Dept of Materials Engineering

M. Tech. PROGRAMME MATERIALS ENGINEERING
(Duration : 2 Years, 64 credits)

Hard core (8 credits)

MT 202	3:0	Thermodynamics and Kinetics
MT 241	3:0	Structure and Characterisation of Materials
MT 243	0:2	Laboratory Experiments in Metallurgy

Soft core (9 credits): Any three out of the following eight courses

MT 203	3:0	Materials Design and Selection
MT 209	3:0	Defects in Materials
MT 220	3:0	Microstructural Design and Development of Engineering Materials
MT 231	3:0	Interfacial Phenomena in Materials Processing
MT 245	3:0	Transport Processes in Process Metallurgy
MT 252	3:0	Science of Materials Processing
MT 253	3:0	Mechanical Behaviour of Materials
MT 260	3:0	Polymer Science and Engineering – I

Project (32 credits)

MT 299 0:32 Dissertation Project

Electives (15 credits): At least 9 credits must be taken from the courses offered by the Department.

MT 209 (AUG) 3:0

Defects in Materials

Review of defect classification and concept of defect equilibrium. Review of point defects in metallic, ionic and covalent crystals. Dislocation theory - continuum and atomistic. Dislocations in different lattices. Role of anisotropy. Dislocation kinetics. Interface thermodynamics and structure. Overview of grain boundaries, interphase boundaries, stacking faults and special boundaries. Interface kinetics: migration and sliding. Defect interactions: point defect-dislocation interaction, dislocation-interface interactions, segregation, etc.. Overview of methods for studying defects including computational techniques

Karthikeyan Subramanian

W.D. Kingery, H.K. Bowen and D.R. Uhlmann: Introduction to Ceramics, 2nd ed., John Wiley and Sons, 1976~D. Hull and D. J. Bacon: Introduction to dislocations, 4th ed., Butterworth-Heinemann, 2001.~D.A. Porter and K.E. Easterling: Phase Transformation in Metals and Alloys, 2nd ed. Chapman and Hall, 1992.~R.W. Balluffi, S.M. Allen, W.C. Carter: Kinetics of Materials, 1st ed. Wiley-Interscience, 2005.~J.P. Hirth and J.L. Lothe: Theory of Dislocations, 2nd ed., Krieger, 1982.

MT 202 (AUG) 3:0

Thermodynamics and Kinetics

Classical and statistical thermodynamics, Interstitial and substitutional solid solutions, solution models, phase diagrams, stability criteria, critical phenomena, disorder-to-order transformations and ordered alloys, ternary alloys and phase diagrams, Thermodynamics of point defects, surfaces and interfaces. Diffusion, fluid flow and heat transfer.

Abinandanan T A

C.H.P. Lupis: Chemical Thermodynamics of Materials, Elsevier Science, 1982~P. Shewmon: Diffusion in Solids, 2nd Edition, Wiley, 1989.~A.W. Adamson and A.P. Gast: Physical Chemistry of Surfaces (Sixth Edition), John Wiley, 1997.

MT 218 (AUG) 3:0

Modeling and Simulation in Materials Engineering

Importance of modeling and simulation in Materials Engineering. nd numerical approaches. Numerical solution of ODEs and PDEs, explicit and implicit methods, Concept of diffusion, phase field technique, modelling of diffusive coupled phase transformations, spinodal decomposition. Level Set methods, Celula Automata,: simple models for simulating microstructure,. Finite element modelling,: Examples in 1D, variational approach, interpolation functions for simple geometries, (rectangular and triangular elements); Atomistic modelling techniques,: Molecular and Monte-Carlo Methods.

Abhik N Choudhury

A.B. Shiflet and G.W. Shiflet: Introduction to Computational Science: Modeling and Simulation for the Sciences, Princeton University Press, 2006.~D.C. Rapaport: The Art of Molecular Dynamics Simulation, Cambridge Univ. Press, 1995.~K. Binder, D. W. Heermann: Monte Carlo Simulation in Statistical Physics, Springer, 1997.~K.G.F Janssens, D. Raabe, E. Kozeschnik, M.A. Miodownik, B. Nestler: Computational Materials Engineering: An Introduction to Microstructure Evolution, Elsevier Academic press, 2007.~David V. Hutton, Fundamentals of Finite Element Analysis

MT 235 (AUG) 3:0

Corrosion Technology

Basic electrochemical principles governing corrosion. Types and mechanisms of corrosion. Advances in corrosion engineering and control. Anodic and Cathodic control-Biocorrosion, mechanisms and microbiological aspects. Corrosion under sub-soil and sea water conditions- Marine biofouling and biocorrosion with respect to industrial conditions. Methods of abatement.

Abinandanan T A

M.G. Fontana: Corrosion Engineering, 3rd Edition, McGraw-Hill, N.Y., 1978.~Borenstein: Microbiologically Influenced Corrosion Handbook.

MT 260 (AUG) 3:0

Polymer Science and Engineering

Fundamentals of polymer science. Polymer nomenclature and classification. Current theories for describing molecular weight, molecular weight distributions. Synthesis of monomers and polymers. Mechanisms of polymerization reactions. Introduction to polymer processing (thermoplastic and thermoset). Structure, property relationships of polymers: crystalline and amorphous states, the degree of crystallinity, cross-linking, and branching. Stereochemistry of polymers. Instrumental methods for the elucidation of polymer structure and properties; basic principles and unique problems encountered when techniques such as thermal (DSC, TGA, DMA, TMA, TOA), electrical, and spectroscopic (IR, Raman, NMR, ESCA, SIMS) analysis GPC, GC-MS, applied to polymeric materials. Polymer Processing - Injection Molding, Extrusion, Compression Molding, Blow Molding, Casting and Spin Coat, Calendaring.

Praveen C Ramamurthy

G. Odian: Principles of Polymerization. McGraw Hill. 2nd Edition.. 1981. N.A. Dotson. R. Galvan. R.L. Laurence and M. Tirrell: Polymerization Process Modeling. Wiley. 1995. F.W. Billmeyer: Textbook of Polymer Science, Wiley. 1984.

MT 253 (AUG) 3:0

Mechanical Behaviour of Materials

Theory of Elasticity. Theory of Plasticity Review of elementary dislocation theory. Deformation of single and polycrystals. Temperature and strain rate effects in plastic flow - strain hardening, grain size strengthening, solid solution strengthening, order hardening, precipitation hardening, dispersion strengthening. Strengthening by martensitic transformation, creep, fatigue and fracture.

Subodh Kumar

Subodh Kumar,Thomas H. Courtney,Mechanical Behaviour of Materials.,G.E. Dieter: Mechanical Metallurgy,McGraw-Hill

MT 245 (AUG) 3:0

Transport Processes in Process Metallurgy

Basic and advanced idea of fluid flow, heat and mass transfer. Integral mass, momentum and energy balances. The equations of continuity and motion and its solutions. Concepts of laminar and turbulent flows. Concept of packed and fluidized bed. Non-wetting flow, Natural and forced convection. Unit processes in process metallurgy. Application of the above principles in process metallurgy.

Govind S Gupta

J. Szekely and N.J. Themelis, Rate Phenomena in Process Metallurgy, Wiley, New York, 1971~G.H. Geiger and D R Poirier: Transport Phenomena in Metallurgy, Addison-Wesley, 1980.~D.R. Gaskell: Introduction to Transport Phenomena in Materials Processing, 1991.~R.B. Bird, W.E. Stewart and E.N. Lightfoot: Transport Phenomena, John Wiley International Edition, 1960~F.M. White: Fluid Mechanics, McGraw Hill, 1994 Various research papers

MT 241 (AUG) 3:0

Structure and Characterization

Bonding and crystal structures, Stereographic projection, Point and space groups, Defects in crystals, Schottky and Frenkel defects, Charged defects, Vacancies and interstitials in non stoichiometric crystals, Basics of diffraction theory, X-ray powder diffraction and its applications, Electron diffraction and Electron microscopy.

Rajeev Ranjan

A. R. West: Solid State Chemistry and its Applications, John Wiley~B. D. Cullity: Elements of x-ray Diffraction~A. Kelly and G. W. Groves: Crystallography and Crystal Defects, Longman~M. D. Graef and M. E. Henry: Structures of Materials, Cambridge~R. J. D. Tilley: Defects in Solids, Wiley 2008

MT 258 (JAN) 3:0

Mechanical Behavior of Thin Films

Short description of common thin film deposition techniques; Origin of residual stresses; Determination of stress state in thin films deposited on substrate; Stress relaxation processes, including hillocking and whiskering, grain boundary sliding, and interface governed phenomenon, such as dewetting, buckling, interfacial fracture, interfacial sliding, etc.; Size effects; Mechanical testing of thin films, including nanoindentation.

Praveen Kumar

Materials Science of Thin Films by M. Ohring,Academic Press,Thin film materials: stress,defect formation and surface evolution. L. B. Freund,S. Suresh

MT 250 (JAN) 3:0

Introduction to Materials Science and Engineering

Compulsory for M.E. students who do not have BE Metallurgy; Compulsory for research students without materials background

Bonding, types of materials, basics of crystal structures and crystallography. Thermodynamics, thermochemistry, unary systems. Methods of structural characterisation. Thermodynamics of solid solutions, phase diagrams, defects, diffusion. Solidification. Solid-solid phase Transformations. Mechanical behaviour: elasticity, plasticity, fracture. Electrochemistry and corrosion. Band structure, electrical, magnetic and optical materials. Classes of practical material systems: metallic alloys, ceramics, semiconductors, composites

Subodh Kumar

W.D. Callister: Materials Science & Engineering,W.D. Callister: Materials Science & Engineering,Wiley (India) 2007,W.D. Callister: Materials Science & Engineering,Wiley (India) 2007

MT 208 (JAN) 3:0

Diffusion in Solids

Aloke Paul

Paul G. Shewmon, Diffusion in Solids,A. Paul, T. Laurila, V. Vuorinen, S. Divinski, Thermodynamics, Diffusion and The Kirkendall effect in Solids,A. Paul, S. Divinski, Handbook of Solid State Diffusion

MT 213 (JAN) 3:0

Electronic Properties of Materials

Introduction to electronic properties; Drude model, its success and failure; energy bands in crystals; density of states; electrical conduction in metals; semiconductors; semiconductor devices; p-n junctions, LEDs, transistors; electrical properties of polymers, ceramics, metal oxides, amorphous semiconductors; dielectric and ferroelectrics; polarization theories; optical, magnetic and thermal properties of materials; application of electronic materials: microelectronics, optoelectronics and magnetoelectrics.

Subho Dasgupta

R. E. Hummel, Electronic Properties of Materials,S. O. Kasap, Principles of Electronic Materials and Devices,S. M. Sze, Semiconductor devices: Physics and Technology,D. Jiles, Introduction to the electronic properties of materials

MT 225 (JAN) 3:0

Deformation and Failure Mechanisms at Elevated Temperatures

Phenomenology of Creep, Microstructural considerations in metals, alloys, ceramics and composites. Creep mechanisms, Deformation mechanism maps, Superpasticity in metal alloys, ceramics and nanophase materials, Commercial applications and considerations, Cavitation failure at elevated temperatures by nucleation, growth and interlinkage of cavities.

The course will also include some laboratory demonstrations of the phenomena discussed in the class together with an appropriate analysis of the data.

Atul H Chokshi

Atul H Chokshi,J. P. Polreer, Creep of Crystals, Cambridge University Press, Cambridge, 1984,H. Riedel, .Fracture at High Temperatures, Springer Verlag, Berlin, 1987

MT 256 (JAN) 3:0

Fracture

Review of elastic and plastic deformation. Historical development of fracture mechanics. Thermodynamics of fracture including Griffith theory. Linear elastic fracture mechanics. Irwin and Dugdale extensions. Stability of cracks. Crack resistance curves and toughening of brittle materials. Ductile failure. J-integral. Indentation failure. Environmental aspects of failure. Cyclic Fatigue. Methods to measure toughness. Fracture in thin films and interfaces. Toughening in hierarchical structures

Vikram Jayaram

B.R. Lawn: Fracture of Brittle Solids. Cambridge University Press (1993).,T.H. Courtney: Mechanical Behaviour of Materials. McGraw Hill (1990).,David Broek: Engineering Fracture Mechanics. . Sijthoff and Nordhoff , The Netherlands (1978).,Richard Hertzberg: Deformation & Fracture of Engineering Materials. John Wiley (1996).

MT 299 (JAN) 0:32

Dissertation Project

The M.E. Project is aimed at training the students to analyse independently any problem posed to them. The project may be a purely analytical piece of work. a completely experimental one or a combination of both. In a few cases. the project can also involve a sophisticated design work. The project report is expected to show clarity of thought and expression. critical appreciation of the existing literature and analytical and/or experimental or design skill.

MT 231 (JAN) 3:0

Interfacial Phenomena in Materials Processing

Materials and surfaces, Adsorption from solution, Thermodynamics of adsorption - surface excess and surface free energy, Gibbs equation, adsorption isotherms, wetting, contact angle, Young's equation, Monolayer and interfacial reactions, Electrical phenomena at interfaces, electrochemistry of the double layer, electrokinetics, flocculation, coagulation and dispersion, Polymers at interfaces, Emulsions. Applications in Materials Processing.

Subramanian S

E. Matrijivic (Ed.): Surface and Colloid Science, Plenum, New York, 1982.,A.W. Adamson: Physical Chemistry of Surfaces, Wiley Interscience, New York, 1996.,J.S. Laskowski and J. Ralston (Ed.): Colloid Chemistry in Mineral Processing, Elsevier, New York, 1992.

MT 248 (JAN) 3:0

Modelling and Computational Methods in Metallurgy

Basic principles of physical and mathematical modelling. Similarity criteria and dimensional analysis. Detailed study of modelling of various metallurgical processes such as blast furnace, induction furnace, ladle steelmaking, rolling, carburizing and drying. Finite difference method. Solution of differential equations using various numerical techniques. Convergence and stability criteria.

Assignments will be based on developing computer code to solve the given problem. Prerequisite: Knowledge of transport phenomena, program language

Govind S Gupta

Govind S Gupta,J.Szekely and N. J. Themelis: Rate Phenomena in Process Metallurgy, Wiley, New York, 1971,B. Carnahan, H. A. Luther, and J. O. Wikes: Applied Numerical Methods, John Wiley, NY 1969.

MT 243 (JAN) 0:2

Laboratory Experiments in Materials Engineering

Experiments in Metallographic techniques, heat treatment, diffraction mineral beneficiation, chemical and process metallurgy, and mechanical metallurgy.

Rajeev Ranjan

MT 201 (JAN) 3:0

Phase Transformations

Overview of phase transformations, nucleation and growth theories, coarsening, precipitation, spinodal decomposition, eutectoid, massive, disorder-to-order, martensitic transformations. crystal interfaces and microstructure. topics in the theory of phase transformations: linear stability analysis, elastic stress effects, sharp interface and diffuse interface models of microstructural evolution.

Chandan Srivastava

Prerequisites: Basic courses on crystallography, thermodynamics, phase diagrams and diffusion.,D.A. Porter. and K.E. Easterling: Phase Transformations in Metal and Alloys, Van Nostrand, 1981.,A.K. Jena, and M. Chaturvedi: Phase Transformations in Materials, Prentice-Hall, 1993.,A.G. Khachaturyan: Theory of Structural Transformation in Solids, John Wiley, 1983.,R.E. Reed-Hill and R. Abbaschian: Physical Metallurgy Principles, P.W.S-Kent, 1992.

MT 255 (JAN) 3:0

Solidification Processing

Advantage of solidification route to manufacturing, the basics of solidification including fluid dynamics, solidification dynamics and the influence of mould in the process of casting. Origin of shrinkage, linear contraction and casting defects in the design and manufacturing of casting, continuous casting, Semi-solid processing including pressure casting, stir casting and thixo casting. Welding as a special form of manufacturing process involving solidification. Modern techniques of welding, the classification of different weld zones, their origin and the influence on properties and weld design. Physical and computer modeling of solidification processes and development of expert systems. New developments and their possible impact on the manufacturing technology in the future with particular reference to the processes adaptable to the flexible manufacturing system.

Abhik N Choudhury

Abhik N Choudhury,J. Campbell: Casting, Butterworth - Haneman, London, 1993,M.C. Flemings: Solidification Processing , McGraw Hill, 1974.

MT 257 (JAN) 3:0

Finite Element Method for Materials Engineers

This course has been specially designed for those students, who did not get a chance to study FEM during undergrad, but want to use FEM as a tool to gain some insight into their project/research problems. The syllabus includes the following: Quick recap of relevant mathematical concepts. Introduction to fundamentals of elasticity and plasticity. Crystal plasticity. Philosophy of FEM. Fundamentals of FEM, such as concepts of meshing, stiffness matrix, interpolation functions. Residual methods, Rayleigh - Ritz method, Galerkin method. 1-D, 2-D and 3-D example problems in elasticity and heat transfer. Solving linear and non-linear structural, thermal and electrical problems using a commercial FEM software (mostly, ANSYS). Finite element crystal plasticity.

Praveen Kumar,Cook,R. D.,et al,Concept and Applications of Finite Element Analysis

MT 261 (JAN) 3:0

Organic Electronics

(Prerequisites: Polymer Science and Engineering and Semiconductor fundamentals) Fundamentals of polymers. Device and materials physics. Polymer electronics materials, processing, and applications. Chemistry of device fabrication, materials characterization. Electroactive polymers. Device physics: Crystal structure, Energy band diagram, Charge carriers, Heterojunctions, Diode characteristics. Device fabrication techniques: Solution, Evaporation, electrospinning. Devices: Organic photovoltaic device, Organic light emitting device, Polymer based sensors.Stability of organic devices.

Praveen C Ramamurthy

T. A. Skotheim and J. R. Reynolds (Editors): Handbook of Conducting Polymers (Third Edition) Conjugated Polymers: Theory, Synthesis, Properties and Characterization, CRC Press.,T.A. Skotheim and J. R. Reynolds (Editors): Handbook of Conducting Polymers (Third Edition) Conjugated Polymers: Processing and Applications Edited by Terje A. Skotheim and John R. Reynolds, CRC Press.,S-S. Sun and N. S. Sariciftci (Editors): Organic Photovoltaics - Mechanisms, Materials, and Devices, CRC Press.,D.A. Neamen: Semiconductor Physics and Devices Basic Principles, McGraw Hill.

MT 271 (JAN) 3:0

Introduction to Biomaterials Science and Engineering

This course will introduce basic concepts of biomaterials research and development including discussion on different types of materials used for biomedical applications and their relevant properties. Content: Surface engineering for biocompatibility; Protein adsorption to materials surfaces; Blood compatibility of materials; Immune response to materials; Corrosion and wear of implanted medical devices; Scaffolds for tissue engineering and regenerative medicine; Concepts in drug delivery;

Kaushik Chatterjee

Ratner et al: Biomaterials science: An introduction to materials in medicine,Lecture notes,Literature

MT 262 (JAN) 3:0

Concepts in Polymer Blends and Nanocomposites

Introduction to polymer blends and composites, nanostructured materials and nanocomposites, Polymer-polymer miscibility, factors governing miscibility, immiscible systems and phase separation, Importance of interface on the property development, compatibilizers and compatibilization, Blends of amorphous & semi-crystalline polymers, rubber toughened polymers, particulate, fiber reinforced composites. Nanostructured materials like nano clay, carbon nanotubes, graphene etc. and polymer nanocomposites. Surface treatment of the reinforcing materials and interface/interphase structures of composites / nanocomposites. Various processing techniques like solution mixing, melt processing. Unique properties of blends, composites/nanocomposites in rheological, mechanical, and physical properties and applications

Suryasarathi Bose

D.R. Paul and S. Newman: Polymer Blends, Vol 1&2 , Academic Press, 2000,L.A. Utracki: Polymer Alloys and Blends, Hanser, 2000,C. Chung: Introduction to Composites, Technomic, Lancaster, PA. 1998.,J. Summerscales and D. Short: Fiber Reinforced Polymers, Technomic. 1988,T.J. Pinnavia and G.W. Beall (Editors): Polymer-Clay Nanocomposites, Wiley, New York 2000. P.M. Ajayan, L.S. Schadler and P.V. Braun: Nanocomposite Science &Technology, Wiley-VCH, Weinheim, 2003.

MT 220 (JAN) 3:0

Microstructural Engineering of Structural Materials

Review of crystal defects: dislocation theory, grain boundaries and heterophase boundaries, defect kinetics and defect interactions; Role of microstructure on mechanical properties: strengthening mechanisms, ductilizing mechanisms, toughening mechanisms, effect of microstructure on creep, fatigue and impact resistance; Methods of controlling microstructures: phase transformations (L?S, V?S, S? S), heat treatments, solidification, mechanical processing, texture control, recovery and recrystallization, sintering, etc; Case studies of microstructural control of engineering metals, alloys and ceramics (Ni-base superalloys, YSZ, ceramic-matric composites, Ti-alloys, steels, etc)

Karthikeyan Subramanian, Dipankar Banerjee, Abhik N Choudhury