8. Introduction to Quantum Mechanics – D J Griffiths (Cambridge University Press, New Delhi,2017)
9. Quantum Mechanics – Eugen Merzbacher (John Wiley, 1970)

MSS 457: NANOSCIENCE AND NANOTECHNOLOGY – I (3 Credits)

Objectives: This course offers an opportunity for the interested student to acquire a basic knowledge about nanoscience and associated technology - one of the most researched topic in the past decade. It aims to (i) serve as an introductory course in the topic and is designed so that any student having just a basic knowledge of science is able to understand the fundamentals involved (ii) deliver the necessary basics required for a proper understanding of (a) the behaviour of nano systems (b) chemistry involved to in their synthesis (iii) familiarize the student with the techniques available for the characterization of nanomaterials.

Expected course outcomes: The student acquires information about (i) the physics behind why nanomaterials exhibit properties different from that of the bulk (ii) the chemistry involved in their synthesis which equips them with knowledge of how matter can be manipulated to give materials with new properties (iii) impart skills for characterization and synthesis of nanosystems (iv) placement opportunities in nanotechnology industries

Unit I

Introduction – Nanostructured materials, nanoparticles, nanorods, nanotubes etc. Brief survey of metals, insulators and semiconductors. Free electron theory and band theory, Low dimensional structures, Particles in a box, Strong and weak confinements, Excitons.

Colloid Chemistry: Introduction. Kinetic properties- Sedimentation rate, Brownian motion. Surface energy, Surface potential and Zeta potential and their consequences. Thermodynamics of surfaces. Coagulation- Kinetics of coagulation. Stability of colloids. 14 hours

Unit II

Chemical Synthesis of Nanoparticles: Bottom-up approach. Chemical reduction. Microwave synthesis, Sol-gel technique, Reverse micelle methods. Functionalized nanoparticles in different medium. Size control. Self assembly. Nanoparticle arrays. Porous nanoparticles, Nanocoatings.

Physical Methods of Nanostructure Fabrication: Top-down approach. High energy ball milling, Vapour condensation, Laser ablation, MBE, MOCVD, LPE.

Nanopatterning- Lithography- Optical, X-ray and Electron beam lithography. Ion-beam lithography, SPM, Dip pen lithography. 14 hours

Unit III

Analysis of Nanostructures: Atomic Force Miscroscope, Scanning Tunneling Microscope, High Resolution Transmission Electron Microscope, Field Emission Scanning Electron Microscope, X-ray Diffraction, Small angle X-ray diffraction, UV-

Vis-NIR spectroscopy, Photoluminiscence, IR spectroscopy, Raman spectroscopy. Zeta potential measurements. Micro SQUID Magnetometry. 14 hours

References:

1.The Science and Engineering of Microelectronic Fabrication – S A Campbell (Oxford, 1996)
2. Nanoscale Materials - (Ed) L M Liz Marzan and P V Kamat, (Kluwer, 2003)
3. Nanostructured Materials and Nanotechnology (Ed) – H S Nalwa (Academic, 2002)
4. Colloidal and Surface Chemistry - M Satake, Y Hayashi, Y Mido, S A Iqbal, M S Sethi (Discovery, 1996)
5. Colloid Chemistry – S Voyutsky (MIR, 1978)
6. Introduction to Nanotechnology – C P Poole and F J Owens (Wiley- Intersci., 2006)
7. Nanotechnology and Nanoelectronics – W R Fahrner (ed) (Springer, 2006)
8. Quantum Dots – L Jacak, P Hawrylak, A Wojs, (Springer, 1997)
9. Physics of Low Dimensional Structures – J H Davis, (Cambridge, 1998)
10. Sol-Gel Science – Scherrer and Brinker (Academic Press, 1990)

MSE 459: SCIENCE OF MATERIALS IN DAILY LIFE (open elctive-1) (3 Credits)

Objectives: Objectives of this course is to (i) provide elementary idea about materials science to the interested students in the open elective system. (ii) introduce different properties and applications of metals, semiconductors, polymers, composites and ceramics. (iii) teach the relevance of these materials in technologically important applications.

Expected course outcomes: By the end of the course, students will be able to (i) distinguish the different classes of materials used in daily life. (ii) explain the nature of bonding in different materials and their properties. (iii) explain how manufacturing processes can bestow materials with different/desirable properties.

Unit I

Conductors: metals, alloys, semiconductors- Definition, elementary ideas of electrical properties, optical properties, mechanical properties, thermal properties. Specific examples of metals- copper, aluminium, iron, gold, silver. Uses of metals. Drawbacks of metals. Alloys- advantages of alloying-brass, bronze, steel, stainless steel, gold alloys, silver alloys and their uses.

Semiconductors: Elemental semiconductors- silicon, germanium. Doping- n-type and p-type semiconductors, p-n junctions, I-V characteristics- diode equation. Qualitative ideas of devices- diodes to ICs. Compound semiconductors. 14 hours

Unit II

Polymers and composites: Plastics- Introduction. Types of plastics. Rubber- types of rubber. Vulcanization of rubber. Thermoplastics and thermosets. Fibres- different types of natural and synthetic fibres – cellulose acetate fibres. Resins, adhesives and polymer coatings. Physical, chemical, mechanical properties and applications of polymers. Recycling of polymers.

Composites- introduction, types. Wood, concrete, FRP and some advanced composites. Properties and applications. 14 hours