Unit III

Ceramics- Introduction, classification, raw materials, fabrication methods, properties and applications. Types of ceramics- oxide and non-oxide ceramics. Allotropes of carbon- graphite, diamond and fullerene – structure dependent properties. Primary refractory materials.

Glasses- introduction, raw materials, manufacture of glass, properties and applications. Types of glasses, properties and applications. Photochromic and photosensitive glasses. 14 hours

References:

1. The Physics of Materials: How Science Improves Our Lives, Solid State Sciences Committee, (National Research Council, 1997)
2. The Science of World Around Us, Solid State Sciences Committee, (National Research Council, 2007)
3. Materials Science and Engineering – V Raghavan (Prentice Hall India, 1993)
4. Introduction to Solids – A J Dekker (McMillan India, 1981)
5. Plastics-How Structure Determines Properties – G Gruenwald (Hanser)
6. Understanding Materials Science – R E Hummel (II Ed.) (Springer, 1993)
7. Materials Science – Nagpal (Khanna, 1983)
8. Polymer Science – V R Gowarikar, N V Viswanath, Jayadev Sridhar (Wiley Eastern, 1987)
9. Composite Materials Engineering & Science – F L Mathews & R D Rawlings (Chapman & Hall, 1990)
10. Introduction to Ceramics – W D Kingery, H K Bower and U R Uhlman (John Wiley, 1960)
11. Glasses and Vitreous State – J Zarzycki (Cambridge University Press, 1982)

III SEMESTER

MSH 501 DIELECTRIC MATERIALS (4 Credits)

Objectives: The objectives of this course are to (i) introduce the students to a class of important insulating materials, viz: dielectrics, (ii) explain the physics behind dielectric behaviour of insulating materials. (iii) classify dielectric materials and their applications. (iv) discuss the optical properties of the dielectrics including colour of crystals, excitons. (vi) study the thermal properties of dielectrics including the concept of heat transport, phonons and the influence of elastic properties on thermal behaviour.

Expected course outcomes: At the end of the course, students will be able to (i) distinguish between dielectric materials and other insulators. (ii) recognize how these differences will be attributed to specific applications (iii) summarize the understanding of lattice dynamics.(iv) develop dielectric materials for energy applications

Unit I

Dielectric polarisation and atomic forces - electronic polarisation. Dielectric law and the generalisation. Atomic or ionic polarisation, orientational polarisability. Static dielectric constant of materials. Determination of dielectric constants. Lorentz internal field. Clausius-Mosotti relation. Polarisation catastrophe. electromechanical coupling - dielectric breakdown - electric energy stored in dielectrics. General

applications of dielectric materials. Problems and recent developments. The complex dielectric constant, dielectric losses and relaxation time - Debye equations - theory of electronic polarisation and optical absorption. Optical Phenomena in Insulators Colour of crystals - Excitons - weakly bound and tightly bound excitons, photoconductivity. Colour centers – F-centers and other electronic centers in alkali halides. 18 hours

Unit II

Ferroelectrics: General characteristics - piezoelectric, pyroelectric and ferroelectric materials - transducer and detector applications. Classification of ferroelectrics and representative materials. Structure of KDP and explanation for its ferroelectric behaviour. Objection against dipole theory, Ionic displacement theory Barium titanate and its ferroelectric behaviour. Crystal structure and theory of spontaneous polarisation in barium titanate and related experiments. Zeroes and poles of the dielectric function – Lyddone-Sachs-Teller relation. Problems. Ferroelectric domains. Thermodynamics of ferroelectric phase transitions. Remarks on antiferroelectric materials - Materials with paired properties like ferroelectric-ferroelastic, ferroelectric-ferromagnetic and recent developments. 18 hours

Unit III

Thermal Properties of Insulators: Heat capacity - Einstein's model - quantisation of lattice vibration - continuum model - Debye's theory –phonons – problems. Vibrations of monoatomic lattice - specific heat of one-dimensional lattice of identical atoms. Vibrations of diatomic lattice - phonon spectra and phonon modes - optical properties in infra-red region and their applications. Scattering of electromagnetic waves and neutrons by phonons – phonon spectra from neutron diffraction. Thermal conductivity of insulators - lattice thermal resistivity – normal and Umklapp process – related problems. Thermal expansion: potential wells in crystal binding - anharmonic interactions and thermal expansion of insulators. 18 hours

Reference

1. Introduction to Properties of Materials – D Rosenthal and R M Asimov (East West, 1974)
2. Elements of Materials Science and Engineering – L H van Vlack (Addison Wesley, 1975)
3. Introduction to Solid State Physics – C Kittel (II & IV Ed. Wiley & sons, 1961 & 1964)
4. Solid State Physics – A J Dekker (McMillan, 1971)
5. Advances in Solid State Physics, Vol. II & V –Seitz and Turnbull (Ed) (Academic, 1957)
6. Physics of Dielectric Materials – B Tareev (MIR, 1979)
7. Crystal Structures, Vol.1-3 – W G Wyckoff (Interscience, 1963)
8. Electronic Properties of Materials – Hummel (Springer-Verlag, 1985)
9. Solid State Physics Source Book – Sybil P Parker (Ed) (McGraw Hill, 1987)
10. Principles of Solid-State Physics – Robert A Levy (Academic Press inc., 1968)
11. Elementary Solid-State Physics; Principles and Applications – Omar M A (Addison Wesley, 2001)

MSH 502 MAGNETIC MATERIALS & MAGNETIC RESONANCE (4 Credits)

Objectives: