



ಮೈಸೂರು ವಿಶ್ವವಿದ್ಯಾಲಯ  
**University Of Mysore**



# CENTRE FOR MATERIALS SCIENCE AND TECHNOLOGY (CMST)

**M.Tech in Materials Science**

**FLEXIBLE CHOICE BASED CREDIT SYSTEM (FCBCS)**

M. Tech MATERIAL SCIENCE



**World leading technology towards sustainable development**



## About The Department

The University of Mysore has started a new job oriented course - M.Tech. in Materials Science with funding and support from University Grants Commission, New Delhi under the banner “University with Potential for Excellence (UPE)” in 2012. The main goal of this UPE scheme is to make the Indian universities as comparable to World-class universities by supporting them to grow further in their chosen areas of teaching, research and development. Materials Science Centre is born out of this major program undertaken by the University of Mysore with big funding from UGC, New Delhi. UGC’s dedicated database Shodh Ganga has indicated that the University of Mysore, is a leading institution in the country in the area of Materials Science. Accordingly, the UGC Expert Committee has recommended to the University of Mysore, to nurture this subject for the future generations and promote this field among the stakeholders and contribute to the generation of specialists in this field. The course content is formulated keeping in mind the demands from Industry and R&D Institutions from India and abroad. The practical training given will well equip the students to pursue higher studies or get entry into Scientific Premier R&D laboratories across the country as well outside the country. This degree is in demand overseas and also has greater industrial job prospects.

The admission to M.Tech. Course is through an entrance examination and is open to Undergraduate Degree holders from diversified background such as Basic Science Subjects, Engineering, Medical, Agricultural Science, Pharmaceutical Science, and Dental Science. M.Tech. in Materials Science Program is of TWO Years for Medical, Pharmaceutical Science, Dental Science, Engineering Students, and M.Sc., Degree holders. However, the course is of THREE Years for students from B.Sc., background. B.Sc., students can have a lateral exit after first four semesters (TWO Years) with M.Sc, Degree in Materials Science.

Materials are the unacknowledged pillars of modern technology. The course is offered under Choice Based Credit System with continuous evaluation. Accordingly, several innovative subjects such as Materials Processing, Materials Characterization, Nanochemistry, Nanophysics, Materials for Energy Storage, Aerospace Materials, Industrial Crystallization, Thermochemical Modeling, etc. are offered to students from diversified background. The students are free to select any subject of their liking. The details of the credits and subjects offered are listed in the page Course Syllabus and available from the University website: [www.uni-mysore.ac.in](http://www.uni-mysore.ac.in)

The University of Mysore, one of the finest legacies of the Princely State of Mysore, was established by the Maharaja of Mysore, His Highness Nalvadi Krishnaraja Wodeyar, on July 27, 1916, and is the sixth oldest University in India. NAAC has accredited the University of Mysore with highest grade point in the state. The University of Mysore has a long established tradition in interdisciplinary and trans-border research involving Major departments like Physics, Chemistry, Earth Science, Environmental Science, Polymer Science, Biotechnology, and Microbiology working on the current topics in the frontier areas of science including Materials Science. The senior faculty of these PG Departments and experts from National Laboratories are actively involved in teaching and training the M.Tech. Students with the state of the art facilities listed overleaf. The participating faculty members have proven strength through high-quality publications, trainings and sponsored research projects with national and international collaborations and consultancy services offered at various levels.

The M.Tech students are encouraged to work on a chosen Minor and Major projects from 3rd semester onwards. The syllabus at present consists of 13 hard core papers and 23 soft core papers.

**UNIVERSITY OF MYSORE**  
**Department of Studies in Materials Science**  
**Manasagangothri, Mysuru-570006**

**Regulations and Syllabus**  
**Master of Materials Science (M.Tech)**  
**(Two-year Semester Scheme for B.E Background/Students &**  
**Three year Semester Scheme for B.Sc Background/Students)**

**Under**  
**Flexible Choice Based Credit System (FCBCS)**

# UNIVERSITY OF MYSORE

## GUIDELINES AND REGULATIONS LEADING TO MATERIALS SCIENCE (TWO/THREE YEARS-SEMESTER SCHEME UNDER FCBCS)

### Programme Details

<b>Name of the Department</b>	: Department of Materials Science
<b>Subject</b>	: Materials Science
<b>Faculty</b>	: Science and Technology
<b>Name of the Course</b>	: Master of Material Science (M.Tech.)
<b>Duration of the Course</b>	: 2 years- divided into 4 Semesters B.E/MBBS/B.Tech/BDS/ B.Pharma Background/Students 3 years- divided into 6 Semesters - B.Sc Background/Students

### Programme Outcomes

- The University of Mysore has started job oriented Course-M.Tech in Materials Science with funding and support from University Grants Commission, New Delhi under the banner “University with Potential for Excellence (UPE)” in 2012.
- The UGC Expert Committee has recommended to the University of Mysore, to nurture this subject for the future generations and promote this field among the stakeholders and contribute to the generation of specialists in this field.
- The Course content is formulated keeping in mind the demands from Industry and R&D Institutions from India and abroad.
- UGC’s dedicated database ShodhGanga has indicated that the University of Mysore is a leading institution in the country in the area of Materials Science.
- The admission to M.Tech. Course is through an entrance examination and is open to Undergraduate Degree holders from diversified background such as Basic Science Subjects, Engineering, Medical, Agricultural Science, Pharmaceutical Science, and Dental Science.

- M.Tech in Materials Science Program is of two years for medical, Pharmaceutical Science Dental Science, Engineering Students, and M.Sc Degree holders. However, the course is of three Years for students from B.Sc., background. B.Sc., Students can have a lateral exit after first semesters (TWO Years) with M.Sc., Degree Materials Science.
- The Course is offered under Flexible Choice Based Credit System with continuous evolution accordingly, Hard Core (13 Papers) and Soft Core (23 Papers) subjects such as Materials Processing, Materials Characterization, Nanochemistry, Nanophysics, Materials for Energy Storage, Aerospace Materials, Chemical Engineering, Materials and Environment, Carbon Nanotubes, Materials for Renewable Energy and Storage, Nanobiomechanical Engineering, Ceramics Engineering, Composites, Nanobiotechnology in HealthCare, Thermo-chemical Modelling, etc are offered to students from diversified background.
- The Syllabus, framed initially was evaluated thrice by UGC expert committee during their visit to review the project University with Potential for Excellence (UPE) and Centre with Potential for Excellence in Particular Area(CPEPA) during 23/03/2016, 9/10/2017 and 21/12/2018.
- The students are free to select any soft core papers of their liking. The details of the credits and subjects are available from the University website: [WWW.uni-mysore.ac.in](http://WWW.uni-mysore.ac.in). Faculty of PG Departments and experts from National Laboratories are actively involved in teaching and training the M.Tech. Students with the state of the art facilities listed overleaf.
- The participating faculty members have proven strength through high-quality publications, trainings and sponsored research projects with national and international collaborations and consultancy services offered at various levels.
- The M.Tech students are encouraged to work on a chosen Minor and Major projects from 3rd semester onwards.

## **Programme Specific Outcomes**

1. Conceptually explain the classification schemes that are used to categorize the materials.
2. Explain the differences in the mechanical behavior of materials based upon bond type, structure, composition, and processing.
3. Describe the basic structures and repeat units for common thermoplastics and relate the distribution of molecular weights, degree of polymerization, percent crystallinity, and glass transition temperature to properties in service.
4. Describe how and why defects (point, line and interfacial) in materials greatly affect properties and limit their use in service
5. Calculate materials stress, strain and the elastic modulus from data and for basic applications.
6. Describe why each of the fundamental mechanical properties of materials covered in the course (stress, strain, elastic constant, creep, fatigue, wear, hardness, Poisson's ratio, toughness, ductility, flexural strength, impact strength, elongation) are important in materials applications.
7. Select the appropriate materials and size basic parts, including the use of appropriate safety factors and cost, for specific applications using mechanical properties such as: yield strength, tensile strength, ductility or elongation, impact strength, toughness, Poisson's ratio, flexural strength, hardness, fatigue life, endurance limit, wear, and creep.
8. Work in team engineering materials in service, understand historical limitations of those materials, evaluate future trends in those applications, and understand long-term sustainability, recycling and life cycle issues.
9. Apply ethical principles, codes of ethics, and professional responsibilities in the selection of materials for application.
10. Use binary phase diagrams to predict microstructures and also to understand precipitation hardening. Understand how thermal treatments affect the microstructure and, thus, properties of materials.
11. Given a type of material, be able to qualitatively describe the bonding scheme and its general physical properties, as well as possible applications.
12. Be able to qualitatively derive a material's Young's modulus from a potential energy curve.
13. Given the structure of a metal, be able to describe resultant elastic properties in terms of its 1D and 2D defects.
14. Given a simple set of diffraction data, be able to index the peaks and infer the structure.
15. Be able to describe a polymer's elastic behavior above and below the glass transition.
16. Be able to do simple diffusion problems.

## **Programme Pedagogy**

- Traditional lecture-centered approaches alone are inadequate for preparing students for the challenges of creative problem solving in the Materials science discipline. The Centre for Materials Science and technology supports several initiatives like experiments conducted by students using advanced instruments like X-ray diffraction(XRD), SEM, UV-Visible, IR, TGA,DTA,AFM, NMR, etc with research internship programme. A student has to study all hardcore papers. The students are free to select any softcore papers of their liking.
  
- After completion of the M.Tech in Materials Science, Students would empowered with multi disciplinary tools as follows: Transform to original researchers and undertake cutting edge research and teaching for an In-Depth understanding of the Materials for different applications in view of current issues.
  
- Students are able to design the novel materials and explore different applications of materials in various fields.
  
- Students also acquire strong knowledge for achieving the synthesis of eco-friendly materials which inturn helps to the society at large.
  
- Students acquire broad knowledge to design the Materials, which are highly important because they are act as important applications in various fields.
  
- Students acquire knowledge related to resolve current issues like biocompitable nanoparticles which are very useful for nano biosensor devices for diagnosis of different Diseases.



## Programme Structure

### Hard Core Courses for M.Tech. Materials Science program.

CODE	Paper title	Core	Credits			
			Lecture	Tutorial	Practical	Total
MSH-1	Introduction to Materials (I-Sem)	Hard	3	1	0	4
MSH-2	Thermodynamics and Statistical Mechanics(I-Sem)	Hard	3	1	0	4
MSH-3	Materials Preparation Techniques (II-Sem)	Hard	3	1	0	4
MSH-4	Methods of Materials Characterization(II-Sem)	Hard	3	1	0	4
MSH-5	Physics and Chemistry of Materials (III-Sem)	Hard	3	1	0	4
MSH-6	Materials and Environmental Effects (III-Sem)	Hard	3	1	0	4
MSH-7	Characterisation lab-1	Hard	0	1	3	4
MSH-8	Characterisation lab-2	Hard	0	1	3	4
MSH-9	Characterisation lab-3	Hard	0	1	3	4
MSH-10	Characterisation lab-4	Hard	0	1	3	4
MSH-11	Characterisation lab-5	Hard	0	1	3	4
MSH-12	Minor Project	Hard	0	1	5	6
MSH-13	Major Project (Only for M.Tech. exit)	Hard	0	2	8	10
			Total : (M.Tech-exit) (For B.E. background)			52
			For B.Sc., background			60

### Soft Core Courses for M.Tech. Materials Science program

CODE	Paper title	Core	Credits			
			Lecture	Tutorial	Practical	Total
MSS-1	Structure, Property and Functions of Materials	Soft	3	1	0	4
MSS-2	Basics of Chemistry	Soft	3	1	0	4
MSS-3	Spectroscopic Techniques for Materials	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	Materials for Aerospace Applications	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	Metals and Alloys	Soft	3	1	0	4
MSS-11	Nano-biotechnology in Health Care	Soft	3	1	0	4
MSS-12	Nano-photonics	Soft	3	1	0	4
MSS-13	Thermodynamic Modelling of Systems	Soft	3	1	0	4
MSS-14	Basics of Engineering Drawing and Graphics	Soft	2	2	0	4
MSS-15	Ceramics Science and Technology	Soft	3	1	0	4
MSS-16	Materials for Renewable Energy and Storage	Soft	3	1	0	4
MSS-17	Basics of Nanotechnology	Soft	3	1	0	4
MSS-18	Enterprise Architecture	Soft	3	1	0	4
MSS-19	Chemical Engineering	Soft	3	1	0	4
MSS-20	Advanced X-ray Diffraction Studies	Soft	3	1	0	4
MSS-21	Analytical and Inorganic Chemistry	Soft	3	1	0	4
MSS-22	Semiconductor Optoelectronics	Soft	3	1	0	4
			Total soft credits available to choose			66

## FIRST SEMESTER

### HARD CORE

#### MSH-1: Introduction to Materials

##### Course Outcome

- Knowledge about different types of Materials
- Identify the crystal structures by using different modern X-ray methods
- Extensive knowledge regarding chemical bonding and crystal defects

##### Course Content

###### *Unit-I: Materials through ages*

What is Materials Science?, The Relationship of Science and Technology, How is Basic Science Linked to Everyday Materials , A Short History of Materials Science, Classification of Materials, Advanced Materials, Modern Materials' Needs. Materials through ages - Palaeolithic to Modern period. Bulk, fine and Nanomaterials, Crystalline - Functional materials, Smart Materials, Centrosymmetric and Non-centrosymmetric materials, Amorphous, Glasses, Metals, Alloys, Semiconductors - types of semiconductors, Opto-electronic, Polymers, Ceramics, Bio-materials Polymer, Blends, Composites.

**12 hours**

###### *Unit-II: Crystal Structure*

The Structure of Crystalline Solids, Fundamental Concepts of Unit Cells, Metallic, Crystal Structures Density Computations, Polymorphism and Allotropy, Crystal Systems, Point Coordinates, Crystallographic Directions, Crystallographic Planes, Linear and Planar Densities, Close-Packed Crystal Structures, Crystalline and Noncrystalline Materials, Single Crystals, Polycrystalline Materials.

**12 hours**

###### *Unit-III: Crystal Diffraction and Reciprocal Lattice (Qualitative)*

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.

**12 hours**

###### *Unit-IV: Chemical Bonding in crystals and Imperfection*

Chemical bonding: Ionic bonding, covalent Bonding, Metallic Bonding, Van Der Wall Bonding. Atomic and Ionic radii, Pauling - Ahrens radii of common atom and ions. Spheres in closest packing Cubic closest packing, Hexagonal closest packing, Body centered cubic packing. Voids in closest packing. Crystal defects –point, line, surface /volume defects.

**12 hours**

## 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

### Course Outcome

- Knowledge about the theory and different types of gas laws and phase equilibria.
- The knowledge of all the types of thermodynamics laws.

### Course Content

#### *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. **12 hours**

#### *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. **12 hours**

#### *Unit-III: Phase equilibrium*

Basic concepts of phase, components, Degrees of freedom. Concept of equilibrium and equilibrium constant, Phase rule and its application to one, two and three component systems. Phase diagram and phase equilibrium studies. **12 hours**

#### *Unit-IV: Laws of Thermodynamics*

Basic concepts and conventions, system and surrounding, Macroscopic physical properties, Time dependent and time independent processes, First law of thermodynamics – expressions for heat and work, Enthalpy, Heat capacity, heats of formations and heats of reactions. Second law of thermodynamics, types of disorders and concept of Entropy and derivation of expressions of entropy. Gibbs free energy, derivation of expression of free energy as function of P and T, Clapyeron equation, partial molar quantities, chemical potential, fugacity and activity. Application of thermodynamics for phase equilibrium studies. **12 hours**

### References

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.
3. Statistical Mechanics by SL Gupta and V Kumar ( 2011) Pragati Prakashan, India

## **Practical Papers for M.Tech. Materials Science**

### **MSH-7 : Characterisation lab-1**

Demonstrate crystal model of seven crystal system and also know the study of materials by x-ray powder pattern method, UV-visible spectrometer, optical diffraction method and X-ray diffraction method

## SECOND SEMESTER

### HARD CORE

#### MSH-3 : MATERIALS PREPARATION TECHNIQUES

##### Course Outcome

The synthesis of materials and nano particles through well known advanced methods

##### Course Content

###### *Unit-I*

Solid state routes; Nucleation; Role of impurities; Mechanical mixing; Grinding; Solid solution techniques. Top-Down reactions. Rate of crystallization. High temperature processes – heating, annealing, sintering treatment; Sputtering, Spin Coating.

**12 hours**

###### *Unit -II*

Evaporation; precipitation; Solution growth; Nucleation; Rate of crystallization; Supersturation; Top seeded solution growth; sol-gel techniques; high temperature solution; Hydrothermal; Solvothermal methods; Ammonothermal method; Glycothermal; Melt methods- super cooling, Czochralskii methods; Skull melting.

**12 hours**

###### *Unit -III*

Vapour phase methods - Thin films, epitaxial growth, substrates selection, carrier gases, metastable growth of materials. Chemical Vapour Deposition - Principles, apparatus, examples of CVD growth of thin films, advantages and disadvantages; Chemical Vapour Transportation; Molecular Beam Epitaxy, Liquid Phase Epitaxy, Vapour growth of Nitrides. Metal-organic Vapour phase epitaxy. Plasma Energetics; Laser ablation.

**12 hours**

###### *Unit -IV*

Biological synthesis, Biomimetic method, bacterial synthesis of nanoparticles; Electrochemistry - solvent selection, apparatus, deposition, growth of thin films, coatings, examples; Multi-energy processing - Mechanochemical; Sonochemical; Photochemical; Biochemical, Microbial, Organic synthesis. Growth of organic crystals.

**12 hours**

##### 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, 2<sup>nd</sup> Edition (2009).

3. Handbook of Crystal Growth, K. Byrappa and T. Ohachi, Springer-Verlag (2003).
4. Growth of Single Crystals, R.A. Laudise, Prentice-Hall (1973).
5. Growth and Characterization of Technologically Important Crystals, By: K. Byrappa Fornari, T. Ohachi, H. Klapper, Allied Sciences, New Delhi (2003).

## **MSH-4 : METHODS OF MATERIALS CHARACTERIZATION**

### **Course Outcome**

- Select an appropriate combination of complementary materials characterization techniques for the investigation of a variety of technological problems, including structural materials, functional materials, biomedical materials and nano structured materials.
- Demonstrate understanding of the fundamental physical underpinning a range of materials characterization techniques.

### **Course Content**

#### ***Unit-I***

Thermal analysis; TGA; DTA; DSC; Basic principle. Differences between DTA and DSC. Instrumentation-power compensated DSC, heat flux measurement in DSC. Applications testing the purity and characterizations of various materials (Polymeric, Pharmaceutical, Agricultural materials) Thermo mechanical analysis, Dynamic mechanical analysis, dilatometry; (Thermal expansion) Principles and applications.

**12 hours**

#### ***Unit-II***

Microscopic techniques, Phase Contrast Microscopy – Principles, types, hot stage microscopy, Electron imaging techniques; Scanning Electron Microscopy; principle, instrumentation, measurement and analysis; Tunnelling Electron Microscopy; principle, instrumentation, measurement and analysis, Field Emission SEM; Scanning Tunnelling Microscopy; Atomic Force Microscopy; principle, instrumentation, measurement and analysis; Scanning Probe Microscopy; High Resolution TEM; principle, instrumentation, measurement and analysis, High Resolution SEM; principle, instrumentation, measurement and analysis.

**12 hours**

#### ***Unit-III***

Particle size measurement; Basic principle of particle analysis, equivalent sphere model,  $D[1,0]$ ,  $D[3,2]$  and  $D[4,3]$  representations, conversion between length and volume/mass means, mean, median and mode statistics; Methods of measurement of particle size, XRD, optical and laser scattering techniques; surface area and porosity; definition and meaning, measurement using BET method, adsorption isotherms, DC polarization, AC impedance measurements.

**12 Hours**



#### ***Unit-IV***

Photoluminescence, principle of working, instrumentation and measurement; demonstration of band gap measurement using PL spectrometer; Positron Annihilation Lifetime Spectroscopy; Basics of positron annihilation, the sources of positrons, three methods of positron annihilation techniques; lifetime, Doppler broadening and angular correlation methods, Application of lifetime spectroscopy for the free volume determination in polymer and polymer nanocomposites.

Non-linear electro-optical properties of materials, mechanical properties, tensile strength, micro hardness; zeta potential.

**12Hours**

#### **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)

#### **Practical Papers for M.Tech. Materials Science**

##### **MSH-8 : Characterisation lab-2**

- To study the materials/organic/in organic compounds by using various spectroscopic techniques like <sup>1</sup>H-NMR, <sup>13</sup>C-NMR and FT-IR..
- To study the band gap energy of the given semiconductor by the method of four probes
- To study the experiments related to polymers like determination of refractive index and thickness of polymer and free volume estimation.
- To study the isolation of different types DNA from E.coli.

## THIRD SEMESTER

### HARD CORE

#### MSH-5 : PHYSICS AND CHEMISTRY OF MATERIALS

##### Course Outcome

- The physical and chemical aspects for the different types of materials and also learn including statistical analytical studies.
- Gives an idea about the identification/structure of crystals/metal composites and their thermal properties.
- The brief explanation for structures, preparation, properties and bonding in case of electron deficient compounds.

##### Course Content

###### *Unit-I*

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.

**12 hours**

###### *Unit-II*

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.

**12 hours**

###### *Unit-III*

Statistical analysis of Analytical Data, measures of central tendency -Averages and moving averages, Measures of dispersion, Moments, skewness and kurtosis. Frequency distribution and Measures of central tendency using grouped data correlation and regression analysis error estimation and curve fitting. Tests of significance / hypothesis, t-test, f-test and  $\chi^2$  test. Probability theory.

**12 hours**

###### *Unit-IV*

Introduction, MX (NaCl, CsCl, ZnS) and MX<sub>2</sub> (fluorite, rutile-cristobalite and cadmium iodide ) types. The perovskite and spinel structures. Thermodynamics of ionic crystal formation. Lattice energy, Born-Haber cycle, Born-Landé equation. Applications of lattice energetics. Ionic radii, factors, affecting the ionic radii, radius ratio rules. Electron deficient compounds: Diborane and its reactions, higher boranes, polyhedral boranes (preparations, properties, structure and bonding). Wade's rules, carboranes and metallocarboranes.

## References

1. Pillai, Solid State Physics, Narosa Publication 999999999s, India (2007)
2. J.I. Gersten and F.W. Smith, The Physics and Chemistry of Materials, Wiley & Sons (2001)
3. A. Navrotsky, Physics and Chemistry of Earth Materials, 6th Edition, (1995) Cambridge Series.

## MSH-6 : MATERIALS AND ENVIRONMENTAL EFFECTS

### Course Outcome

- The extensive knowledge about cause of corrosion and its preventive measures to protect the materials from the environment.
- The effect of industrial effluents from different chemical industries on environment.

### Course Content

#### *Unit-I*

Basics of Corrosion, Different forms of Corrosion, basis of electrochemical corrosion, theories of corrosion. Local cell theory (Wagner and Traud theory). Current – potential relations (Evan diagram) in corrosion cells. Effect of *pH*, nature of metal and dissolved oxygen (principle of differential aeration) on corrosion. thermodynamic principles of electrochemical reactions, Electromotive Force Series, Pourbaix Diagrams, Evans Diagrams, Mixed Potential Theory, Passivity,

**12 hours**

#### *Unit-II*

Electrochemical methods to Measure Corrosion: DC Polarization, linear polarization method, AC Impedance; Experimental measurement of corrosion Quantification of corrosion Environmentally Induced Cracking, Corrosion Fatigue, Hydrogen Induced Cracking, Application of Fracture mechanics.

**12 hours**

#### *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. Corrosion prevention by painting, phosphating and anodic (passivation) and cathodic protection.

**12 hours**

### ***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.

**12 hour**

### **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).
5. W. Revie (ed.): Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons, 2000: Metals Handbook, Vol. 13: Corrosion, ASM International

## **Practical Papers for M.Tech. Materials Science program**

### **MSH-9 : Characterisation lab-3**

- To study the different types of purification techniques of organic compounds like crystallization, Distillation and fractional crystallization.
- To study the synthesis and characterization of important drugs such as Aspirin and antipyrine.
- To study the biological material characterization by X-ray diffraction studies.

### **MSH-10 : Characterisation lab-4**

To study the synthesis and characterization of simple materials like crystals, glasses, polymers and composites by hydrothermal, solvothermal, flux, melt and sol-gel techniques.

### **MSH-11 : Characterisation lab-5**

- To study the preparation and characterization of nano particles by X-ray.
- To study the polymers by FT and UV-Visible spectrophotometer.
- To study the polymer film/composite materials/nano materials by AFM and SEM.

### **MSH-12 : Minor Project**

Minor Project during III Semester for non B.Sc students and in V Semester for B.Sc students

### **MSH-13 : Major Project ( Only for M.Tech. exit)**

Major Project during IV Semester for non B.Sc students and in VI Semester for B.Sc students

## SOFT CORE

### MSS-1 : STRUCTURE, PROPERTY AND FUNCTIONS OF MATERIALS

#### Course Outcome

- The idea about different types of material which are derived from metals, polymers.
- Learn about the synthesis of biomaterials and their functions.

#### Course Content

##### *Unit-I:Materials*

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

**12 hours**

##### *Unit-II:Polymers*

Importance of polymers. Fundamentals of polymers-Monomers the repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers. Polymerization-condensation, addition, free radical, ionic, co-ordination polymerization and ring opening polymerization. Molecular weight and Polydispersion. Average molecular weight concepts-number weight and viscosity average molecular weight. Practical significance of molecular weight. Size of polymer molecules.

**12 hours**

##### *Unit-III Earths Materials*

Basic components of earths Materials, Minerals & rocks- Physical properties of Minerals – density, specific gravity. Silicate structure, Description and classification of minerals – Oxides, Hydroxides Carbonates, Sulphides. and silicates. Solid solutions exsolution, polymorphism and isomorphism, Description of important rock types and ore minerals.

**12 hours**

##### *Unit-IV:Biomaterials*

Protein, antibodies, Enzymes, Nucleotides, immobilization, functionalization methods for biomaterials (Antibody/enzyme/protein), encapsulation methods, biocompatible materials, Biodegradable polymers Bio-compatibility criteria, Toxicity evaluation (Inflammation, hypersensitivity, carcinogenesis). Application of biomaterials in orthopedics (artificial ligaments and tendons), cardiovascular tissues engineering (pacemakers). Biosensors, targeted drug delivery and affordable diagnostics. Carbohydrates, Nucleic acids

**12 hours**

## References

1. Re.E.Newnham, Properties of Materials: Anisotropy, Symmetry, Structure, Oxford University Press.
2. Buddy Ratner. Biomaterials Science. Second edition. Orlando, Academic Press, 2000;
3. Jonathan Black. Biological performance of materials: fundamentals of biocompatibility New York, Marcel Dekker, 1999
4. Joon Park and Joseph Bronzino. Biomaterials: Principles and Applications. Fort Lauderdale FL, CRC Press, 2003.
5. Ferry : Viscoelasticity properties of polymers
6. Aklonis, et al., An introduction of Viscoelasticity in polymers
7. Research and Development on Biosensors for food Analysis in India In: Advances in Biosensors M.S. Thakur and N.G. Karanth, 2003, Oxford University, Press, 2003.
8. From Bioimaging to Biosensors – Noble Metal Nanoparticles in Biodetection, by Lai-kwan Chau (National Chung Cheng University, Taiwan), Huan-Tsung Chang (National Taiwan University, Taiwan)
9. Advances in Biosensors, Volume 1, Reinhard Rennerberg and A.P.F. Turner, 1991.
10. Nanoparticles and Biophotonics as Efficient Tools in Resonance Energy Transfer-Based Biosensing for Monitoring Food Toxins and Pesticides, M. S. Thakur, Rajeev Ranjan, Aaydha C. Vinayak, Kunhitlu S. Abhijith, and Richa Sharma. Advances in Applied Nanotechnology for Agriculture, Chapter 4, 2013, pp 55-84, ACS Symposium Series, Volume 1143.

## MSS-2 : BASICS OF CHEMISTRY

### Course Outcome

The basic fundamental concepts of chemistry in the area of inorganic, organic, physical and analytical chemistry.

### Course Content

#### Unit I:

**Elements of quantum mechanics:** Wave mechanical concept of the atom, dual nature of electron, derivation of de-Broglie's equation. Heisenberg's uncertainty principle and its significance. Schrodinger wave equation-explanation of the terms therein (no derivation) **Eigen values and functions, significance of  $\psi$  and  $\psi^2$ .** Quantum numbers and their

significance. Shapes of s, p and d orbitals. Effective nuclear charge, screening effect-based on Slater's rules (problems to be worked out). General energy level diagram of multi electron atom (up to  $n=4$ ). Pauli's exclusion principle, Hund's rule,  $(n+1)$  rule, Aufbau principle.

**Periodic Table and Periodicity:** Classification of elements into s, p, d, and f-blocks, cause of periodicity. Detailed discussion of the following periodic properties of elements with examples: Atomic radius, Ionization enthalpy, Electron gain enthalpy and Electronegativity. **Chemical bonding:** Ionic bond, Covalent bond, Coordinate bond, metallic bonding and hydrogen bonding.

**12 hours**

#### Unit II:

**Hybridization:** Tetravalency of carbon,  $sp^3$ ,  $sp^2$  and  $sp$  – hybridization (in brief). Bond length, bond angle, bond energy, localized and delocalized chemical bonds – resonance and hyperconjugation effects.

**Types of organic reactions:** Definition with examples of addition, substitution, elimination, isomerisation, oxidation, reduction, condensation and rearrangement reactions.

**Stereochemistry:** Introduction, definition, elements of symmetry (plane, centre, simple axes and alternative axes), asymmetry and dissymmetry, Chirality, designation of configuration – R-S notation. Optical activity – explanation – cause of optical activity (non-super impossibility). Enantiomers and diastereomers optical isomerism in tartaric acid and biphenyls, racemisation, resolution, methods of resolution (Chemical and biochemical methods) Walden inversion, asymmetric synthesis (partial and absolute).

**Geometrical isomerism:** Definition with example, designation of cis-trans and E-Z notations with examples. Geometrical isomerization of aldoximes and ketoximes,

**12 hours**

#### Unit III

**Colligative Properties:** Concept of vapour pressure, variation of vapour pressure with temperature. Definition of boiling point and freezing point, effect of dissolution of solute on the vapour pressure of the solvent. Lowering of vapour pressure. Raoult's law – relation between relative lowering of vapour pressure and molar mass (to be derived). Determination of relative molar mass of solute by dynamic method. Elevation of boiling point and its relation to lowering of vapour pressure and molar mass (to be derived). Ebullioscopic constant of the solvent and its relation to the boiling point (only



equation). Determination of molar mass of the solute by Walker-Lumsden method. Depression in freezing point and its relation to lowering of vapour pressure and molar mass (to be derived). Cryoscopic constant and its relation to the melting point (equation). Determination of molar mass of a non-volatile solute by Beckmann's method (problems to be worked out).

**Semi permeable membrane** – natural and artificial, preparation of copper ferrocyanide membrane by Morse-Frazer method. Definition of osmosis, osmotic pressure (mention application), determination of osmotic pressure by Berkley-Hartley's method, laws of osmotic pressure analogy with gas laws, determination of molar mass from osmotic pressure measurements (relation to be derived), isotonic solutions, plasmolysis.

**12 hours**

#### **Unit IV**

Indicator – Definitions, types (acid-base, redox, adsorption indicators), examples for each type. Theory of indicators – Oswald's theory and Quinonoid theory – indicator constant – action of phenolphthalein and methyl orange in acid-base solutions – pH titration curves for strong acid vs strong base, weak acid vs strong base, weak base vs strong acid, choice of indicators in these types of titrations – color change and pH range. Universal indicator – definition.

**Chromatography:** i. Paper: introduction to ascending, descending and circular,  $R_f$  value and its applications; ii. **TLC:** Introduction and applications; iii. **Column Chromatography:** Introduction, principle and experimental details and applications; iv. **Gas Chromatography:** Introduction, apparatus, programmed temperature gas chromatography, quantitative analysis of GLC and v. **HPLC:** Introduction, schematic diagram of instrumentation and application.

**12 hours**

#### **Reference:**

1. Basic Inorganic Chemistry – 3<sup>rd</sup> edition. F.A. Cotton, G. Wilkinson and P.L. Gaus, John Wiley and Sons (2002).
2. Inorganic Chemistry, 3<sup>rd</sup> edition. James E. Huheey, Harper and Row Publishers (1983).
3. Inorganic Chemistry, 3<sup>rd</sup> edition. G.L. Miessler and D.A. Tarr, Pearson Education (2004).
4. Inorganic Chemistry, 2<sup>nd</sup> edition. D.F. Shriver, P.W. Atkins and C.H. Langford, Oxford University Press (1994).
5. H. Pine, Hendrickson, Cram and Hammond, Organic Chemistry, Mc Graw Hill, New York, 1987.
6. I.L. Finar, Organic Chemistry, ELBS Longmann, Vol. I & II, 1984.
7. R.K. Bansal, Organic Reaction Mechanism, Wiley Eastern Limited, New Delhi, 1993.
8. J. March, Advanced Organic Chemistry, Wiley Interscience, 1994.
9. Physical Chemistry by P.W. Atkins, ELBS, 5<sup>th</sup> edition, Oxford University Press (1995).
10. Text Book of Physical Chemistry by Samuel Glasstone, MacMillan Indian Ltd., 2<sup>nd</sup> edition (1974).
11. Elements of Physical Chemistry by Lewis and Glasstone.
12. Fundamentals of physical chemistry – Maron and Lando (Collier Macmillan) 1974.

## MSS-3 : SPECTROSCOPIC TECHNIQUES FOR MATERIALS

### Course Outcome

- The extensive knowledge in different types of spectroscopic techniques and this is useful for the characterization or structural elucidation of novel materials.
- The identification of conjugation, functional groups, environment of H/C nucleus and electronic environment of any chemical entity.

### Course Content

#### Unit I

**UV-Visible spectroscopy:** Modes of electronic excitations, simple chromophoric groups— systems of extended conjugation, aromatic systems. Types of auxochromes— functions of auxochromes, absorption and intensity shift. Types of transition probability, types of absorption bands, solvent effects and choice of solvent. Effect of polarity on various type of bands, Woodward's empirical rules for predicting the wavelength of maximum absorption: - Olefins, conjugated dienes, cyclic trienes and polyenes, -unsaturated aldehydes and ketones, benzene and substituted benzene rings.

**12 hours**

**IR spectroscopy:** Principles, Hook's law, characteristic group frequencies and skeletal frequencies. Finger print region. Identification of functional groups: Alkenes, alkynes, aromatics, carbonyl compounds (aldehydes and ketones, esters and lactones), halogen compounds, sulphur and phosphorous compounds, amides, lactams, amino acids, and imines. Factors affecting group frequencies and band shapes, conjugation, resonance and inductance, hydrogen bonding and ring strain, tautomerism, cis-trans isomerism. Applications of IR spectra to co-ordination compounds, organotransition metal complexes (N,N-dimethyl acetamides, urea, DMSO,  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_2^-$ )

**12 hours**

#### Unit II

**Nuclear magnetic resonance spectroscopy:** General introduction and definition, magnetic properties of nuclei (magnetic moment, g factor) and theory of nuclear resonance. Larmor precession frequency, resonance condition and relaxation processes.

**Chemical shift:** Standards employed in NMR, factors affecting chemical shift, electronegativity, shielding and deshielding mechanism, Vander waals deshielding, H-bonding, diamagnetic and paramagnetic anisotropics. Spin-spin coupling, chemical shift values and correlation for protons bonded to carbon and other nuclei. Instrumentation and sample handling.

Equivalence and magnetic equivalence proton exchange reactions, effects of chiral center, complex spin-spin interaction, stereochemistry, hindered rotation, Karplus curve-variation of coupling constants with dihedral angles. Simplification of complex spectra: isotopic substitution, increasing magnetic field strength, double resonance, spin decoupling, constant shift reagents, solvent effect, Fourier-transfer technique, variable temperature profile, nuclear overhauser effect (NOE).

### Unit III

Mass spectrometry: Principles, instrumentation, different methods of ionization, EI, CI, FD and FAB, ion separators: single focusing separator with magnetic diffraction, focusing analyzer, time-of-flight separator and quadrupole analyzer. Mass spectra: molecular ion, base peak, meta-stable peak, nitrogen rule and McLafferty rearrangement. Mass spectral fragmentation of organic compounds and common functional groups: normal and branched alkanes, alkenes, cycloalkanes, benzene and its derivatives, alcohols, phenols, aldehydes and ketones, carboxylic acids, and their derivatives, amines, nitrocompounds. Determination of molecular formula by accurate molecular weight and isotopic abundance methods. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination. LC-MS, LC-MS/MS, GC-MS: Principles and applications

Composite problems involving the applications of UV, IR, and  $^1\text{H}$  -NMR and mass spectroscopic techniques. **12 hours**

### UNIT – IV

**Electron Spin Resonance Spectroscopy:** Basic principles, hyperfine couplings, the 'g' values, factors affecting 'g' values, isotropic and anisotropic hyperfine coupling constants, Zero Field splitting and Kramer's degeneracy. Measurement techniques and Applications to simple inorganic and organic free radicals and to inorganic complexes.

**Mössbauer spectroscopy:** The Mössbauer effect, chemical isomer shifts, quadrupole interactions, measurement techniques and spectrum display, application to the study of  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$  compounds,  $\text{Sn}^{2+}$  and  $\text{Sn}^{4+}$  compounds (nature of M-L bond, coordination number and structure), detection of oxidation states and inequivalent Mössbauer atoms.

**Photoelectron spectroscopy (PES):** Brief theory, principle of working, instrumentation and data acquisition analysis. **12 hours**

### REFERENCES:

1. Organic Spectroscopy-3rd Ed.-W.Kemp(Paggrave Publishers, New York), 1991.
2. Spectrometric Identification of Organic Compounds - Silverstein,Bassler & Monnill (Wiley) 1981.
3. Spectroscopy of Organic Compounds-3rd Ed.-P.S.Kalsi (New Age, New Delhi) 2000.
4. E.A.V.Ebsworth, D.W.H.Ranklin and S.Cradock: Structural Methods in Inorganic Chemistry, Blackwell Scientific, 1991.
5. J. A. Iggo: NMR Spectroscopy in Inorganic Chemistry, Oxford University Press, 1999.
6. C. N. R .Rao and J. R. Ferraro: Spectroscopy in Inorganic Chemistry, Vol I & II (Academic) 1970
7. Spectroscopy, B. P. Straughan and S. Salker, John Wiley and Sons Inc., New Yourk, Vol.2, 1976.
8. Application of Absorption Spectroscopy of Organic Compounds, John R. Dyer, Prentice/Hall of India Private Limited, New Delhi, 1974.
9. Organic Spectroscopy, V. R. Dani, Tata McGraw-Hall Publishing Company Limited, New Delhi. 1995.

10. Interpretation of Carbon-13 NMR Spectra, F.W. Wehrli and T. Wirthin, Heyden, London, 1976.
11. NMR spectroscopy-Powai

## **MSS-4 : NANO SCALE DEVICES**

### **Course Outcome**

- Learn about applications of nano scale devices in field of fabrication of nanostructures and lithographic techniques.

### **Course Content**

#### **Unit - I Processing**

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

**12 hours**

#### **Unit -II Fabrication**

Thermal manufacturing - Rapid Thermal Processing and beyond: Applications in Semiconductor Processing of Complimentary Metal Oxide Semiconductor. Memory devices

– Volatile and Non-volatile memory. The material challenge of Ultra thin body (UTB) - metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) for technology. Insulated-gate field-effect transistor (IGFET). 3D inter-connect technology.

**12 hours**

#### **Unit -III Lithographic techniques**

Top down approach to nanolithography-Immersion lithography- Optical lithography, UVphotolithography- Phase lithography- Including Plasma X-ray sources- E-Beam Lithography-Focused Ion beams- Photoresist. Soft lithography for nanofilms and nanoscale patterning. Lithographic techniques and surface chemistry for the fabrication of PEG-passivated protein microarrays.

**12 hours**

#### **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, Nanoflowers, and Nanodots. Invention jet prints nanostructures with self-assembling material. Surfaces, Interfaces and Thin films. Fabrication of nanostructures using polymer brushes. Top down fabrication of nanostructures. Template assisted nanostructure growth. Nanostructured Films on Silicon Surfaces, Deposition, Characterization and Application of Nanocrystalline Diamond Films, Boron Nitride films.

**12 hours**

## 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
- 5) R. Kassing, P. Petkov, W. Kulish, C. Popov., *Functional Properties of Nanostructured Materials*. Springer (ISBN: 978-1-4020-4595-0 (Print) 978-1-4020-4594-3 (Online))

## MSS-5 : NANOCHEMISTRY

### Course Outcome

Students will be able to understand the technology of nano materials in various fields such as Solar energy harvesting, supra molecular machines and photolithography.

### Course Content

#### *Unit-I Fundamentals of molecular self-assembly*

The nanoscale and colloidal systems-Fundamentals of Surface and interfacial chemistry-Surface 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.

**12 hours**

#### *Unit-II Nanomaterials*

Defining nanodimensional materials-Size 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 methods available for the synthesis of nanomaterials-Manipulation of Nanoparticles-Nanofabrication-Methods- Bottom up methods- Photolithography-Scanning probe methods-Soft lithography

**12 hours**

#### *Unit-III Dendrimers and their applications*

PPI and PAMAM dendrimers, Synthesis-Generation 1 and Generation 2, Application in Drug targeting

**12 hours**

#### ***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 functionalised Gold Nanocores and their application in cancer therapy.

**12 hours**

#### **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**

##### **Course Outcome**

Learn about the morphology of different types of carbon nano tubes and their production techniques. In addition to that understand the electro chemical properties, functionalization of nano tubes and applications of nano tubes.

##### **Course Content**

##### ***Unit-I Introduction and Morphology***

Carbon allotropes , Fullerenes, Discovery of carbon nanotubes, Single and double walled carbon nanotubes, Bundled Nanotubes. The structure of carbon nanotubes: From a Graphene Sheet to a Nanotube - Archiral and Chiral Nanotubes, theoretical discussion, experimental studies, ZigZag and Armchair Nanotubes - Eulers Theorem in Cylindrical and Defective Nanotubes.

**12 Hours**

##### ***Unit-II Production Techniques of Nanotubes***

Carbon nanotube production: Arc discharge, Laser ablation, Chemical vapour deposition, Hydrothermal, Miscellaneous synthesis methods. Growth mechanism of Multi/Singlewalled nanotubes by arc discharge and Chemical vapour deposition method. Role of Metal Catalyst, High- Pressure CO Conversion (HIPCO), Experimental Puzzles of MWNT - Aspect Ratio-Perfection-chemical inertness. Purification and processing of MWCNTs and SWCNTs, separation of metallic and semiconducting SWCNTs.

**12 Hours**

### ***Unit- III Electrochemical properties and functionalization of Nanotubes***

Electronic properties of SWCNTs, Electrode potentials versus work functions, electrochemistry of Carbon nanotubes, cyclic voltammetric investigations of SWCNTs, Standard redox potentials of SWCNTs. Physical properties: theoretical and experimental predictions of mechanical properties, optical properties of nanotubes, raman spectroscopy. Covalent functionalization: Chemical functionalization, Defect group functionalization, Direct sidewall functionalization. Noncovalent functionalization: with small aromatic molecules, heterocyclic polyaromatic systems, polymers, surfactants and ionic liquids.

**12 Hours**

### ***Unit-IV Applications of Nanotubes***

Catalytic: Macroscopic shaping of CNTs, specific metal support interaction, dispersion of the active phase, electrically and thermally conductive supports. Biomedicine: cell penetration, drug delivery, gene delivery, anticancer approaches, antioxidants properties, toxicity. Probes and Sensors: nanotube tips for atomic force microscopy, gas sensors, biosensors, physical sensors. Containers: mechanisms of nanotube filling, fullerene C<sub>60</sub>, higher fullerenes, endohedral fullerenes, functionalized fullerenes, molecules without metal atoms, organometallic and coordination compounds, oxides and hydroxides, inorganic materials. Effect of Doping on conductivity - Harnessing Field Enhancement - Flat Panel Displays

**12 hours**

### **References**

1. Dirk M. Guldi and Nazario Martin, Carbon nanotubes and related structures
2. Peter J. F. Harris, Carbon nanotube science.
3. M.Endo, S.Iijima, M.S. Dresselhaus, Carbon Nanotubes, Pergamon; 1st Edition (December 1st 1996), ISBN-10: 0080426824
4. 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 : MATERIALS FOR AEROSPACE APPLICATIONS**

### **Course Outcome**

Understand the applications of materials in the most emerging field such as aerospace and describes manufacturing and applications of fibre-polymer in the field of aerospace.

### **Course Content**

#### ***Unit I: Introduction to aerospace materials***

The importance of aerospace materials, understanding aerospace materials, the main types of polymer based aerospace materials, advantages of polymer based materials, High performance like light weight and other important properties of materials for aerospace applications including modified structures on nano-scale materials

**12 hours**

#### ***Unit II: Polymers for aerospace structures***

Aerospace applications of polymers, advantages and disadvantages of polymers for aerospace applications, Polymerization routes, Thermoset, Thermoplastics and elastomers, Structural adhesives, Mechanical properties, Polymer additives, Polymers for radar absorbing materials, Fracture toughness properties, Ductile/brittle fracture transition for polymers, Improving the fracture toughness of aerospace materials

**12 hours**

#### ***Unit III: Manufacturing of fibre-polymer composite materials***

Fibre reinforcements for composites, Production of prepregs and fabrics ,Core materials for sandwich composites, Composites manufacturing using prepregs, Composites manufacturing by resin infusion, Machining of composites , Damage mechanics of composites. Fracture processes, Stress concentration effects in materials, Fracture mechanics, Application of fracture mechanics to aerospace materials

**12 hours**

#### ***Unit IV: Fibre-polymer composites for aerospace structures and engines***

Types of composite materials, Aerospace applications of fibre-polymer composites, Advantages and problems with using fibre-polymer composites, Mechanics of continuous fibre composites, Sandwich composites, Environmental durability of composites Fatigue stress, Fatigue life (S-N) curves, Fatigue crack growth curves, Fatigue of fibre-polymer composites, Creep behaviour of materials, Creep of polymers and polymer composites, Designing Creep resistant materials.

### **References:**

1. Mechanics of Fibrous Composites, C.T. Herakovich, John Wiley & Sons, Inc., New York, 1998



2. Analysis and Performance of Fibre Composites, B.D. Agarwal and L.J. Broutman, John Wiley & Sons, Inc. New York.
3. Fundamentals of Modern Manufacturing, Materials, Processing, and Systems, 2 edition, Mikell P. Grover, John Wiley & Sons, inc
4. Structure and properties of engineering materials, fifth edition, Henkel and Pense, McGraw Hill, 2002
5. Mechanical Testing of Advanced Fibre Composites, J.M. Hodgkinson, Woodhead Publishing Limited, Cambridge, 2000.
6. ASTM standards.

## **MSS-8 : COMPOSITE MATERIALS**

### **Course Outcome**

Understand the synthesis of different types of material composites and nano composites and their applications in the field of Aerospace, transport, marine, structural, electrical, electronic and biomedical applications

### **Course Content**

**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. **12 hours**

**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. **12 hours**

**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. **12 hours**

**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.

**12 hours**

## **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**

### **Course Outcome .**

To develop an understanding of the unique properties and characteristics of polymer based materials and gives an outline about the cell structures.

### **Course Content**

#### ***Unit-I: Basic Polymer Science***

Basic concepts: Classification of Polymers, Nomenclature of Polymers, 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, condensation including co-ordination, cationic, anionic, Ring opening Redox polymerization, Living Radical polymerization-Atom transfer radical polymerization.

**12 hours**

#### ***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, Bulk, solution, precipitation polymerization, Suspensions, emulsion, melt polycondensation, Criteria of polymer solubility, solubility parameter, thermodynamics and phase equilibria of polymer solution, Fractionation of polymers by solubility.

**12 hours**

#### ***Unit-III: Cell Structure***

Origin and overview of cells, prokaryotic and eukaryotic cells, subcellular organelles, cells as experimental models, Chemistry of cells, molecular composition. Enzymes as biological catalysts. Metabolic energy, Biosynthesis of cell constituents.

Bio energetics and metabolism, cytoskeleton and cell movement, Cell signalling, Cell cycle, Cancer cells.

**12 hours**

***Unit-IV: Central Dogma of Life:*** Flow of genetic information, RNA and DNA as genetic materials. Organization and sequence of cellular genomes, DNA replication, RNA synthesis and Processing, Protein synthesis and processing protein sorting and transport. Recombinant DNA, detection of nucleic acids and proteins.

**12 hours**

### **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 : METALS AND ALLOYS

### Course Outcome

Gained a broad perspective on crystal defects in metals, solidification of binary alloys and applications of physical metallurgy in the field of strength Vs toughness, thermo mechanical processing, micro alloyed steel manufacturing, manufacture of super alloy and control of texture.

### Course Content

**Unit- I Crystal defects in metals:** Vacancy, interstitial, substitutional, free energy of mixing, dislocation (elementary concepts only), edge / screw dislocation, partial dislocation, stacking fault, dislocation lock, dislocation pile up, Hall Petch relation, grain boundary structure. **Diffusion:** Elementary concepts of phenomenological & atomistic approaches.

**12 hours**

**Unit-II Solidification of binary alloys:** Limits of solubility, isomorphous system, lever rule, constitutional super cooling, effect of non equilibrium cooling, eutectic, peritectic, eutectoid & peritectoid system, complex phase diagram, ternary diagram, composition triangle, ternary eutectic, vertical & horizontal sections, structure of cast metal, segregation & porosity, iron-carbon diagram, steel & cast iron. **Binary phase diagrams of common commercial alloys:** Cu-Ni, Au-Cu, Ni-Cr, Al-Si, Al-Zn, Al-Ag, Pb-Sn, Cu-Zn, Cu-Sn, Cu-Al, Ti-Al, Ti-V: interpretation of microstructure & properties.

**12 hours**

**Unit-III Cold working & Annealing:** Recovery, recrystallization & grain growth, phenomenological & mechanistic approaches. **Precipitation from super-saturated terminal solid solution:** Thermodynamics & kinetics of precipitation, precipitation hardening. **Heat treatment of steel:** T-T-T diagram, Pearlitic, Martensitic & Bainitic transformation, effect of alloy elements on phase diagram & TTT diagram, CCT diagram, Annealing, normalizing, hardening & tempering, hardenability.

**12 hours**

**Unit-IV Application of physical metallurgy:** Strengthening mechanism, strength vs. toughness (ductility), thermo mechanical processing, micro alloyed steel, ultra high strength steel, superalloy, control of texture.

**12 hours**

### References:

1. Textbook of Polymer science-Fred-w billmeyers, J. R. John wiley & son Newyork(1990)
2. Polymer Science – V.R. Gowarikar, N.V. Vishwanathan, Jayadev Shreedhar Wiley Eastern Ltd. New Dehli, India(1986)
3. Analysis of polymers – an introduction – T.R. Crompton. Smithers Rapra Technology Pvt Ltd., SY4 4NR, UK, 2008

4. Experimental methods in polymer chemistry – J.F. Rabek. John Wiley and Sons NY(1980)
5. Polymer Science, P.L. Nayak, Kalyani publishers, New Dehli.(2005)
6. Analysis and Characterisation of Polymers – Sukumar Maiti, Ansandhan Prakashan, Midnapur, India.(1978)

## **MSS-11 : NANO-BIOTECHNOLOGY IN HEALTH CARE**

### **Course Outcome**

- Describe the biocompatible nano-particles synthesis and their uses as nano biosensors and ultra sensitive diagnostics
- Understand the techniques involved in nano particles application in diagnostics.
- Understand the nano particles for optical imaging of cancer, nano gold in cancer therapy and diagnosis.

### **Course Content**

#### **Unit-I**

Introduction on biocompatible nano-particles (Gold, silver, zinc, carbon, graphene and quantum dots), synthesis and applications. Nano-biosensors and Lab-on-chip devices for ultrasensitive diagnostics: Amperometric, potentiometric and potentiometric and flurometric biosensors (glucose biosensors, enzyme biosensors, screen printed electrodes). Affordables diagnostics. **12 hours**

#### **Unit-II**

Techniques involved in Nanoparticles application in diagnostics and characterization: Fluorescence resonance energy transfer (FRET), Surface energy transfer (SET), Raman light scattering, Surface Plasmon Resonance (SPR), Transmission electron microscopy, Scanning electron microscopy Atomic force microscopy, confocal microscopy, scanning tunneling microscopy, fluorescence spectroscopy. **12hours**

#### **Unit-III**

Micro-array (DNA and Protein array)-concepts and advantages of Microfluidic devices, Materials for manufacture of microfluidic devices, (Silicon and PDMS). Nanoparticles for Optical Imaging of Cancer, Nanogold in Cancer Therapy and Diagnosis, Nanotubes, Nanowires, Nanocantilevers and Nanorods in Cancer Treatment and Diagnosis. Carbon Nanotubes in Cancer Therapy and Diagnosis. **12hours**

#### **Unit-IV**

Introduction, Liposomes, dendrimers, Layer by layer deposition, self-assembled monolayers, In-vivo imaging. Nanobiotechnology for food health and environment. **12hours**

**References:**

1. From Bioimaging to Biosensors – Noble Metal Nanoparticles in Biodetection, by Lai-kwan Chau (National Chung Cheng University, Taiwan), Huan-Tsung Chang (National Taiwan University, Taiwan)
2. Advances in Biosensors, Volume 1, Volume 1, Reinhard Renneberg and A.P.F. Tuner, 1991.
3. Nanoparticles and Biophotonics as Efficient Tools in Resonance Energy Transfer-Based Biosensing for Monitoring Food Toxins and Pesticides, M. S. Thakur, Rajeev Ranjan, Aaydha C. Vinayaka, Kunhitlu S. Abhijith, and Richa Sharma. Advances in Applied Nanotechnology for Agriculture, Chapter 4, 2013, pp 55-84, ACS Symposium Series, Volume 1143.
4. Nanomaterials for Cancer Diagnosis, Challa S. S. R. Kumar (Editor), ISBN: 978-3-527-31387-7, 448 pages, January 2007.
5. Microarray Technology and Its Applications, Uwe R. Muller, Dan V. Nicolau, Springer, 30-Mar-2006- Technology and Engineering.
6. Nanoparticulates as Drug Carriers edited by Vladimir P Torchilin (Northeastern University, USA), 2006, Imperial college press.

## **MSS-12 : NANO-PHOTONICS**

### **Course Outcome**

Describes an outline about quantum confined materials, plasmonics and new approaches in nano photonics and bio photonics.

### **Course Content**

#### ***Unit-I: Quantum confined materials***

Quantum dots - Optical transitions absorption - interband transitions - quantum confinement - intraband transitions fluorescence/luminescence - photoluminescence/fluorescence optically excited emission electroluminescence emission. **12 hours**

#### ***Unit-II: Plasmonics***

Internal reflection and evanescent waves - plasmons and surface plasmon resonance - Attenuated Total reflection - Grating SPR coupling - Optical waveguide SPR coupling - SPR dependencies and materials - plasmonics and nanoparticles. **12 hours**

#### ***Unit-III: New Approaches in Nanophotonics***

Near field optics - Aperture less near field optics - near field scanning optical microscopy (NSOM or SNOM) - SNOM based detection of plasmonic energy transport - SNOM based visualization of waveguide structures - SNOM in nanolithography - SNOM based optical data storage and recovery. **12 hours**

#### ***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. **12 hours**

### **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, New York 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 MODELLING OF SYSTEMS**

### **Course Outcome**

Describes the kinetics of crystallization, study of thermodynamic equilibrium and basic concepts of thermodynamic modelling.

### **Course Content**

#### ***Unit-I***

Entropy as a measure of unavailable energy. Entropy change during spontaneous process. Helmholtz and Gibbs free energies. Thermodynamic criteria of equilibrium and spontaneity. Variation of free energy with temperature and pressure. Maxwell's relations, Van't Hoff's reaction isotherm and isochore, Gibbs-Helmholtz equation. Determination of free energy changes. Nernst heat theorem and Third law of thermodynamics-calculation of absolute entropies. Concepts of thermodynamics. Partial molar volume and its determination by density measurements. Order of reaction and determination. Energy activation and its determination. Assumptions of activated complex theory. Fast reactions with examples. Polymers and their classification

**12 hours**

#### ***Unit-II***

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

**12 hours**

#### ***Unit-III***

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.

**12 hours**

#### ***Unit-IV***

Thermodynamic modeling basic concept. Thermodynamic variables. Equation of state for predicting partial molar 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.

**12 hours**

### **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. Jrgen Gmehling, Brbel Kolbe, Michael Kleiber, Jrgen Rarey, Chemical Thermodynamics: For Process Simulation, John Wiley & Sons (2012). Advanced Course on Thermodynamic Models: Fundamentals & Computational Aspects, www.cere.dtu.dk, Department of Chemical and Biochemical Engineering - Sltofts Plads - Building 229 - DK2800 Kgs. Lyngby.

## **MSS-14 : BASICS OF ENGINEERING DRAWING AND GRAPHICS**

### **Course Outcome**

- It gives extensive knowledge about the principle and applications of graphic technology.
- Describes hard ware and software display technology.

### **Course Content**

#### ***Unit I : Principles of Graphics***

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.

**12 hours**

#### ***Unit II: Orthographic Projections***

Projections of points, straight line and planes - ' Auxiliary projections '- Projection and sectioning of solids -Intersection of surfaces - Development of surfaces.

**12 hours**

#### ***Unit III: Pictorial Projections***

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.

**12 hours**

#### ***Unit IV: Computer Graphics***

Hardware - Display technology - Software - Introduction to drafting software

**12 hours**

### **References**

1. Narayanan, K.L., and Kannaiah, P., " Engineering Graphics ", Tata McGraw-Hill Publishers Co., Ltd., 1992.
2. William M. Neumann and Robert F.Sproul, " Principles of Computer Graphics ",McGraw Hill, 1989.

4. Warren J. Luzzadder and John M. Duff, " Fundamentals of Engineering Drawing ",Prentice-Hall of India Private Ltd., Eastern Economy Edition, 1995.
5. Natarajan K.V., " A Text Book of Engineering Drawing ", Private Publication, Madras, 1990.
6. Mathur, M.L. and Vaishwanar, R.S., " Engineering Drawing and Graphics ", Jain Brothers,New Delhi, 1993.

**Note:**

1. 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**

### **Course Outcome**

- Describes an understanding of definition, scope, bonding, structure of ceramics and study of polymorphism in ceramics.
- Gives an elementary idea of manufacturing process technology and developments of ceramics
- Gives an idea about the raw material used in the different types of ceramics

### **Course Content**

#### **Unit I**

Ceramics: Definition, scope, bonding and structure, crystal structure, defects, polymorphism, ceramics as a class of material, variations within ceramics; defect structures; chronological developments, structure of silicates; polymorphic transformations, raw materials.

#### **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.

**12 hours**

### ***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.

**12 hours**

### ***Unit-IV***

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

**12 hours**

### **References**

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)
6. Richerson D. W., 'Modern Ceramic Engineering - Properties Processing and Use in Design, 3rd Edition, CRC Press, 2006
7. Chiang Y.M., Birnie D. P., Kingery W.D., Physical Ceramics: Principles for Ceramic Science and Engineering, John Wiley, 1997
8. James E. Shelby., 'Introduction to Glass Science and Technology' 2nd Edition, The Royal Society of Chemistry Publications, 2005

## **MSS-16 : MATERIALS FOR RENEWABLE ENERGY AND STORAGE**

### **Course Outcome**

- Describes the materials are used as sustainable energy economy and use of materials as high performance renewable energy production, storage, conversion and usage.
- Describes materials for solar photo voltaic cells, materials for concentrated solar power and materials in fuel cells.

### **Course Content**

#### **Unit I**

Ceramics: Definition, scope, bonding and structure, crystal structure, defects, polymorphism, ceramics as a class of material, variations within ceramics; defect structures; chronological developments, structure of silicates; polymorphic transformations, raw materials.

#### **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.

**12 hours**

#### **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.

**12 hours**

### **References**

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)
6. Richerson D. W., 'Modern Ceramic Engineering - Properties Processing and Use in Design, 3rd Edition, CRC Press, 2006
7. Chiang Y.M., Birnie D. P., Kingery W.D., Physical Ceramics: Principles for Ceramic Science and Engineering, John Wiley, 1997
8. James E. Shelby., 'Introduction to Glass Science and Technology' 2nd Edition, The Royal Society of Chemistry Publications, 2005

## **MSS-17 : BASICS OF NANOTECHNOLOGY**

### **Course Outcome**

Gives basic idea about the nanotechnology, nano material synthesis and characterization of nano materials using different types of techniques includes X-rays, IR, UV-Vis, Laser Raman, photoluminescence, electron microscopic techniques, thermal analysis and light scattering methods.

### **Course Content**

#### ***Unit-I***

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, super ionic, magnetic, optic, opto-electronic, spintronics, lasers, photonics, ceramics, bio ceramics, biomedical, biosensors, bio imagers, photocatalysts, quantum dots. **12 hours**

#### ***Unit-II***

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. **12 hours**

#### ***Unit-III***

Nanomaterials synthesis techniques nanoengineering of materials. Bottom up and Top down routes. Solution, Melt and Gas Processing of nanomaterials. Nature inspired processes. **12 hours**

#### ***Unit-IV***

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. **12 hours**

## 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-18 : ENTERPRISE ARCHITECTURE

### Course Outcome

- To know the basic idea about Enterprise architecture related to the engineering discipline and also knows the growing enterprise opportunities.
- To know the use of enterprise architecture by industry, healthcare, banking and finance, manufacturing, government and government departments.

### Course Content

#### *Unit I:*

1. What is Enterprise Architecture?
2. History of Architecture in the context of engineering discipline
3. History of Enterprise Architecture
4. Why Enterprise Architecture?
5. What are the various Enterprise Architecture Frameworks?
6. Why Zachman Framework an Ontology?

#### *Unit II:*

1. Growing enterprise opportunities
2. Enterprise Disorders & limitations of current approach
3. Zachman Framework & Primitive Models
4. Sample – Strategy Primitive model
5. Sample – Business process primitive models
6. Busting biggest myth about Enterprise Architecture
7. Summary

***Unit III:***

1. Case study1 Sample Problem–Application Rationalization arising out of Acquisition & Merger
2. Identify the cells responsible for the problem
3. Identify the primitives for each cell
4. Creating the composite models – 11 departments
5. Sample – Finance Department models, composites, relationship matrix, performance indicators
6. Composite Models & Traceability
7. Relationship Matrix, GAP Analysis & Application Maturity Index
8. Current status of Baseline Architecture v1.0
9. Timeline, Effort, Cost Estimations & Benefits

***Unit IV:***

1. Sample case 2 : Which cells are key to define the Disaster Recovery Plan
2. Sample case 3 - HR: Resource Request Process
3. Visual diagnosis for effective enterprise treatment
4. Use of Enterprise Architecture by Governments and Government Departments
5. Use of Enterprise Architecture in Telecom Industry
6. Use of Enterprise Architecture in Healthcare
7. Use of Enterprise Architecture in Banking & Finance
8. Use of Enterprise Architecture in Manufacturing

How to use Enterprise Architecture in managing Universities & Colleges



## **MSS-19 : CHEMICAL ENGINEERING**

### **Course Outcome**

- To study the units and Dimensions and dimension analysis
- To study the reaction engineering includes reaction kinetics, order of reaction, reactor design, Batch, fed batch and continuous reactors and also know about process controllers, basics of flow sheet, material Balance, material economics and safety analysis.

### **Course Content**

#### ***Unit I:***

Introduction, concepts of Unit operation and Unit Processes, Units and Dimensions, Dimensional Analysis.

**12 hours**

#### ***Unit II:***

Mass Transfer: Molecular and convective mass transfer, mass transfer equations. Heat Transfer: Heat transfer by conduction, convection and radiation, heat transfer equations, Heat exchangers. Momentum Transfer: Fluid flow, pipes and tubes, fittings, valves and pumps, measurement of pressure and flow.

**12 Hours**

#### ***Unit III:***

Size reduction, size separation, sedimentation, centrifugation, filtration, crystallization, Extraction, drying, evaporation, distillation. Sedimentation, Centrifugation, filtration, extraction, drying, evaporation, (Adsorption and partition) Techniques, Column thin layer and paper chromatography and their application. Criteria of purity-Melting and Boiling point. Surface tension, Viscosity.

**12 hours**

#### ***Unit IV:***

Reaction Engineering: Reaction kinetics, order of reaction, Batch, fed batch and continuous reactors, reactor design. Process Control: Proportional, integral, derivative and PID controllers, stability of controllers. Basics of Flow sheet, material balance, materials economics, safety analysis.

**12 hours**

### **References**

1. Badger Walter, L. and Banchero Julis, T., Introduction to Chemical Engineering, Tata McGraw Hill Pub. 1997.
2. McCabe, W.L., Smith, J.C. and Harriot, H.P., Unit Operations in Chemical Engineering, Mc Graw Hill, 2009
3. Jonson, C.D., Process Control and Instrumentation Technology, Prentic Hall India, 2003
4. Peters, Max S., and Timmerhaus, Klauss D., Plant Design and Economics for Chemical Engineers, Mc Graw Hill, 1991

## **MSS-20 : ADVANCED X-RAY DIFFRACTION STUDIES**

### **Course Outcome**

Describes crystallographic studies by using advanced X-ray diffraction method and includes study of single crystal methods and applications of Debye functions to amorphous structures and nano-composites.

### **Course Content**

#### ***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.: **12 hours**

#### ***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": **12 hours**

#### ***UNIT-III***

Debye 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). **12 hours**

#### ***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). **12 hours**

### **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)

## **MSS-21 : ANALYTICAL AND INORGANIC CHEMISTRY**

### **Course Outcome**

- Learn about the Photo degradation of materials and effect of photodegradation on chemical oxygen demand.
- Describes the role of physical chemistry for the study of phase rule, concepts of entropy, order of reaction and molecular symmetry.
- Describes the industrial application of natural and synthetic materials.

### **Course Content**

#### ***Unit I: Statistical Treatment of Analytical Data:***

Limitations of analytical methods. Classification of errors:- Systematic errors- Sources, effects and their reduction. Random errors - Sources and distribution. Accuracy and precision. Fundamentals of chromatography: General description- Definition, terms and parameters used in chromatography (RF- value, retention volume and time). Ion-exchange chromatography (ICH), The synthesis of novel cation (Amberlite TR-1204) and anion exchange resin materials and its application in ion exchange chromatographic separation of the components from the reaction mixture. Potentiometry and conductometry: Theory, principle of working and few applications. Ionic bond and covalent bond: Properties of ionic substances, structure of ionic crystals, Hybridization, VSEPR concept to explaining the structure of simple molecules of materials.

**12 hours**

#### ***Unit II: Physical Chemistry***

##### **Application of physical chemistry**

Application of phase rule to two and three component systems. Concepts of entropy and free energy. Partial molar volume and its determination by density measurements. Symmetry elements and symmetry operations with examples of simple molecule materials. X-ray diffraction, Bragg equation and Miller indices. Order of a reaction and its determination. Energy of activation and its determination. Assumption of activated complex theory. Fast reactions with examples, polymers and their classification. Arrhenius theory of strong and weak electrolytes. Corrosion and its prevention. Law of photochemistry. Quantum yield and its determination.

**12 hours**

#### ***Unit III:***

Photodegradation of materials, Photocatalyst- ZnO, TiO<sub>2</sub>, principle of photocatalyst, application of ZnO, TiO<sub>2</sub> in the photo degradation of various types, pesticides and in industrial effluents. Effect of photodegradation on chemical oxygen demand in drinking water and in industrial waste water. Photophysical properties of materials; Theory, instrumentation, and applications of fluorescence, characteristic of fluorescence,

resonance fluorescence, sensitized fluorescence, quenching of fluorescence. Theory, principle, and applications of phosphorescence.

**12 hours**

***Unit IV: Organic Chemistry***

Importance of natural products and synthetic products of organic origin materials in industry, pharmaceutical, petroleum refinery and agricultural fields. Uses of Dyes, polymers (plastics) soaps and detergents in industry, drugs and cosmetics in pharmaceutical industries, waxes, coal tar from petroleum industry and pesticides, (insecticides, pesticides, herbicides, fumigacide etc.)

**12 hours**

**References:**

- 1) Quantitative analysis. R.A.DAY and A.L. Underwood 6<sup>th</sup> edition prentice hall, Inc1999
- 2) Principle of Instrumental analysis, D.A.skoog, F.J.Holler and T.A.Nieman, 5<sup>th</sup> edition. Thomson Asia pvt.Ltd. Singapore 1998
- 3) Analytical chemistry. G.D. Christian 5<sup>th</sup> edition 2001, John-wiley and sons Inc. India
- 4) Chemical kinetics. K.J. Laidler
- 5) Chemical kinetics. Moore and Pearson
- 6) Kinetics and Mechanism of Chemical Transformation by J. Rajaram and J.C. Kuriacose.
- 7) Advances in Photochemistry - Rohatgi Mukherjee
- 8) Principle and applications of Photochemistry – R.P. Wayne, Elsevier, New York, (1970).
- 9) Elements of physical chemistry – Glass Stone and Lewis
- 10) Encyclopedia of chemical technology – Kirk-Othmer series
- 11) Inorganic chemistry – J.E. Huheey
- 12) Chemical Kinetics – L.K. Jain.
- 13) Physical chemistry by P.W. Atkins, ELBS, 4<sup>th</sup> edition, Oxford University press (1990).

## **MSS-22 : SEMICONDUCTOR OPTOELECTRONICS**

### **Course Outcome**

- Describe the overview on semiconductors, semiconductors optoelectronic materials, band gap modification, heterostructures and quantum wells.
- Learn about the interaction of photons with electrons and holes in a semiconductor
- Describe the types of photo detectors, photoconductors, phototransistors, solar cells, and CCDs.

### **Course Content**

#### ***Unit-I: Review of Semiconductor Device Physics:***

Energy bands on solids, the E-k diagram, Density of states, Occupation probability, Fermi level and quasi Fermi levels, p-n junctions, Schottky junction and Ohmic contacts. Semiconductor optoelectronic materials, Bandgap modification, Heterostructures and Quantum Wells.

**12 hours**

#### ***Unit –II: Interaction of photons with electrons and holes in a semiconductor:***

Rates of emission and absorption, Condition for amplification by stimulated emission, the laser amplifier. Semiconductor Optical Amplifiers & Modulators: Semiconductor optical amplifiers (SOA), SOA characteristics and some applications, Quantum-confined Stark Effect and Electro-Absorption Modulators.

12 hours

#### ***Unit –III: Semiconductor Photon Sources:***

Electroluminescence. The LED: Device structure, materials and characteristics. The Semiconductor Laser: Basic structure, theory and device characteristics; direct modulation. Quantum-well laser; DFB-, DBR- and vertical-cavity surface-emitting lasers (VCSEL); Laser diode arrays. Device packages and handling.

**12 hours**

#### ***Unit-IV: Semiconductor Photodetectors:***

Types of photodetectors, Photoconductors, Single junction under illumination: photon and carrier-loss mechanisms, Noise in photodetection; Photodiodes, PIN diodes and APDs: structure, materials, characteristics, and device performance. Photo-transistors, solar cells, and CCDs. Optoelectronic integrated circuits – OEICs.

**12 hours**

### **Reference**

1. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2<sup>nd</sup> Ed. (2007), Ch.16, 17, and 18.
2. P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
3. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995)
4. G. Keiser, Optical Fiber Communications, McGraw-Hill Inc., 3<sup>rd</sup> Ed. (2000), Ch.4,6.
5. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, Oxford University Press, New York (2007), 6<sup>th</sup> Ed. Ch.15-17.
6. J. M. Senior, Optical Fiber Communication: Principles and Practice.

# Syllabus - Ph.D in Materials Science

## Modalities for the Assessment of Marks for Ph.D. Course Work

### Paper 1 : Research Methodology and Advanced Materials Science

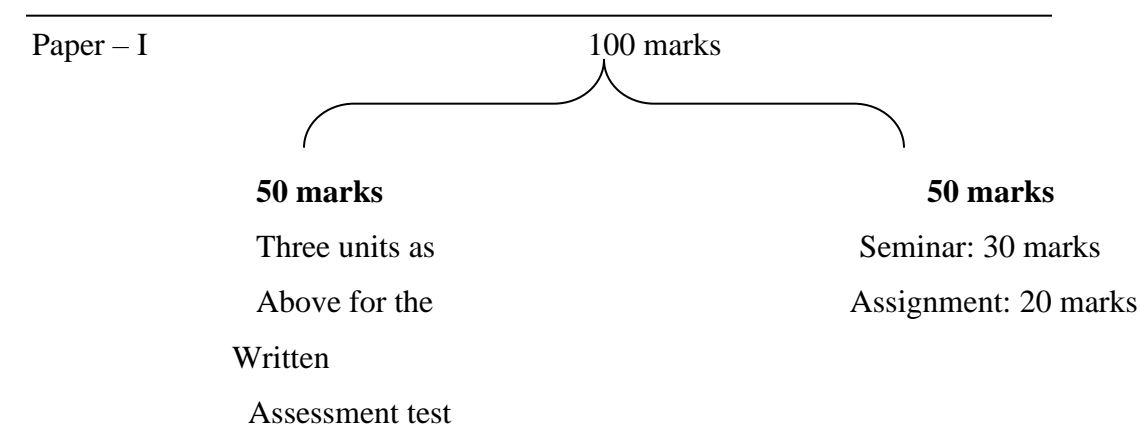
In Paper – I, there will be three units of 16 hours each. The units are as follows:

**Unit-I:** Research Methodology

**Unit-II :** Advanced Materials Science

**Unit-III:** Materials characterization Techniques – Giving equal importance for all the branches of Science where materials are involved i.e., Physics, Chemistry and Biology

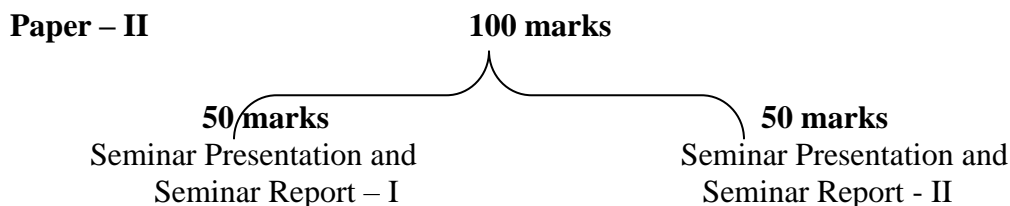
The units will be taught by the faculty members of the department. A student has to study all the three units during the course and appear for the written assessment test for 50 marks conducted by the Directorate of Research. The remaining 50 marks is distributed as follows: A student has to present one seminar and submit one assignment during the course work as far as the Paper I is concerned. SEMINAR WILL BE ASSESSED FOR 30 marks which will be of 30 minutes duration. Assignment will be given by all the teachers who are engaged in teaching the course work. Further, at the end of the course work average marks will be taken for seminar and assignments/ separately.



## **Paper 2: Review of Literature in the Area of Research**

In Paper – II, a student has to present two seminars (I & II), one during 8<sup>th</sup> week and another during 15<sup>th</sup> week of the course. In seminars I, a student has to highlight his/her broad area of the research work and in seminar II the review of literature, objectives etc should be given. It is stated in the letter No: UOM/DOR/5Ph.D/2011-12 dated 26/08/2011 ( (d) on page 2) that Department Council shall assess the students for paper – II in the area of research paper. Doctoral Committee members (Guide, Chairman of the department and two senior faculty members) shall assess the same.

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### **UNIT I:**

#### **RESEARCH METHODOLOGY**

**INTRODUCTION** :Definition of Research, Qualities of Researcher, Components of Research problem, Various Steps in Scientific Research : Hypotheses, Research Purposes, Research Design, Literature searching

**DESIGN AND PLANNING OF EXPERIMENTS, TIME SCHEDULING** : Aims and Objectives, Expected outcome, Methodology to be adapted, planning of experiments for achieving the aims and objectives, Importance of reproducibility of research work.

**DATA COLLECTION** : Sources of Data : Primary Data, Secondary Data; Sampling Merits and Demerits of Experiments, Procedure and Control Observation, sampling errors – Type-I Error – Type-IIError.

**STATISTICAL ANALYSIS AND FITTING OF DATA** : Introduction to Statistics – Probability, Estimates of Means and Properties; Chi – Square Test, Association of Attributes –t-Test –Standard deviation – Co-efficient of variations. Correlation and Regression Analysis. Introduction to statistical packages, plotting of graphs

**USING COMPUTERS IN RESEARCH**: Literature survey using web, handing search engines Preparing presentations: i) Research papers: Using word processing software – MS Word/Latex/others, Drawing graphs and diagrams – Origin and others ii) Seminar presentations – Power point for oral and poster presentations

**SCIENTIFIC WRITING** : Structure and Components of Research Report, Types of Report: research papers, thesis., Research Project Reports, Pictures and Graphs, citation styles.

Reference:

1. “How to write and Publish” by Robert A. Dayand Barbara Gastel, (Cambridge University Press).
2. “Survival skills for Scientists” by Federico Rosei and Tudor Johnson, (Imperial College Press).

3. “How to Research” by Loraine Blaxter, Christina Hughes and Malcolm Tight, (Viva Books).
4. “Probability and Statistics for Engineers and Scientists” by Sheldon Ross, (Elsevier Academic Press).
5. “The Craft of Scientific Writing” by Michael Alley, (Springer).
6. “A Students’s Guide to Methodology” by Peter Clough and Cathy Nutbrown, (Sage Publications). Unit II:

## **UNIT II**

### **Advanced Materials Science**

#### **Introduction**

Materials and their classification

#### **Thermodynamics and Statistical Mechanics**

Thermal Equilibrium, (Zeroth Law of Thermodynamics), First Law of Thermodynamics, Isothermal Process, Adiabatic Process, Isobaric Process; Isochoric Process; Second Law of Thermodynamics, Entropy, Third Law of Thermodynamics, Statistical Mechanics, Statistical Equilibrium, Statistical definition of entropy, Gibbs Paradox, Statistical Thermodynamics, Maxwell-Boltzmann Distribution Law Maxwell – Boltzmann Distribution & Ideal Gas, Quantum Statistics, Phase Space, Fermi-Distribution Law, Electron Gas, Bose-Einstein Distribution Law.

#### **Polymers**

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

#### **Nanomaterials and Nanoscience:**

Introduction: Different types of nanomaterials- Inorganic Quantum well, Quantum wires and Quantum dots, Metal cluster, Metal oxide nanocrystals, Semiconductor nanocrystals, Assemblies of Nanocrystals, Carbon based nanomaterials, Carbon nanotubes (SWCNT and MWCNT), and Graphene, Core shell structure of different materials.

#### **Synthesis of Nanomaterials Techniques**

Top down and Bottom up approaches, Solid states routes; mechanical mixing; grinding; solid solution techniques; Evaporation; precipitation; Top seeded solution growth; sol-gel techniques; high temperature solution; hydrothermal solvothermal methods; Melt methods-super cooling, Czochralskii methods; Skull melting; Electrochemical deposition and electrochemical oxidation using two and three electro, Vapour phase methods, CVD; CVT; MBE; Plasma; Laser ablation. Biological synthesis; Electrochemistry; Multi-energy processing; Mechano-Chemical; Sono-Chemical; Photo-Chemical; and Bio-Chemical, Micelle and Reverse Micelle, Template based synthesis.



### **Applications of Nanotechnology in various fields:**

Renewable energy, solar energy, hydrogen production and fuel cells
Biomedical science, medicine, diagnostics, pharma
Food science and Nutrition, Biotechnology
Environmental sciences

**Composites and Nanocomposites** : Classification of Composites, Raw Materials, Nanocomposites, their properties and application. Properties and applications. Matrix: Thermoplastics.

### **UNIT III**

#### **Materials characterization Techniques**

**Introduction:** Physical and chemical properties, Macroscopic properties: Optical. Electrical, dielectric, magnetic, mechanical. Microscopic properties: chemical structure, composition, surface characterization.

**Probing bulk and nano-structure** – XRD, TEM, HRTEM, Neutron scattering.

**Surface structure and topography** – SEM, STM, LEED, AFM

**Microstructure** – UV – VIS, Raman, FTIR, Optical microscopy, small angle scattering, NMR

**Optical spectroscopy:** Luminescence spectroscopy (PL, TL), Fluorescence spectroscopy.

**Phase changes.** Crystalline and amorphous fractions – DSC(2)

**Thermo-gravimetric methods** – TGA, DTA(2)

**Others:** XPS, ESCA, Auger etc.

#### **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: BharathBhushan, Springer Verlag, 2<sup>nd</sup> Editon (2009).
3. Willard, Merritt, Dean, Settle, Instrumental Methods of Analysis, CBS publishers & Distributors, Delhi, Sixth Edition, 1986.
4. Colin N. Banwell and Elaine M.McCash, Molecular Spectroscopy, Mcgraw-Hill College; 4 Sub edition (June 1, 1994), ISBN-10: 0077079760
5. Sam Zhang, Lin Li and Ashok Kumar, Materials Characterization Techniques, CRC Press, (2008)
6. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Wiley & Sons (2008)
7. Elton N.Kaufmann, Characterization of Materials, Vol. 1, Wiley & Sons (2003)

8. R.A. Laudise, Growth of Single Crystals, Prentice Hall, (1973)
9. G. Dhanaraj, K.Byrappa, V.Prasad and M.Dudley (Eds), Springer Handbook of Crystal Growth, Springer- Verlag (2010)
10. Peter E.J. Flewitt and R.K. Wild, Physical Methods of Materials Characterization, 2<sup>nd</sup> Edition, Taylor & Francis (2003)

## Details of the Faculty

### Prof. S. Srikantaswamy, Co-ordinator, M.Tech in Materials Science, Vijnana Bhavan, MGM



**Email Id** srikantaswamy@envsci.uni-mysore.ac.in, srikantas@hotmail.com  
**Phone No** +91-821-2410552  
**Qualification** M.Sc., Ph.D  
**Area of Specialization** Materials Science, Nanotechnology, Crystallography, Crystal Growth Environmental Science, (Environmental Earth Science) Biomaterials, Nanomaterials Carbon nanotubes)

### Prof. K. Byrappa - Pro-Vice Chancellor Adichunchanagiri University, Mandya



**Email Id** kbyrappa@gmail.com  
**PhoneNo** +91-7259667666  
**Qualification** M.Sc., Ph.D., (Moscow)  
**Area of Specialization** Materials Science, Nanotechnology, Crystallography, Crystal Growth, Experimental Mineralogy, Environmental Science, Solution Chemistry, Solid State Chemistry and Solid State Physics, Authority in Hydrothermal Technology

### Prof. R Somashekar, Visiting Professor, M.Tech in Materials Science, Vijnana Bhavan, MGM



**Email Id** rs@physics.uni-mysore.ac.in  
**Phone No** +91-9449130134  
**Qualification** M.Sc., Ph.D.  
**Area of Specialization** Physics, Condensed matter physics

**Prof. B. Basavalingu, Visiting Professor, M.Tech in Materials Science MGM**



**Email Id** bbmysore@yahoo.com  
**Phone No** +91-9448601183  
**Qualification** M.Sc (Geology), PhD. (Geology), P.G. Dip(Computer Programming)  
**Area of Specialization** Material Science and Thermodynamics Mineralogy, Petrology,

**Prof. K. M. Lokanath Rai, Visiting Professor, M.Tech in Materials Science, MGM**



**Email Id** kmlrai@yahoo.com  
**Phone No** +91-821-2419667  
**Qualification** M.Sc., Ph.D.  
**Area of Specialization** Organic Chemistry, Synthetic Organic Chemistry

**Prof. M. Y. Sreenivasa, Visiting Faculty, M.Tech in Materials Science, MGM**



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mys@microbiology.uni-mysore.ac.in  
**Phone No** +91-821-2419733  
**Qualification** M. Sc., Ph. D, Post Doc (USA)  
**Area of Specialization** Mycology, Molecular mycology and Mycotoxicology

**Dr. Payal, Women Scientist- B, DST, M.Tech in Materials Science**



**Email Id** payalpu\_82@yahoo.co.in  
**Phone No** +91-9888675661  
**Qualification** M.Sc., Ph.D.  
**Area of Specialization** Biophysics, osteoporosis, diagnosis, biomaterials  
characterization, electrical impedance spectroscopy

## Details of Research Projects

Sl. No	Names of the Principal Investigator and other Investigators	Title of the Project	Sponsoring Agency	Total amount of the project
1	Prof. S. Srikantaswamy	Water Sample analysis and Biodiversity studies in the water bodies of proposed Mysore-Nanjangud Local Planning Area.	EMPRI, (Govt. of Karnataka)	Rs. 9,08,500=00 (2014-2016)
2	Prof. S. Srikantaswamy, Prof. Sunil Nautiyal (Principle Investigator)	Climate Smart Livelihood and Socio-ecological Development of Biodiversity Hotspots of India	DST, New Delhi	Rs.22 Lakhs
3	Prof. K. Byrappa Prof. R. Somashekar Prof. S. Srikantaswamy Prof. B. Basavalingu Prof. K. M. Lokanatha Rai	Processing, Characterization & Applications of Advanced Functional Materials	University With Potential for Excellence (UPE), UGC	Rs.50,00,00,000=00
4	Prof. K. Byrappa Prof. R. Somashekar Prof. S. Srikantaswamy Prof. B. Basavalingu Prof. K. M. Lokanatha Rai	Processing Characterization and Applications of Advanced Functional Nanomaterial's	Center with Potential for Excellence in a Particular Area (CPEPA),UGC	Rs.4,30,00,000=00

## Details of the Guest Faculty:

### Dr. K. B. Harsha, Guest Faculty, M.Tech in Materials Science



**Email Id** shanthaharsha@gmail.com  
**Phone No** +91-9844075637  
**Qualification** M.Sc., Ph.D.  
**Area of Specialization** Synthetic Organic Chemistry, Catalysis, Bio organic chemistry

### Mr. Dhananjay, Guest Faculty, M.Tech in Materials Science



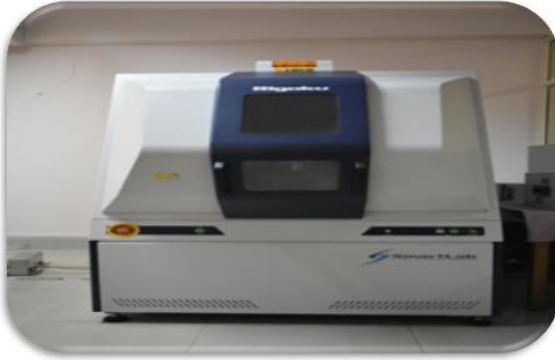
**Email Id** [dhananjay@ioe.uni-mysore.ac.in](mailto:dhananjay@ioe.uni-mysore.ac.in)  
**Phone No** +91-7019746368  
**Qualification** M.Tech., KSET  
**Area of Specialization** Material Science, Nanotechnology, Carbon 2D Materials.

### Dr. M. B. Nayan, Guest Faculty, M.Tech in Materials Science



**Email Id** nayanbyran@gmail.com  
**Phone No** +91- 7349564954  
**Qualification** M.Sc., Ph.D.  
**Area of Specialization** : Environmental Science, Nanotechnology, & Materials Science

# Instrumentation facility



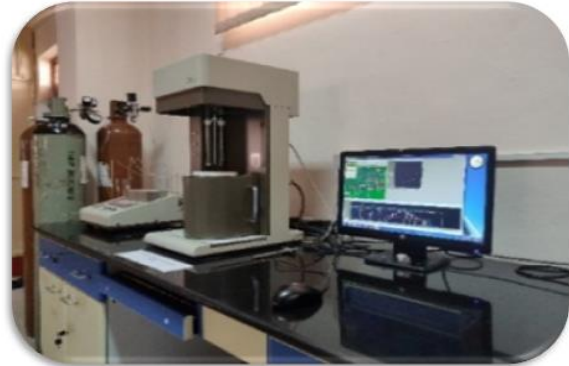
X-ray Powder Diffractometer (Japan)



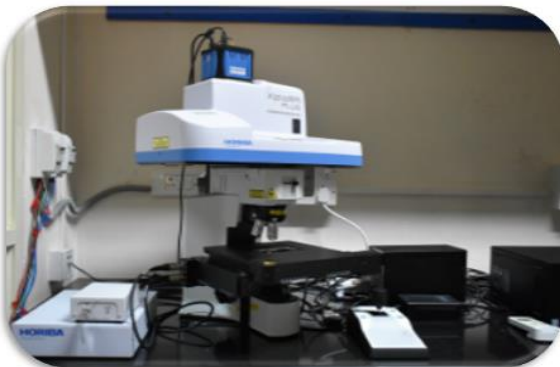
Scanning Electron Microscope (Japan)



Atomic Force Microscope (Italy)



BET Surface area analyser (Japan)



Raman Spectroscopy



TGA System (Switzerland)

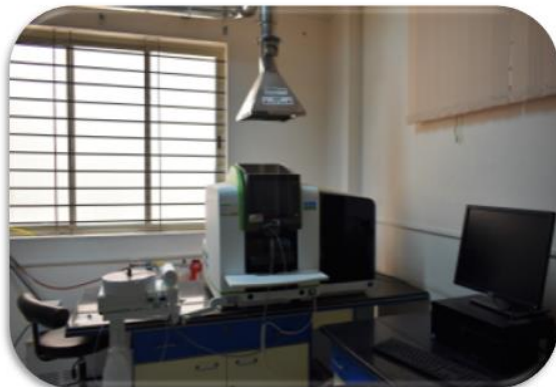


.Particles Size Analyzer (USA)



Photoluminescence (PL Spectroscopy)





Atomic Absorption Spectroscopy



Contact Angle Analyzer FTA 200 (USA)



UV-Vis spectrophotometer



Magnetic susceptibility



Microwave Hydrothermal Reactor (USA)



Chemical vapour deposition (CVD)

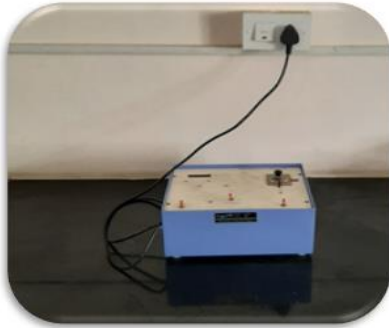


Electrochemical work station (USA)



Materials synthesis lab.

## Lab Equipment's



**CHARACTERIZATION OF THERMISTER**



**AUTO CLAVE**



**PARA MAGNETIC SUSCEPTIBILITY  
GAUSS BALANCE**



**HEATING MANTLE**



**MAGNETIC STIRRER**



**FERMI ENERGY**



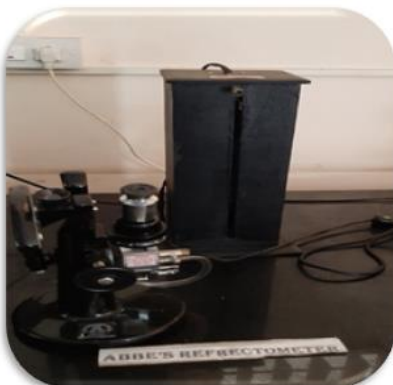
**COMPOUND MICROSCOPE**



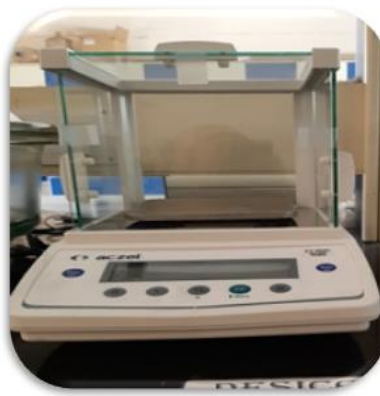
**UV - CHAMBER**



**DESSICATOR**



**ABBE'S REFRACTMETER**



**WEIGHING BALANCE**



**UV - SPECTROPHOTOMETER**



DIGITAL CALORIMETER



LAMINER AIR FLOW



ROTARY EVAPORATOR WITH CHILLER AND VACUUM PUMP



CENTRIFUGE



PH ANALYZER



HOT AIR OVEN



WATER BATH



FOUR PROBE WITH HEATING OVEN



HALL EFFECT WITH GAUSS BALANCE

### **Details of the Ph.D Awardee**

Sl.No	Name of the Ph.D awardee list	Name of the guide	Year of award
1	Dr. Kashinath	Prof. K. Byrappa	10-10-2018
2	Dr. Abdo Hezam Abdullah Mohsen	Prof. K. Byrappa	01-09-2020
3	Dr. Mina Zare	Prof. K. Byrappa	13-10-2020

## Details of the Research Scholars

Sl.No	Name of the Research Scholar	Date of Joining	Fellowships/ without fellowships
1	Mr. Dhananjay	06-08-2019	Without fellowships
2	Mr. H. R. Deepu	26-11-2019	With fellowship- (Institute of Excellence (IOE) project, Vijnana Bhavan, Manasagangothri, Mysuru.
3	Mr. Chandrakantha	12-02-2021	With fellowship- PURSE project, Vijnana Bhavan, Manasagangothri, Mysuru.

## Details of the Non-Teaching Staff

Sl.No	Name of the Non-Teaching Staffs	Designation
1	Ms. Shwetha. M	Second Division Clerk
2	Ms. Nayanashree	Lab Technitian
3	Mr. Vikram. L. Rai	Lab Assistant
4	Mr. H. B. Basavaraju	Attender

## Details of the Students of M.Tech in Materials Science for the academic year 2020-2021

Sl. No	Names of the students	Register Number	E-mail ID	Gender
<b>II Semester</b>				
1	Adithya Raj. B. S	20MTS351	adirajbs0@gmail.com	Male
2	Faraj Mohammed Allafi Kamsavi	20MTS352	frjm28760@gmail.com	Male
3	Hareesha. V	20MTS353	hareeshahvh@gmail.com	Male
4	Harsha. P	20MTS354	manuharsha8@gmail.com	Male
5	Harshith. M	20MTS355	mharshith54@gmail.com	Male
6	Harshitha. M. C	20MTS356	harshithagowdamc@gmail.com	Female
7	Kiran Kumar. N	20MTS357	kiru0528@gmail.com	Male
8	Mohan. B	20MTS358	mohanmoni700@gmail.com	Male
9	Nesara Nirantharodaya Nijaguna. K. S	20MTS359	nesaraksnijaguna@gmail.com	Female
10	Pavan Kumar. B. J	20MTS360	pavankumarp0607@gmail.com	Male
11	Prashanth. K.S	20MTS361	prashanthlee605@gmail.com	Male
12	Rebecca Linal Martin	20MTS362	rebeccalinalm@gmail.com	Female
13	Sindhu. K	20MTS363	sindhu281998@gmail.com	Female
14	Vinay. B.D	20MTS364	vinay.me.gec@gmail.com	Male
<b>IV Semester</b>				
1	Bhumika. H. R	19MTS351	Bhoomikahr800@gmail.com	Female
2	Kshetraa Chittiappa. B	19MTS352	Kshetraaiaf@gmail.com	Female
3	Mallikarjuna Swamy. A. N	19MTS353	mallikarjunaswamyam@gmail.com	Male
4	Namithashree. H. N	19MTS354	Namithashree1301@gmail.com	Female
5	Prashanti. M.Y	19MTS355	Prashantimy7@gmail.com	Female
6	Rakshith. A. M	19MTS356	Rakshithm43@gmail.com	Male
7	Siddarth. M	19MTS357	Sid.mdchtt@yahoo.com	Male
8	Suraj Singh. S	19MTS358	Surajsingh19796@gmail.com	Male
9	Sathyanarayana Murthy	19MTS359	asatyababu@yahoo.com	Male
10	Shreyas. L. N	19MTS360	shreyasl@gmail.com	Male
11	Yashaswi Kumar. A.M	19MTS361	Yashaswikumar123@gmail.com	Male
<b>VI Semester</b>				
1	Athira Raj	18MTS351	Athiraraj11214@gmail.com	Female
2	Mahesh Kumar. K. L	18MTS353	Sine4991@gmail.com	Male
3	Rajashekara	18MTS355	Raj777c@gmail.com	Male
4	Shree Ranjani. S	18MTS358	ranjanibhatsri@gmail.com	Female

## Details of the Project work/Internship:

Sl.No	Name of the Institutions
1	Facilitation Centre for Industrial Plasma Technologies, Institute for Plasma Research, Gandhinagar, Gujarat.
2	AGM & Head CTI, Bangalore.
3	M.Tech Engineering Department, Vidhyavardhaka College, Mysuru.
4	DGM Ceramic Technological Institute, Bangalore.
5	Indian Institute of Science, Bangalore
6	Defence Institute of Advanced Technology, Girinagar, Pune.
7	International and intern centre for nanoscience and Technology, Kerala
8	Prof.Abdul Khader Govt. Science college, Chitradurga
9	Radiation Technology Development division Bhabha Atomic research Centre, Mumbai, Maharashtra
10	DOS in Chemistry,UOM
11	Central Electrical research Institute(CSIR) Karaikudi
12	Director(Academic and Administration) JSS Technical Institute , Mysuru.
	National Institute of Technology, Karnataka, Surattgal.
14	Irin Technology LLP, Bengalore
15	Raman Research Institute, Bengalore
16	Centre for Nano and soft matter sciences, Bengaluru.
17	Raman Research Institute, Bengalore
18	Raman Research Institute, Bengalore
19	Dept. of Physics and Ashrophysics, University of Delhi
20	RMG Polyvinyl India limited,
21	Centre for Materials Science and Technology
22	Centre for Materials Science and Technology
23	Indian Oil Corporation Ltd.
24	Bony polymers Pvt. Ltd, Faridabad
25	School of Physics University of Hyderabad.
26	Defence Institute of Advanced Technology (DRDO), Pune



27	UGC-DAE CSR, Kalpakkam Node, Kokilamedu-603104
28	Mohit rampal, quality in charge Fine adhesives, New Delhi.
29	CIPET:SARP, APDDRL, Bangalore-560058
30	Centre for Nano & Soft matter Science (CeNS), Jalahalli, Bangalore
31	Defence Research and Developmet Organization (DRDO)Ministry of Defence, Govt. of India, DMSRDE P.O.,G.T.Road, Kanpur-208013
32	Centre for Nano Science and soft matter Sciences, Jallahalli, Bangalore.
33	Surface Engineering Division, CSIR-National Aerospace Laboratories, Bangalore-570017
34	Department of Metallurgical Engineering and Materials Science, IIT Bombay.
35	Central Manufacturing Technology Institute, Bangalore 560022.
36	Radius Engineering Solution, Bangalore.
37	Polymer Blends, Chennai.

## Placement details of previous batch student:

Sl. No	Names of the Student	Year	Currently working
1	Mahendra. R. C	2012-13	Officer, Technical Support marketing Grasim Industries limited (Chemical Division), Birlagam-456331MP, India.
2	Shubha. P	2012-13	Research Scholar, University of Mangalore, Mangalore
3	Kishor Kumar. N	2012-13	University of Mc Master , Canada
4	Swapneel. V	2013-14	Research intern at <i>Defence Institute of Advanced Technology.</i>
5	Thulya.P	2013-14	Programme officer- Scientist B Vikram a Sarabhai Community Science Centre
6	Chandrakantha. K. S	2013-14	Project Fellow at DST-PURSE Project, Vijnana Bhavan, MGM.
8	Hemanth Kumar. C. K	2013-14	Technical Sales Engineer, Sames Kremlin Ltd, Bangalore.
9	Gopikrishna. G. V	2013-14	Engineer measurement system
10	Avinash. N	2014-15	Research Scholar, Mangalore University, Mangalore.
11	Daniel Edward	2014-15	CEO, ICD Tuning, Chennai.
12	Nivetha	2014-15	Project Fellow, Central Electro Chemical Research Institute (CECRI), Tamilnadu, Karaikudi.
13	Rakesh. P.V	2014-15	Working at Accenture solution Pvt. Ltd Bangalore as Trial Specialist Designation : (Medical Services Associate)
14	Supriya. K. S	2014-15	Working in Rangson-Schuster Technologies Pvt. Ltd, Mandya.
15	Pabitra Das	2014-15	Project Assistant at the Council of Scientific & Industrial Research.
16	Vinod Raj	2014-15	Accenture, Bangalore.
17	Reeshma Rameshan	2014-15	Birla Institute of Technology and Science (BITS) Pilani, Hyderabad campus as JRF in the Department of Chemistry.
18	Narasimha Jayanth Baradwaj	2015-16	Working in Hydro Electric cell at National Physics Laboratory, New Delhi.
19	Mahesh.B.L	2015-16	Raman Research Institute, Bangalore.
20	Sharadhi.N.Raj	2015-16	R & D Assistant at Centre for Nano and Soft matter Science, Bangalore.
21	Prutha. N. Raj	2015-16	PhD in Electronics and Computer Engineering, Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong
22	Manohara. M	2015-16	Raman Research Institute, Bangalore.
23	Nandeeshwara	2015-16	Working in Backward classes Department, Mangalore.
24	Sudhin Sukumaran	2015-16	Doctoral student at National Institute of Technology( NIT )

			<b>Rourkela, Odisha.</b>
25	<b>Mahesha. C. B</b>	<b>2015-16</b>	<b>Lecture, Shanthinikethana College, Ramanagara.</b>
26	<b>Mohith Kumar Sharma</b>	<b>2015-16</b>	<b>Lab chemist, Polymer Papers Ltd., 12/6, Mathura Road, Faridabad-121003.</b>
27	<b>Anuj Mehta</b>	<b>2015-16</b>	<b>Working at Oriental Carbon &amp; Chemicals Limited in the Corporate Office as a Technical Sales Executive.</b>
28	<b>Sundram Pandey</b>	<b>2015-16</b>	<b>Chemtech Process Services, Inc as Technical Sales Engineer, New Delhi, India.</b>
29	<b>Mohan. N. A</b>	<b>2016-17</b>	<b>Self – Employed.</b>
30	<b>Harisha. H. G</b>	<b>2016-17</b>	<b>TVS Motor Pvt. Ltd.</b>
31	<b>Roohan Farooq Lala</b>	<b>2016-17</b>	<b>Research Scholar, Indian Institute of Science (IISc), Bangalore.</b>
32	<b>Shilpa. U</b>	<b>2016-17</b>	<b>Project assistant level 2, Council of Scientific and Industrial Research CSIR, Chennai.</b>
33	<b>Prajna. B</b>	<b>2016-17</b>	<b>Learning and development specialist, Think and Learn pvt ltd. (Byju's), Bengaluru, Karnataka.</b>
34	<b>Archana. C. S</b>	<b>2016-17</b>	<b>Purchase Executive, Bal-Pharma Ltd, Bangalore.</b>
35	<b>Ashish Raghavan</b>	<b>2016-17</b>	<b>Project Associate-1, CIPET: School for Advanced Research in Polymers (Sarp), Laboratory for Advanced Research in Polymeric Material (Larpm), Bhubaneswar, Orissa</b>
36	<b>Mahendra. D. M</b>	<b>2017-18</b>	<b>Senior Engineer , TechMahindra India LTD, Bangalore.560100</b>
37	<b>Naveen. G. S</b>	<b>2017-18</b>	<b>Working in Bharat Earth Movers <i>Limited (BEML), Mysuru.</i></b>
38	<b>Jagadeeshanayaka. N</b>	<b>2017-18</b>	<b>Working as Junior Researcher Fellow (JRF) National Institute of Technology Karnataka, Surathkal.</b>
39	<b>Sumit Kumar Parida</b>	<b>2017-18</b>	<b>Teacher, Delhi Public School, Bhugathgalli Village, Bannur road, Mysore.</b>
40	<b>Govindaraju. B. R</b>	<b>2017-18</b>	<b>Civil Engineering Consultant, Real Estate freelance, Bangalore.</b>
41	<b>Punith Kumar</b>	<b>2017-18</b>	<b>Production Manager, Hi-tech Services Private Limited, Bangalore.</b>
42	<b>Shwetha. G</b>	<b>2017-18</b>	<b>Documentation Officer, Swami Vivekananda Youth Movement (SVYM), Mysore.</b>
43	<b>Dhananjay</b>	<b>2017-18</b>	<b>Guest Faculty, Centre for Materials Science and Technology, Vijnana Bhavan, Manasagangothri, Mysore.</b>

## Contact Details of the Department

### **Co-ordinator**

Prof. S. Srikantaswamy  
M.Tech in Materials Science  
E-Mail: [srikantaswamy@envsci.uni-mysore.ac.in](mailto:srikantaswamy@envsci.uni-mysore.ac.in).  
Contact No: 9448275348

### **Administrative Officer**

University with Potential for Excellence(UPE)  
University of Mysore, Vijnana Bhavan, Open Theatre road, Manasagangothri, Mysore-570006,  
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