UNIVERSITY OF MYSORE
MANASAGANGOTRI, MYSORE 570006

Course Structure and Syllabus

M.Tech Program in Materials Science

2012

ADMISSION CRITERIA FOR M.TECH IN MATERIALS SCIENCE PROGRAM

Admission Eligibility Qualification	Degree after the Program	Hard Core credits (including project)	Soft core credits	Open elective credits	Total credits	Number of Years
B.Sc (Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science)	M.Tech	52	46-50	8-12	110	3 years
B.Sc(Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science)	M.Sc(optional exit)	42	22-26	8-12	76	2 years
B.E/MBBS/B.Tech/B.Pharma/BDS/BSc(Ag)(any branch)	M.Tech	52	12	-	64	2 years
M.Sc(Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science, Nanotechnology)	M.Tech	52	12	-	64	2 years

Terms and Conditions:
Total number of seats : 30
Admission is purely based on all India basis.
Admission is purely based on the marks obtained in the entrance exam.
(Syllabus will be specified by the board of studies. The question paper for entrance examination contains four parts each containing Physics, chemistry, Mathematics and Biology. Out of which the candidate can opt for any two parts.)
Other admission regulations are as per the CBCS regulations of University of Mysore 2010.
Project internship can be pursued in any reputed lab or industry or institution in India or abroad.
Odd semester will be during August/September to December/Jan
Even semester will be during Feb/March to June/July

Hard core courses for M.Tech in Materials Science program.

Valuation process is continuous and internal in concurrence with the Department of Computer Science, University of Mysore.

CODE	Paper title	Core	Credits			
			Lecture	Tutorial	Practicals	Total
MSH-1	**Introduction to Materials**	Hard	3	1	0	4
MSH-2	**Thermodynamics and Statistical Mechanics**	Hard	3	1	0	4
MSH-3	**Materials preparation techniques**	Hard	3	1	0	4
MSH-4	**Methods of materials characterization**	Hard	3	1	0	4
MSH-5	Characterisation lab-1	Hard	0	1	3	4
MSH-6	**Advanced X-ray diffraction studies**	Hard	3	1	0	4
MSH-7	**Materials and Environmental effects**	Hard	3	1	0	4
MSH-8	Characterisation lab-2	Hard	0	1	3	4
MSH-9	Characterisation lab-3	Hard	0	1	3	4
MSH-10	Project (Minor)	Hard	0	1	5	6
MSH-11	Project (Major – Only for M.Tech exit)	Hard	0	2	8	10
		Total (MSc-exit)				42
		Total (M.Tech - exit)				52

Soft core courses for M.Tech in Materials Science program

Code	Paper title	Core	Credits			
			Lecture	Tutorial	Practicals	Total
MSS-1	**Structure, Property and Functions of Materials**	Soft	3	1	0	4
MSS-2	**Spectroscopic Techniques for Materials**	Soft	3	1	0	4
MSS-3	**Physics of Nanoscience and Nanotechnology**	Soft	3	1	0	4
MSS-4	**Nanoscale devices**	Soft	3	1	0	4
MSS-5	**Nanochemistry**	Soft	3	1	0	4
MSS-6	**Carbon Nanotubes**	Soft	3	1	0	4
MSS-7	**Physics and Chemistry of Materials**	Soft	3	1	0	4
MSS-8	**Composite Materials**	Soft	3	1	0	4
MSS-9	**Polymer Science and Cell Biology**	Soft	3	1	0	4
MSS-10	**Physics and Chemistry of Polymers**	Soft	3	1	0	4
MSS-11	**Nanobiotechnology in Health care**	Soft	3	1	0	4
MSS-12	**Nanophotonics**	Soft	3	1	0	4
MSS-13	**Thermodynamic Modeling of systems**	Soft	3	1	0	4
MSS-14	**Basics of Engineering Drawing**	Soft	2	2	0	4
MSS-15	**Ceramics Science and Technology**	Soft	3	1	0	4
MSS-16	**Materials for energy**	Soft	3	1	0	4
MSS-17	**Basics of Nanotechnology**	Soft	3	1	0	4
		Total soft credits available to choose				62

Open elective can be taken from any other departments in the campus.
Total credits to be completed by B.Sc graduates is 8.

Scheme of Evaluation

Each student shall be evaluated continuously by means of tests and/or assignments. There will be two tests: C1 in the eighth week and C2 in the sixteenth week of the semester. A final examination C3 will be held around eighteenth week.

The C1 and C2 tests will be for 25 marks each and C3 will be for 50 marks. If marks scored in C1+C2 is less than 30%, the student is not allowed to take C3. If the attendance is less than 75% the student is not allowed to take C3.

C1 and C2 tests will be for 1 hour duration. C3 examination will be for 2 hrs duration. Practical tests/examinations will be for 4 hours respectively.

MSH-1 : Introduction to Materials **4 Credits** ***Hard core***

Unit-I Materials through ages

Materials, Clarification, Crystalline, Amorphous, Glasses; Metals, Alloys, Semiconductors, Polymers Ceramics, Bio-materials Polymers, Blends, Composites. Bulk and Nanomaterials. Quantization effect.

Unit-II Crystal Structure

Periodic Array of Atoms – Crystal Lattice-Lattice Translation Vectors - United-Basis-Symmetry Consideration- Bravis Lattice - Crystal Planes and Millers Indices-Simple Crystal Structure (HCP, FCC, BCC, SC, Diamond).

Unit-III Crystal Diffraction and Reciprocal Lattice (Qualitatives)

Bragg's Law, Laue Equations, Reciprocal Lattice, Braggs Condition, Brillouin Zones, Atomic Scattering, Geometrical Structure Factor, Experimental X-Ray Diffraction, Methods of Crystal Structure, Laue Method, Rotary Crystal Method, Powder Method or Debye Scherrer Method, Weber Feckner Method.

Unit-IV Crystal Chemical Bonding and Imperfection

Ionic Crystals, Covalent Crystals, Metallic Crystals Molecular Crystals and Vander Waals Attraction, Hydrogen Bonded Crystals, Mixed or Multiple Bond Crystals. Classification of Imperfections, Concentration of Vacancies (Schottky Defects), Frenkel Defects, Extrinsic vacancies, Color Centers, Dislocations, Dislocation Energies, Dislocation and Shear Strength of Single Crystal, Defects, Grain Boundaries, Staining Faults.

Total: 48 hrs

References:

1. Murugesan R, Modern Physics, S. Chand & Company, 9/e.Rev. Edn. 2003, EN8305SC011.
2. Arthur Beiser, Modern Physics, Addison Wesley Longman Publishing Co (January 1968) ISBN-10: 0201005158
3. Leonid Azaroff, An Introduction to Solids, McGraw-Hill Companies; New edition (1984)
4. Charles Kittel, Introduction to Solid State Physics, John Wiley & Sons, UK 7th Edition (1995)
5. Donald E. Sands, Introduction to Crystallography, Dover Publications, (1994).
6. Darrell Irvine and Nicola Marzari, Fundamentals of Materials Science, MIT Open Course Ware Publications (2005).

MSH-2 :Thermodynamics and Statistical Mechanics 4 Credits *Hard core*

Unit I: Kinetic Theory and Gas Laws

Kinetic Theory of Matter, Different States of Matter, Concept of Ideal or Perfect Gas, Kinetic Theory of Gases, Expression for the Pressure of a Gas, Kinetic interpretation of Temperature.

Unit II: Equation of State

Derivation of Gas Equation, Derivation of Gas Laws, Avogadro's Hypothesis, Graham's Law of Diffusion of Gases, Degree of Freedom & Maxwell's Law of Equipartition of Energy, Mean Free Path, Van-der Waals Equation of State, Critical Constants, Corresponding States, Critical Coefficient.

Unit III: Laws of Thermodynamics

Thermal Equilibrium – Concept of Temperature (Zeroth Law of Thermodynamics), Concept of Heat-Heat: A Path Function, Work: A Path Function, Comparison of Heat and Work - First Law of Thermodynamics, Isothermal Process, Adiabatic Process, Isobaric Process, Isochoric Process, Second Law of Thermodynamics, Entropy, Third Law of Thermodynamics.

Unit IV: Statistical Thermodynamics

Statistical Mechanics, Statistical Equilibrium, Statistical definition of entropy, Gibbs'Paradox-Probability Theorems, Statistical Thermodynamics, Maxwell-Boltzmann Distribution Law, Maxwell-Boltzmann Distribution & Ideal Gas, Quantum Statistics, Phase Space, Fermi-Dirac Distribution Law, Electron Gas, Bose-Einstein Distribution Law, Photon Gas, Comparison of Three Statistics –Bragg Weiler's approximation.Therories of simple liquids-Monte-Carlo Molecular dynamics simulations-Reaction dynamics from microscopic viewpoint.

Total:48 Hrs

Reference Books:

1. Richard E. Sonntag and Claus Borgnakke, Introduction to Engineering Thermodynamics, Wiley; 2 edition (March 3, 2006), ISBN-10: 0471737593.
2. Ken A. Dill and Sarina Bromberg, Molecular Driving Forces: Statistical Thermodynamics in Chemistry and Biology Garland Science. (Taylor & Francis Group), 2003.

MSS-1: Structure, Property and Functions of Materials *Soft core*

Unit I Materials

Solid Solutions and Alloys: Phase Transitions: Overview of Crystal Strucutres: Strucutre - Property Relations: Neumann's Law: Thermal Properties: Optical Properities: Electrical Properties: Dielectric Properties: Magnetic Properties: Mechanical Properties.

Unit II Polymers

Introduction and significance of polymer characteristics for property determination: Molecular modelling

Unit III Viscoelasticity

Aspects relating process and morphology : Kinetics and thermodynamics of melting nucleation ,and crystal growth : phase separations and transitions in solution and bulk polymers : Anisotropy in polymers : Structure/mechanical property relations: Diffusion :

Unit IV Biomaterials

Protien adsorption on biomateirals; surface modification of biomaterials; biocompatibility testing; cell-biomaterial interaction; inflammation hypersensitivity, carcinogenesis; cardiovascular grafts; orthopaedic applications; drug delivery and gene therapy; microencapsulation; cardiovascular tissue engineering.

Total: 48 Hrs

References :

1.Review of structure and physical states of polymers : Conformations and spatial configurations – single chains : Rubber elasticity

2. Re.E.Newnham, "Properties of Materials: Anisotropy, Symmetry, Structure", Oxford University Press.

3. Buddy Ratner. Biomaterials Science. Second edition. Orlando, Academic Press, 2000;

4. Jonathan Black. Biological performance of materials: fundamentals of biocompatibility New York, Marcel Dekker, 1999

5. Joon Park and Joseph Bronzino. Biomaterials: Principles and Applications. Fort Lauderadale FL, CRC Press, 2003.

6. Richard stein and Joseph Powers: Topics in polymer Physics

7. Rubinstein & Colby: polymer Physics of rubber elasticity

8. Ferry : Vescoelasticity properties of polymers

9. Aklonies,et al., An introduction of Vescoelasticity in polymers

10.Schultz: Polymer material science

MSS-2: Spectroscopic Techniques for Materials ***Soft core***

UNIT-I UV-Visible & Raman Spectroscopy

Electromagnetic Radiation Spectrum-UV-Visible Spectroscopy of Materials FITR Spectroscopy-Theory of Raman Spectroscopy-Instrumentation-Sample Handling and Illumination – Diagnostic Structural Analysis-Polarization Measurements-Quantitative Analysis-Micro Raman.

UNIT-II Nuclear Magnetic Resonance Spectroscopy

Basic Principles of NMRS - Continuous Wave NMR Spectrometers - Pulsed Fourier Transform NMR Spectrometer - Spectra & Molecular Structure - Quantitative Analysis.

UNIT-III Electron Spin Resonance Spectroscopy

Electron Behavior - ESR Spectrometer - ESR Spectra - Interpretation of ESR Spectra - Quantitative Analysis.

UNIT-IV Mass Spectrometry

Ion Scattering Spectrometry (ISS-Secondary Ion Mass Spectrometry (SIMS) - Auger Emission Spectroscopy (AES) - Electron Spectroscopy for Chemical Analysis (ESCA)-Low Energy Electron Diffraction (LEED) - Photoelectron Spectroscopy (PES).

Total: 48 Hrs

References*:*

1. Willard, Merritt, Dean, Settle, "Instrumental Methods of Analysis", CBS publishers & Distributors, Delhi, Sixth Edition, 1986.
2. Colin N. Banwell and Elaine M. McCash, Molecular Spectroscopy, Mcgraw-Hill College; 4 Sub edition (June 1, 1994), ISBN-10: 0077079760

MSH-3: Characterisation lab -1 ***Hard core***

1) Crystal Models
2) X-ray powder pattern method
3) UV-Visible spectrometer recording of a material and interpretation
4) FTIR recording of a materials and interpretation

MSH-6: Characterisation lab-2

1) Size determination of bio-materials using microscope and Zeta potential
2) Protein adsorption in bio-materials
3) Cell biomaterial interpretation.
4) Size determination using light scattering method

MSH-3: Materials Preparation Techniques ***Hard core***

UNIT-I
Solid states routes; mechanical mixing; grinding; solid solution techniques

UNIT-II
Evaporation; precipitation; Top seeded solution growth; sol-gel techniques; high temperature solution; hydrothermal solvothermal methods; Melt methods- super cooling, Czechorlskii methods; Skull melting.

UNIT-III
Vapour phase methods, CVD; CVT; MBE; Plasma; Laser ablation.

UNIT-IV
Biological synthesis; Electrochemistry; Multi-energy processing; Mechano-Chemical; Sono-Chemical; Photo-Chemical; and Bio-Chemical.

References:

1. Springer Handbook of Crystal Growth; Eds: G. Dhanraj, K. Byrappa, V. Prasad, M. Dudley, Springer Verlag (2010)
2. Springer Handbook of Nanotechnology; Eds: Bharath Bhushan, Springer Verlag, 2nd Edition (2009).

Total: 48 Hrs

MSH-4: Methods of Materials Characterization ***Hard core***

UNIT-I

Thermal analysis; TGA; DTA; DSC; dilatometry; (Thermal expansion) Principles and applications.

UNIT-II

Electron imaging techniques; SEM; TEM; FESEM; STM; AFM; SPM; HRTEM; HRSEM

UNIT-III

Particle size measurement, surface area measurement, DC polarization, AC impedance measurements.

UNIT-IV

Photoluminescence, Positron Annihilation Lifetime Spectroscopy, Non-linear electro-optical studies, mechanical properties, tensile strength, microhardness, conductivity measurements; particle size analysis; zeta potential.

References:

1. Sam Zhang, Lin Li and Ashok Kumar, Materials Characterization Techniques, CRC Press, (2008)
2. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Wiley & Sons (2008)
3. Elton N. Kaufmann, Characterization of Materials, Vol.1, Wiley & Sons (2003)
4. R.A. Laudise, Growth of Single Crystals, Prentice Hall, (1973)
5. G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley (Eds.), Springer Handbook of Crystal Growth, Springer-Verlag (2010)
6. Peter E.J. Flewitt and R.K. Wild, Physical Methods of Materials Characterization, 2nd Edition, Taylor & Francis (2003)

MSS-3: Physics of Nanoscience and Nanotechnology ***Soft core***

UNIT-I *Crystal Structure*

Periodic array of atoms- Crystal lattice- Lattice translation vectors- Basis -Symmetry consideration- Basis Lattice-Crystal planes and Miller Indices- Simple crystal structure (HCP, SC,BCC,FCC, Diamond)

UNIT -II *Crystal Diffraction and reciprocal lattice*

Bragg's Law-Laue equations- Reciprocal lattice- Bragg's Condition- Brillouin Zones- Atomic Scattering-Geometrical structure factor- Experimental X-ray diffraction- Methods of crystal structure-Laue method- Rotary crystal method- Powder method or Debye -Scherrer method-Weber-Feckner Method.

UNIT-III *Crystal Bonding*

Ionic crystals- Covalent crystals- Metallic crystals- Molecular crystals and Van der Waals attraction- Hydrogen bonded crystals- Mixed or multiple bond crystals

UNIT -IV *Imperfection in Crystals*

Classification of imperfections-Concentration of vacancies (Schottky defects) -Frenkel defects- Extrinsics vacancies- Color centers- Dislocations - Dislocation energies- Dislocation and shear strength of single crystal-Defects-Grain boundaries-Staining faults.

References

1) Murugesan R, *Modern Physics,* S Chand and Company, 9/e Rev. Edn 2003 EN8305SC011

2) Arthur Beiser, *Modern Physics,* Addison Wesley , Longman Publishing Co (1968) ISBN-10:0201005158

MSS-4: Nanoscale Devices ***Soft core***

UNIT- I *Processing*

Silicon Processing methods-Cleaning /Etching- Oxidation- Getttering- Doping-Epitaxy-Sputtering-Chemical Vapor Deposition (CVD), Plasm Enhanced CVD- Reactive Ion Etching (RIE)- Moore's law-Design rules for 45nm, 32nm, and beyond- Semiconductor device roadmap- Silicon -insultaor technology- Gate of high -K dielectrics

UNIT-II *Fabrication*

Thermal manufacturing-Beyon CMOS- The material challenge of Ultra thin body (UTB)-MOSFETs for technology-3-D interconnect technology.

UNIT-III *Lithographic techniques*

Top down approach to nanolithography-Immersion lithography- UV photolithography- Phase lithography- Including Plasma X-ray sources- E-Beam Lithography- Focused Ion beams- Photoresist.

UNIT-IV *Fabrication of nanostructures.*

Si-Ge-Si-C , Diamond,-Synthesis- Defects and properties on the nanoscale-Bottom up approach-Chemical self assembly- Properties of nanoparticles, Nanoclusters, Nanotubes, Nanowires and Nanodots.

References:

1) Mark J Jackson, *Micro and Nanomanufacturing* , Springer; First Edition, (2006) ISBN-10:038725744

2) Dieter K, Schroder, *Semiconductor Material and Device Characterization,* Wiley-IEEE Press, 3rd Edition, (2006) ISBN-10:0471739065

3) L. B. Freund and S Suresh, *Thin film materials: Stress, Defect formation and surface Evolution,* Cambridge University Press, (2004) ISBN-10:0521822815

4) Zheng Cui, *Micro-nanofabrication: Technologies and Applications,* Springer First Edition (2006), ISBN-10:3540289224

MSS-5: Nanochemistry **4 Credits** ***Soft core***

UNIT-I *Fundamentals of molecular self-assembly*

The nanoscale and colloidal systems-Fundamentals of Surface and interfacial chemistry-Suraface tension and Wettability-Insoluble monolayers-Surface Chemistry and monolayers-Electrostatic interactions in self assembling systems-Self-Assemble of amphiphiles-Monolayers-Micelles and microemulsions-the Structure and properties of Micelles.

UNIT-II *Nanomaterials*

Defining nanodimensional materials-Sice effects in Nanomaterials-Application and technology development-Supramolecular machines-Fundamentals of energy transfer and photon motion manipulation-Solar energy harvesting-Fundamentals of electron motion manipulation-Electron pumping and molecular wires-General methos available for the synthesis of nanomaterials-Manipulation o Nanopartices-Nanofabrication-Methods- Bottom up methods- Photolithography-Scanning probe methods-Soft lithography

UNIT-III *Polymers*

The interaction of polymers with surfaces-Polyelectrolyte multilayer assemblies-The application of electrostatic self-assembly to construct multilayers in a layer -Bilayer fashion- Fabrication methos-including self assembly

UNIT-IV *Functionalization and applications of Nanomaterials*

Chemical functionalization - Recent advances in Thiol-Au and Silane Chemistry- Layer-by-Layer synthesis of multilayer assemblies – Applications - Quantum dots - nanocores and applications. Detailed description of the fabrication of functinalised Gold Nanocores and their application in cancer therapy.

References:

1) *The chemistry of nanomaterials* Volume 1, Synthesis, Properties and Applications: Edited by CNR Rao, A Muller, A K Cheetham; (2005) John-Wiley and Sons, Inc, ISBN:3-527-30686-2

2) *The chemistry of nanomaterials* Volume 2, Synthesis, Properties and Applications: Edited by CNR Rao, A Muller, A K Cheetham; (2005) John-Wiley and Sons, Inc, ISBN:3-527-30686-2

MSS-6: Carbon Nanotubes

4 Credits ***Soft core***

Unit-I *Morphology*

From a Graphene Sheet to a Nanotube - Archiral and Chiral Nanotubes - Singlewall, Multiwall and Bundled Nanotubes - ZigZag and Armchair Nanotubes - Euler's Theorem in Cylindrical and Defective Nanotubes.

Unit-II *Production Techniques of Nanotubes*

Carbon Arc Bulk Synthesis in Presence and Absence of Catalysts - High - Purity Material (Bucky Paper) Production Using Pulsed Laser Vaporization (PLV) of Pure and Doped Graphite - High-Pressure CO Conversion (HIPCO) - Nanotube Synthesis Based on Boudoir Reaction-Chemical Vapor Deposition (CVD) - Synthesis of Aligned Nanotube Films.

Unit- III *Growth of Single-Wall / Multiwall Nanotubes*

Experimental Puzzles of SWNT - High Yield - Universality of Diameter - Role of Metal Catalyst - Key Question - Shape of Baby Tube - Application of Continuum Elasticity Theory to Nanotubes - Tube Diameter Optimization in a Finite System-Continuous Growth By Addition of Carbon at The Open Edge- Role of Metal Catalyst - Termination of Growth. Experimental Puzzles of MWNT - Aspect Ratio-Perfection-chemical inertness - Key Quwestion - Independent or Concerted Growth – Equilibrium Structure of Double - Wall Nanotubes-Structure Stability at The Growing Edge-Termination By a Multi - Walled Dome.

Unit-IV *Structural, Electronic Properties & Applications of Nanotubes*

Structural Changes in Free - Standing and Interacting Nanotubes – Librations, Rotations - Effect of Inter tube interactions on the Electronic Structure –Electronic Structure of Graphite as Building Block of Nanotubes. Effect of Chirality and Discrete Atoms-Conducting versus Insulating Nanotubes - Band Structure of Metallic Carbon Nanotubes - Effect of Doping on conductivity - Harnessing Field Enhancement - Flat Panel Displays - Carbon nanotubes & Drug Delivery.

Reference

1) M.Endo, S.Iijima, M.S. Dresselhaus, Carbon Nanotubes, Pergamon; Ist Ed Edition (December 1st 1996), ISBN-10: 0080426824

2)Ado Jorio, Mildred S. Dresselhaus, and Gene Dresselhaus Carbon Nanotubes: Advanced Topics in the Synthesis, Structure, Properties and Applications, Springer; 1 edition (April 20, 2001) ISBN-10: 3540410864

MSS-7: Physics and Chemistry of Materials **Soft Core**

Unit 1

Electromagnetic spectrum, accelerator beams, synchrotron radiation, Fermi energy in metals and semiconductors, Specific heat of solids, Conductivity and susceptibility of solids, Energy gap of semiconductors, Hall effect in metals and semiconductors, Quantum theory of metals, Quantized Hall effect.

Unit 2

Physical properties of materials – Conductivity, density, refractive index, tensile strength, microstructure of bulk, small and nanoscale materials. Optical, Magnetic, Electronic, Semiconducting, Superconducting, Thermal, Electro-optic, Thermo-optic, Superionic, insulator properties of materials.

Unit 3

Statistical Treatment of Analytical Data. Limitations of analytical methods. Classification of errors. distributions: Student's t-test, F-test, Chi-square test; Linear correlation; Nonparametric or Rank correlation; Smoothing of data. Fundamentals of chromatography. Phase rule studies. Energetics of cell reations.

Unit 4

Major Inorganic Structure types – MX (NaCl, CsCl, ZnS) and MX_2 (Fluorite, Rutile, Cristobalite and Cadmium Iodide) types. Perovskite, Garnet and Spinel structures.

Structure Properties in Compounds of Native elements, Coordination compounds, Silicates, Phosphates, Oxides, Hydroxides, Sulphides, Pigments, Silicones, Insecticides.

References

- Pillai, Solid State Physics, Narosa Publication999999999s, India (2007)
- J.I. Gersten and F.W. Smith, The Physics and Chemistry of Materials, Wiley & Sons (2001)
- A. Navrotsky, Physics and Chemistry of Earth Materials, 6th Edition, (1995) Cambridge Series.

Paper 2.1: Lab-2.2
Experiments:

1. Preparation of materials: Crystals, glasses, polymers, and composites by different techniques
2. Biological studies
3. X-ray diffraction studies of prepared materials
4. Preparation of thin films of poly-Z-HEMP and incorporation of growth factor
5. Preparation of lipsomes and immunolipsomes drug delivery to carrier cells
6. Preparation of materials exposed to microwave radiations
7. Preparation of pellets of materials
8. Morphological studies of prepared materials.
9. Morphological changes in materials due to irradiation.

MSH-6: Advanced X-ray Diffraction Studies **4 Credits** ***Hard core***

UNIT-I
Powder Diffraction Methods and calibration techniques: The modern Automated diffractometer: Applications of the Powder Method: Qualitative phase analysis: Crystallography and space group analysis: Indexing and lattice parameter determination, refinement and identification: Powder pattern calculation :Crystal structure determination - The Rietveld method.:

UNIT-II
Single Crystal Methods : Quantitative X-ray Diffraction: Interaction of X-rays with matter: absorption and EXAFS (time?): X-ray reflectometry analysis: Small Angle Scattering (5 lectures): Patterson Function: Pair correlation functions and linkage to structure function: Application to spherical, elliptical and needle shape inclusions":

UNIT-III
Debye's function: Application to amorphous structures, nano-composites: (20 lectures) : Particle size and strain analysis – line profile and Fourier techniques : Texture, Micro-texture and Residual stress "Pole figure in x-ray (single crystal and area detector)".

UNIT-IV
Electron Diffraction (Orientation Imaging Microscopy): Fourier Analysis of Distributions: Euler angle definition of orientation space: Orientation Distribution Function: Fourier analysis of Orientation Distribution Function and quantification of texture: Stress (residual stress analysis)

References

1) R. Jenkins and R. L. Snyder, Introduction to X-ray Analysis Diffractometry, John Wiley and Sons (1996):
2) Jens Als-Nielsen and Des Mc Morrow, Elements of Modern X-ray Physics, 2nd Edition Wiley & Sons (2011)
3) D. L. Bish and J. E. Post ed., Modern Powder, Diffraction Reviews in Mineralogy Vol. 20, Mineralogical Society of America, (1989).:
4) John Mc. Cowley Diffraction Physics, Klug and Alexander, X-ray Diffraction Procedures, J. Wiley and Son, New York (1972)
5) B. D. Cullity, Elements of X-ray Diffraction, Addison Wesley Publishing Company, Reading, Mass. (1956)

Total 48 Hours

MSH-7: Materials and Environmental effects ***4 Credits*** ***Hard Core***

UNIT-I

Basics of Corrosion, Different forms of Corrosion, electrochemical corrosion, thermodynamic principles of electrochemical reactions, Electromotive Force Series, Pourbaix Diagrams, Evans Diagrams, Mixed Potential Theory, Passivity,

UNIT-II

Electrochemical methods to Measure Corrosion: DC Polarization, AC Impedance, Environmentally Induced Cracking, Corrosion Fatigue, Hydrogen Induced Cracking, Application of Fracture mechanics.

UNIT-III

Atmospheric Corrosion, Oxidation in Gaseous Environments, Ellingham Diagrams, Role of Protective Scale, Molten Salt Corrosion, Environmental degradation of ceramics, Degradation of Polymeric Materials, Microbial corrosion, Corrosion of Bio-Implants, Corrosion Prevention methods.

UNIT-IV

Environmental effects from the chemical processes industry (like Pulp mill operations, bleach plants, boilers, paper machine, water treatment plants in the pulp and paper industry and others), infrastructure, and transportation industry.

References:

1) D. A. Jones: *Principles and Prevention of Corrosion*, Macmillan Publ. Co. (1996).
2) C. Scully: The Fundamental of Corrosion, 2nd ed., Pergamon Press: E. E.Stansbury and R. A. Buchanan, Fundamentals of Electrochemical Corrosion, ASM International (2000)
3) M.G. Fontana: Corrosion Engineering, 3rd. Ed., McGraw Hill. (1986)
4) J. M. West: Electrodeposition and Corrosion Control, J. Wiley W. Revie (ed.): Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons (2000).
4) W. Revie (ed.): Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons, 2000: Metals Handbook, Vol. 13: Corrosion, ASM International

Total 48 Hours

MSS-8: Composite Materials **4 Credits** ***Soft Core***

UNIT-I

Introduction: Definition, Reason for composites, classification of composites, Raw materials, classification, Chemistry, Properties and applications. Matrix: Thermoplastics-Raw materials, Physical and chemical properties, Thermal behaviour and mechanical properties, Thermosets-Epoxy; Curing reactions, Hardener, Gel time Viscosity Modifications, Prepreg making, Unsaturated polyester resin; catalyst, curing reaction, Viscosity modifier, Alkyd Resin, Vinly ester, polyimides, Physical and chemical properties, Thermal behaviour, Mechanical Properties and uses, Elastomeric composites.

UNIT-II

Reinforcements; Types, Properties, Uses of silica, Titanium dioxide, Talc, Mica, etc., Flake, Fibres - Structure, property and applications of natural and synthetic fibres, organic and inorganic fibres. Example: Glass, Carbon, Aramid, Nylon, Boron, Aluminium carbide, Silk, Jute, Sisal, Cotton, etc, Coupling agents.

UNIT-III

Processing : Thermoplastic, Thermosets, etc., Types of methods, Processing conditions advantages and disadvantages, Film forming, Lamination, Sandwich, etc., Hand Layup methods, compression and Transfer molding, Pressure and Vacuum bag process, Filament winding, Spin coating, Pultrusion, Reinforced RIM, Injection molding of Thermosets, SMC and DMC, Factors affecting the performance of Composites. Testing of Composites; Destructive and non-destructive tests, Tensile, Compression, Flexural, ILSS, Impact strength, HDT, Basic Concepts of fracture mechanism.

UNIT-IV

Composite product design, Fundamentals, Definitions, Structure -Material -Design relationships, Design methodologies, Material Considerations, Application of Composites-Aerospace, Transport, marine, Structural, Chemical and Corrosion resistant products, sports, electrical, Electronic, Communication, Biomedical Applications, Repairs and maintenance, etc., Nanocomposites: -Types, preparation, characterization and applications.

References

1. Handbook of Composites by G. Lubin, Van Nostrand, New York, 1982.
2. Polymers and Polymer Composites in Construction L.C. Holleway,1990
3. Engineering plastics and Composites by John C.Bittence,1990
4. Handbook of Plastics, Elastomers and Composites by Charles A Harper,1975
5. Designing with Reinforced Composites - Technology – Performance, Economics – Rosato, 2nd ED.1997
6. Delwane Composite design Encyclopedia – (Vol 3 Processing and Fabrication / Technology_ Ed. Leif A. Carlssen. and Joahn W. Hillispie, Technomic Publishing Ah. Lancaster U.S.A.
7. Fibre Glass Reinforced Plastics – Nicholas P.Cheremisinoff and Composites Paul N.Cheremmisinoff., Noyes publications,N.J. U.S.A (1995)
8. Composite applications – The Future is now, Thomas J. Drozdr, (Eds), Published by Society of Manufacturing Engineers, Michigan,1989.
9. Polymer Layered Silicate and silica nano Composites, Y.C.Ke,P.stroeve and F.s.Wang, Elesvier,2005
10. Hand Book of Plastics Testing Technology – Vishu Shah, John Wiley & Sons, Inc NY. (1998)

MSS-9: Polymer Science and Cell Biology **4 Credits** ***Soft Core***

UNIT-I: Basic Polymer Science

Polymer synthesis and structure-chain structure and configuration - Amorphous polymer state-Conformation of polymer chain - Macromolecular dynamics - structure of crystalline polymers-polymers in the liquid crystalline state - Glass, Rubber - Transition behaviour

UNIT-II: Properties of polymers.

Methods of measuring transitions in polymers - Cross linked polymers and rubber elasticity -Polymer Visco elasticity and Rheology, Mechanical Behaviour of polymers - Polymer surfaces and interface.

UNIT-III: Cell Structure

Overview of cells- Origin and overview of cells- Cells as experimental model - Chemistry of cells - Molecular composition- Enzymes as biological catalysis- Metabolic energy- Biosynthesis of cell consitutents- Cell membranes - Fundamentals of molecular biology- Hereditary genes and DNA-Expression of Genetic DNA -Recombinant DNA- Detection of nucleic acid and proteins.

UNIT-IV: Central Dogma of life

Flow of genetic information-Organisation and sequence of cellular genomes, Replicating-Maintenance of genomic DNA- RNA synthesis and processing- Protein synthesis and regulation. Cell structure and function- the nucleus- Protein sorting and transport, Bioenergetics and metabolism-Cytoskeleton and cell movement- the cell structure -cell regulation-Cell signalling -Cell Cycle-Cancerous cells.

References:

1) Leslie Howar Sperling, *Introduction of physical polymer science,* Wiley-Interscience; 4th Edition (2005) ISBN-10: 047170606X

2) Geoffrey M Cooper, *The cell- A molecular approach,* Sinauer Associates Inc; 4 the Edition, (2006) ISBN-10: 0878932194

MSS-10: Physics and Chemistry of Polymers **4 Credits** ***Soft Core***

UNIT-I

Basic concepts: Classification of polymers, concepts such as monomer; Functionality and physical state (Amorphous and crystalline) Stereo-regular polymers, co-polymers, block and graft co-polymers, molecular forces and chemical bonding in polymers. Polymerization mechanism, Addition and condensation including co-ordination, cationic, Anionic, Ring opening Redox polymerizatin, Living Radical polymerization-Atom transfer radical polymerization.

UNIT-II

Methods of polymerization - bulk, solution, precipitation, suspension, emulsion polymerization, polymer solutions, and criteria for polymer solubility, solubility parameter, thermodynamics and phase equalibria of polymer solution, Fractionation of polymers by solubility. Molecular weight and size: Importance of molecular weight, Molecualr weight distribution, Average molecular weights, Measurement of molecular weight by end group analysis, colligative property, Light scattering, Ultra centrifugation, dilute solution viscosity, Gel permeating chromatography.

UNIT-III

Structure property relationship in polymers, configuration of polymer chains, crystallinity in polymers, crystallization and melting, strain induced morphology, crystalline melting point, glass transition temperature, factors influencing Tg and Tm. Polymer rheology: Viscous flow, Kinetic theory of rubber elasticity, Visco-elasticity.

UNIT-IV

Analysis of polymers; chemical analysis, spectroscopic, XRD, DSC, TGA, TEM, SEM, AFM, etc Electrical and photoconducting polymers.

References

1. Text book of Polymer Science - Fred W.Billmeyer, J.R. John Wiley & Sons, New York.(1990)
2. Polymer Science -V.R.Gowarikar, N.V.Viswanathan, Jayadev Sreedhar Wiley Eastern Ltd. New Delhi, India (1986)
3. Analysis of polymers – an introduction- T.R.Crompton. Smithers Rapra Technology Pvt Ltd, SY4 4NR,UK,2008
4. Polymer characterisation – D. Cambell and J.R. White. Chapman & Hall, NY(1989)
5. Experimental methods in polymer chemistry – J.F. Rabek. John Wiley and sons NY(1980)
6. Polymer Science, P.L. Nayak, Kalyani Publishers, New Delhi.(2005)
7. Spectroscopy of Polymers, Jack L. Koenig, Elsevier Science Inc., N.Y. Vol 12,2001.
8. Analysis and Characterization of Polymers – Sukumar Maiti, Ansandhan Prakashan, Midnapur, India.(1978)

MSS-11: Nanobiotechnology in Health Care **4 Credits** ***Soft Core***

UNIT-I

Behaviour of molecules in solution-DNA machines- Molecular motors- Patterning simple molecules-Nanostructures surfaces-Applications in cell engineering-Optical and electronic measurements of charge transport in biomolecules-Membrane proteins-Nanopore engineering; bilayer techniques.

UNIT-II

Introduction, DNA arrays-DNA Nanomechanical devices-DNA for coding and information storage-DNA based computation-Atomic Force Microscopy of DNA- Scanning Tunnelling microscopy of DNA -Confocal microscopy.

UNIT-III

Introduction - Concepts and advantages of microfluidic devices - Fluidic transport - stacking and scaling - Materials for the manufacture (Silicon, Glass, Polymers) -Fluidic structures - Fabrication methods - Surface modifications - Spotting - Detection mecahnisms.

UNIT-IV

Introduction, Lipsomes, biotechnology, polymer nanocontainers in therapy, dendrimers, Layer-By-Layer deposition, Block copolymers self assembly and nanocontainers - Polymer nanocontainers with controlled permeability - Block copolymer protein hybrid system, Stimuli responsive nanocapsules, Biomaterials and Gene therapy- *In vivo* imaging of quantum dots - Encapsulated in Phospholipids micelles.

References:

1) Christof M Niemeyer and Chad A Mirkin , *Nanobiotechnology: Concepts, Application and perspectives,* Wiley-VCH (2004) ISBN-10: 3527306587

MSS-12: Nanophotonics **4 Credits** ***Soft Core***

UNIT-I: Quantum confined materials

Quantum dots - Optial transitions – absorption - interband transitins - quantum confinement - intraband transitions flurescence/luminescence - photoluminescence/flurescence optically excited emission electroluminescence emission.

UNIT-II: Plasmonics

Internal reflection and evanescent waves - plasmons and surface plasmon resonance - Attenuated Total reflection - Grating SPR soupling - Optical wavegide SPR coupling - SPR dependencies and materials - plasmonics and nanoparticles.

UNIT-III: New Approaches in Nanophotonics.

Near filed optics - Aperture less near field optics - near field scanning optical miroscopy (NSOM or SNOM) - SNOM based detection of plasmonic energy transport - SNOM based visualization of waveguide structures - SNOM in nanolithography - SNOM based optical data storage and recovery.

UNIT-IV: Biophotonics

Interaction of light with cells-tissues - nonlinear optical processes with intense laser beams - photo induced effects in biological systems - generation of optical forces - optical trapping and manipulation of single molecules and cells in optical confinement - laser trapping and dissection for biological systems-single molecules biophysics - DNA protein interaction.

References:

1) H Masuhara, S Kawata and F Tokunga, *Nanobiophotonics,* Elsevier Science 2007.
2) BEA Sale and A C Teich, *Fundamentals of photonics,* John Wiley and Sons, NewYork 1993.
3) M Ohtsu, K Kobayashi, T Kawazoe and T Yatsui, *Principals of Nanophotonics (Optics and Optoelectronics),* University of Tokyo, Japan (2003).
4) P N Prasad, *Introduction to Biophotonics,* JohnWiley and Sons (2003).

MSS-13: Thermodynamic Modeling **4 Credits** **Soft Core**

Unit 1.

Application of a Phase Rule to two and three component systems. Concepts of Thermodynamics. Partial molar volume and its determination by density measurements. Order of reaction and its determination. Energy of activation and its determination. Assumption of activated complex theory. Fast reactions with examples, polymers and their classification.

Unit 2.
Crystallization kinetics. Basic concepts. Different methods Models for determining the crystallization kinetics for simple systems. *In situ* studies on crystallization kinetics.

Unit 3.
Thermodynamic equilibrium for simple to complex systems. Equilibrium reactions. Equilibrium and non-equilibrium phases. Estimation of solubility and stability. Dissociation constant. Activation coefficient. Speciation constant. Isoelectric points. Thermal stability and Chemical stability.

Unit 4.
Thermodynamic modeling – basic concept. Thermodynamic variables. Equation of state for predicting partial molal standard state properties of the system species. Helgeson equation of state. Calculation of excess properties of ions. Simple models. Pitzer model, Setschenow model. Bromley –Zemaitis model. Helgeson – Kirkham – Flowers (HKF) model. Theoretical Phase diagrams with examples. Yield diagrams. Commercial softwares - CALPHAD, ChemApp, SimuSage, OLI Systems - FactSage Interface, etc.

References

1. J. Thoma and B.O. Bouamama, Modelling and Simulation in Thermal and Chemical Engineering: A Bond Graph Approach, Springer (2000)
2. H. L. Lukas, Suzana G. Fries, Bo Sundman, Computational thermodynamics: the CALPHAD method, Cambridge University Press, UK (2007)
3. Jürgen Gmehling, Bärbel Kolbe, Michael Kleiber, Jürgen Rarey, Chemical Thermodynamics: For Process Simulation, John Wiley & Sons (2012)
4. Advanced Course on Thermodynamic Models: Fundamentals & Computational Aspects, www.cere.dtu.dk, Department of Chemical and Biochemical Engineering - Søltofts Plads - Building 229 - DK2800 Kgs. Lyngby.

MSS-14: Basics of engineering drawing and graphics Credits = 4 Soft Course

Unit I : PRINCIPLES OF GRAPHICS 12 Hours
Two dimensional geometrical construction – Concept of section planes - Conic sections, involutes and cycloids - Representation of three dimensional objects - Principles of projections - standard codes of principles.

Unit II: ORTHOGRAPHIC PROJECTIONS 12 Hours
Projections of points, straight line and planes - ' Auxiliary projections '- Projection and sectioning of solids - Intersection of surfaces - Development of surfaces.

Unit III: PICTORIAL PROJECTIONS 12 Hours
Isometric projections - ' Perspectives '- Free hand sketching. Conversion of pictorial views of simple machine parts into orthographic views, conversion of orthographic views of simple machine parts into isometric views.

Unit IV: COMPUTER GRAPHICS **12 Hours**

Hardware - Display technology - Software - Introduction to drafting software.

Suggested Total No of periods: 48

Text Books:

1. Narayanan, K.L., and Kannaiah, P., " Engineering Graphics ", Tata McGraw-Hill Publishers Co., Ltd., 1992.

References:

1. William M. Neumann and Robert F.Sproul, " Principles of Computer Graphics ", McGraw Hill, 1989.

2. Warren J. Luzzadder and John M. Duff, " Fundamentals of Engineering Drawing ", Prentice-Hall of India Private Ltd., Eastern Economy Edition, 1995.

3. Natarajan K.V., " A Text Book of Engineering Drawing ", Private Publication, Madras, 1990.

4. Mathur, M.L. and Vaishwanar, R.S., " Engineering Drawing and Graphics ", Jain Brothers, New Delhi, 1993.

Note: Further details on Basics of engineering drawing and graphics are illustrated below since this is a new course introduced to enhance the industrial acceptability of the M.Tech Program.

MSS-15: Ceramics Science and Technology **4 Credits** **Soft Core**

Unit I :

Definition & scope of ceramics and ceramic materials. Examples of ceramic crystals, short-range and long-range order, imperfections, polymorphism. Ceramic Binary and ternary systems, ceramic microstructures. Crystallization of glass and glass-ceramics. Thermal, electrical, magnetic and optical properties of ceramics and application. Classification of ceramic materials – conventional and advanced, Areas of applications.

Unit II:

Conventional Ceramics:

b) Refractories : Classification of Refractories, Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, basic properties and areas of application.

c) Whitewares : Classification and type of Whitewares, Elementary idea of manufacturing process technology including body preparation, basic properties and application areas.

d) Ceramic Coatings : Types of glazes and enamels, Elementary ideas on compositions, Process of enameling & glazing and their properties.

e) Glass : Definition of glass, Basic concepts of glass structure, Batch materials and minor ingredients and their functions, Elementary concept of glass manufacturing process, Different types of glasses.Application of glasses.

f) Cement & Concrete : Concept of hydraulic materials, Basic raw materials, Manufacturing process, Basic compositions of OPC. Compound formation,setting and hardening.Tests of cement and concrete.

Unit III:

Elementary ideas about the raw materials used in pottery, Heavy clayweres,

Refractoriers, Glass, Cement, Industries. Raw materials – clays and their classification, Quartz, Polymorphism of quartz, Feldspar and its classification, Talc, Steatite and Mica.

Fabrication methods: Packing of Powders, Classification and scope of various fabrication methods. Dry and semi dry pressing. extrusion, Jiggering & jollying, Slip casting HP & HIP.

Drying & Firing of ceramics: Biscuit firing and glost firing, fast firing technology, action of heat on triaxial body, Elementary ideas of various furnaces used is ceramic industries.

Unit IV:
Advanced ceramics: Bio-ceramics, Space ceramics, Automotive ceramics, Electronic ceramics, Superconducting ceramics, Elementary ideas of their preparation and applications.

Reference books :-
1) F.H Norton, Elements of Ceramics, Addison-Wesley Press (1974)
2) M.W. Barsoum, Fundamentals of Ceramics, McGraw-Hill (2003)
3) W.D Kingery, Introduction to Ceramics, Wiley & Sons (1976)
4) Lawrence H. Van Vlack, Physical Ceramics for Engineers, Addison-Wesley Publishing (1964)
5) F. Singer and S.J. Singer, Industrial Ceramics, Chapman & Hall, UK (1963)

MSS-16: Materials for Renewable Energy and Storage 4 Credits Soft Core

Unit I :
Introduction to new generation of materials and nano-engineering of their structures for sustainable energy economy. Contribution to high performance renewable energy production, storage, conversion and usage.
Solar grade glass; (a) properties-transparency, emissivity and reflectivity, (b) manufacturing- Flat glass for PV & CSP, tube glass for Evacuated Tube Receiver (ETR) and Collector (ETC).

Unit II:
Solar Photo Voltaic (PV) cells: Single and multi-crystalline silicon solar cells, amorphous silicon, thin film; Cd-Te, CIGS, CZTS, nano-, micro-, poly-Si. Transparent conducting coating, Multi-junction, solar PV concentrator, flexible solar cells, Emerging PV; dye sensitized, other organic, and quantum dot cells. Nano-engineered materials.

Unit III:
Materials for Concentrated Solar Power (CSP):
Reflector materials; glass, metal, polymer and film. Receiver and collectors; absorptive coating and anti-reflective coating. Materials and shapes for thermal storage, Lithium ion Batteries.

Unit IV:
Fuel cells; materials and construction; PEM Fuel Cell(FC), AFC, PAFC, MCFC, SOFC. Catalysts for electro catalysis, fuel reformer and water splitting.

Reference books :-
1) Vielstich, W., et al. (eds.) (2009). Handbook of fuel cells: advances in electrocatalysis, materials, diagnostics and durability. 6 vol. Hoboken: Wiley, 2009
2) Francis de Winter, Solar Collectors, Energy Storage, and Materials (Solar Heat Technologies), MIT Press, USA (1991)
3) David S. Ginley, David Cahen, Fundamentals of Materials for Energy and Environmental Sustainability, Cambridge University Press (2011)

4) Materials, Electronics, and Renewable Energy Part III Physics, Small lecture theatre, Cavendish Laboratory lecturers: David MacKay and Neil Greenham
5) Fuel Cell Handbook,
6) Introduction to Fuel Cell Technology

MSS-17: Basics of Nanotechnology **4 Credits** **Soft Core**

Unit 1.

Introduction to nanotechnology – basics, definition. History of nanotechnology. Nanotechnology in relation to other branches of science. Structure of solids – crystalline and non-crystalline. Types of common materials and advanced materials – inorganic, organic, biologic. Types of nanomaterials depending upon their properties – electronic, semiconductors, superconductors, superionic, magnetic, optic, opto-electronic, spintronics, lasers, photonics, ceramics, bioceramics, biomedical, biosensors, bioimagers, photocatalysts, quantum dots.

Unit 2.

Basic properties of materials and the instrumentation used to study these properties. Size effect of materials on properties. Quantization effect on the properties of materials with examples. Nanocomposites and their applications in modern technology. Nanotubes – carbon nanotubes and other nanotubes. Nanomaterials – natural and synthetic. Nanocomposites and Nanohybrid materials.

Unit 3.

Nanomaterials synthesis techniques – nanoengineering of materials. Bottom up and Top down routes. Solution, Melt and Gas Processing of nanomaterials. Nature inspired processes.

Unit 4.

Nanomaterials characterization – X-rays, Spectroscopic - infrared, UV-Vis, Laser Raman, Photoluminescence, Electron Microscopic techniques, Thermal analysis, surface characteristics, light scattering methods, gas adsorption, magnetic susceptibility, conductivity, band gap calculations. Nanotechnology in modern technology in relation to electronic, biological, consumer and domestic applications. Applied nanobiotechnology and nanobiomedical science – drug delivery, drug targeting, biosensors, bioimaging, neutron capture therapy.

References:

1.Bharath Bhusan, Springer Handbook of Nanotechnology, 3rd edition, Springer-Verlag (2009)
2.CNR Rao and T. Cheetham, Chemistry of Nanomaterials : Synthesis, Properties and Applications, Wiley & Sons (2005)
3.Hari Singh Nalwa, Encyclopedia of Nanotechnology, American Scientific Publishers (2004)
4.K. Byrappa and M. Yoshimura, Handbook of Hydrothermal Technology, 2nd edition, Elsevier (2012)
5.K. Byrappa and T. Adschiri, Hydrothermal Technology for Nanotechnology, Progress in Crystal Growth and Characteriation of Materials, Volume 53 (2007) pp.117-166.
6.K. Byrappa and M. Yoshimura (Editors): Special Edition of Journal of Materials Science, Volume 41, No.6 (2006).
7.K. Byrappa and T. Adschiri (Editors), Special Edition of Journal of Materials Science, Volume 43, No.7 (2008).
8.Charles P. Poole Jr. and Franks J. Qwens, Introduction to Nanotechnology, Wiley & sons (2003)

MSS-9: Characterisation Lab-3

Experiments

1) Preparation of carbon nanoparticles and X-ray investigation
2) Preparation of polymer film and x-ray investigation
3) X-ray studies of natural polymers like silk, cotton, hemp and jute
4) FTIR and UV-Visible studies of polymers (both natural and man-made)
5) AFM Study of a polymer film.
6) SEM study of a polymer film
7) Conductivity of a polymer film

SEMESTER-IV

PROJECT WORK