MATERIALS SCIENCE
(Inter-disciplinary Programme)

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Understanding, developing and characterisation of materials are at the root of man's progress in the modern world. Recent advances in electronics, energy conversion, space flight, to name only a few, have become possible due to the extension of materials behaviour. For further progress and to meet the future requirements, a thorough study of existing materials and tailor-making of newer functional materials are to be continued with increasing vigour. Such a task, however, requires an interdisciplinary approach to the subject. Keeping this objective in view and to provide focus and co-ordination for teaching, research and development, an interdiciplinary programme in materials science leading to Master of Technology (M. Tech.) degree was initiated at the Indian Institute of Technology, Kanpur in July 1971. The doctoral programme leading to Ph. D. degree was started two years later in 1973.

The above M. Tech. and Ph.D. postgraduate programmes provide opportunities to young engineers and scientists to undergo training in different aspects of materials science and engineering. The courses are designed to illustrate the applications of fundamental principles of solid state physics, chemistry and engineering and also to understand and utilize the properties of a broad range of materials including metals and alloys, semiconductors, ceramics, glasses, composites, polymers, etc. Emphasis is given to various aspects of preparation, structural properties and application of materials.

The M. Tech. programme requires crediting a set number of courses covering the basic concepts of the materials science and engineering and modern experimental techniques and a few electives chosen from among the existing courses (listed below) and others offered by various engineering and science departments. Students besides undertaking course work participate in research activities and submit their individual contributions in the form of a thesis to fulfill the requirements of the M.Tech.

degree. For Ph. D. degree, one has to credit at least four courses, pass the comprehensive examination and complete a research project leading to an acceptable thesis.

Research and development in modern materials require an integrated approach based on different established disciplines of science and engineering. Excellent infrastructure exists for materials research at the Advanced Centre for Materials Science and at various other laboratories in the Institute. Students are encouraged to select an interdisciplinary problem for their thesis work. The broad areas of research under progress include electronic materials, ceramics, composites, solid state ionics, the energy storage materials, thin films, high T_c superconductors, magnetic materials, polymers, nano-structured materials and specialised techniques. Summer work in industries or R and D organisations can also be arranged on a personalised basis to complement the student's training in Institute.

COURSE DESCRIPTION

MS 601 **STRUCTURAL AND MAGNETIC PROPERTIES OF MATERIALS**

L-T-P-D-[C]

3-0-0-0-[4] Crystal structure, Bonding of atoms, Crystal chemistry, Equilibrium thermodynamics, Phase equilibria, Phase transformations, Dia, Para-, Ferro-, Ferri- and Antiferro-magnetism, Magnetic domains, Anisotropy effects, Magnetostriction, Measurement of magnetic properties, Soft and hard magnetic materials and their technology.

MS 602 **ELECTRICAL AND DIELETRIC MATERIALS**

L-T-P-D-[C]

3-0-0-0-[4] Metallic conduction, Energy bands, Brillouin zones, Temperature dependence of metallic conductivity, Impurity contributions, Semiconductor materials, Doping effects, Law of mass action, Electrical resistivity and Hall effect measurements, Recombination Processes, p-n junctions, MOS field effect transistors, Semiconductor technology, Point defects, Diffusion phenomenon, Ionic conduction, Temperature and (aliovalent) impurity effects, Superionic conductors and devices, Di-, piezo- and ferro-electric materials, Mechanisms of polarization, Dielectric parameters and their measurements.

MS 603 **MECHANICAL PROPERTIES OF MATERIALS**

L-T-P-D-[C]

3-0-0-0-[4] Stress and strain tensors, Elastic constants, Effect of structure on elastic behaviour, Elastic stress distributions, Viscosity and viscoelasticity in polymers, Yielding criteria, Dislocations and plastic deformation of metals and ceramics, Strengthening mechanisms, Creep, Brittle fracture in ceramics and glasses, Toughening of ceramics and composites, Fatigue, Mechanical testing, Strength and engineering design with brittle solids, Heat treatment, Powder processing.

MS 604 **CHARACTERIZATION OF MATERIALS**

L-T-P-D-[C]

3-0-1-0-[5] Crystallography, Reciprocal lattice, Diffraction methods, Electron microscopy, Metallography, Thermal analysis, Chemical analysis, Spectroscopic techniques, Laboratory sessions.

MS 605 **MATERIALS ENGINEERING**

L-T-P-D-[C]

3-0-0-0-[4] Solidification, Powder processing, Crystal growth, Heat treatment and microstructures, Non destructive evaluation, Processing of glasses and polymers, Novel processing methods, Thin films, Surface phenomena and corrosion.

MS 606 **ELECTRONIC MATERIALS** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4] Classification, Crystal growth techniques, Wafer processing, Doping methods, Formation of oxide layer, CVD, MOCVD and MBE, Metallic contacts and interconnects, Lithography, Processing integration.

Photonic materials-solar cells, photodetectors, light emitting diodes, Superlattice structures, Materials for high frequency and high temperature devices, Application of linear and non-linear dielectric materials, Electro-optic ceramics, Materials for signal processing, transducers and digital data storage, Superconducting materials and applications.

MS 607 **ELECTRO CERAMICS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to electronic ceramics, Defects and diffusion in ionic solids, Ionic conductivity, Applications, Liner dielectrics, Frequency dependence of polarization, impedance spectroscopy, Dielectric material design for microwave, thin film capacitor, microelectronics and VLSI applications; Nonlinear dielectrics, Structural origin, Thermodynamic formulation, Ferroelectrics and piezoelectrics, Applications; Electro-optic ceramics, Birefringence, Linear and quadratic optoelectric effects, Electro-optic coefficients, KDP, $LiNbO_3$, $LiTaO_3$, PLZT; Processing, Applications, Magnetic ceramics, Ferro-, Ferri-, ferrites and other magnetic materials, Applications, New high permeability magnets, Giant and colossal magnetoresistance, Magneto-electronics; High temperature superconductors : Structure, synthesis and characterization, Applications.

MS 611 **MATERIALS FOR ENERGY CONVERSION AND STORAGE** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Characteristics of solar radiation, Basic features of solar cells, Various junction configurations, p -n homojunction, Schottky barrier, Heterojunction, Photo-electrochemical cells, Desired material properties, Promising semiconductor materials, Various fabrication techniques, Solid state diffusion, Vacuum evaporation, Sputtering, Thermal oxidation, Chemical displacement, Plasma deposition, Energy storage devices.

MS 612 **ELECTRON MICROSCOPY AND MICROANALSIS, 3-1-0-0-5** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[5]

TEM-Introduction, Instrument details, Resolution, Modes of operation, Specimen preparation, Principles of electron diffraction, Formation of ring, spot and textured patterns, Indexing procedures, identification of phase, Amplitude and phase contrast, BF and DF images, Kinematical and dynamical theories, Contrast from defects, Weak beam technique, Lattice resolution, etc.

SEM- Electron-specimen interactions, Signal characteristics, Image formation, SE, BSE and CL detecting systems, Contrast mechanisms, Resolution, EBIC microscopy, Electron channelling Patterns and Kossel technique.

MICROANALYSIS- X-ray emission, Wavelength and Energy dispersive analyzers, Point analysis, Line scans, Distributiion mapping, Quantitative analysis.

MS 614 **ENGINEERING POLYMERS**

L-T-P-D-[C]

3-0-0-0-[4]

Classification and structure of polymers, Glass transition, Linear viscoelasticity, Stress relaxation and dynamic experiments, Mechanical models, Superposition principles, Effect of structure on mechanical properties, Rubber elasticity, Yield and fracture.

MS 615 **PRINCIPLES OF CERAMIC PROCESSING**

L-T-P-D-[C]

3-0-0-0-[4]

Particle size, Particle packing, Size reduction, Particles in liquid suspension, Rheology, Polymers in ceramic processing, Colloidal processing, Sintering, Sintering defects, Surfaces and interfaces in processing, Sol-gel and other chemical processing methods.

MS 616 **HIGH PERFORMANCE POLYMERS AND COMPOSITES** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction to high performance polymers and composites, Classifications and examples, Characterization methods, Processing of high performance polymers and composites; Open two roll mill, Internal mixer, Extruder, Calendering, Various moulding units, Fibre spinning, Lamination, etc, Structure, chemistry, grade, processing parameters, properties and application of various high performance polymers and composites, Application of polymers in space, ocean, electronics, medical, agriculture, automobile, sports, building construction, etc.

MS 617 **INTRODUCTION TO NANO MATERIALS AND NANOTECHNOLOGY** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Effects of confinement and finite size-zero, one and two dimensional nano-structures (concepts of surface and interfacial energies), Intermolecular and interfacial forces in organic, polymeric, biological and aqueous systems-Van der Waals, electrostatic, double layer, acid base, depletion interactions, hydrophobic force, layering, mesoscale thermodynamics, Gibbs treatment of interfaces, mesoscale fluid dynamics, thin soft films, mesoscale phenomena in soft matter and applications: adhesion, wetting, nucleation, Nanofabrication: patterning of soft materials by self organisation and other techniques, chemical self assembly, artificial multilayers, cluster fabrication, Langmuir-Blodget growth, Nanolithography, Scanning probe lithography, Micro contact printing, Synthesis of nanoparticles and films: sol-gel, hydrothermal, freeze drying, intercalation, attrition, ion implantation, Gas phase condensation, Chemical vapour deposition, Nanosuspensions-ferrofluids, Compaction of nanocrystlline materials, Carbon nanotubes, short and long term applications and perspectives, Demonstration of some techniques in preparation and characterization of nanomaterials.

MS 691 **SPECIAL TOPICS**
L-T-P-D-[C]
3-0-0-0-[4]

MS 698 **GRADUATE SEMINAR**
L-T-P-D-[C]
1-0-0-0-[0]

MS 699 **M. TECH. THESIS UNITS - MULTIPLE OF 4**

MS 799 **PH. D. RESEARCH UNITS - MULTIPLE OF 4**