NANOTECHNOLOGY

B.TECH III SEMESTER

SUB. CODE	PAPER	TEACHING PERIOD			
THEORY		L	T	P	CREDITS
03BNT101	Solid State Physics	2	1	0	3
03BNT102	Foundation of Nanoscale Science and Technology	3	1	0	4
03BNT103	Electronic and Optical Properties of Material	3	1	0	4
03BNT104	Material Science Non conventional Energy Sources	2	1	0	3
03BNT105	Nano Measurement	2	1	0	3
03BNT106	Cell-& Molecular Biology	3	1	0	3
LABORATORY		0	0	0	
03BNT201	Solid State Physics	0	0	3	2
03BNT202	Electronic and Optical Properties of Material	0	0	3	2
03BNT203	Material Science	0	0	3	2
03BNT204	Cell-& Molecular Biology	0	0	2	1
03BNT301	Discipline & Co-Curricular activities	--	--	4	1
	TOTAL	15	6	15	28

B.TECH IV SEMESTER

SUB. CODE	PAPER	TEACHING PERIOD			CREDITS
THEORY		L	T	P	
04BNT101	Bio Nano Technology	2	1	0	3
04BNT102	Atomic and electronic structure of matter	3	1	0	4
04BNT103	Introduction to Materials	3	1	0	4
04BNT104	Photonics	3	1	0	4
04BNT105	Ceramic science & Technology	3	1	0	4
04BNT106	Molecular Biophysics	2	1	0	3
LABORATORY		0	0	0	
04BNT 201	Atomic and electronic structure of matter	0	0	3	2
04BNT 202	Introduction to Materials	0	0	2	1
04BNT 203	Ceramic Science & technology	0	0	2	1
04BNT 204	Molecular Biophysics	0	0	3	2
04BNT 301	Discipline & Co-Curricular activities	--	--	4	1
	TOTAL	16	6	14	29

B.TECH V SEMESTER

CODE	SUBJECT	TEACHING PERIOD			CREDITS
		L	T	P	
05BNT101	EXPERIMENTAL METHODS IN NANOTECHNOLOGY	3	1	0	4
05BNT102	CHARACTERIZATION TOOLS FOR NOMATERIALS	3	0	0	3
05BNT103	MICRO-ELECTRO MECHANICAL SYSTEM (MEMS) & NANO-ELECTRO MECHANICAL SYSTEMS (NEMS)	3	0	0	3
05BNT104	NANO- LITHOGRAPHY	3	0	0	3
05BNT105	GENETICS AND MOLECULAR BIOLOGY	3	1	0	4
05BNT106	BIOENGINEERED NANOMATERIALS	3	0	0	3
05BNT201	EXPERIMENTAL METHODS IN NENOTECHNOLOGY	0	0	3	2
05BNT202	MICRO-ELECTRO MECHANICAL SYSTEM (MEMS) & NANO-ELECTRO MECHANICAL SYSTEMS (NEMS)	0	0	3	2
05BNT203	NANO- LITHOGRAPHY	0	0	3	2
05BNT204	CELL BIOLOGY	0	0	3	2
05BNT301	Discipline & Extra Curricular activities	--	--	4	1
TOTAL CREDITS		18	2	16	29

B.TECH VI SEMESTER

CODE	SUBJECT	TEACHING PERIOD			
		L	T	P	CREDITS
06BNT101	Nano Chemistry	3	1	0	4
06BNT102	MOLECULAR SELF-ASSEMBLY	3	0	0	3
06BNT103	GENERIC METHODOLOGY FOR NANOTECHNOLOGY	3	0	0	3
06BNT104	NANOSCALE MAGNETIC MATERIALS AND DEVICES	3	0	0	3
06BNT105	BASICS OF NANOTECHNOLOGY AND ITS APPLICATIONS	3	1	0	4
06BNT106	NANOTECHNOLOGY APPLICATIONS	3	0	0	3
06BNT201	NENOELECTRONICS & DEVICES	0	0	3	2
06BNT202	MOLECULAR SELF ASSEMBLE	0	0	3	2
06BNT203	GENERIC METHODOLOGY FOR NANOTECHNOLOGY	0	0	3	2
06BNT204	BASICS OF NANOTECHNOLOGY AND ITS APPLICATIONS	0	0	3	2
06BNT301	Discipline & Extra Curricular activities	--	--	4	1
TOTAL CREDITS		18	2	16	29

B.TECH VII SEMESTER

CODE	SUBJECT	TEACHING PERIOD			CREDITS
		L	T	P	
07BNT101	NANOTRIBOLOGY	3	1	0	4
07BNT102	INORGANIC SEMICONDUCTOR NANOSTRUCTURES	3	0	0	3
07BNT103	PLASTIC AND MOLECULAR ELECTRONICS	3	0	0	3
07BNT104	BIOSENSORS	3	0	0	3
07BNT105	NANOPHYSICS	3	1	0	4
07BNT106	NANOSCIENCE	3	0	0	3
07BNT201	INORGANIC SEMICONDUCTOR NANOSTRUCTURES	0	0	3	2
07BNT202	PLASTIC AND MOLECULAR ELECTRONICS	0	0	3	2
07BNT203	BIO-SENSORS	0	0	3	2
07BNT204	NANOPHYSICS	0	0	3	2
07BNT301	Discipline & Extra Curricular activities	--	--	4	1
TOTAL CREDITS		18	2	16	29

B.TECH VIII SEMESTER

CODE	SUBJECT	TEACHING PERIOD			CREDITS
		L	T	P	
08BNT101	Nanofabrication Techniques	**3**	**1**	**0**	**4**
08BNT102	TEMPERATURE TECHNIQUE	**3**	**1**	**0**	**4**
08BNT103	Nuclear Magnetic Resonance	**3**	**1**	**0**	**4**
08BNT104	**NANO ENGINEERING OF SOFT MATERIAL**	**3**	**0**	**0**	**3**
08BNT201	Nanofabrication Techniques	**0**	**0**	**3**	**2**
08BNT202	TEMPERATURE TECHNIQUE	**0**	**0**	**3**	**2**
08BNT203	Nuclear Magnetic Resonance	**0**	**0**	**3**	**2**
08BNT204	**NANO ENGINEERING OF SOFT MATERIAL**	**0**	**0**	**3**	**2**
Project work 08BNT205	**Major Project work**	**5**	**0**	**0**	**5**
08BNT301	**Discipline & Extra Curricular activities**	**--**	**--**	**4**	**1**
TOTAL CREDITS		**17**	**3**	**16**	**29**

SOLID STATE PHYSICS

Course/Paper: 03BNT-101
BNT Semester-III

UNIT-1:- CRYSTALPHYSICS:Periodic array of atoms, translation vectors, unit cell, space lattice, Miller indices, simple crystal structures, bonds in solids. Nano crystalline solids, physical properties of nanomaterials, melting points and lattice phonons, constants, mechanical properties-ray diffraction methods and their applications in identification of crystal structures ,Geometric factor reciprocal lattice.

UNIT-2:-LATTICE VIBRATIONS AND THERMAL PROPERTIES OF SOLIDS : Concept of lattice vibrations and thermal heat capacity, classical, Einstein and Debye theories of molar heat capacity and their limitations, concept of phonons.

UNIT-3:-BANDTHEORYOFSOLIDS : Origin of bands, band theory of solids, motion of electron in periodic field of crystal, Kronig-Penny model, Brillion zones, concept of holes, distinction between metal, insulator and semi- conductor, Hall effect, size effect on energy gap- quantum confinement, quantum dots.

UNIT-4:-SEMICONDUCTORS: Intrinsic semiconductors, doping and extrinsic semiconductors, simple models for semiconductors, Donor and acceptor levels, p-n junction and rectification, tunneling and resonant tunneling, Hall effect in semiconductors.

Reference

1. Introduction to Solid State Physics C. Kittle
2. Solid State Physics:A.J. Decker
3. Solid State Physics: S.O. Pillai
4. Nanostructures and Nano materials Guozhong CaO, Imperial College Press, 2006

FOUNDATIONS OF NANOSCALE SCIENCE AND TECHNOLOGY

Course/Paper: 03BNT-102
BNTSemester-III

UNIT-1:-NANOTECHNOLOGY: Background, what is nanotechnology, types of nonotechnology and nano-machines, top down and bottom up techniques, Molecular nanotechnology, atomic manipulation-nanodots, self-assembly, Dip pen nanolithography, Simple details of characterization tools- SEM, TEM, STM,AFM.

UNIT-2:-NANOMATERIALS : What are nanomaterials? Preparation of nanomaterials-Plasma arcing, Chemical Vapor Deposition, Sol-gels techniques,Electrodeposition, Ball Milling, Natural nanomaterials, Applications of nanomaterials-Insulation materials, Machine tools, Phosphors, Batteries, High power magnets Medical implants.

UNIT-3:-CARBONTUBES: New forms of carbon, Carbon tubes-types of nanotubes, formation of nanotubes, Assemblies, purification of Carbon nanotubes, Properties of nanotubes, applications of nanotubes.

UNIT-4:-OPTICS, PHOTONICS AND SOLAR ENERGY:Light and nanotechnology, Interaction of light and nanotechnology, Nanoholes and photons, Solar cells, nanoparticles and nanostructures; Optically useful nanostructured polymers, Photonic Crystals.

UNIT-5:-NANOELECTRONICS: Introduction, Tools of Micro- and Nanofebrication-optical and electron beam lithography, Molecular beam lithography, Quantum electronic devices, Molecular electronics, Simple ideas about quantum computers.
APPLICATIONS :MEMs, robots, Nanomachines, Nanodevices, New Computing System, Optic-electronic devices, Environmental applications,Nanomedicine, Biological nano-technological future.

Reference

1. Nanotechnology-Basic Science and Emerging Technologies Mick Wilson, Kamali Kannangra Geoff Smith, Michelle Simons and Burkhard
Raguse, Overseas Press.
2. Nanotechnology-AGentle Introduction to the Next Big Idea Mark Ratner and Daniel Ratner, Prentice Hall
3. Nanotechnology: RebeccaLJohnson, Lerner Publications.
4. Introduction to Nanotechnogy: Charles P. Poole Jr., Chapman and Hall/CR

ELECTRONIC AND OPTICAL PROPERTIES OF MATERIALS

Course/Paper: 03BNT-103
BNT Semester-III

UNIT-1:-OPTICAL PROPERTIES OFMATERIALS : Photoconductivity in insulating crystals, variation with illumination, effect of traps, space charge effects, applications of photoconductivity. Luminescence: Fluorescence, Phosphorescence phosphors, various types of luminescences. Photoluminescent&electro luminescent properties of porous silicon. Fluorescence,Thermo luminescence and photoluminescence of Nanoparticles.

UNIT-2:-OPTICALPROPERTIES OFQUANTUM DOTS Excitons: Weekly bound excitons, tightly bound excitons, excitons in molecular crystals and in nanostructures. NON-LINEAR OPTICS:Non-linear optical susceptibility second and third order optical susceptibilities. Harmonic Generation. Multiple photon excitations. Stimulated Raman Scattering. Stimulated Brillion Scattering. Non-linear optical properties of nano structure.

UNIT-3:-OPTICAL PHENOMENA IN NANOMATERIALS : Surface enhanced optical phenomena in nanostructured fractal materials. Linear and non-linear spectroscopy of semiconductor nano crystals.

UNIT-4:-ELECTRONIC PROPERTIES OFMATERIALS : Classical free electron theory and its limitations, quantum theory of free electrons, Density of states, Fermi level, Semiconductor lasters, Size effects on the band gap of semiconductor Quantum-dot lasers.

UNIT-5:-ELECTRONIC PROPERTIES OF NANO-MATERIALS : Theory of Electronic Conduction through Organic molecules: Theoretical model, Factors affecting the current voltage-characteristics. Electronic Properties of Molecular Nano-structures, cluster arrays & networks: Experimental considerations Electronic properties of individual Molecules, Electronic conduction through supported clusters, and Electronic properties of Encapsulated gold clusters. Estimating the Electrical Resistance of a molecule, Electrical measurements and conduction model. Majority Carrier Injection devices, Single-Electron Electronics in Silicon-Based Nanostructures. Conductive properties of porous silicon.
ELECTRICAL PROPERTIES OF NANO MATERIALS : Electrical Properties of zero-Three Dimensional Arrangements of Nanoparticles: Single-Particle Properties, One,Twoand Three DimensionalArrangements.

Reference

1. Optical ElectronicsAGhatak & K.Thyagarajan
2. Quantum ElectronicsYariv
3. Solid State Physics Charles Kittel
4. Optics- Eugene Hecht
5. Nano materials synthesis, properties and applications: EdelesteinA.S and CammarataRC
6. Handbook of Nano structured Materials and Nanotechnology Electrical PropertiesVol.3 Hari Singh Nalwa
7. Handbook of Nano structured Materials and Nanotechnology, Optical PropertiesVol.4 Hari Singh Nalwa.

MATERIALSCIENCE - NON-CONVENTIONAL ENERGY SOURCES

Course/Paper: 03BNT-104
BNT Semester-III

Unit1 - Introduction : Energy scene of supply and demand in India and the world, energy consumption in various sectors, potential of nonconventional energy resources. Detailed study of the following sources with particular reference to India. Solar Energy: Solar radiation and its measurement, limitations in the applications of Solar Energy, Solar collectors types, and constructional details. Solar water heating, applications of Solar Energy for heating, drying, space cooling, water desalination, solar concentrators, photovoltaic power generation using silicon cells.

Unit 2 - Bio-Fuels : Importance, combustion, pyrolysis and other thermo chemical processes for biomass utilization. Alcoholic fermentation, anaerobic digestion for biogas production.

Unit 3 -Wind Power : Principle of energy from wind, windmill construction and operational details and electricity generation and mechanical power production. Tidal Power: Its meaning, causes of tides and their energy potential, enhancement of tides, power generation from tides and problems.Principles of ocean thermal energy conversion (OTEC) analysis and sizing of heat exchangers for OTEC.
Unit 4- Geothermal Energy : Geo technical wells and other resources dry rock and hot aquifer analysis , harnessing geothermal energy resources.

Unit 5- Energy Storage and Distribution : Importance, biochemical, chemical, thermal, electric storage. Fuel cells, distribution of energy.

Reference

1. Rai, G.D, Non-conventional Energy Sources, Khanna Publishers, Delhi.
2. Twiddle, J.Weir,T. "Renewable Energy Resources," Cambridge University Press, 1986.
3. Kreith, F. and Kreider, J. F., "Principles of Solar Engineering," McGraw Hill, 1978.
4. Duffie, J.A., Beckman,W.A., "Solar Engineering of Thermal Processes," John Wiley, 1980.
5. Veziroglu, N., "Alternative Energy Sources,"Volume 5&6, McGraw-Hill, 1978.

NANO MEASUREMENTS

Course/Paper: 03BNT-105
BNT Semester-III

UNIT- I

Monitoring techniques such as residual gas analysis, optical emission spectroscopy and end point detection are discussed.

UNIT-II

Measurement tools such as Scanning Electron Microscopy (SEM), x-ray spectroscopy, Atomic Probe Microscopy (APM), Transmission Electron Microscopy (TEM), Advanced Optical Microscopy (AOM), laser microscopy, Fourier

UNIT- III

Transform Infrared Spectroscopy (FTIR)

UNIT-IV

Optical thin film measurements, ellipsometry, profilometry, and resistively/conductivity measurements are tied to process control. These include breakdown measurements, junction testing, and capacitance-voltage and current voltage measurements. In addition, the measurements of some simple chip structures and Micro-Electrical Mechanical Systems(MEMS)devices are obtained and discussed.

UNIT-V

The general application of SEM, TEM & Spectroscopy.

Reference

1. • Encyclopedia of Materials Characterization Tools/Equipment, Brundle, Evans
2. • Jr.Watson, Manning Publishing, 1992.

CELL & MOLECULAR BIOLOGY

Course/Paper: 03BNT-106
BNT Semester-III

UNIT-I : Cell : Structural Organization : Development of cell theory, Eukaryotic and Prokaryotic cells., nucleus and cell cycle (Mitosis and Meiosis), ultra structure of the cytoplasm cytoskeleton, microtubules, micro tubular, organelles, micro filaments, the Endomembrane system, nuclear envelop, endoplasmic reticulum&Golgi complex, membrane organelles : mitochondria, chloroplast, lysosome, peroxisomes.

UNIT-2: Transport Across Cell Membrane : Molecular organization of cell membrane, passive and active transport, Na-K pump, Ca AT Pase pumps, Lysosomal and Vacuolar membrane,ATP dependent proton pumps, Co transport into prokaryotic cells, endocytosis and exocytosis, entry of viruses and toxins into cells.

UNIT-3: Receptors and models of extra cellular signaling: Cytosolic, nuclear and membrane bound receptors, examples of receptors, autocrine, paracrine and endocrine model of action, quantitation and characterization of receptors.

UNIT-4: Signal Transduction: Signal amplification, different models of signal amplification, cyclicAMP, role of inositol phosphates messengers.Biosynthesis of inositol triphosphatases, cyclic GMPand G proteins in signal transduction. Calcium models of signal amplification, phosphorylation of protein kinases.

UNIT-5: Cell Culture: Techniques of propagation of prokaryotic and eukaryotic cells (animal and plant). Cell line, generation of cell lines, maintenance of stock cells, characterization of cells, immunochemistry, morphological analysis, techniques in cell culture, explants cultures, primary cultures, contamination, differentiation, three dimensional cultures, role of matrix in cell growth.

Reference

1. Cell&Molecular Biology by De Robertis, Lea and Febiger
2. Cell&Molecular Biology by H. Baltimore,WHFreeman
3. Cell Biology by KimballT.W. ,Wesley Pub.

Solid state physics

Course/Paper: 03BNT-201
BNT Semester-III

1. To study and perform the Hall Effect phenomenon.
2. To study and perform the solar cell
3. To study and perform the LED.
4. To study the glass formation
5. To determine the melting point of Nano materials
6. X-Ray diffraction (Power crystal method) for identification of crystal structure

Electronic and optical properties of Material

Course/Paper: 03BNT-202
BNT Semester-III

To perform following experiment based on fiber optic trainer

1: To set-up fiber optic analog link.

2: To set-up fiber optic digital link.

3: Measurement of propagation loss and numerical aperture.

4: Characterization of laser diode.

5: Characterization of light emitting diode.

6: To study the optical properties of materials.

7: Introduction to fiber optics.

8: Study of bending loss.

Material science

Course/Paper: 03BNT-203
BNT Semester-III

1. To study the solar energy and its applications
2. To study the Bio-Gas Production
3. To study the Alcoholic fermentations
4. To study the wind energy and its applications

CELL & MOLECULAR BIOLOGY

Course/Paper: 03BNT-204
BNT Semester

1. Microscopic study of Cell

2. preparation of slides of stages of mitosis

3. preparation of slides of stages of meiosis

4. study stages of mitosis and meiosis (permanent slides)

5. microscopy

6. demonstration of DNA gel-electrophoresis

BIONANOTECHNOLOGY

Course/Paper: 04BNT-101
BNT Semester-IV

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

Reference

1. Engineering Materials Science Mittas Obring , Elsevier
2 An introduction to Materials Engineering and Science For Chemical and Materials Engineering Brian S.MitchellWiley - IEEE
3. Applied Materials Science Deborah DL Chung ,CRC Press.
4. Nano-structures and Nano-materials Synthesis Properties &Application G. Gao, Imp. College Press.
5. Biotech,A(1991) NucleicAcid Res.
6. Peters, P(1993) Biotechnology—a guide to genetic engineering, WMC, Brown Publishers Dubuwve.

ATOMIC AND ELECTRONIC STRUCTURE OF MATTER

Course/Paper:04BNT-102
BNT Semester-IV

DEVELOPMENTAND CONCEPTS OFATOMIC PHYSICS : The Bohr. Atom model and its developments, the quantum mechanics of atoms, radiative transitions between discrete states of atoms, continuous spectra.

THEHYDROGEN ATOM: Electron states of the Hydrogen atoms, fine splitting of levels of hydrogen atom, superfine splitting and isotope shift of levels of Hydrogen atoms.

TWO-ELECTRON ATOMS: The Pauli's exclusion principle and symmetry of the atomic wave function, the helium atom.

LIGHT AND HEAVY ATOMS : Quantum Nos. of light atoms, the atom shell model. Fine splitting of levels of light atoms, periodic system of elements and atoms with valent s-electrons, he structure of heavy toms atoms with valent d and f electrons, exchange interaction in heavy atoms, filling of electron shells for jj-coupling.

EXCITED ATOMS: Metastable and resonantly excited atoms, metastable atoms in gas ischarge and gas lasers, properties of highly excited atoms.

Reference

1. Physics of Atoms & Ions Richard L. Liboff, Borns M. Smirnov, Springer
2. Introduction to Quantum Mechanics Linus Pauling, E. Brignt Wilson Corrier, Dover Publication.
3. Elementary Atomic Structure Wood gate, Oxford Uni. Press.

INTRODUCTION TO MATERIALS

Course/Paper: 04BNT-103
BNT Semester-IV

UNIT-1:INTRODUCTION TO MATERIALS : Science and Engineering-Materials resources and their implications, materials and engineering, engineering materials and selected application, special nano materials carbon fullerences, carbon nano tubes, micro and mesoporous structures.

UNIT-2:ELECTRONS,ATOMSANDSOLIDS: Introduction, atomic electrons in single atoms, electrons in molecules and solids, bonding in solids.

UNIT-3:STRUCTURE OF SOLIDS : Introduction, to crystal structure, common crystal structure experimental evidence for crystal structure, defects in crystalline solids, structural morphologies and their revelation.

UNIT-4:POLYMERS,GLASSES,CERAMICS,CARBON-MATRIX,OMPOSITESANDNON-METALLICMIXTURES: Introduction, Polymers and their chemistry structure and morphology, inorganic glasses ceramics structure, carbon matrix composites, carbon and graphite, self-sensing carbon fiber polymer matrix composites.

UNIT-5:KINETICS OF MASS TRANSPORT AND PHASE TRANSFORMATION : Introduction, macroscopic diffusion phenomena, atomic movements in diffusion, nucleation, kinetics of phase transformatics, generalized solid-state kinetics.

ELECTRICAL, MAGNETIC AND OPTICAL PROPERTIES OF MATERIALS : Brief introduction to electrical, magnetic and optical properties.

Reference

1.Engineering Materials Science Mittas Obring, Elsevier
2. An introduction to Materials Engineering and Science Brian S. MitchellWiley - IEEE
3. Applied Materials Science Deborah DL Chung, CRC Press.
4. Nano-structures and Nano-materials Synthesis Properties &Application G. Gao ,Imp. College Press.

PHOTONICS

Course/Paper: 04BNT-104
BNTSemester-IV

UNIT-1: INTRODUCTION: PHOTONICS & INTERACTIONS: Electronics & Photonics brief history, future outlook of photonics. Quantum optics, interactions of photons atoms, interaction of light with light, Non-linear optics, second-order non-linearity, third order non-linearity, non-linear crystals, interaction of light and sound.

UNIT-2:RECENT ADVANCES IN SEMI-CONDUCTOR AND TECHNOLOGY: Introduction, Review of semiconductor lasers, quantum wire and quantum box, wavelength tuning in quantum well lasers.

UNIT-3:FIBER LASERS: Introduction, Operating principle of Fiber lasers, resonant cavity for a fiber oscillator, typical fiber lasers, pump source requirements for end-pumped lasers, mode locking in fiber lasers, mode locking methods, high power fiber lasers, Diode laser pumping.

UNIT-4:SOLID STATE LASERS AND OTHER LASER SOURCES: Introduction, Fundamental concepts of solid-state lasers, tunable lasers, ultra-fast solid state lasers, gaseous discharge lasers dye lasers, exciter, free electrons, X-ray and extreme-UV lasers.

UNIT-5:NANO-PHOTONICS: Introduction, Foundations for nano-photonics, Plasmonics, photonic, crystals nano-photonics for biotechnology and nanomedicine.

Reference

1. Advanced photonics Chai Yeh, Elsevier.
2. Hand book of Photonics Mool C. Gupta, CRC Press.
3. Photonics Essentials Thamas P. Pearsall, McGraw-Hill
4. Nano-photonics Paras N Prasad, Wiley IEEE

CERAMIC SCIENCE AND TECHNOLOGY

Course/Paper: 04BNT-105
BNT Semester-IV

UNIT-1: Introduction: Definition Classification of Ceramics Traditional Ceramics Structural Ceramics Fine Ceramics Bio ceramics Ceramic super conductors.

UNIT-2: Structure of Ceramic Crystals: Atomic structure Interatomic bonds Atomic bonding in Solids Crystal structures grouping of ions and Pouling's rules Oxide structures Silicate structures Glass formation Models of glass structure Types of glasses

UNIT-3:Ceramic Phase - Equilibrium Diagrams: Two component systemsa(Al2O3 SiO2 b)BaO TiO2,Three component systems MgO Al2O3 SiO2.
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UNIT-4:Powder Preparation Techniques: Preparation of Al2O3, ZrO2, SiC, Si3N4BN&B4CPowder by various Techniques. Sol-gel technology Precipitation, Coprecipitation Hydrothermal precipitation.

UNIT-5:Ceramic Processing Techniques: Hot Pressing Hot Isostatic Pressing - (HIP), Sintering Sinter / HIP-Injection moulding - Slip casting -Tape casting Gel casting Extrusion
Reference

MOLECULAR BIOPHYSICS

Course/Paper:04BNT-106
BNT Semester-IV

UNIT-1: Levels of molecular organization. Composition of primary structures of proteins and nucleic acids, Hydrogen bonding, hydrophobic interactions, ionic interactions, disulphide bonds and their role in proteins structure.

UNIT-2: General characteristics of protein structure and functions. Ramachandra or steric contour diagram and potential energy calculation of proteins, secondary structural elements and organization of tertiary structure, Helix-coil transition and zipper model, method for structural elucidation, aspects of protein folding kinetics, ligand interactions, Scatchard plot, cooperative interactions, the Hill constant and linked functions.

UNIT-3: General characteristics and structure of nucleic acid, backbone rotation angles and steric hindrances, conformational properties of bases, stabilizing order forms, base stacking interactions, A, B and Z type double helices, tRNA structure, tertiary structure, higher organization of DNA, protein nucleic acid interactions-secondary and tertiary.

UNIT-4: Micelle and bilayer formation, studies of bilayer structure and function, order disorder Transitions, interforces, transport across membranes (the Nerst Planks approach andrate theory of transport).

UNIT-5: Photochemical and photobiological phenomena, mechanism of photosynthesis, vision, absorption and fluorescence.

Reference
1. C.R. Cantor and P.R. Schirmer, Biophysical Chemistry (Parts 1 and 3).W.H. Freeman, 1980.
2. G. Schuiz and R.H. Shrimer, Principles of protein structure. SpringerVerlag, 1984.
3. W. Saenger, Principles of Nucleic acid structure.
4. B.L. Siler, Physical Chemistry of Membranes:An introduction to the structure and dynamics of biological membranes. Allen and Unwin and the
Solomon Press, 1985.

04BNT201 – Atomic and electronic structure of matter

1. To study and perform the He-Ne Laser
2. To study and perform the semiconductor Laser
3. To study and perform the shell model
4. To study and perform the hydrogen atoms
5. To study and perform the helium atoms
6. To study the operating principle of optical fibers

04BNT202 – Introduction to Materials

1. To Study the fullerene Carbon
2. To study the Carbon Nano tube
3. To study the Manufacturing process of Glasses
4. To study the Manufacturing process of Ceramics
5. To study and measure of Powder preparation technique using Sol-gel Precipitation

Code-04BNT 203--Ceramic Science & Technology

i. Determination of calcium oxide volumetrically.
ii. Determination of magnesium Oxide volumetrically.
iii. Determination of Loss on Ignition of raw materials and final ceramic body.
iv. Determination of Iron oxide volumetrically.
v. Determination of Sodium oxide and Potassium oxide.
vi. Determination of finess of quartz/ feldspan.
vii. Determination of finess by brain air apparatus.
viii. Determination of specific gravity of raw materials and ceramic body.
ix. Determination of water absorption and tolerance limit of tiles.
x. Determination of compressive strength test of cement cubes & tiles.
xi. Determination of Initial setting & final setting of concrete mixture by vicat apparatus.
xii. Determination of soundness by lechatelier and autoclave method.

04BNT204 MOLECULAR BIOPHYSICS

1. spectrophotometric estimation of carbohydrate
2. spectrophotometric estimation of proteins
3. test of presence of carbohydrate and proteins
4. SDS page run for proteins
5. DNA gel electrophoresis extraction of bacterial DNA from E-coli.

V SEMETER

05BNT-101:

EXPERIMENTAL METHODS IN NANOTECHNOLOGY

Course/Paper: 05BNT-101
BNT Semester-V

UNIT-I Introduction: Review of various experimental techniques used in synthesis, fabrication, and characterization of nano-materials and devices.

UNIT-II Experimental methods for fabrication : semiconductor processing techniques- Cleaning, etching, oxidation, Gettering, Doping, Epitaxy; Lithography-Photolithography, Electron beam lithography, X-Ray lithography, Focused Ion Beam Lithography (FIB); Soft Lithography- Micro-contact Printing, Molding, Nanoimprint, Dip-Pen Nanolithography, AFM based Nanolithography.

UNIT-III Experimental techniques used in synthesis of Carbon nanotubes:Arc Discharge, Laser Furnace, Chemical Vapor Deposition(CVD);Template Synthesis.; Self Assembly and Bio/Chemical Methods.

UNIT-IV Experimental techniques for characterization: Structural Characterization- X-Ray Diffraction (XRD), Small Angle X-Ray Scattering (SAXS), Scanning Electron Microscopy; Atomic Force Microscopy; Optical Spectroscopy; Raman Spectrometry.

UNIT-V Application of SEM , TEM, XPD, raman optical spectroscopy and current research.

REFERENCE BOOKS:

1. Nanostructures and Nano materials-Synthesis, Properties and Applications Guozhong Cao, Imperial College Press
2. Nanotechnology-An Introduction to Nano structuring Techniques Michael Kohler, Wolfgang Fritzsche, Wiley-VCH
3. Micro fabrication and Nano manufacturing Mark J (ed) Jackson, Taylor and Francis
4. Carbon Nano tubes: Science and Applications Laurie Kelly, Meyyappan Meyyappen, CRC Press

05BNT-102:

CHARACTERIZATION TOOLS FOR NANOMATERIALS

Course/Paper: 05BNT-102
BNT Semester-V
UNIT-I Introduction: Need for characterization, Challenges, Brief review of various Characterization tools.

UNIT-II Structural characterization tools**:** Introduction, X-ray Diffraction; Small Angle X-ray Scattering (SAXS); Scanning Electron Microscopy (SEM); Transmission Electron Microscopy(TEM); Scanning Tunneling Microscopy(STM),Atomic Force-Microscopy(AFM) -Scanning Probe Microscopy (SPM).

UNIT-III Chemical characterization, Introduction, Optical Spectroscopy-Absorption and Transmission Spectroscopy; Photoluminescence (PL); Infrared Spectroscopy; Raman Spectroscopy; Electron Spectroscopy; Ionic Spectroscopy-Rutherford Back Scattering Spectrometry(RBS);Secondary Ion Mass Spectrometry(SIMS).

UNIT-IV Capabilities and limitations of techniques, Elemental sensitivity, Detection Limit, Lateral Resolution, Effective probing depth.

UNIT-V Comparative study of latest and conventional techniques and applications.

Reference

1. Nanostructures and -Synthesis, Properties and Applications Guozhong Cao, Imperial College Press
2. Handbook of Nanophase and Nanomaterials (Vol 1 and II) Zhong Lin Wang, Springer
3. Encyclopedia of Materials Characterization C.R.Brundle, C.A.Evans Jr., and S.Wilson (eds), Butterworth-Heinemann, Stoneham, Ma
4. Surface Analysis: The Principal Techniques J.C.Vickerman, John Wiley and Sons
5. Scanning Probe Microscopy and Spectroscopy: Methods and Applications Roland Wiesendanger, Cambridge Univ Pre

05BNT-103:

MICRO-ELECTRO MECHANICAL SYSTEM (MEMS)
& NANO-ELECTRO MECHANICAL SYSTEMS (NEMS)

Course/Paper: 05BNT-103
BNT Semester-V

UNIT-I Nano and Microscience, engineering and technology:Introduction and overview, MEMS and NEMS definitions, Taxonomy of Nano-and Microsystems-Synthesis and Design.

UNIT-II Nano and Micro systems: Classification and considerations, Biomimetics, Biological analogies, and design– Biomimetics Fundamentals, Biomimetics for NEMS and MEMS, Nano-ICs and Nanocomputer architectures, Biomimetics and nervous systems.

UNIT-III Modeling of micro and nano scale electromechanical systems,
Introduction to modeling, analysis and simulation, basic electro-magnetic with application to MEMS and NEMS, modeling developments of micro-and nano actuators using electromagnetic-Lumped-parameter mathematical models of MEMS, energy conversion in NEMS and MEMS.

UNIT-IV Synthesis, design and fabrication of MEMS, Introduction, Micro fabrication of micro coils / windings through copper, nickel and aluminium electro deposition, micromachined polymer magnets, axial electromagnetic micro motors, micro machined polycrystalline SiC micro imotors.

UNIT-V Nano machines, nano robots, electronics based on CNT, molecular Electronics.

Reference

1.Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering Sergey Edward Lyshevski, Lyshevski Edward Lyshevski, CRC Press
2.Nanomaterials: Synthesis, Properties and Applications A.S.Edelstein and Cammarata (edits), Institute of Physics
3.Micro-Electro Mechanical and Nano-Electro Mechanical Systems Sergy Edward Lyshevski, CRC Press

05BNT-104:

NANO- LITHOGRAPHY

Course/Paper: 05BNT-104
BNT Semester-V

UNIT-I Introduction: Nanofabrication-Tools and Processes; Resists-Resists as Templates, Resists as Etch Masks, Self-Assembly Monolayer (SAM) Resists
UNIT-II Lithography: Photolithography Principles; Phase Shifting Optical Lithography; Electron Beam Lithography (EBL); Neutral Atomic Beam Lithography; Ion-Beam Lithography (IBL); X-ray Lithography (XRL); Proximal Probe Lithography-The technique, Proximal Probes, STM based Electron-Beam Lithography

UNIT-III Pattern transfer process: Techniques: Metal gates or wires by evaporation and lift-off; Dry Etching Processes-Reactive Ion Etching (RIE); Electron Cyclotron Resonance (ECR) Reactive ion etching; Chemically Assisted Ion-Beam (CAIBE) Etching and Reaction Ion-Beam Etching (RIBE)

UNIT-IV Nano manipulation and nanolithography: STM based nano manipulation and fabrication; AFM based techniques; Field Evaporation or Field Desorption technique for nanolithography; Soft Lithography

UNIT-V Nano lithographic application and current research.

Reference

1.Nanomaterials: Synthesis, Properties and Applications A.S.Edelstein and R.C.Cammarata (edits), Institute of Physics
2.Nano structures and Nano materials-Synthesis, Properties and Applications
Guozhong Cao, Imperial College Press
3 Nanolithography M.Gentili et al.(edits),Springer

05BNT-105:

GENETICS AND MOLECULAR BIOLOGY

Course/Paper: 05BNT-105
BNT Semester-V
UNIT-I Mendel's Laws of Inheritance, Deviations of Mendel's Laws, Sex linked inheritance, Polygenic and Maternal inheritance

UNIT-II Chromosome structure and replication; DNA Structure, DNA Replication (Prokaryotic and Eukaryotic), Inhibitors of DNA replication, Mutation-elementary concept, Types of mutations; Point mutation (Base pair change, frame shift, deletion, inversion, insertion etc.)

UNIT-III Structure and functions of m-RNA, r-RNA and t-RNA, Transcription apparatus, Transcription in eukaryotes and procaryotes, post transcriptional processing of RNA's (t-RNA, r-RNA, m-RNA). Inhibitors of transcription, reverse transcription.

UNIT-IV The genetic code and its features, deciphering of genetic code, protein synthesis in prokaryotes and eukaryotes, post translational modifications. Inhibitors of protein synthesis.
UNIT-V Gene regulation and expression in prokaryotic and eukaryotic systems, lactose, Arabinose and Tryptophane operons, reprenose and activators, promoters, enhancer elements, gene rearrangement and amplification.

Reference

1 Molecular Genetics of Bacterial by Larry Synder and Wendey Champness,
ASM Press, Washington, 1997.
2 Genetics by Goodenough U, Hold Saunders International, 1985.
3 Principles of Genetics by Gardner, E.J., Simmons M.J. Slustad DP.
4 Genes VIII by Benajmin Lewin, Oxford University Press, Oxford NY.
5 Molecular Biology by Freifelder D., Jones and Barilett Pub. Inc

05BNT-106:

BIOENGINEERED NANOMATERIALS

Course/Paper: 05BNT-106
BNT Semester-V

Unit-I Nanoscale Cell Biology Development of nano- and micro fabricated devices that probe cellular function in highly parallel devices for proteomics and drug testing • Protein-protein interactions and fusion poreopenings, single molecule and vesicle tracking using nanoparticles and nano sensors
Unit-II: Physics and Nano-structured Materials for Bio applications Principles of structure and self-assembly of natural biomaterials • Natural composite materials and interfacing role of proteins • Design of biological nanofibers, nanotubes, and closed-caged nanoassemblies
Unit-III: Imaging of Biomaterials X-ray diffraction • Transmission Electron Microscopy • Magnetization measurements • Nuclear Magnetic Resonance • Spectroscopy • 2-D electrophoresis and mass spectrometry of proteins Confocal microscopy
Unit-IV: Cellular Micro dynamics Program Utilization of micro fabricated devices to fractionate and characterize cells based on their morphology, density, charge, antigenicity, or function • Sonic MEMS technology in conjunction with micro fluidics to separate particles, including blood cells • Immunosensors: Principles of optical Immunosensors
Unit-V: Cell Signaling Pathways Cyto-nucleoplasmic transport, nucleus organization and dynamics • ER and mitochondria structural dynamics and function • Relocation of proteins and their activation • Molecular motors involved in cell motility and contractility • Cell-cell interactions • Pathogen infection, intracellular trafficking, cytoskeleton remodeling, axonal transport, and chromosomal segregation at mitosis

LABORATORY WORK

1.Techniques for Physical Vapour and Chemical Vapour thin layer Deposition (CVD and PVD).
2.. High resolution analysis and characterization of nanostructures,
3.NanotechniquesAuger electron spectroscopy-ray Nano techniques, scanning probes methods (SPM). Clean room technology. Scanning-probe-based nanotechnology *Polymer fractionation techniques*: gel electrophoresis.
4.Microscopy
Scanning Electron Microscopy - SEM - including Energy Dispersive X-Ray Analysis (EDX)
Transmission Electron Microscopy - TEM - including access to high-resolution TEM
Surface profile at micro scale (interferometer) Scanning Probe Microscopy - SPM Atomic Force Microscopy - AFM Light Microscopy Fluorescence Microscopy Particle sizing Capillary Electrophoresis - CE Size Exclusion Chromatography - SEC Multi-Angle Laser Light Scattering- MALLS SEM/TEM with image processing
Crystallography Powder X-Ray Diffraction - XRD

VI SEMESTER
06BNT-101:

Nano Chemistry

Course/Paper: 06BNT-101
BNT Semester-VI
Unit-I Introduction, Self Assembly of Materials, Self Assembly of Molecules, Directing Self Assembly of Materials/ Molecules, Family of Self Assembling Materials, Porous Solids, Bio-Mineralization, Samand Soft Lithography, Nano wires, Nano machines,
Unit-II Nano Particles :Introduction, Types of Nanoparticles, Pur Metal, Gold, Silicon, Silver, Cobalt, Metal Oxides, Silica, Zinc oxide, Iron oxide, Alumina, Titania, Techniques to Synthesize Nanoparticles, Characterization of Nanoparticles, Applications, Toxic effects of Nano materials, Significance of Nanoparticles

Unit-III Nano reactors: Alkali and Alkali earth elements, transition metal groups IIIVII in the periodic table, Elements of the group VIII, Subgroups of copper and Zinc, subgroup of boron and Arsenic, Assemblies involving nanoparticles
Unit-IV Carbon Nano tubes : Introduction, Studies in Carbon Nano tubes, Chemistry of Carbon Nanotubes, Types of Carbon Nano tubes, Techniques to Synthesize Carbon Nano tubes, Functionalisation of Carbon Nano tubes, Characterization of Carbon Nano tubes, Applications
Unit-V Nano Composites : Introduction, Polymer as Matrix, Nylons, Polyolefins, Polystyrene, Epoxy resins, Nano Materials as a Filler, Nano fibre, Nano clay, Fabrication and Processing of Composites, Benefits to Ultimate Physical, Mechanical and Thermal Properties, Nano structured Materials,

06BNT-102:

MOLECULAR SELF-ASSEMBLY

Course/Paper: 06BNT-102
BNT Semester-VI
UNIT-I Introduction, What is self-assembling process? Examples of directed and Controlled Self-Assembly; Nanotechnology and Self-Assembly; Intermolecular interactions, Molecular mobility, Process Medium; Factors responsible for self-assembly

UNIT-II Molecular building blocks (MBBS), What are MBBs; Top-down and Bottom-Up approaches; Nanotechnology Molecular Building Blocks; Concept of Diomondoids and their applications as MBBs.

UNIT-III Self- assembly techniques, Self-Assembly using Solid-Surfaces-Immobilization techniques; Affinity Coupling via Antibodies;

UNIT-IV Affinity Coupling by Biotin-Streptavidin (Bio-STV) System and its Modification; Immobilized Metal Ion Complexation (IMIC); Self-Assembled Monolayer (SAM) and its examples; Strain Directed Self-Assembly; DNA Directed Self-Assembly; Self-Assembly on Silicon Surfaces.

UNIT-V Self assembly in fluid media, Generic Principle of fluidic self-assembly using a template surface; Dynamic Combinational Chemistry; Design of Molecular Cages.

REFERENCE BOOKS:
Principles of Nanotechnology G.Ali Mansoori, World Scientific
Nano materials: Synthesis, Properties and Applications A.S. Edelstein and R.C. Cammarata (edits), Institute of Physics
Nanostructures and Nano materials-Synthesis, Properties and Applications
Cao, Imperial College Press
Self-Assembly Brian Robinson, IOS Press

06BNT-103:

GENERIC METHODOLOGY FOR NANOTECHNOLOGY

Course/Paper: 06BNT-103
BNT Semester-VI
UNIT-I Introduction, classification of nanostructures; Nano-scale architectures;

UNIT-II Electronic properties of atoms and solids- Giant molecular solids, crystalline solids; Electronic conduction; Effects of nanometer length scale- changes to the system total energy and system structure, Effect on properties;

UNIT-III Fabrication methods- Top down processes, Bottom-up processes, Methods for templating the growth of nano-materials; Ordering of Nano-systems; Preparation, safety and storage issues.

UNIT-IV Characterization: General classification of characterization methods-Analytical and imaging techniques, Microscopy techniques-general considerations, Image magnification and resolution; Spectroscopy techniques; Surface analysis and depth profiling.

UNIT-V Techniques for property measurement, Mechanical, Electron transport, Magnetic and Thermal properties.

REFERENCE BOOKS:
1. **Nano scale Science and Technology** Robert Kelsall, Ian Hamley, and Mark Geoghegan (Editors) John-Wiley
2. **Nanomaterials: Synthesis, Properties and Applications** A.S.Edelstein and R.C.Cammarata (edits), Institute of Physics
3. **Nanostructures and Nano materials-Synthesis, Properties and Applications** Cao, Imperial College Press
4. **Nanotechnology-Basic Science and Emerging Technologies** Mick Wilson et al, Overseas Press

06BNT-104:

NANOSCALE MAGNETIC MATERIALS AND DEVICES

Course/Paper: 06BNT-104
BNT Semester-VI

UNIT-I Magnetism, Magnetostatics; Para-, dia and ferromagnetism; Magnetic anisotropy; Domains and domain walls;

UNIT-II Nano magnetic materials-Particulate nano magnets; Geometrical Magnets; Magnetoresistance- Giant Magneto Resistance(GMR); Spin Valves; Tunneling Magnetoresistance.

UNIT-III Processing and properties of nano materials, Introduction; Classification; The thermodynamics and Kinetics of Phase Transformations; Synthesis Methods- Rapid Solidification Processing from the Liquid State, De-vitrification, Inert Gas Condensation, Electro deposition and Mechanical Methods.

UNIT-IV Ferromagnetic and catalytic properties, Fundamental Magnetic Properties; Nano composite Soft Magnetic Materials; Hard Magnetic Materials; Effects of Particle size and Surface Chemistry on Magnetic Properties; Catalytic Properties

UNIT-V Application, Ultraviolet Absorbers; Magnetic Applications; Coatings; Nano magnetism in Technology

REFERENCE BOOKS:

1. **Nano scale Science and Technology** Robert Kelsall, Ian Hamley, and Mark Geoghegan (Editors) John-Wiley
2. **Nano materials: Synthesis, Properties and Applications** A.S.Edelstein and R.C.Cammarata (edits), Institute of Physics
3. **Nanostructures and Nano materials-Synthesis, Properties and Applications** Cao, Imperial College Press
4. **Nanotechnology-Basic Science and Emerging Technologie**Mick Wilson et al, Overseas Press1

06BNT-105:

BASICS OF NANOTECHNOLOGY AND ITS APPLICATIONS

Course/Paper: 06BNT-105
BNT Semester-VI

UNIT-I Introduction and definition of nanotechnology, Introduction, Definition, Length scales, Importance of Nanoscale and Technology, History of Nanotechnology, Future of Nanotechnology: Nano Technology Revolution, Silicon based Technology.

UNIT-II Benefits and challenges in Molecular manufacturing: The Molecular assembler concept, Controversies and confusions, Understanding advanced capabilities, Visions and Objective of Nanotechnology, Nanotechnology in Different, Fields: Automobile, Electronics, Nano biotechnology, Materials, Medicine, Dental care, Nanocomputers, Power storage, Nanotechnology products.

UNIT-III Latest Developments in Nanotechnology(Introduction, Current situation, Future Assumptions, Latest Developments, Nanocopters, Nano tubes **,** Biosensors, Nano structure fluid, Computers, Plastic electronics, Light emitting diodes, Solar cells.

UNIT-IV Nanotechnology and Future Perspectives, Current Perspectives, Research Work at a Glance, Nano pioneers, Convergence of Nanotechnology, Nanotechnology Globally: Introduction, Potential Through R & D, Timelines for Beginning of Industrial Commercialization, Areas of Investments in Different Aspects in Nanotechnology, Efforts of Western Countries, Nanotechnology in Asia, Nanotechnology in India Introduction.

UNIT-V Present status, basic requirements in India**,** Research Areas in Nanotechnology, Promotion of Nanotechnology Ethical Issues in Nanotechnology Introduction, Socioeconomic Challenges, Ethical Issues in Nanotechnology: With Especial Reference to Nano medicine, Nano medicine Applied in Non-medical Contexts, Social Issues Relating to Nano medicine. Social and Ethical Issues, Economic Impacts, Other Issues.

06BNT-106:

NANOTECHNOLOGY APPLICATIONS

Course/Paper: 06BNT-106
BNT Semester-VI
.

UNIT-I Basics of Nano Physics :Introduction, Building Block for Nano devices, Quantum Dots, Mesoscopic Superlattices, Super Conductivity at Nano Scale, Single Electron Tunneling, Application of Nanophysics Nanomaterials: Top down and bottom up approaches, common growth methods. Properties of selected nanomaterials including carbon nano tubes and other carbon based materials, metallic nano clusters, Materials for
Advanced devices

UNIT-II Nano Magnetism, Introduction, Magnetic Order - Dimension Dependence, Anisotropy, Magneto electronics, Super paramagnetism, Spin Waves in Nano elements, Quantum Phenomena in Magnetic Nano Clusters, Magneto-Optics, Magnetic Computer

UNIT-III Nano Electronics, Introduction, Theory of Electron Scattering, Coulomb Blockade Effects, Quantum Communication/ Computing, Spintronics, Electronics Based on Carbon anotubes, Single Electron Device, Molecular Electronics

UNIT-IV Nano Robotics, Introduction, Nano robots and NEMS, Background, Sensors, Actuators, Artificial molecular machines, Biomotors, Other nano machines, Propulsion, Control, Communication, Programming and coordination, Nano assembly with the SPM, Background, TheAFM as a robot, Manipulation phenomena and protocols, Nano particle patterns, Linking and embedding, Summary and Outlook

UNIT-V Nanoreactor, introduction

REFERENCE BOOKS:

1. Nano Technology:A Gentle Introduction to the Next Big Idea by Mark Ratner and Daniel Ratner, 2002
2. There's Plenty of Room at the Bottom: An Invitation to Enter a Newfield of Physics – Richard Feyman, Free on line book **http://www.zyvex.com/nanotech/feynman.html**
3. Nanophysics and Nanotechnology, E.L. Wolf, Wiley 2006
4. Nanotechnology in Biology and Medicine: Method, Devices and Applications by Tuan Vo Dinh, CRC Press 2007
5.The Chemistry of Nano material: Synthesis, Properties & Applications, Vol I &II by CNR Rao, Springer 2006

LABORATRY WORK

1. Measurement of wear; bearings and its types
2. Measurement tools used in nano tribology: SFA, STM, AFM
3. Microscale and nano scale wear; no fabrication/nano machining; Nano hydrodynamics
4. Lubrication Techniques; Full film lubrication; mixed film lubrication; Boundary lubrication; Nanolubrication
5.Study of Optical sensors, including evanescent field sensors; Optical wave guide sensors; Surface Plasmon Resonance sensors; Capillary Fill devices;
6.Study of Electrochemical Impedance Spectroscopy;
7Demo of electro-mechanical devices e.g. cantilever sensors;
8.Stem cell the techniques arising from nano technology processing that may contribute to such aspects of tissue engineering as better stem cell scaffolds.10.Detection of NMR using SQUIDs.
9. Imaging methods. Fourier reconstruction techniques
10.Development of nano- and micro fabricated devices that probe cellular function in highly
11.openings, single molecule and vesicle tracking using nanoparticles and nano sensors
12.Designings of biological nano fibers, nano tubes, and closed-caged nano assembly

VII SEMESTER

07BNT-101:

NANOTRIBOLOGY

Course/Paper: 07BNT-101
BNT Semester-VII

UNIT 1: Definition, brief history and industrial significance of tribology. Surface texture and its measurement, statistical parameters for surface texture. Friction-brief review of theories of friction; Wear and its types; Measurement of wear; Bearings and its types

UNIT 2: Measurement tools used in nanotribology: SFA, STM, AFM. Microscale and nanoscale wear; Nanofabrication/nano machining; Nano hydrodynamics

UNIT 3: Lubrication; Full film lubrication; Mixed film lubrication; Boundary lubrication; Nano lubrication ; Tribological issues in MEMS; Challenges for lubrication in high speed MEMS

UNIT 4: Basics of Nano biology: Introduction, Nano biology, Bio nano technology, Molecular Nanotechnology, Benefits of Molecular Nanotechnology, Nano biology Today: Nano Dendrimers, Buckyball and Nano tube, Self Assembly, Molecular self assembly, Molecular self assembly in biology.

UNIT 5: Nano medicine: Introduction, Regenerative and Replacement Medicine, Nanorobots, Reciprocated, Excusing out of the body, Nano robots and immune system, Reading the nanorobots, Fear factor, Applications of nanorobots, Advantages of Nano medicine, Bio mimetic Robots, Biomedical Applications of Nano biology; Introduction. Nano pharmacology, Nano capsule, Biosensor Chips, Medibots, Artificial Pancreas, Spinal Cord Treatment, Artificial

REFERENCE BOOKS:

1. **NanoTribology and Nanomechanics: An Introduction** Bharat Bhushan, Springer.
2. **Nano Tribology** Hsu and Ying, Springer
3. **Engineering Tribology** Prasanta Sahoo, PHI
4. **Engineering Tribology** Stachowiak and Batchelor, Elsevier
5.

07BNT-102:

INORGANIC SEMICONDUCTOR NANOSTRUCTURES

Course/Paper: 07BNT-102
BNT Semester-VII

UNIT-I Semiconductor physics ,Types of semiconductors; Doping in semiconductors; Optical and carrier transport properties; Phonons and excitons; Physical processes in semiconductors; Nanostructures-modulation doping, Quantum Hall effect; Resonant tunneling; Charging effects; Ballistic carrier transport; Light emission processes in nanostructures; The phonon bottleneck in quantum dots.

UNIT-II quantum confinement in semiconductor nanostructures: Quantum confinement in one dimension-Quantum wells; Quantum confinement in two-dimensions- Quantum wires; Quantum confinement in three-dimensions-Quantum dots; Super Lattices, Band off-sets.
UNIT-III fabrication and characterization techniques**:** Requirements for an ideal

semiconductor nanostructure; The epitaxial growth of quantum wells; Lithography and etching; Cleaved-edge overgrowth, growth on vicinal substrates; Strain- induced dots and wires; Quantum well width fluctuations, thermally annealed quantum wells.

UNIT-IV Semiconductor nano-crystals; Colloidal quantum dots; Self-assembly techniques; Optical and Electrical characterization.

UNIT-V Applications of semiconductor nanostructures: Injection lasers; Single photon sources; Optical memories; Coulomb blockade devices.

REFERENCE BOOKS:

1. **Nano scale Science and Technology** Robert Kelsall, Ian Hamley, and Mark Geoghegan (Editors) John-Wiley
2. **Nano materials: Synthesis, Properties and Applications**
3. A.S.Edelstein and R.C.Cammarata (edits), Institute of Physics
4. **Nanostructures and Nanomaterials-Synthesis, Properties and Applications**
5. Cao, Imperial College Press
6. **Handbook of Nano structured Materials and Nanotechnology Electrical Properties Vol.3 and 1** Hari Singh Nalwa
7. **Electron and Photon Confinement in Semiconductors**
8. Antonio Quadraphonic et al. IoS Press07BNT-103:

07BNT-103:

PLASTIC AND MOLECULAR ELECTRONICS

Course/Paper: 07BNT-103
BNT Semester-VII

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

UNIT-II Polymer-based light-emitting diodes (LEDs) Structure Fundamental processes; Charge injection; Charge transport; Exciton formation Mutual capture Exciton characteristics (binding energy, spin-multiplicity, capture cross-section); Exciton decay, Radiative and non-radiative decay; Exciton lifetime Efficiency; Characterisation of PLEDs; Relevant performance parameters.

UNIT-III Characterizing metal-semiconductor contacts: electroabsorption measurements as a non-invasive tool for the study of the energy level line up in finished devices; Practical implementations; Anodes; Cathodes; Active materials; Singlet emitters; Triplet emitters; enhanced spin-orbit coupling via doping with rare-earth ligands; Blends: trying to achieve the best of all worlds; Prototypical materials for red, green and blue emission (singlet emitters).

UNIT-IV Fabrication technology: the advantage of solution processability; Spin-coating Ink-jet printing (IJP); Screen-printing and other examples.

UNIT-V State of the art devices and future prospects Polymer-based photovoltaic diodes (PVDs) Fundamental process; Exciton absorption; Exciton dissociation; Charge collection; Characterisation of PVDs; Relevant performance parameters; Examples of polymer-based PVDs; Polymer-polymer heterojunctions; Enhanced dissociation at type II heterojunctions; Preparation methods: polymer blends and spontaneous phase separation; C60-polymer structures; Heterojunctions with nano crystals, nano rods, etc.

07BNT-104:

BIOSENSORS

Course/Paper: 07BNT-104
BNT Semester-VII

1. Introduction to Biosensors: Concepts and applications.
2. Biosensors for personal diabetes management.
3. Micro fabricated Sensors and the Commercial Development of the I- stat Point-of-Care System.
4. Noninvasive Biosensors in Clinical Analysis.
5. Surface Plasmon Resonance.
6. Biosensors based on Evanescent Waves.
7. Applications of Biosensor-based instruments to the bioprocess industry.
8. Application of Biosensors to environmental samples.
9. Introduction to Biochips and their application in modern sciences.

REFERENCE BOOKS:

1. Commercial Biosensor: Grahm Ramsay, John Wiley & Son, INC. (1998)

07BNT-105:

NANOPHYSICS

Course/Paper: 07BNT-105
BNT Semester-VII

UNIT-I Quantum interference. Dephasing. Fundamental temperature dependent effects.
UNIT-II Characteristic length scales. Macroscopic, Mesoscopic and Microscopic regimes. Dimensionality. Weak and strong localization. Aharonov-Bohm effect. Periodic inductance Oscillations in Magnetic Field.
UNIT-III Universal Conductance Fluctuations. Ballistic regime. Quantum Wires. Quantum Dots. Single Electron Quantum Tunneling. Mesoscopic upperconductivity.
UNIT-IV Mesoscopic proximity effects. Andreev reflection. Phase periodic quantum transport. Quantum Bit. High Tc Mesoscopics.
UNIT-V Hybrid ferromagnetic/normal and ferromagnetic/super conducting systems. Spin electronics. Electron properties of clusters. Overview of experimental methods in nanophysics.

REFERENCE BOOKS:

1. Fundamentals of the theory of metals by A. A. Abrikosov, North-Holland, Amsterdam, 1988.
2. Introduction to mesoscopic physics by Y.Imry, New York: Oxford University Press, 1997.
3. Mesoscopic Electron Transport, eds.L.L. Sohn et al., Kluwer Academic, Dordrecht, The Netherlands 1997

07BNT-106:

NANOSCIENCE

Course/Paper: 07BNT-106
BNT Semester-VII

UNIT-I Applications in different areas, Introduction Nanotechnology in Industries, Nanotechnology in Computing, Quantum computing, Molecular computation, Nanotechnology in Electronics, Computational nanotechnology, Computational optoelectronics.

UNIT-II Mechanical nano computers, Supercomputing systems, Nanotechnology in Health and Life Sciences.

UNIT-III Nanotechnology in medicine, Drug delivery, Drug encapsulation, Tissue repair and implantation, Bioresorable materials, Other application of nano technology in health and medicine, Nanotechnology in Smart Materials, Sensors, Smart instruments- atom computers.

UNIT-IV Nanotechnology in Defense, Nanotechnology in Optics, Optical industry, Metrology, Electronics, optoelectronics and ICT, Nanotechnology in Environment, Nanotechnology Products &Applications.

UNIT-V Recent Applications of Nanotechnology – Sector Wise Classification Experiments & Demonstrations: STM, AFM, X-ray Diffraction, TEM Select any one of unit from following.

REFERENCE BOOKS:

1. Nano Technology: A Gentle Introduction to the Next Big Idea by Mark Ratner and Daniel Ratner, 2002
2. There's Plenty of Room at the Bottom: An Invitation to Enter a New Field of Physics – Richard Feyman , Free on line book
http://www.zyvex.com/nanotech/feynman.html
3. Nanophysics and Nanotechnology, E.L. Wolf, Wiley 2006
4. Nanotechnology in Biology and Medicine: Method, Devices and Applications by Tuan Vo Dinh, CRC Press 2007
5. The Chemistry of Nano material: Synthesis, Properties & Applications, Vol I &II by CNR Rao, Springer 2006

Major Project Part-I
The student should select any one of the topics offered from the department or select one on his own duly approved from the department. As part of the project work, candidate should give oral presentation of the work at least one in a semester (CT - 653). The candidate is required to submit the detailed synopsis of the work that he would complete in the part-II (CT - 652) along with the report of the work already completed.

LABORATORY WORK

1.Development of Electronics-Semiconductor Transistors; Some tools of Micro-and Nanofabrication.
2. Experimental Implementation of Quantum Computers
3. Development of Nano transistor Designs; Carbon Nano tube Sensors and devices, Nano Motors
4. Demo of Quantum Phenomena in Magnetic Nano Clusters, Magneto- Optics, Magnetic Computer
5. Study of nano materials using Scanning Tunneling Microscope,
6. Methods for templating the growth of nano-materials;
7. Demo of effects of nanometer length scale- changes to the system total synergy and system structure
8. Synthesis Phase Transformations Methods- Rapid Solidification Processing from the Liquid State,
9. Effects of Particle size and Surface Chemistry on magnetic properties; catalytic properties

08BNT-101:

Nanofabrication Techniques

Course/Paper: 08BNT-101
BNT Semester-VIII

UNIT-I Principles of electron beam lithography. Physics and chemistry of resists. Processes of interaction electrons with solids, diffusion, secondary electrons, proximity effect and principles of its correction. Alignment of nano-elements in hybrid nanostructures.
UNIT-II Self-alignment techniques, Self Narrowing Atomic-beam Pantography. Physical Vapour and Chemical Vapour thin layer Deposition techniques (CVD and PVD). Thickness and deposition rate monitoring. Medium, high, and ultra high vacuum systems. Ionbeam and plasma sources and principles of their operation.
UNIT-III High-resolution analysis and characterization of nanostructures, Auger electron spectroscopy, X-ray techniques, scanning probes methods (SPM). Clean room technology. Scanning-probe-based nanotechnology.
UNIT-IV Nanofabrication methods combining SPM and e-beam lithography.
UNIT-V Useful recipes and specialist techniques.

REFERENCE BOOKS:

1. Morgan D. V. and Board K.An Introduction to Semiconductor Micro technology
(John Wiley & Sons, Second Edition 1996)
2. Sze S. M. Semiconductor Devices: Physics and Technology (John Wiley & Sons, Second Edition 1985)
3. Wiesendanger Ronald Scanning Probe Microscopy and Spectroscopy: Methods and
Applications (Cambridge University Press 1994)

08BNT-102:

Temperature Techniques

Course/Paper: 08BNT-102
BNT Semester-VIII

UNIT-I Cryogenic liquids and principles of cryostat design. Properties of materials at low temperatures. Thermal contact and isolation. Pumps and vacuum technique.
UNIT-II Thermometry and temperature control, principles and instrumentation.
UNIT-III Thermometric methods. Pumped 4He and 3He refrigerators. The dilution refrigerator. Adiabatic refrigeration techniques.
UNIT-IV Applications of low temperature physics in space physics.
UNIT-V Applications of superconductivity: Superconducting magnets and SQUID techniques.

REFERENCE BOOKS:

1. G.K.White, Experimental Techniques in Low Temperature Physics (OUP)
2. T.A.Delchar, Vacuum Physics and Techniques (Chapman and Hall)
3. F Pobell, Matter and Methods at Low Temperatures, (Springer Verlag)
4. R C Richardson and E N Smith, Experimental Techniques in Condensed Matter Physics at Low Temperatures, (Addison Wesley)
5. A Kent, Experimental Low Temperature Physics, (Macmillan)

08BNT-103:

Nuclear Magnetic Resonance

Course/Paper: 08BNT-103
BNT Semester-VIII

UNIT-I Introduction: static and dynamic aspects of magnetism, Larmor precession, relaxation to equilibrium, $T1$ and $T2$, Bloch equations.
UNIT-II Pulse and continuous wave methods: time and frequency domains. Manipulation and observation of magnetization, 90º and 180º pulses, free induction decay.
UNIT-III Experimental methods of pulse and CW NMR: the spectrometer, magnet. Detection of NMR using SQUIDs.
UNIT-IV Theory of relaxation: transverse relaxation of stationary spins, the effect of motion. Spin lattice relaxation. Spin echoes: 'violation' of the Second Law of Thermodynamics, recovery of lost magnetisation.
UNIT-V Application to the measurement of diffusion. Analytical NMR: chemical shifts, metals, NQR. NMR imaging: Imaging methods. Fourier reconstruction techniques. Gradient echoes. Imaging other parameters.

REFERENCE BOOKS:

1. B P Cowan, *Nuclear Magnetic Resonance and Relaxation*, CUP, 1997
2. Journal and web references given during course.

08BNT-104:

NANO ENGINEERING OF SOFT MATERIAL

Course/Paper: 08BNT-104
BNT Semester-VIII

UNIT-I Soft materials:
Soft materials and their properties, ways to control and measure the properties of soft materials.
UNIT-II Intermolecular forces:
Vander Waals, Acid-Base, Double layer and other forces, their decay behavior and measurement.
UNIT-III Surface instabilities:
Conditions for onset of surface instability; Morphological changes during evolution of instability. Ways to tune this evolution to result in desired morphology.
UNIT-IV Application
Application of nanocoposites, introduction, and polymer as matrix, nylons, and polylefiens polystyrene, Epoxy reins Nano Materials as filler Nano fiber Nano clay.
UNIT-V Fabrication and Processing
Fabrication and Processing of Composites benefits to ultimate Physical mechanical and thermal properties nanostructure Materials Application

LABORATORY WORK

- .1. Application of CAD/CAM Tools for Micro-and Nan manufacturing processes.
- Demonstration of Mechanical properties, X-ray diffraction methods and their applications in identification of crystal structures
- Micro scale and nano scale wear; no fabrication/Nan machining; Nano hydrodynamics
- . Nano techniques Auger electron spectroscopy, X-ray Nano techniques, scanning probes methods (SPM).Clean room technology. Scanning-probe-based nanotechnology *Polymer fractionation techniques*: gel electrophoresis.

Major Project

The student should select any one of the topics offered from the department or select one on his own duly approved from the department. As part of the project work, candidate should give oral presentation of the work at least one in a semester (CT - 653). The candidate is required to submit the detailed synopsis of the work that he would complete in the part-II (CT - 652) along with the report of the work already completed.
