2. Elements of Materials Science and Engineering – L H van Vlack (Addison Wesley, 1975)
3. Introduction to Properties of Materials – D Rosenthal and R M Asimov (East West, 1974)
4. Introduction to Solid State Physics – C Kittel (II & IV Ed. Wiley & sons, 1961 & 1964)
5. Solid State Physics – A J Dekker (McMillan, 1971)
6. Advances in Solid State Physics, Vol. II & V – Seitz and Turnbull (Ed) (Academic, 1957)
7. Mossbauer Effect and its Applications – V G Bhide (Tata McGraw Hill, 1973)
8. Magnetic Resonance – C P Slichter (Harper and Row, 1985)
9. Solid State Chemistry – C N R Rao (Ed) (Marcel Dekker, 1974)
10. Solid State Physics Source Book – Sybil P Parker (Ed) (McGraw Hill, 1987)
11. Materials Science and Technology-A Comprehensive Treatment (ed.) – R W Cahn, P Haasen & E J Kramer - Electronic and Magnetic properties of metals and ceramics, Vol 3A & 3B (VCH Weinheim, 1992 & 1994)
12. Fundamentals of Molecular Spectroscopy – Colin M Banwell and Elaine M McCash, (Tata McGraw Hill, 2013)
13. Introduction to Magnetism and Magnetic Materials – David Jiles (CRC Press-2016)

MSH 503: SOLID STATE ENGINEERING MATERIALS (4 Credits)

Objectives: Objectives of this course are to (i) introduce the students to a detailed basic knowledge of technologically important materials such as superconductors, liquid crystals, and ceramics. (ii) impart the applications of solid-state engineering materials in semiconductor devices such as lasers and solar cells. (iii) introduce the students to application of dielectrics in the optical fibers for communication.

Expected course outcomes: By the end of this course, students will be able to (i) identify the behaviour of superconductors and their applications in magnetic levitation and high-field magnets. (ii) explain the electrical and optical phenomena in liquid crystals, lasers, and solar cells. (iii) further their interest in research work/career in industries.

Unit I

Superconductivity: Nature and properties of superconducting materials - Type I and II superconductors –mixed state- fluxon lattice. Thermodynamical approach to superconducting state- Phenomenological theories - BCS theory – concept of energy gap. Superconducting tunneling phenomena: metal-insulator-superconductor (MIS) and superconductor-insulator-superconductors (SIS). AC and DC Josephson effect, Applications - superconducting magnets, SQUID and magnetic levitation, High temperature (High T_c) superconductors: material preparation - ceramic technique, structure.

Liquid Crystalline Materials: Introduction - classification of thermotropic liquid crystals. Lyotropic and metallotropic liquid crystals- elementary ideas. Elementaryideas on material. Properties of liquid crystals - birefringence, dielectric anisotropy, viscosity, conductivity anisotropy. Elasticity of liquid crystals, electro-optic, thermo-optic effects – Freederickz transition. LCD devices and applications.

18 hours

Unit II

Lasers and applications: Introduction to lasers- spontaneous emission - stimulated transitions and rate equation balance, amplifications in a medium, population inversion methods, oscillation threshold, optical resonator theory. Gas lasers, He-Ne, Solid state lasers, Ruby, Nd:YAG lasers, - applications.

Solid state lasers: Semiconductor lasers – absorption-direct and indirect band gaps, material requirement, conditions for laser oscillations, homojunction and heterojunction lasers – Excimer-femtosecond lasers and recent developments - applications.

Photovoltaic solar cells and LEDs: Material requirement, efficiency, efficiency limits, spectral response, types of solar cells -conventional tandem-junction in solar cells, heterojunction solar cells, thin film solar cells, amorphous silicon solar cells. Organic, Perovskite and hybrid solar cell. Light emitting diodes- materials requirements, fabrication, efficiency. Problems and related experiments. 18 hours

Unit III

Ceramics: Ceramics and their structure- silicate structure - polymorphism and allotropy. Processing - recrystallization and grain growth, sintering, hot pressing, fire shrinkage. Basic refractory materials. Areas of applications.

Glasses: Preparation and structure - types of glasses -borate glasses, silicate glasses, oxide glasses, metallic and semiconducting glasses. Properties of glasses – electrical, optical, thermal, mechanical properties, Applications - photo sensitive, photochromic glasses, optical fiber- principle of fiber communication. Recent developments and applications. Optical properties: Luminescence: Frank Condon principle, excitation process - thermoluminescence and electroluminescence. Luminescent materials and industrial applications. 18 hours

References

1. Introduction to Superconductivity – A C Rose Innes and E H Rhoderick (Pergamon Press, 1978)
2. Superconductivity and Superconducting Materials – A V Narlikar and S N Ekbote (South Asian Pub., 1983)
3. Physics of high T_c Superconductors – J C Phillips (Academic Press, 1989)
4. Liquid Crystals – S Chandrasekhar (Cambridge University Press, 1977)
5. The Physics of Liquid Crystals – P G de Gennes (Oxford, 1975)
6. Electronic Materials and Devices – D K Ferry (Academic Press, New York, 2001)
7. Semiconductor Physics – P S Kireev (MIR Publishers, 1978)
8. Physics of Semiconductors Devices – S M Sze (Wiley Eastern, 1991)
9. Solid State Devices – Ben G Streetman (Prentice-Hall, 1995)
10. High Efficiency Silicon Solar Cells – M A Green (Tran. tech., 1987)
11. Solid State and Semiconductor Physics – John Mckelvey (John Wiley, 1976)
12. Introduction to Ceramics – W D Kingery, H K Bower and U R Uhlman (John Wiley, 1960)
13. Glasses and Vitreous State – J Zarzycki (Cambridge University Press, 1982)
14. Materials Science and Technology Vol. 9: Glasses and Amorphous Materials, (Ed.) R W Cahn, P Haasen, E J Kramer, (VCH Weinheim, 1991)
15. Optical Fiber Communications – G Keiser (McGraw-Hill, 2000)
16. Introduction to Superconductivity – Michael Tinkham, (McGraw Hill, 1996)