M. Tech. Program in Materials Engineering (Duration: 2 Years, Total Credits: 100)

Course Structure

Semester I

Subject type	Subject No.	Subject Name	L-T-P	Credit
Core	MT401	Thermodynamics and phase equilibria of Materials	4-0-0	4
Core	MT402	Materials Characterization- I	4-0-0	4
Core	MT403	Concepts of Nanoscience and Engineering	4-0-0	4
Core	MT404	Polymer Science and Composites	4-0-0	4
Core	MT 405	Mechanical Behavior of Materials	4-0-0	4
Core	MT406	Concepts in Materials Science and Engineering	4-0-0	4
Core	MT407	Material Processing and Characterization: Laboratory- I	0-0-4	4
Core	MT 408	Advanced Engineering Mathematics	2-0-0	2
		Total		**30**

Semester II

Subject type	Subject No.	Subject Name	L-T-P	Credit
Core	MT452	Diffusion, phase transformation and Kinetics	4-0-0	4
Core	MT453	Materials Modelling	4-0-0	4
Core	MT 454	Materials Characterization II	4-0-0	4
Core	MT 455	Material Processing and Characterization: Laboratory II	0-0-4	4
Core	MT456	Seminar I	0-0-2	2
Elective	MT…	Elective I	4-0-0	4
Elective	MT…	Elective II	4-0-0	4
Elective	MT..	Elective III	4-0-0	4
		Total		**30**

Semester III

Subject type	Subject No.	Subject Name	L-T-P	Credit
Core	MT463	Project Part-I	0-0-18	18
Core	MT464	Seminar III	0-0- 2	2
		Total		**20**

Semester IV

Subject type	Subject No.	Subject Name	L-T-P	Credit
Core	MT463	Project Part II	0-0-18	18
	MT465	Dissertation Seminar	0-0- 2	2
		Total		**20**

Electives:

Any three from the following list of courses. The minimum no. of students required for a course to be offered is **SIX:**

Group A

MT 457 Powder Metallurgy/ Advanced Ceramics

MT 458 Corrosion Engineering

MT 459 Crystallography and Texture Analysis

Group B:

MT 460 Nano Biomaterials/ Nano biotechnology

MT 461 Smart Materials and Nanostructures

MT 462 Surface Engineering

Semester I

MT 401: Thermodynamics and phase equilibria of Materials

Introduction & definition of thermodynamic terms (system, extensive/intensive properties, variables, state, isothermal/adiabatic processes, component, phase, equilibrium, internal energy, heat capacity, enthalpy, entropy, free energy)

Laws of Thermodynamics; Equation of state; Homogeneous systems; Reversibility and irreversibility; Maxwell's relationships; Gibbs-Helmoltz equation

Single Component Systems; Variation of G with P and T; Triple point; Phase equilibria; Critical point; Impure substances; Solubility; Ideal and non-ideal solutions; Activity; Chemical Potential; Solution models; Gibbs' phase rule; Phase diagrams

Behaviour of gases; P-V-T relationships in gases; Thermodynamics of non-ideal gases;

Analysis & synthesis of phase diagrams; Construction of phase diagrams from thermodynamic data; extraction of thermodynamic data from phase diagrams; Current status of phase diagrams

Thermodynamics of: Nucleation; Reactions involving gases; Oxidation & reduction; Electrolysis…. (add some specific processes)

Suggested Reading:

1. Introduction to the Thermodynamics of Materials, by David R Gaskell

2. Thermodynamics of Solids, by Richard Arthur Swalin

3. Engineering in Process Metallurgy, by R. I. Guthrie

MT 402 : Material Characterisation –I

Scope of Characterization of materials; Materials beam interaction Optical Microscopy:Techniques, Polarised and interferomery phase contrast. In-situ metallography, colour metallorgaphy, inclusion characterization.

Quantitative Microscopy: Techniques

Diffraction Techniques: X-ray diffraction technique for phase identification, strain & particle size, phase diagram and Texture determinations, synchrotron radiation, Neutron diffraction.

Scanning electron microscopy and Electron probe micro analysis: Principles of image formation in SEM and application. Energy dispersive X-ray analysis and wavelength dispersive X-ray analysis. Electron probe micro analysis and its application for chemical analysis. Scanning Transmission electron microscopy.

Transmission and analytical electron microscopy. Formation of image and selection area diffraction patterns. Theories of image contrast and their application to perfect and imperfect crystalline specimens.

Surface probe microscopy: Scanning Tunneling microscopy, Atomic Force microscopy (AFM), different mode for characterizations (contact, non-contact and tapping), Nanostructure characterization, Defect analysis in materials, surface topography, electrical properties at nanoscale (resistivity, surface potential, and capacitance), Scanning capacitance microscopy (SCM), applications in advanced materials and MEMS/NEMS devices.

Reference Books:

1. Cullity, B.D., Elements of X- Ray diffraction, Addison Wesley

2. Sridhar, G., Ghosh Choudhary, S., and Goswami, N. G., Materials characterization techniques (ed) NML, Jamshedpur.

3. Williams, D.B., and Carter, C.B., Transmission electron microscopy: A Text Book of Materials Science.

4. David Brandon, Wayne D. Kaplan, Microstructural Characterization of Materials.

MT 403: Concepts of Nano- Science & Engineering

History of nano- science and technology (Case studies);

Introduction & fundamental terms (Physics & Chemistry); Perspectives;

Discussion on "There's is plenty of room at the bottom".

Scaling laws (Mechanics, Optics, Fluids, Electromagnetism, Thermodynamics, Quantum Effects etc., and Case Studies);

Quantum mechanics (Wave equation, HF-, DFT- etc.,) and its applications;

Statistical mechanics and its applications;

Chemical kinetics and its applications;

Classification of nanomaterials; How to characterize nanomaterials?;

Electrons in nanomaterials;

Nano-biotechnoloy: Bio-molecules; Biosensors; Nanomaterials in drug delivery;

Working in clean room environments;

Safety and environment related aspects of nanomaterials;

M. F. Ashby, **P. J. Ferreira**, and **D. L. Schodek**, "Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects", Elsevier Ltd., 2009.

S. M. Lindsay, "Introduction to Nanoscience", Oxford University Press, 2010.

C. Dupas, P. Houdy, and **M. Lahmani**, "Nanoscience: Nanotechnologies and Nanophysics", Springer, Heidelberg, 2007.

K. K. Chattopadhyay and **A. N. Banerjee**, "Introduction to Nanoscience and Nanotechnology", PHI Learning Ltd., 2011.

Guozhong Cao, "Nanostructures and Nanomaterials: Synthesis, Properties & Applications", Imperial College Press, London, 2004.

M. Ratner and **D. Ratner**, "Nanotechnology: A Gentle Introduction to the Next Big Idea", Princeton Hall, 2002.

MT 404: Polymer Science and Composites

Chemistry of high polymers: Monomers, functionality, degree of polymerizations, classification of polymers, glass transition, melting transition, criteria for rubberiness, polymerization methods: addition and condensation; their kinetics, metallocene polymers and other newer techniques of polymerization, copolymerization, monomer reactivity ratios and its significance, kinetics, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, techniques for copolymerization-bulk, solution, suspension, emulsion.

Polymer Characterization: Solubility and swelling, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, polymer crystallinity, analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical and electronic) techniques.

Synthesis and properties Selected High performance Polymers: Commodity and general purpose thermoplastics: PE, PP, PS, PVC, Polyesters, Acrylic, PU polymers. Engineering Plastics: Nylon, PC, PBT, PSU, PPO, ABS, Fluoropolymers Thermosetting polymers: PF, MF, UF, Epoxy, Unsaturated polyester, Alkyds. Natural and synthetic rubbers: Recovery of NR hydrocarbon from latex, SBR, Nitrile, CR, CSM, EPDM, IIR, BR, Silicone, TPE.

Polymer blends and composites: Difference between blends and composites, their significance, choice of polymers for blending, blend miscibility-miscible and immiscible blends, thermodynamics, phase morphology, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends, FRP, particulate, long and short fibre reinforced composites.

Polymer Technology: Polymer compounding-need and significance, different compounding ingredients for rubber and plastics, crosslinking and vulcanization, vulcanization kinetics.

Polymer rheology: Flow of Newtonian and non-Newtonian fluids, different flow equations, dependence of shear modulus on temperature, molecular/segmental deformations at different zones and transitions. Measurements of rheological parameters by capillary rotating, parallel plate, cone-plate rheometer. viscoelasticity-creep and stress relaxations, mechanical models, control of rheological characteristics through compounding, rubber curing in parallel plate viscometer, ODR and MDR.

Polymer processing: Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.

Polymer testing: Mechanical-static and dynamic tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tear, resilience, impact, toughness. Conductivity-thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, swelling, ageing resistance, environmental stress cracking resistance.

Advanced polymer: Conductive polymers, Liquid crystal polymers, Biopolymers, Polymer nanoparticles, Polypeptides, Polymer for drug and gene delivery

MT 405: Mechanical behaviour of materials

Strength of Materials: Basic assumptions, elastic and plastic behavior, stress- strain relationship for elastic behavior, elements of plastic deformation of metallic materials, Mohr's circle, yielding theories.

Theory of plasticity: Dislocation theory, properties of dislocations, stress fields around dislocations, application of dislocation theory to work hardening, solid solution strengthening, grain boundary strengthening, dispersion hardening.

Ductile and brittle fracture: Charpy and Izod testing, Significance of DBTT, Elements of fractography;

Fatigue failure: Initiation and propagation of Fatigue cracks, factor affecting fatigue strength and methods of improving fatigue behaviour, testing analysis of fatigue data, mechanism of fatigue crack propagation, Corrosion fatigue.

Creep failure: Creep mechanism, creep curve, variables affecting creep, accelerated creep testing, development of creep resisting alloys, Larsen- Miller parameter, Manson Hafred parameter.

Mechanical behaviour of thin films : Residual/intrinsic stress, strength - a size effect, epitaxy and stress, composite thin films, bending of beam, different structure mechanical behavior at micro-nano scale, applications in MEMS.

Mechanical behaviour of materials at nanoscale : Depth-sensing nanoindentation, micro beam bending, micro tensile testing, substrate curvature testing for elastic, plastic, fracture toughness and interfacial toughness.

Reference Books

1. Dieter, G. E., Mechanical metallurgy, McGraw Hill.

2. Hertzberg, R.W., Deformation and fracture mechanics of engineering materials, John

Wiley

3. Hull, D., Introductions to dislocations, Pergamon.

4. Garofalo, F., Fundamentals of creep and creep rupture in metals, McMillan.

5. Meyers, M. A., and Chawla, K.K., Mechanical behavior of materials, Prentice Hall

MT 406: Concepts in Materials Science and Engineering

Introduction: Atomic structure, electronic configuration, periodic table, bonding forces and energies, ionic bonding, covalent bonding, metallic bonding, van der Waals bonding, hydrogen bonding, dipole bonding

Electrical and Dielectric Properties: Electrical conduction, electronic and ionic conduction, band structure in solids, conduction in terms of band structure and atomic bonding model, electrical resistivity of metals, measurement of electrical resistivity, intrinsic and extrinsic semiconductors, temperature dependence of carrier concentration, electrical conduction in ionic ceramics and polymers, dielectric behavior – capacitance, types of polarization, frequency dependence of dielectric constant, dielectric strength, ferroelectricity, piezoelectricity

Magnetic Properties: Basic concepts, diamagnetism and paramagnetism, ferromagnetism, antiferro- and ferrimagnetism, influence of temperature on magnetic behavior, domains and hysteresis, magnetic anisotropy, magnetostriction, magnetocaloric effect, soft magnetic materials, hard magnetic materials, magnetic storage, superconductivity

Thermal Properties: Heat capacity, thermal expansion, thermal conductivity, thermal stress/shock

Optical Properties: Basic concepts, electromagnetic radiation, light interaction with solids, atomic and electronic interactions, refraction, reflection, absorption, transmission, optical birefringence, color, opacity and translucency in insulators, luminescence, photoconductivity, lasers

Suggested References:

1. **Materials Science and Engineering – William D Callister, Jr.**
2. **Electronic Properties of Material – Rolf E. Hummel**
3. Materials Science for Engineers – James F. Shackelford
4. Science and Engineering of Materials – Askeland
5. Physical Ceramics – Yet-Ming Chiang, Dunbar Birnie III, W. D. Kingery
6. Introduction to Ceramics - W. D. Kingery Kingery

MT 407: Material Processing and Characterization: Laboratory- I

Thin film deposition, Materials (alloys, powders, ceramics etc.) preparation by different techniques, characterization using x-ray diffraction, electron microscopy, optical microscopy and atomic force microscopy. Measurement of optical and transport properties of different materials.

MT 408: Advanced Engineering Mathematics

Linear vector spaces
Functions as elements of a linear vector space; Basis sets and expansion; Operators and matrix representations; eigen value problem and diagonalization.

Integral transforms:
Fourier and Laplace transforms; Their properties; Equivalence of conjugate Fourier spaces; Application to differential equations with examples.

Probability and statistics
Random variables and joint distributions; Functions of random variables; Basic statistical estimators; Method of linear least squares; Random processes

Numerical methods
Numerical differentiation and integration; Solution of differential equations through computations; Introduction to MATLAB commands

Reference Books
1. M. D. Greenberg: *Advanced Engineering Mathematics* , Prentice Hall!
2. K. F. Riley and M. P. Hobson: *Mathematical Methods for Physics and Engineering*. Cambridge University Press!
3. Sadri Hassani: *Mathematical Physics* - *A Modern Introduction to its Foundations*, Springer !
4. D. Hanselman and B. Littlefield: *Mastering MATLAB* - *A Comprehensive Tutorial*

Semester II

MT 452: Diffusion, phase transformation and Kinetics

Phenomenological Laws of Diffusion: Fick's Laws, Chemical Potential Gradient & Driving Force for Diffusion, Relationship between Mobility and Diffusion

Solution to Diffusion Equations: Semi Infinite & Infinite Diffusion Couples, Finite Diffusion couples

Mechanisms of Diffusion: Lattice Defects & Diffusion, Random Walk Problem & Einstein Equation, Interstitial and Substitutional Diffusion Mechanisms, Activation Energy for Diffusion, Crystal boundary & Surface Diffusion, Diffusion Data base

Diffusional Transformations: Solidification & Solid – Liquid Transformations: Solid – Solid Transformations: Nucleation & Growth; Particle Coarsening, Grain Growth, Sintering; Diffusion Controlled Gas – Solid Reactions: Oxidation Reactions, Carburization/Decarburization, Diffusion of Hydrogen. Diffusion Controlled Deformation: Creep

Diffusion Controlled Phenomena in Systems

Several topics related to Kinetics

Text Book/References/Suggested Reading

1. P.G. Shewman, "Diffusion in Solids", McGraw Hill (1963)
2. P. Shewmon: Diffusion in solids, 2nd Edition, TMS, Warrendale, PA, 1989.
3. A, Rudin, The Elements of Polymer Science and Engineering, Academic Press, New York, 1982.
4. J. Crank: The Mathematics of Diffusion, 2nd Edition, Clarendon Press, Oxford, 1994.
5. R.B. Bird, W. E. Stewart, and E. N. Lightfoot, Transport Phenomena, John Wiley and Sons, New York, 1960.
6. E.L. Cussler, Diffusion: Mass transfer in Flid Systems, 2nd Edition, Cambridge University Press, New York, 1997.
7. H. S. Carslaw and J. C. Jaeger, Conduction of Heat in Solids, Clarendon Press, Oxford, 1959.
8. Martin E. Glicksman: Diffusion in solids: field theory, solid-state principles, and applications., John Wiley and Sons, Inc., New York, 1999.
9. Kinetics of Materials by R.W. Ballubi, S.M. Allen and W.C. Carter,

   John Wiley & Sons, Inc., Publication 2005.

MT 453: Materials Modelling

Numerical differentiation and integration, solution of simple differential equations, Curve fitting with least squares method, Introduction to variational calculus.

Monte Carlo Methods: Random variables, Generation of different distributions, Metropolis algorithm, Phase transitions (magnetic systems as example).

Molecular Dynamics: Newtonian dynamics, Finite-difference methods, Molecular dynamics of hard spheres, phase transitions (solid-liquid transformation as example). Stochastic processes, Markov chains, Diffusion models based on random walks, Transport phenomena (heat conduction as an example).

Many-particle quantum mechanics, Introduction to density functional theory, Illustration with simple examples.

Laboratory component: o Numerical integration and differentiation o Solution of ordinary differential equations (Newtonian mechanics) o Random number generation and testing for randomness o Construction of ensembles of different standard distributions o Monte Carlo simulations based on Metropolis algorithm

Suggested Reading

1. Sidney Yip (ed), Handbook of Materials Modeling, Volumes A and B, (Springer, 2005).
2. Fong C Y, Topics in Computational Materials Science (Singapore: World Scienti_c, 1999).
3. Landau R H, Paez M J, and Bordeianu C C, A Survey of Computational Physics (Princeton: Princeton University Press, 2008).
4. Martin R M, Electronic Structure (Cambridge: Cambridge University Press, 2004).
5. Hoover WG, Computational Statistical Mechanics (Elsevier, 1991).
6. Allen M P and Tildesley D J, Computer Simulation of Liquids (Oxford: Oxford University Press, 1989).
7. Haile J M, Molecular Dynamics Simulation: Elementary Methods (New York: Wiley, 1992).
8. Rapaport DC, The Art of Molecular Dynamics Simulations, Second Edition, (Cambridge University Press, 2004).
9. Landau and Binder, A Guide to Monte Carlo Simulations in Statistical Physics, 2nd.ed. (CUP, 2005).
10. Kalos M H and Whitlock P A, Monte Carlo Methods Volume I: Basics (New York: Wiley, 1996).

MT 454: Materials Characterization II

Raman spectroscopy, materials defects/disorder, Uv- spectroscopy, band gap measurement, Optical properties, Fourier Transform infrared spectroscopy (FT IR), Drude free-electron model, Auger electron spectroscopy(AES), X-ray photoelectron spectroscopy (XPS), Hall-effect measurement, Differential scanning calorimetry(DSC).

MT 455: Material Processing and Characterization: Laboratory II

1. Evaluation of mechanical properties at small length scales
2. Compaction of powders and density measurement
3. Thin film deposition using various techniques
4. Transmission electron microscopy
5. Atomic force microscopy
6. Nanoparticle size measurement
7. Raman spectroscopy
8. Corrosion rate measurement

Electives

MT457: Powder Metallurgy and Advanced Ceramics

Introduction – What is powder metallurgy, Need for powder metallurgy
Powder Processing – Synthesis of powders: Mechanical methods, thermal decomposition and pyrolysis, chemical precipitation and sol gel techniques, electrolytic methods, atomization and other spray forming techniques, etc.
Powder Characterisation – Particle size, shape and size distribution, flow, apparent density and tap density, granulation.
Shape Fabrication – compaction behavior, uniaxial and isostatic compaction, powder processing with Laser Engineered Net Shaping (LENS), Extrusion and forging, Roll compaction, Injection moulding, Tape casting, Slip casting, Sol-gel casting
Sintering and Densification – Solid state sintering, Liquid phase sintering, Reaction sintering, Hot pressing, Hot isostatic pressing, self propagating combustion sintering
Advanced Sintering Techniques – Spark plasma sintering, Microwave sintering
Ceramic PM Materials – Al_2O_3, ZrO_2, SiC, Si_3N_4, Cermets, Ceramic-ceramic composites, Soft and hard magnetic materials: ferrites, garnets
Application of P/M Materials – Structural components, porous components, electrical and magnetic components, friction materials, hard and wear resistant components, high temperature high strength components and components for special applications
Structure of Ceramics: Closed packet lattices, stability of ionic crystals, ceramic crystal structures-FCC based structures, HCP based structures, perovskite, spinel, covalent ceramics, crystalline silicates, glass structure
Defects in Ceramics: Point defects, Kroger-Vink notation, defect chemical reaction, electronic disorder, simultaneous defect equilibrium, Brouwer diagram, defect association and precipitation, Debye-Huckel correlation, line and planar defects
Mass and Electrical transport: Continuum diffusion kinetics, atomistic diffusion process, electrical conductivity, electrochemical potential
Sintering of ceramics: solid state sintering, liquid phase sintering, MWS, SPS, HP, HIP
Microstructure development in ceramics: Capillary action, grain growth and coarsening, single phase sintering, reactive additive sintering, hot pressing, glasses and glass ceramics, strength and toughness, toughening of ceramics, toughening mechanism, microstructural toughening, ZTA, TTZ
Electronic ceramics: piezoelectric and magnetic ceramics, ceramics for sensors, relaxors, and electro-optic applications
Suggested Reading for Powder Metallurgy

1. "Powder Metallurgy & Particulate Materials Processing" by Randall M. German, Metal Powder Industries Federation
2. "Powder Metallurgy Science Technology and Materials" by Upadhyaya and Upadhyaya, University Press
3. "Introduction to Ceramics" by W. D. Kingery, H. K. Bowen and D. R. Uhlmann, John Wiley & Sons.
4. "Ceramic Processing and Sintering" by M. N. Rahaman, Marcel Dekker.
5. "Modern Ceramic Engineering: Properties, Processing, and Use in Design" by D. W. Richerdson, CRC Press.

Suggested Reading for Ceramics

1. Introduction to ceramics – Kingery, Browen, Uhlmann
2. Modern Ceramic Engineering – David W. Richerson
3. Physical Ceramics – Yet-Ming Chiang, Dunbar Birnie III, W. D. Kingery

4. Fundamental of Ceramics – M. W. Barsoum
5. Ceramic Materials for Electronics – R. C. Buchanan
6. Introduction to Polymers, by R. J. Young and P. A. Lovell
7. Advanced Polymeric Materials Edited by Gabriel O. Shonaike, Suresh G. Advani
8. "X-Ray Diffraction Methods of in Polymer Science" by **Leroy E. Alexander**, 547.84Al27X
9. Production of Polymer Properties, Jozef Bicerona, 668.9B472p3
10. Fundamentals of Polymer Engineering, Anil Kumar and Rakesh K Gupta, 668.9An53f2
11. Comprehensive Polymer Science: The Synthesis, Characterization, Reactions & Applications of Polymers, Allen, Geoffryey
12. Introduction to Industrial Polymers, Ulrich, Henri
13. Rheology of Polymers, Vinogradov, G. V.; Malkin, A. Ya.
14. Mechanical Properties of Solid Polymers, Ward, Ian Macmillan
15. Mechanical Properties of Polymers and Composites, Nielsen, Lawrence E.

MT458: Corrosion engineering

Introduction, Importance of corrosion, Economics of corrosion.

Corrosion of Materials: Oxidation, Corrosion and wear. Basics of Thermodynamics and Kinetics of oxidation and corrosion. Pourbaix diagram, Polarization, Mixed potential theory. Passivity, Characteristics of passivation, degradation of composites.

Corrosion: Fundamental of corrosion studies, types of corrosion, atmospheric, galvanic, pitting, crevice corrosion, intergranular corrosion and dealloying. Stress corrosion cracking, Season cracking, Corrosion rate measurement, Tafel extrapolation

Hydrogen damage and radiation damage, hydrogen embrittlement.

Weld decay and knife line attack., oxidation and hot corrosion of materials

Kinetics of oxidation, Pilling- Bed Worth ratio.

Prevention of degradation: Alloying environment, environment conditioning, design modification,

Cathodic and anodic protection, organic and inorganic coating, inhibitors and passivators, Wear resistant coating.

Reference Books:

1. Glasstone, S., An introduction to electrochemistry, Van Nostrand

2. Fontana, M.C., Corrosion Engineering, McGraw Hill

3. Scully, J.C., The fundamentals of Corrosion, Pergamon

4. Mantell, C.L., Electrochemical Engineering, McGraw Hill

MT459: Crytallography and Texture analysis

Representation of orientation, Crystal, Sample symmetry. Concepts of texture in materials, their representation by pole figure and orientation distribution functions. Texture measurement by different techniques. Origin and development of textures during materials processing stages: solidification, deformation, annealing, phase transformation, coating processes and thin film deposition. Influence of texture on mechanical and physical properties. Texture control in aluminum industry, automotive grade and electrical steels, magnetic and electronic materials. Introduction to grain boundary engineering and its applications. Texture modelling, Crystal plasticity.

Reference Books:

Olaf Engler, Valarie Randle, Introduction to texture analysis, 2nd Edition, CRC Press, Taylor & Francis, 2009.

Satyam Suwas, R.K. Ray, Crystallographic Texture of Materials, Springer, 2014.

A.J. Schwartz, M. Kumar, B.L. Adams, D. Field, Electron Back Scattered Diffraction in Materials Science, 2nd Edition, Springer, 2010.

U.F. Kocks, H.R. Wenk, C.N. Tome, Texture and anisotropy, Cambridge University Press, 2000.

MT 460: Nano biomaterials/ Nano Biotechnology

1. Introduction & terms used in Biotechnology
2. A. Building blocks in Biology – Monomer – Polymer concept
   B. Molecular asymmetry in macromolecules
   C. Aminoacids, peptides, proteins – Structure and functions
   D. Purine and pyrinative bases, nucleosides nucleotides, nucleic acid – Structure and function
   E. Carbohydrates – Mono, di, oligo and polysaccharides
   F. Lipids & liposomes
   G. Enzymes – Structure and function
3. Synthesis of peptides and oligo nucleotides invivo and invitro - Preparation and characterization
4. Self – assembly and fabrication of nano-structures based on DNA and Proteins : Structural DNA assembly, Nanopore DNA sequence, DNA modified surface, Polyelectrolyte behaviour in DNA : Self-assembling Toroidal Nanoparticles
5. Biosensors
6. Nano immunology
7. miRNA and RNA transcription
8. Introduction to cancer and its biology
9. Nanostructures (other than particles) for biological application
11. Biomaterials (Metal, polymers, ceramics and composites
12. Nanostructures (Nanoparticles : Preparation & characterization – Au, Ag, Ti CNT, Fullerenes)

A. Polymer nanoparticles and nanostructure (Micro emulsion mini emulsion), template synthesis, polymer gel, Nanocapsules; Hydroxyapatite; dendrimer, bioconjugate nanoparticles

B. Nanoscale technology in Biological system:
Nano drug delivery: Mesoporous materials for drug delivery system
Function Nanocapsules for gene delivery,
Nanotechnology and Cancer: Upconversion Nanocapsules for photodynamic therapy
Nanotechnology in Organ Transplantation
Bionanoimaging (Quantum dots, Ultrasound contrast agents, magnetic nanoparticles)

C. Biomineralization: Physiochemical and Biological Processes in Nanotechnology

D. Nanomedicine – case studies
Nanoparticles in cell biology and diagnostics

MT461: Smart Materials and Nanostructures

Introduction : Basic of semiconductor materials, doping, P-type and N-type, band gap theory and band gap engineering.

Thin films: Chemical vapour deposition(PECVD, LPCVD), Atomic layer deposition, physical vapour deposition, Sputtering (DC, RF), thermal evaporation.

Lithography: Different lithography, E-beam lithography, thick film lithography, thin film lithography, soft lithography, Photoresist (+ve and –ve), Resist profile, Contrast and lithographic sensitivity, Resolution, MTF, spin coating, soft baking, Pre and post baking, Stripping.

Bulk Micromachining : Dry Etching, Loading effect (uniformity and non uniformity), DRIE, Wet etching, Mask materials, Etch stop, Under etching and undercutting.

Surface Micromaching : Sacrificial layer, Selection of materials, Lift-off process, Thin films (CVD, PECVD, PVD, Evaporation and sputtering), Oxidation, LIGA process.

Nanofabrication: AAO template based mask less, Metal assisted etching, Novel nanofabrication

References:

1. Fundamentals of Microfabrication, *CRC Press*, Marc J. Madou.
2. Foundations of MEMS, *Person Education (Prentice Hall)*, Chang Liu.
3. Micromachined Transducers Sourcebook, *McGraw-Hill*, G. Kovacs

MT462: Surface Engineering

Introduction: Definitions and Application Examples;

Surface Cleaning and Surface Degradation;

Vacuum Science and Technology: Gas Kinetics, Gas Pumping and Transport;

Thin Film Deposition:

Physical Vapor Deposition:

Evaporation: Thermal evaporation, Evaporation of alloy and compound films, Reactive evaporation, Activated evaporation and other modern evaporation techniques

Sputtering: Basic principles, sputtering of alloys, reactive sputtering and setting up sputtering units, Ion and ionized cluster assisted deposition

Chemical Vapor Deposition: Basic principles, Conventional CVD methods (4.3) Plasma enhanced CVD

Thin film nucleation and growth: Volmer-Weber, Frank Van der Merwe and SK growth modes; Zone Model; Evolutionary selection principle;

Chemical conversion coatings and plating processes;

Thermo chemical surface treatments; Thermal Barrier Coatings;

Hardfacing & Cladding, Thermal and Plasma Spray Processes;

Post synthesis processing and surface modification/functionalization;

Characterization and Performance evaluation of Coatings;

Suggested Reading

H. Dimigen, "Surface Engineering", Wiley-VCH, 2000.
J. B. Hudson, "Surface Engineering: An Introduction", Butterworth Heinemann, 2000.
S. Grainger and **J. Blunt**, "Engineering Coatings", Woodhead Publishing, 1998.
M. Ohring, "The Materials Science of Thin Films", Academic Press, 1992.
D. L. Smith, "Thin Film Deposition, Principles and Practice", McGraw-Hill, 2000.
ASM Handbook, Volume 5, "Surface Engineering", ASM International, 1994.