17. Superconductivity Today: An Elementary Introduction – Ramakrishnan T V (University Press, 1999)
18. Liquid crystals: Natures Delicate Phase of Matter, Peter Collings (Princeton University Press, 2007)
19. Solar cells: Materials, Manufacture and Operation – Markvart and Castaner (Elsevier, 2005)

MSS 504: NEW MATERIALS AND TECHNOLOGIES (3 Credits)

Objectives: This course aims to (i) provide the idea of new materials and technologies in current science and research including shape memory alloys, conducting polymers and nanomaterials. (ii) introduce the properties, synthesis, processing, and applications of new materials(iii) instil in the students the urge to explore newer materials for modern-day challenges.

Expected course outcomes: At the end of the course, students will be able to (i) discuss on new technology materials and their properties. (ii) distinguish the characteristic properties between alloys vs superalloys, polymers vs conducting polymers, and bulk vs nanomaterials. (iii) apply the synthetic techniques for conducting polymers and nanoparticles in their laboratory. (iv) apply the knowledge of the design of materials for new technologies and develop an interest in research in the field of materials science. (v) find equal opportunities in polymer, nanotechnology industries and also as researchers in universities/institutes.

Unit I

Super alloys: Alloys and their applications, alloys at high temperature, Types of super alloys – iron based – nickel based – cobalt based super alloys –fabrication – their characteristic features and areas of application.

Smart Materials: Introduction to smart materials – shape memory effect (SME) and martensitic transformation, SME related changes in material properties, SME and Superelasticity. Ti - Ni SM Alloys – Effect of thermal and mechanical cycling Cu - based SM Alloys. Ferrous SM alloys. Fabrication of SM Alloys. Characteristic fundamental properties- Shape memory ceramics and polymers, photo responsive and chemo responsive SME. Experimental determination of phase transformation temperatures in SMA. General applications of Smart materials – design of actuators, couplings, electrical connectors, medical and dental applications. 14 hours

Unit II

Conducting Polymers: Introduction to conducting polymers. Polyacetylene. Structural features – factors affecting conductivity of polymers. Preparation of conducting polymers – doping. Band structures inconducting polymers – charge transport, nature of charge carriers (soliton, polaron, bipolarons). Models of charge transport – structure-property relationship. Mechanisms of conduction in doped polyheterocyclics, polyaromatics, conducting co-polymers. Molecular designing of novel conducting polymers – substitution / fusion, ladder structure formation, copolymerization, donor - acceptor polymer formation, advantages and challenges, practical applications of conducting polymers– electronic, electrochemical, photonic applications, sensors, medical applications. Related experiments - synthesis and mechanism of formation of polyacetylene, polyaniline, polypyrrole. 14 hours

Unit III

Nano-materials: Introduction – nanostructured materials – metals, semiconductors and ceramics. Synthesis of nanoparticles– inert gas evaporation – laser pyrolysis – sputtering techniques, plasma techniques. Various chemical methods of synthesis. Unique properties of nanomaterials. Metal nanoparticles – electronic and optical properties – surface plasmon resonance. Functionalized metal nanoparticles- synthesis, characterization, organization and applications –- semiconductor nanoparticles - synthesis, characterization and applications of quantum dots – size dependent properties – experimental determination of size from absorption studies. Magnetic nanoparticles- assembly and nanostructures. Manipulation of nanoscale biological assemblies. Carbon nanotubes and fullerene as nanoclustures. Nanostructured films. Characterization of nanoparticles and nanostructures– optical spectroscopy, electron microscopy, atomic force microscopy, X-Ray diffraction of nanoscale materials. 14 hours

References:

1. The Science and Engineering of Microelectronic Fabrication- S A Campbell (Oxford,1996).
2. Intrinsically Conducting Polymers: An Emerging Technology- M Aldissi (editor), (Kluwer, 1993).
3. Quantum Chemistry Aided Design of Organic Polymers- J M Andre, J Delhalle & J L Bredas (World Scientific, 1991).
4. Electrical Properties of Polymers: Chemical Principles- C C Ku and Leilpens (Hanser, 1987).
5. Science and Applications of Conducting Polymers- W R Salaneck, D T Clark, E J Samuelson (Adam Hilger, 1991).
6. Special Polymers for Electronics and Optoelectronics- J A Chilton, M T Goosey, (Chapman and Hall, 1995).
7. Langmuir - Blodgett Films - Gareth Roberts (Ed), (Oxford, 1989).
8. Chemistry of Advanced Materials- D Chakravorty and A K Giri (C N R Rao Editor), (Blaclwell, 1992).
9. Physics and Chemistry of Small Clusters- P Jena, B K Rao and S N Khanna (ed) (Plenum Press, 1986).
10. Physics and Chemistry of Finite Systems: From Clusters to Crystals, (Kluwer, 1992).
11. Selection of Engineering Materials- G Lewis, (Prentice Hall, 1990).
12. Engineering Materials and Their Applications- R A Flinn and P K Trojan, (Jaico, 1998).
13. Fundamentals of Ceramics- M W Barsoum, (McGraw Hill, 1997).
14. Shape Memory Materials- K Otsuka and C W Wayman, (Cambridge, 1998).
15. Nanoscale Materials (Ed)- L M Liz, Marzan and P V Kamat (Kluwer, 2003).
16. Nanostructured Materials and Nanotechnology (Ed)- H S Nalwa (Academic Press, 1999).
17. An Introduction to Interfaces and Colloids: The Bridge to Nanoscience- John Berg C (World Scientific, Academic Press, 2002)
18. Conducting Polymers: A New Ira in Electrochemistry- Inzelt Gyorgy (Springer, 2008)
19. Introduction to Nanotechnology- C P Poole and Frank J Owens (Wiley, 2006)
20. Shape Memory Alloys: Manufacture, Properties and Applications – H R Chen (Nova Science, 2010)