Electron spin resonance -— principles –comparison with NMR- areas of applications. Related experiment – determination of Lande splitting factor g. Areas of applications and related problems.

Mossbauer effect - Elements of theory – Mossbauer spectroscopy – centre shift, chemical shift, Zeeman shift, Experimental techniques and applications and related problems. 18 hours

References

1. Modern Magnetism – L F Bates (Cambridge University Press, 1963)
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 (Wiley India Publications, New Delhi, 2018)
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 Spectrosopy – Colin M Banwell and Elaine M McCash, (Tata McGraw Hill, 2013)
13. Introduction to Magnetism and Magnetic Materials- David Jiles (CRC Press, 2016)

MSH 552: SOLID STATE ENGINEERING MATERIALS – II (4 Credits)

Objectives: Objective of this course is to provide a detailed basic knowledge about technologically important materials such as superconducting materials, liquid crystalline materials, ceramics, etc. The studies of semiconductor devices such as lasers and solar cells are included to provide essential knowledge on the modern optoelectronic devices.

Expected course outcomes: This course provides good basic knowledge to the students about the superconductivity, liquid crystals, lasers, solar cells and ceramic materials. This would help them to perform research work in these areas and it is also useful in continuing their career in many 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, super density switches, SQUID and magnetic levitation. Superconducting composites- Nb_3Sn/Cu. High temperature (High T_c) superconductors: material preparation - ceramic and thin film technique, structure.

Liquid Crystalline Materials: Introduction - classification of thermotropic liquid crystals. Lyotropic and metallotropic liquid crystals- elementary ideas. Elementary ideas 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 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 optic 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, 2010)
5. The Physics of Liquid Crystals – P G de Gennes (Clarendon Press, 1993)
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, 2006)
9. Solid State Devices – Ben G Streetman and Sanjay Banerjee (Prentice-Hall, 2000)