MANGALORE UNIVERSITY

Department of Materials Science

MSc Materials Science

MSH 501: **DIELECTRIC MATERIALS** (4 Credits)

Objectives: This course introduces the student to a class of important insulating materials ,viz: dielectrics and the physics responsible for their behavior. The thermal properties of dielectrics beautifully introduces the concept of heat transport by the lattice – the different modes of vibrations of the lattice, phonons etc and how they are controlled by their elastic properties.

Expected course outcomes: A good grasp on what differentiates a dielectric material from a mere insulator and how these differences makes them useful in specific applications. A reasonably good understanding of lattice dynamics is also expected.

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. Lorentz internal field. Clausius-Mosotti relation. Polarisation catastrophe. electromechanical coupling - dielectric breakdown - electric energy stored in dielectrics. general applications of dielectric materials. 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. 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. Barium titanate and its ferroelectric behaviour. Crystal structure and theory of spontaneous polarisation in barium titanate. Zeroes and poles of the dielectric function – Lyddone-Sachs-Teller relation. Ferroelectric domains. Thermodynamics of ferroelectric phase transitions. Remarks on antiferroelectric materials - Materials with paired properties like ferroelectric-ferroelastic, ferroelectric-ferromagnetic etc. 18 hours

Unit III

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

References

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)