

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)

