Preparation of thick and thin film materials: Definition of thick and thin films. Physical vapour deposition - thermal evaporation - Knudsen cosine law. Sputtering- DC glow discharge and low-pressure sputtering. Reactive sputtering. Chemical vapour deposition. MBE, MOCVD, ALD methods of preparing device grade films. Spray pyrolysis and other chemical methods of film preparation for large area applications. LB films and their applications. Thickness measurement techniques- electrical, and mechanical methods. Optical methods- spectrophotometric and interference methods. Microbalance methods – quartz crystal oscillator technique. Related problems and applications. 14 hours

Unit II

Nucleation and growth of thin films: Theories of nucleation-capillarity theory, effect of deposition parameters. atomistic theory and rate equation approach of nucleation. Growth of thin films- mechanisms and influence of deposition parameters. Epitaxial growth - theory of epitaxial nucleation. Durability of films - adhesion and internal stress.

Optical properties of thin films: Reflection and transmission at interface between isotropic transparent media. Reflectance and transmitance in thin films. Methods for determining optical constants - spectrophotometer and polarimetric methods. Antireflection coatings - theory and design of single layer coatings. Double and multilayer coatings - brief description. Related problems and applications. 14 hours

Unit III

Electron transport phenomena in thin films: Electrical conduction in discontinuous metal films - quantum mechanical tunneling model. Conduction in continuous metal films- size effect and specular scattering. Thermoelectric power in metal films. Electrical conduction in semi-conductor and insulator films - hybrid microcircuits, thin film resistors, thermopiles. Quantum Hall effect- quantum well devices. Spintronics-GMR and TMR. Related problems and applications. 14 hours

References

1. Handbook of Thin Film Technology – L I Maissel and R Glang (Ed) (McGraw Hill, 1970)
2. Vacuum Deposition of Thin Films – L Holland (Wiley, 1956)
3. Thin Film Phenomena – K L Chopra (Mc Graw Hill, 1969)
4. Physics of Thin Films Vol.1-4 – G Hass and R E Thun (Ed) (Academic, 1963)
5. Electrical Conduction in Thin Metal Films – T J Coutts (Elsevier, 1974)
6. Optical Properties of Thin Solid Films – O S Heavens (Dover, 1955)
7. Thin Film Technology and Applications – K L Chopra and L K Malhotra (Ed) (Tata Mc Graw Hill, 1985)
8. Materials Science of Thin Films- Milton Ohring (Academic, 2010)

MSS 456 QUANTUM MECHANICS (3Credits)

Objectives: This course introduces the concept of the language of Physics which makes use of the mathematical tools, learnt earlier, in abundance. As some of the concepts are far removed from the classical picture, they need to be understood well. The objectives of the course include (i) providing an enhanced level of understanding of the principles of quantum mechanics (ii) understanding the use of quantum mechanics to solve simple to not-so-simple textbook examples/problems.

Expected course outcomes: On completion of the course the student the student should be on a sound footing with the concept of quantum mechanics and its mathematical tools. Therefore the students should be able to (i) utilize the postulates of quantum mechanics to describe quantum systems (ii) use operator techniques to solve relevant problems (iii) use the properties of angular momentum and spin to describe quantum systems such as the hydrogen atom and an electron in a magnetic field (iv) analyze the time dependence of quantum systems. (v) apply the principles to solve physical problems in condensed matter.

Unit I

Quantum Physics: Matter waves. Uncertainty principle. Interpretation of the wave particle dualism and complimentarity.

Wave Equation and Operators: The Schroedinger equation - free particle in one and three dimensions-the operator correspondence and commutating relations. Mean squared deviation. Commutation of operators. Simultaneous eigen functions. Normalization of wave functions and statistical interpretation-Box normalization, the Dirac delta functions- expectation values - Ehrenfest's theorem. Postulates of quantum mechanics. Stationary states - the time independent Schroedinger equation - particle in one dimensional square well potential, potential barriers-transmission and reflection coefficients. Simple problems and applications. 14 hours

Unit II

Eigen values and Eigen functions; One dimensional simple harmonic oscillators – the angular momentum operator - the eigen value equation for the square of the angular momentum - orbital angular and magnetic quantum numbers- the hydrogen atom-solution of the radial equations – Degeneracy. Ground state of hydrogen atom. Rigid rotator– energy eigen values. 14 hours

Unit-III

General formalism of quantum theory: Linear operators. Operator methods**,** Hilbert space and observables, Dirac notation, Bra and Ket spaces. Momentum and space representations. Schroedinger, Heisenberg and interaction pictures, simple harmonic oscillator by operator method. Ladder operators, matrix representations of angular momentum operators, Pauli matrices, addition of angular momentum, Clebsch-Gordan coefficients. Related problems and applications. 14 hours

References

1. Applied X-rays – G W Clark (McGraw Hill, 1955)
2. Quantum Mechanics – Leonard I Schff, 4th edition (McGraw HillEducation Pvt Limited, 2014)
3. Quantum Mechanics – Sokolov (MIR Publications Moscow, 1984)
4. Quantum Mechanics – Mathews and Venkatesan (Tata McGraw Hill, 1981)
5. Quantum Mechanics – Powel and Craseman (Oxford & IBH, 1985)
6. The Feynman Lectures on Physics, Vol. 3- R. P. Feynman, R.B. Leighton and M. Sands,(Pearson New York, 2013).
7. Introduction to Quantum Mechanics – R. L. Liboff (Pearson Education, 2003).