solid State Chemistry and its Applications, John Wiley (1998).

Reference Books

1. P. W. Atkins. Molecular Quantum Mechanics, Oxford University Press (1986)
2. R. McWeeny. Coulson's Valence, ELBS (1979).
3. N. B. Hannay. Solid State Chemistry, Prentice-Hall (1979).
4. D. K. Chakraborty. Solid State, New Age International, New Deldi (1996).

12NS211 MATERIALS SCIENCE ENGINEERING

Credits: 4:0:0

Course Objective:

- To understand of mechanics, physical and chemical properties of materials

Course outcome:

- To apply the basic principles of Materials for Science and Engineering applications

Course Outcome:

- The student should be conversant with the material Science
- To understand the Principles of Cauterization of the materials

Unit I

Introduction & Structure of Materials : Historical perspective of Materials Science. Why study properties of materials? - Classification of materials.- Advanced Materials, Future materials and modern materials, Atomic structure. -Atomic bonding in solids,- Crystal structures, Crystalline and noncrystalline materials- Miller indices.

Unit II

Imperfection in Solids & Mechanical Properties of Metals: Point defects and other types of defects- Theoretical yield point. Line defects and dislocations. Interfacial defects. Bulk or volume defects. Atomic vibrations, Elastic deformation. Plastic deformation. Interpretation of tensile stress-strain curves Yielding under multiaxial stress. Yield criteria and macroscopic aspects of plastic deformation.

Unit III

Diffusion mechanism: Diffusion mechanisms. Steady and non-steady state diffusion. Factors that influence diffusion. Non-equilibrium transformation and microstructure, Fick's laws and application of diffusion in sintering, doping of semiconductors and surface hardening of metals,

Unit IV

Application and Processing: Types of metals and alloys, Fabrication of metals, Thermal processing of metals, Heat treatment, Precipitation hardening. Types and applications of ceramics-Fabrication and processing of ceramics. Mechanical behavior of polymers-Mechanisms of deformation and strengthening of polymers. Crystallization, melting and glass transition- Polymer types- Polymer synthesis and processing. Particle reinforced composites - Fiber reinforced composites- Structural composites.

Unit V

Properties (electrical, thermal, magnetic, and optical): Electrical conduction-Semi conductivity- Super conductivity- Electrical conduction in ionic ceramics and in polymers. Dielectric behavior- Ferroelectricity- Piezoelectricity. Heat capacity- Thermal expansion-Thermal conductivity- Thermal stresses. Diamagnetism and paramagnetism- Ferro-magnetism. Anti-ferro magnetism and ferri-magnetism. Influence of temperature on magnetic behavior. Domains and Hysteresis, Basic concepts. Optical properties of metals. Optical properties of nonmetals.

Text Books

1. W.D. Calister, Materials Science and Engineering - An Introduction; BY John Wiley & Sons Canada, Limited, 1993.
2. W.D. Calister, Fundamentals of Materials Science and Engineering: An Integrated Approach, John Wiley,

Reference Books

1. C. Kittel, Introduction to Solid State Physics, John Wiley, 2008.
2. J.F. Shackelford, Introduction to Materials Science for Engineers, 7th Edition, Pearson Prentice Hall (2009).
3. V. Gerold, Materials Science and Technology, Volume 1, VCH Publication.(1992)
4. E.N. Kaufmann, Characterization of Materials, 2 Volume Set Wiley 2003.

12NS212 LABORATORY WORK FOR NSNT

(PHYSICS, CHEMISTRY, BIOLOGY, COMPUTATIONAL AND NANOTECHNOLOGY)

Credits: 0:0:4

Course Objective:

- To synthesize nanomaterials by various chemical and physical routes.

Course Outcome:

- To understand the methodology of synthesizing nanomaterials by different processes and techniques.

List of Experiments:

1. Synthesis of TiO_2 nanoparticles by sol-gel method
2. Synthesis of ZnO nanoparticles using chemical method
3. Synthesis of $Ce_{1-x}Sr_xO_{2-\delta}$ nanoparticles
4. Synthesis of nano $BaCeO_3$ powder
5. Synthesis of γ- $LiAlO_2$ nanoparticles
6. Synthesis of Magnetite Nanoparticles (Aqueous Ferro fluid)
7. Synthesis of Nickel Oxide nanoparticles by chemical precipitation method
8. Synthesis of silver nanoparticles by chemical reduction method
9. Chemical Synthesis of MgO nanoparticles
10. Preparation of CuO nanomaterials by wet chemical method
11. Synthesis of Cadmium sulphide nanocrystals
12. Preparation of Barium Sulphate nanocrystals by aqueous colloidal method
13. Preparation of CuO nanorods using Ultrasonic bath
14. Synthesis of gold nanoparticles by simple chemical reduction method
15. Preparation of Fe_2O_3 nanoparticles by new sol-gel method

12 experiments will be notified by the Lab supervisor/HOD time to time

LIST OF SUBJECTS

Sub. Code	Name of the Subject	Credits
12NT328	Research Methodology in Nanotechnology	4:0:0
13NT201	Introduction to Nanotechnology Inventions and Patents	3:0:0

12NT328 RESEARCH METHODOLOGY IN NANOTECHNOLOGY

Credits: 4:0:0

Objective:

- Awareness will be created on the research methodology in nanotechnology among research scholars/students and the concept of sustainable nanotechnology will be introduced.
- The student will get clear exposure on research techniques based on spectroscopic and other instrumentation methods.

Outcome:

- The student will understand the concepts of research methodology in nanotechnology and its related techniques.

Unit I

RESEARCH METHODOLOGY: Problem Identification and survey design, hypothesis generation and testing : collecting evidences and notion based correlation, survey literature and design, scope for the hypothetical problem and its formulation, designing and planning of research tools and experimentation, preparation of synopses, work plan and data collection, data processing using qualitative and quantitative analytical/statistical approaches, writing of abstracts, research projects, reports, papers, dissertation and thesis, (Formatting and submission of on-line manuscripts). General idea of seminars, symposia, workshops and conferences. Planning and making deliberations, General idea about impact factor of journals, IPR and patents.

Unit II

QUANTITATIVE APPROACHES IN RESEARCH METHODOLOGY: Statistical tools and approaches, testing confidence limits, normal binomial and Poisson distribution, method of least square and successive approximation, correlation and regression – Linear and non linear; multiple variable matrix and its analysis, drawing of good fit lines, slopes, correlation coefficients and their significance.

Unit III

MICROSCOPIC TECHNIQUES FOR NANOTECHNOLOGY: Optical microscopy of aggregates, Electron Microscopy- Scanning Electron Microscopy (SEM)-Modern advances in SEM Transmission Electron microscopy (TEM)- Biological sample preparation for TEM Environmental TEM- Scanning probe microscopy-STEM- Atomic Force Microscopy (AFM)- Confocal Microscopy- Scanning Near Field Microscopy- Nanoindendation.

Unit IV

SPECTROSCOPIC AND ELECTROCHEMICAL TECHNIQUES- UV-Vis Spectroscopy- Raman Spectroscopy – Electron Paramagnetic Resonance technique, Energy Dispersive X-ray Spectroscopy (EDAX), Nuclear Magnetic Resonance (NMR) Spectroscopy, Differential Scanning Calorimetry (DSC) - Electrochemistry fundamentals, Electro-analytical techniques- Voltametry- Linear Scan Voltametry- Cyclic Voltametry (CV)- Impedence Spectroscopy- Applications.

Unit V

INSTRUMENTATION: Thermo gravimetric analytical (TGA) methods - characteristic features of theromgram –instrumentation of thermogravimetry –factors affecting TGA- applications of TGA- DTA-characteristic of DTA curves –instrumentation of DTA –factors affecting DTA-applications of DTA. XRD- a brief account of the principles of molecular structure determination by X-ray diffraction by single crystal-structure factor- Biology instrument testing – antimicrobial assay-ultra centrifuge- cell culture - cytotoxicity measurement.

Text Books

1. N. Yao and L. W. Zhong, Handbook of Microscopy for Nanotechnology Kluwer Academic Publishers, 2005.
2. C. R. Kothari, II nd edition, Research methodology: Methods and Techniques, New Age International (p) Ltd Publishers, New Delhi, 2004.

Reference Books

1. C. Nicolini, Nanobiotechnology & Nanobiosciences, Pan Stanford Publishing Pvt, Ltd, 2009
2. T. Pradeep, NANO: The Essentials, Understanding Nanoscience and Nanotechnology, Tata McGraw-Hill Publishing Company Limited, 2007.

13NT201 INTRODUCTION TO NANOTECHNOLOGY INVENTIONS AND PATENTS

Credit 3:0:0

Objective:

- To learn about the latest nanotechnology inventions and current nanotechnology patents

Outcome:

- Students should be able to comprehend and analyze pros and cons of the nanotechnology inventions, innovations and patents

Unit I

OVERVIEW OF NANOTECHNOLOGY INVENTIONS AND PATENTS

Introduction to nanotechnology, patents, concepts of nanotechnology inventions, concepts of nanotechnology patents. Discussions and analysis of latest Noble Laureates inventions in nanotechnology. Formats and guidelines of the US and Indian Patent filings.

Unit II

NANOTECHNOLOGY INVENTIONS AND PATENTS IN EVERYDAY LIFE

Basic concepts of inventions and patents, Nanotechnology patents and associated products- associated concepts-advantages of using nanotechnology products. A case study of a nanotechnology patent and a nanotechnology product.

Unit III

NANOTECHNOLOGY INVENTIONS AND PATENTS IN SCIENCES

Basic of inventions and patents in sciences, concepts of converting knowledge into patents. Case study of a invention in science. Case study of a patent in general science.

Unit IV

NANOTECHNOLOGY INVENTIONS AND PATENTS IN ENGINEERING

Important nanotechnology inventions and patents in engineering, case study of a invention and a patent in each branch of engineering, NEMS/MEMS, Microprocessors, devices and sensors. Pros and cons of a existing patent (Mechanical engineering, Electrical engineering, Computer engineering)

Unit V

NANOTECHNOLOGY INVENTIONS AND PATENTS IN BIOMEDICAL ENGINEERING

Important nanotechnology inventions and patents in biomedical engineering, case study of a patent and invention in biomedical engineering, cancer treatment and targeted drug delivery patents. Pros and cons of a existing patents.

Text Books

1. Mark Ratner and Daniel Ratner, Nanotechnology: A gentle introduction to the next big idea. Pearson Education Inc., 2003, Prentice Hall/PTR, New Jersy, USA
2. Manasi Karkare Nanotechnology: Fundamentals and Applications, I. K. International Publishing House Pvt. Ltd 2008.

Reference Books

1. Springer Handbook of Nanotechnology: Volume 2, edited by Bharat Bhushan, Springer-Verlag. 2nd ed., 2007
2. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience and Nanotechnology, PHI Learning Ltd, New Delhi, 2009.