Department of Metallurgical and Materials Engineering

M. Tech in Materials Engineering

Brief Description:

The Department of Metallurgical and Materials Engineering aims to develop a core competence in teaching and research in the areas of materials engineering and its applications to Defence technologies and products. Being in Defence University, the Department offers M. Tech and Ph. D. programs on materials engineering and engaged in conducting various short term courses to DRDO and Defence Officers. The main focus of our research is to investigate the structure-property-performance relationship of various materials for Defence applications.

This programme is open for civilian GATE qualified candidates, DRDO Scientists/Officers, Officers from Tri-services, Industries and PSU. This program is also open to friendly foreign countries.

At present, the Department is equipped with characterization facilities such as:

- High Resolution Transmission electron microscope (TEM) with STEM, Lorentz, HAADF and EDAX facilities
- Field emission scanning electron microscope (FESEM) with EDS
- Small angle x-ray scattering (SAXS)
- Wear and friction measurement equipment
- Micro-Hardness Tester
- Brinnel and Rockwell Hardness Tester
- Automatic grinding and polishing machines
- Optical polarizable microscope with image analyzer
- Surface Area Analyzer
- Impedance Analyzer and Electrochemical workstation
- Piezometer
- Corona Poling Unit
- UV-Visible Spectroscopy
- Contact Angle measurement unit
- CH-Analyzer
- Ball Milling
- PPMS

and many materials synthesis facilities also available in the Department such as:

- Spray Pyrolysis set-up
- High-Temperature Furnace
- Centrifuge
- Autoclave
- Vacuum Oven
- Orbital Shaker
- Twin screw extruder
- Plastography

- Two roll mill
- Hydraulic press
- Electro spinning unit
- Homogenizer
- Sonicator

The development of know-how and manufacturing technologies of many strategic and advanced materials like intelligent textiles, biosensors, electrospinning, magnetic materials, engineering adhesives, structural composites, hybrid supercapacitors, functional materials, biomaterials for prosthetics, tissue engineering, plastics processing, piezoelectric materials, super critical foaming technology are taken up by the faculties and students. The Department is working on many sponsored research projects and the researchers have developed a range of products, including propellers for fuel cells, encapsulated drugs on fibers, magnetic alloys, inorganic oxides for drug delivery, encapsulation and sustained release of anti-cholesterol drugs, polymeric beads and membranes for toxic and heavy metal adsorption (effluent treatment), carbon foams for high-temperature applications and open cell polyurethane foams for automobile applications. Moreover, the Department participates extensively in R&D activities in collaboration with Defence Labs and Establishments of India. International collaborative work is being carried out with Naval Post-graduate School (NPS), California, Crainfield University, UK, Loughborough University, UK, National Ding Hwa University, Taiwan, Weizmann Institute of Science, Israel etc.

Eligibility:

B.E./B.Tech or equivalent in any branch of Engineering/Technology; M.Sc or equivalent in any branch of science.

Organization:

The programme is of four-semester duration. In first and second semester have six courses respectively including one lab in the first semester. Third semester comprises the dissertation work in addition to two courses and fourth semester have only the dissertation work. In the first, second and third semester the students have options to choose elective courses. In the first, second and third semesters there will be one mid semester examination and a final examination for theory subjects. After the second semester, scholarship students are encouraged do a summer internship for about one and half months at their place of choice. This will be entirely based student's own arrangements and expenses. The Department will not sponsor for this; except official arrangements, like issuing no-objection certificate etc. As part of the dissertation work in the third semester, the dissertation work will be evaluated by the expert committee at the end of the third semester. At the end of the final semester, students will submit their thesis before going for final evaluation and present their project works before the expert committee (consists of External / Internal members from various R&D organisations / Universities etc.). No credits are counted for attending an audit course.

Course Structure

Semester I

Sl. No.	Course Code	Course Name	Contact hours/week		Credits (*)
			L	T/P	
1	MM 601	Concepts in Metal and Ceramic	3	2	4
2	MM 602	Materials Characterization	3	2	4
3	MM 603	Thermodynamics of materials	3	1	4
4	MM 604	Polymer and Composite Technology	3	1	4
5	MM 605	Physical and Mechanical Metallurgy	3	2	4
6	MM 606	Introduction to Computational Materials Engineering	3	1	4
		TOTAL	**18**	**9**	**24**

Semester II

Sl. No.	Course Code	Course Name	Contact hours/week		Credits (*)
			L	T/P	
1	MM 619	Millitary Materials	3	1	4
2	MM 608	Fatigue, Fracture and Failure Analysis	3	1	4
3		Elective I (from Department Electives)	3	1	4
4		Elective II (from Department Electives)	3	1	4
5		Elective III (from Open Electives)	3	1	4
6		Elective IV (from Open Electives)	3	1	4
		TOTAL	**18**	**6**	**24**

Semester III

Sl. No.	Course Code	Course Name	Contact hours/week		Credits (*)
			L	T/P	
1	MM 651	M. Tech. Dissertation Phase - I	28**		14
		TOTAL	**28**		**14**

Semester IV:

Sl. No.	Course Code	Course Name	Contact hours/week		Credits (*)
			L	T/P	
1	MM 652	M. Tech Dissertation Phase - II	28**		14
		TOTAL	**28**		**14**

* 1 credit in Theory/Tutorial means 1 contact hour and 1 credit in Practical/practice/project thesis means 2 contact hours in a week.

**Contact hours per week

List of Electives

Sr. No.	Course Code	Name of the Course
Electives from the Department		
1	MM 609	Materials Processing
2	MM 610	Nanomaterial and Their Applications
3	MM 611	Non-Destructive Evaluations
4	MM 612	Polymer blends and Nanocomposites
5	MM 613	Biomaterials
6	MM 614	Electrical and Electronic Materials
7	MM 615	Magnetism and Magnetic Materials
8	MM 616	Heat-treatment of Metals and alloys
9	MM 617	Materials for High -Temperature Applications
10	MM 618	Advanced Steel Technology
11	MM 607	Design of Materials
Open Electives from other Departments		

12	ME 602	Advanced Mechanics of Materials
13	ME 603	Advanced Fluid and Thermal Science
14	ME 604	Advanced Materials and Processing
15	ME 607	Computational Fluid Dynamics
16	ME 608	Finite Element Methods
17	AP 614	Sensors and Actuators
18	AM 621	Advanced Modeling Techniques
19	EE 601	Microwave Engineering

Course Name: Concepts in Metal and Ceramic

Course Code: MM 601

Unit 1: Introduction, classification of materials; atomic structure, bonding in solids, bonding forces and energies; crystal structure, unit cells, crystal systems, crystallographic points, directions, and planes,

Unit 2: crystalline and non-crystalline materials, anisotropy; Structure of crystalline solids: metallic crystal structure

Unit 3: ceramic materials, Basic properties, classification of ceramic materials–conventional and advanced, ceramic crystal structure, Defects in ceramics: types of defects, origin of point defects, defects and electron energy levels, defect equllibria in ceramic crystals, Phase equlibria in ceramics

Unit 4: Dielectrics: Dielectric strength, Loss factor. Equivalent circuit description of linear dielectrics, Power factor, Dielectric polarisation, Polarisation mechanisms, Applications. Refractories: Classification of Refractories, Applications. Glass: Definition of glass, Basic concepts of glass structure, Different types of glasses. Application of glasses.

Unit 5: Practical: Solid state, Sol-Gel, Hydrothermal and Co-precipitation process

Text Book(s):

- *Materials Science and Engineering by William D. Callister, JohnWiley & Sons, Inc.*
- *Elements of Materials Science and Engineering by Lawrence H. van Vlack.*

Reference Book(s):

- *Elements of Ceramics: F.H Norton*
- *Fundamentals of Ceramics: Barsoum*
- *Introduction to Ceramics: W.D.Kingery*
- *Physical Ceramics for Engineers: VanVlack*
- *Handbook of Ceramics: Editor S. Kumar Ceramic*
- *Materials for Electronics: R.C. Buchanon*

Course Name: Materials Characterization

Course Code: MM 602

Unit 1: Diffraction Techniques- Concepts of diffraction, scattering and radiation-matter interactions, X-ray diffraction: phase identification, strain and grain size determination

Unit 2: Microscopy and Imaging- Fundamentals of Imaging: magnification, resolution, depth of field and depth of focus, aberration and astigmatism, SEM: imaging modes, image contrast, illustrative applications,Basic principle and components of TEM: Contrast mechanisms, bright field, dark field, TEM application in crystal defect analysis, Electron diffraction in TEM, STM and AFM

Unit 3: Spectroscopic Techniques- Fundamental basis of Spectroscopic analysis EDS and WDS applications, X-ray Photon Spectroscopy and Auger electron spectroscopy

Unit 4: Thermal Analysis Techniques- DSC, DTA, TGA and Dilatometry, Electrochemical polarization characterization, Electrochemical Impedance spectroscopy.

Unit 5: Practical: XRD, TEM, SEM, Cyclic voltammetry, Tafelplot, and Salt Spray, weathrometer, cyclic corrosion test, cathodic protection monitoring, localised corrosion monitoring methods (SECM, SEVT)

Text Book(s):

- *Elements of X-ray Diffraction, B. D. Cullity, Prentice Hall, 2001*
- *Solid State Chemistry and its Applications, Anthony R. West, Wiley.*

Reference Book(s):

- *Materials Characterization, ASM Handbook Vol 10.*
- *Characterization of Materials, Vol 1, Elton N. Kaufmann*

Course Name:Thermodynamics of Materials

Course Code: MM 603

Unit 1: Simple and composite systems, phases, Internal energy, Enthalpy, Entropy, Gibbs Free energy, Specific heat, Laws of thermodynamics, Reversible and Irreversible processes, adiabatic work interaction.

Unit 2: Generation of Auxiliary Functions: Legendre transforms, Coefficient relations, Maxwells relations, Thermodynamic relations among state functions variables and its application to solids

Unit 3: Statistical definition of temperature and entropy, Micro- and Macro-states, Maxwell-Boltzmann distribution, Thermodynamic equilibrium: stable equilibrium states, criteria for equilibrium

Unit 4: Free energy of single component system: Free energy as a function of temperature, Clausius-Clapeyron Equation, Driving force for solidification; Equilibrium vacancy concentration and Analysis of Magnetic transitions

Unit 5: Free energy of binary system: Entropy of mixing, Enthalpy of mixing, Free energy of ideal, regular and real solutions, Activity, Ordered and intermediate phases, Types of solutions, Chemical potential, Unary and binary phase diagrams and Gibbs free energy

Text Book(s):

- *Ahindra Ghosh, Textbook of Materials and Metallurgical thermodynamics. Prentice Hall of INDIA 2003*
- *Taiji Nishizawa, Thermodynamics of microstructures, ASM International*

Reference Book(s):

- *R.T. DeHoff, Thermodynamics in Materials Science, McGraw-Hill, Singapore, 1993*
- *D. A. Porter and K. E. Easterling, Phase transformations in Metals and Alloys, Chapman and Hall, London, 1996*
- *David R. Gaskell, Introduction to the Thermodyanamics of Materials, Taylor & Francis, 1798*

Course Name: Polymer and Composite Technology

Course Code: MM 604

Unit 1: Polymers: Classification of Polymers, Co-Polymers, Thermoset and Thermoplastics, Crystalline and Amorphous Polymers, Polymerization, Degree of Polymerization, Glass transition temperature, Molecular weight of polymer and its determination by various techniques,

Unit 2: Physical methods of polymer analysis such as IR, DSC, TGA, XRD etc, Viscoelasticity, Polymer blends and alloys: thermodynamics, morphology and properties.

Unit 3: Composites: Conventional polymer composites, Fiber reinforced composites, Nanofillers and their composites,

Unit 4: Composite manufacturing techniques: Solution-cast, Melt-mixing, Extrusion, Compression molding, Resin transfer, Resin infusion, Vacuum casting and electrospinning.

Unit 5: Defence Applications: Coatings (Superhydrophobic, Self Healing), Fire retardant, Corrosion Resistant, EMI Shielding, Environmental responsive polymers (Self healing, Phase change and Shape Memory), Polymer composites in aerospace applications. Service life prediction methodologies of polymers and composites

Text Book(s):

- *V.R. Gowariker, Polymer Science, Wiley Eastern, 1995*
- *F. N. Billmeyer, Textbook of Polymer Science, Wiley Interscience, 1971.*

Reference Book(s):

- *Kumar and S. K. Gupta, Fundamentals and Polymer Science and Engineering, Tata McGraw-Hill, 1978*
- *Epel, J.N.:Engineering Plastics, Engineering Materials Handbook, ASM International 1988.*

Brydson, A.J. : Plastics Materials, Princeton, N.J., 1966.

Course Name: Physical and Mechanical Metallurgy
Course Code: MM 605

Unit 1: Crystal defects/imperfaction in Metals, dislocations, burger vectors, dislocations multiplications, dislocation interactions, stacking faults, Phase rule, Phase diagram, Eutectic, Iron-Carbon diagram, TTT and CCT diagrams

Unit 2: Plastic deformation in single crystal, critical resolved shear strength, deformation by slip, and deformation by twinning. Dislocations pile-ups, dislocations climb and cross slip.

Unit 3: Strengthening mechanisms: Solid solution strengthening, strengthening from grain boundaries, strains hardening, strain ageing, annealing of cold worked materials, strengthening from particles, precipitation hardening

Unit 4: Hardness and tensile testing, stress-strain relationships, effect of strain, strain rate and temperature on flow stress, nanoindentation, High temperature deformation and Creep, Superplasticity

Unit 5: Practical: Metal Polishing and Etching, Optical Microstructural Characterization, Wear and friction, hardness testing

Text Book(s):

- *Mechanical Metallurgy, G.E. Dieter, McGraw-Hill book company, 1988*

Reference Book(s):

- *Mechanical behaviour of Materials, Williams F Hosford, Cambridge University press, 2005*
- *Materials Science and Engineering by William D. Callister, JohnWiley& Sons, Inc.*
- *Physical Metallurgy Principles, Robert E Reed Hill, Cengage Learning, Inc publications, 1992*
- *Physical Metallurgy, Vijendra Singh, Standard Publishers Distributors, 2010.*

Course Name: Introduction to Computational Materials Engineering
Course Code:MM 606

Unit 1: Review of programming in high level languages such as Python / Matlab / Mathematica and low level languages such as C / C++ / Fortran

Unit 2: Fitting and visualization of multidimensional data; Quantification of experimental microstructures using programs as well as software tools

Unit 3: Application of linear algebra towards solution to a system of linear and non linear equations; Numerical integration; Numerical solution of diffusion equation;

Unit 4: Computational techniques such as phase field method and Monte Carlo towards evolution of microstructure; synthetic microstructures

Unit 5: Evaluation of properties from the computed microstructures using mean field and full field approaches; data analytics using principal component analysis; ICME approach

Text Book(s):

- Introduction to Computational Materials Science – Richard LeSar, Cambridge University Press (2013). ISBN: 9781316614877

Reference Book(s):

- Mathematical Methods for Physics and Engineering, 3rd Edition – R.F. Riley, M.P. Hobson, S.J. Bence, Cambridge University Press (2012). ISBN: 9780521139878
- Integrated Computational Materials Engineering (ICME) for Metals – Mark F. Horstemeyer, TMS (2012). ISBN: 9781118022528
- Integrative Computational Materials Engineering : Concepts and Applications of a Modular Simulation Platform – Georg J. Schmitz and Ulrich Prahl, Wiley-VCH Verlag GmbH & Co (2012). ISBN: 9783527330812

Course Name: Military Materials
Course Code: MM 619

Unit 1: Overview metallic materials for military application, Needs of complex metals and alloys required for modern and sophisticated warfare weapons systems.

Conventional alloys for military application: Functional requirements of cartridge case and manufacture, Brass and steel cartridge cases, Cased ammunition. Steel shell bodies – High explosive squash head, Steel guns barrels- Direct fire tank guns, Indirect fire artillery guns,

Alloys for military bridges: Mild steel- Bailey bridge and heavy girder bridge, Aluminium alloy – Medium girder bridge and BR 90.

Unit 2: Special Alloys for Armour applications: Rolled Homogeneous Armour steels: Kanchan armour for Arjun tank, Steel armour plate, Aluminium alloy armour for light armoured vehicles, Body armour.

Unit 3: Alloys for ammunition applications: Ferrous fragmenting projectiles: Cast iron mortar bomb bodies, Steel 155 mm anti-personnel artillery shell body. Conical shaped charge weapon system, Hydrodynamic penetration, Copper charge penetrators. Kinetic energy penetrators: Armour piercing fin stabilised discarding Sabot, Tungsten heavy alloys as long rod penetrator, Recent development.

Unit 4: Alloys for aerospace applications: Materials required for engine parts, Superalloys for high temperature applications, Single crystal blades made of Ni based super alloys, Aerospace grade low density high strength Ti and Al alloys, Ultra-high-strength steel with the toughness for missile applications.

Unit 5: Special alloys for naval applications: Special alloys with functional properties: Advanced magnetic materials - Ultra high energy product permanent magnets, emerging materials such as nanomaterials and smart materials.

Text Book(s):

- *Alistair Doig, Military metallurgy, Maney publishing, 2002*

Reference Book(s):

- *Physical Metallurgy Principles, Robert E Reed Hill, Cengage Learning, Inc publications, 1992*
- *Physical Metallurgy, Vijendra Singh, Standard Publishers Distributors, 2010.*
- *Paul J Hazell, Armour Materials Theory and Design, CRC Press, 2015*

Course Name: Fatigue, Fracture and Failure Analysis

Course Code: MM 608

Unit 1: Stress cycles, Interpretation of Fatigue Data. Endurance Limit, Effect of Mean Stress on Fatigue, Cyclic Stress-Strain Curve, Low Cycle Fatigue, Plastic Strain & Fatigue Life,

Unit 2: Effect of Structural Features, Fatigue Crack Propagation, Stress Concentration & Fatigue, Size & Surface Effect, Effect of Metallurgical Variables & Enhancement of Fatigue Life,

Unit 3: Classification of Fracture, Theoretical Strength of Metals, Griffith Theory of Brittle Fracture, Metallographic features of Fracture, Fractography,

Unit 4: Dislocation Theory of Brittle Fracture, Effect of Tri-axial Stress, Strain Energy Release Rate, Stress Intensity Factor,

Unit 5: Fracture Toughness & Design, KIC , CTOD, JIntegral, R-Curve, Toughness of Metals & Alloys. Stress corrosion cracking.

Text Book(s):

- *Mechanical Metallurgy, 3rd Ed, George E Dieter, Mc-Graw Hill, New York, 1986.*

Reference Book(s):

- *Deformation and fracture mechanics of engineering materials, 4th Ed., R. W. Hertzberg, John Wiley & Sons, 1995.*
- *Elementary engineering fracture mechanics By David BroekNoordhoff 1974.*
- *Fatigue and Fracture of Metals, W. M. Murray, John Wiley, 1952.*

Course Name: Materials Processing

Course Code: MM 609

Unit 1: Processing of Polymers- Extrusion, compounding, fibre spinning, injection moulding, compression moulding, Additive manufacturing

Unit 2: Processing of ceramics- Compaction, moulding, sintering, refractory manufacturing processes, glass manufacturing techniques.

Unit 3: Processing of Metals- Casting, Hot working, Cold working, Rolling, Annealing, Forging, Extrusion,

Unit 4: Wire drawing, Sheet metal forming, Joining Techniques, Friction stir welding, Powder Metallurgy

Unit 5: Practical: Metal processing- rolling, annealing; polymer processing-Extrusion and compression molding, electrospinning

Text Book(s):

- *Mechanical Metallurgy, 3rd Ed, George E Dieter, Mc-Graw Hill, New York, 1986.*
- *Manufacturing Processes and Materials for Engineers, L. E. Doyle, 1975. Powder*

Reference Book(s)

- *Metallurgy, Applications, Advantages and Limitations, Klar, Erhard, ASM, 1983, Ohio.*
- *Plastics Processing Data Handbook (2nd Edition), Rosato, Dominick, 1997.*
- *Plastic Injection Molding: Manufacturing by Douglas M. Bryce, 2007.*
- *Concise encyclopedia of plastics, Rosato, Marlene G, 2005*
- *Extrusion: the definitive processing guide and handbook, Giles, Harold F.; Wagner, John R.; Mount, Eldridge M, 2005.*

Course Name: Nanomaterials and their application

Course Code: MM 610

Unit 1: Overview of Nanostructures and Nanomaterials; Synthesis of Nanomaterials: Types and strategies for synthesis of nanomaterials;

Unit 2: Crystalline nanomaterials and defects therein; Hybrid nanomaterials; Multiscale hierarchical structures built out of nanosized building blocks (nano to macro); Nanomaterials in Nature: Nacre, Gecko, Teeth; Nanostructures: Carbon Nanotubes, Fullerenes, Nanowires, Quantum Dots.

Unit 3: Cells response to Nanostructures; Surfaces and interfaces in nanostructures, Ceramic interfaces, Superhydrophobic surfaces, Grain boundaries in Nanocrystalline materials, Defects associated with interfaces;

Unit 4: Thermodynamics of Nanomaterials; Overview of properties of nanostructures and nanomaterials; Overview of characterization of nanostructures and nanomaterials; Deformation behaviour of nanomaterials: Fracture and creep; Nanomechanics and nanotribology; Electrical, Magnetic and Optical properties;

Unit 5: Applications of Nanotechnology in various fields: Defence, Aerospace and Marine Nanotechnology, Renewable energy, solar energy, fuel cells, Reinforcement in Ceramics, Drug delivery, Electronics etc.

Text Book(s)

- *T. Pradeep, NANO: The Essentials,Tata McGraw-Hill Publisher, 2007. ISBN-13:978-0-07-061788-9.*

Reference Book(s)

- *K. Haghi, G. E. Zaikov, Advanced Nanotube and Nanofiber Materials, Nova Science Publishers Inc, 2012*

- *Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications, Cambridge University Press, 2008*

Course Name: Non-Destructive Evaluation

Course Code: MM 611

Unit 1: Visual Inspection, Liquid Penetrant Testing, Magnetic Particle Testing,
Unit 2: Eddy Current Testing, Ultrasonic Testing,
Unit 3: Acoustic Emission Technique, Radiography Technique,
Unit 4: Residual Stress Analysis, In-situ Metallography, Automation and Robot in NDT,
Unit 5: Case study: Grain Size, Weldment and other Structural Components.

Test Book(s)

- *Non-destructive Testing of welds, Baldev Raj, C.V. Subramanian and T. Jayakumar, Narosa Publishing House, 2000, Delhi.*

Reference book(s)

- *International Advances in non-destructive testing, (Ed.) W. J. Mcgonnagle, Gordon and Breach Science Publishers, 1981, NY.*
- *Non-destructive Testing, Views, Reviews, Previews, (Ed.) L.L.Alston, Oxford University Press, 1970*
- *Nondestructive Evaluation and quality control, ASM handbook, Volume 17,ASM International*

Course Name:Polymer Blends and Nanocomposites

Course Code: MM 612

Unit 1: Introduction to polymer blends and composites, nanostructured materials and nanocomposites Thermodynamical aspects of polymer miscibility, mixing, factors governing miscibility, immiscible polymers and phase separation. Importance of interface on the property development,compatibilizers and compatibilization.

Unit 2: Blends of amorphous & semi-crystalline polymers, inter-penetrating networks, thermoplastic and thermoset blends, rubber toughened polymers, particulate and fiber reinforced composites.

Unit 3: Nanostructured materials like nanoclay, carbon nanotubes, graphene, magnetic nanoparticles etc. and polymer nanocomposites. Surface treatment of the reinforcing materials and interface/interphase structures of composites/nanocomposites.

Unit 4: Various processing techniques like solution mixing, melt processing. Physical and thermo-mechanical properties of polymer blends, composites and nanocomposites.

Unit 5: Potential Applications in Defence.

Text Book(s)

- *Textbook of Polymer Science, Fred W. Billmeyer (Wiley)*
- *Polymer alloys and blends by L A Utracki*

Reference Book(s)

- *Polymer nanocomposites: processing, characterization, and applications by Josheph H. Koo (McGraw-Hill Nanoscience and Technology)*

Course Name: Biomaterials

Course Code: MM 613

Unit 1: Introduction to biomaterials, Tissue Engineering, Biocompatibility, Biodegradation Biofluids and medical devices, Biostructures

Unit 2: Ceramic based biomaterials, metallic biomaterials, polymer based biomaterials, Biofluidici, medical devices, Biostructures

Unit 3: Nano-biomaterials: Self assembly of nanomaterials, hydrophilic, hydrophobic and surfaces, biomimicking

Unit 4: Medical imaging, electrospinning of scaffold structures, Additive manufacturing of medical devices, biofluidics and biostructure

Unit 5: Case studies: Lotusleaf, Gecko feet, Nacre/Bone. Application of nanocomposite biomaterials: artificial biomaterials, antidrag coatings,self-cleaning surfaces,sensors, Riboswitches

Text Book(s):

- *Biomaterials- An Introduction, Joon Park- Publisher Springer*

Reference Book(s):

- *Biomaterials- Principals and Applications- Joon Park- CRC Press*
- *Handbook of Biomaterial Properties- Garth Hastings- Springer*
- *Handbook of Biomaterials Properties- William Murphy- Springer*
- *Handbook of Biomaterial Properties- Jonathan Black- Chapman and Hall*

Course Name: Electrical and Electronic Materials

Course Code:MM 614

Unit 1: Band Theory of Solids, Semiconductors, Electron Effective Mass, Density of States in an Energy Band, Fermi-Dirac Statistics

Unit 2: Intrinsic Semiconductors, Extrinsic Semiconductors, Temperature Dependence of Conductivity, Recombination and Minority Carriers, Continuity Equations, Optical Absorption, Ideal *pn* Junction and Band Diagram, Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET),

Unit 3: Supercapacitors, Types of supercapacitor. Ceramic substrates (Al_2O_3, SiC, BeO, AlN, Glass ceramic etc.), Processing of Thick Film, Thin Film, Multi layer Packages, Properties of Ceramic Insulators, Ceramic Capacitor

Unit 4: Dielectrics-Barium titanate, Other titanate based dielectrics, Composition with high Pb content, Processing of thick and thin film capacitors, Integrated capacitors,

Unit 5: Relaxor Dielectrics, Piezoelectric Ceramics and electrostrictive materials, Powders and Processes, Piezoelectric ceramic applications. Nano Ceramics: Different Compositions, Synthesis, Applications, Introduction to electric vehicle.

Text Book(s)

- *Materials for Electronics: R.C. Buchanon.*
- *Introduction to Ceramics: W.D.Kingery*
- *Fundamentals of Ceramics: Barsoum*

Reference Book(s)

- *Physical Ceramics for Engineers: VanVlack*

- *Handbook of Ceramics: Editor S. Kumar Ceramic*
- *Electronic Ceramics: B.C.H Steele.*
- *Adv. Ceram. Materl. Vol I by K Furuta & K U chino*

Course Name: Magnetism and Magnetic Materials

Course Code: MM 615

Unit 1: Moment of a current loop, Orbital angular momentum and magnetic moments, Spin magnetic moment, gyromagnetic ratio, Vector atom model.

Unit 2: Classical diamagnetism, Superconductors, Paramagnetic moments, classical paramagnetic.

Unit 3: Weiss molecular field, Brillioun function and spontaneous magnetization, Curie Weiss law, Magnetocaloric effect, Exchange interaction, Spin waves, Antiferrognetism and Néel temperature, Exchange Bias effect and applications, Ferrimagnetism: Spinel structure and Ferrite moments.

Unit 4: Uniaxial and Cubic anisotropy, Shape anisotropy, Crystal field effects, Origin of magnetic domains, Equilibrium domain size and domain wall, Néel and Bloch Walls

Unit 5: Differentiation between Soft and hard magnetic materials, Finemet alloys, Rare earth permanent magnets, Magnetostriction: TERFNOL-D, Multiferroics, Magnetic Anomaly Detection.

Text Book(s):

- *Introduction to Magnetic Materials*
  B. D. Cullity and C. D. Graham; IEEE Press, A. Jon Wiley & Sons Publications

Reference Book(s):

- *Fausto Florillo, Measurement and Characterization of Magnetic Materials, Elsevier Academic Press, 2004*
- *Modern magnetic Materials: Principles and applications*
  Robert C. O'Handaley; Wiley-Interscience Publications
- *Physics of magnetism and Magnetic materials*

K. H. J. Bushaw and F. R. de Boer; Kluwer Academic Publishers

Course Name: Heat-treatment of Metals and Alloys

Course Code: MM 616

Unit 1: Steel Heat-Treatment, Annealing, Stress relief annealing, Process Annealing, Normalizing, Spheroidizing, Tempering , Quenching, Hardening, TTT Curve, Hardenability,

Unit 2: Case hardening, carburizing, Nitriding, Boronizing,

Unit 3: Flame hardening, Induction hardening, Laser hardening, Electron beam hardening,

Unit 4: Heat treatment of Aluminium, Titanium and Magnesium Alloys

Unit 5: Deformation and annealing.

Text Book(s):

- Heat Treatment Principles & Techniques, TV Rajan, CP Sharma & Ashok Sharma Prntice Hall of India, New Delhi, 2007.
- Metallurgy for Engineers-EC Rollason, 4th Ed, Edward Arnold, UK, 1973.
- Introduction to Physical Metallurgy, S H Avner, TATA Mc-Graw Hill, New Delhi,

2001.

Reference Book(s)

- Engineering Physical Metallurgy by Yuri Lakhtin, Moscow, MIR Publishers, 1963.
- Grain boundary migration in metals: thermodynamics, kinetics, applications, G. Gottstein & L. Shvindlerman, Boca Raton (FL), CRC, 1999

Course Name: Materials for High -Temperature Applications

Course Code: MM 617

Unit 1: Melt processing of Superalloy, Single crystal Superalloy, Processing of Superalloy, Alloying effect.

Unit 2: Oxide Dispersion Strengthened alloys. Powder Metallurgy

Unit 3: High temperature deformation, Room and high temperature Wear, Advanced coating materials

Unit 4: Fiber Reinforced Composite Superalloy,

Unit 5: Processing and properties of advanced Structural Ceramics.

Text Book(s):

- *Superalloys, supercomposites and super ceramics, ed. J. K Tien and T. Caulfield, Academic Press, 1989, Boston.*
- *High temperature structural materials, R. W. Cahn, Chapman and Hall, 1996, London.*

Reference Book(s):

- *Materials for High Temp. Engg. Applications, G. W. Meetham and M.H. Van de Voorde, Springer, 2000, Berlin.*
- *Friction, wear and Lubrications, K.C. Ludema, CRC Press, 1996.*
- *Powder Metallurgy: Science, Technology, and Materials Anish Upadhyaya and G. S. Upadhyaya, Taylor & Francis, 2011*

Course Name: Advanced Steel Technology

Course Code: MM 618

Unit 1: Strengthening mechanisms: Work hardening, Solid solution strengthening, Grain size refinement, Dispersion strengthening

Unit 2: Low Carbon steels: Austenite to ferrite transformation, High strength low alloys steels, Interstitial free steels, Dual phase and TRIP steels

Unit 3: Medium and high carbon steels: Austenite to pearlite transformation, Ferritic-pearlitic microstructures in medium carbon steels, Austenite to Cementite transformation,

Unit 4: Fully pearlitic microstructures: Rail steels, high strength steel wires

Unit 5: Special steels: Bainite: Upper and lower Bainite microstructures, Bainite transformation mechanisms and transition, nanostructured Bainite; Marraging steels, Stainless steel, TWIP steels, Case studies for defence applications.

Text Book(s):

- *Steels: Processing, Structure, and Performance, George Krauss; ASM International*

Reference Book(s):

- *Steels: Microstructure and Properties HKDH Bhadeshia and Sir R. Honeycomb; Butterworth-Heinmann, Elsevier Publications*

Course Name: Design of Materials

Course Code: MM607

Unit 1: First and Second law of diffusion, Solution to diffusion equations and error function, Types of diffusion, Krikendall effect and applications

Unit 2: Generic classes of Metallic alloys and applications, Equilibrium shapes of grains and phases, Applications of phase diagrams: Soft solders, Zone Refinement of Semiconductors, Bubble free Ice

Unit 3: Kinetics of nucleation, diffusive and Martensitic phase transformations, Fine grain castings, Rapid solidification and amorphous materials, Light alloys: Age-hardening and thermal stability

Unit 4: Mechanical properties of Ceramics, Statistics of Brittle fracture: Flaw size and dispersion of strength, Weibull distribution, Design of pressure windows

Unit 5: Fibrous, particulate and foamed composites, Improving stiffness, strength and toughness. Case studies in Defence applications: Turbine blades, bullet-proof vests, uses of metal matrix composites and carbon-carbon composites.

Text Book(s):

- *Engineering Materials 1 Michale F. Ashbey and David R. H. Jones; Butterworth-Heinmann, Elsevier Publications*
- *Engineering Materials 2 Michale F. Ashbey and David R. H. Jones; Butterworth-Heinmann, Elsevier Publications*

Reference Book(s):

- *D. A. Porter and K. E. Easterling, Phase transformations in Metals and Alloys, Chapman and Hall, London, 1996*
- *Physical Metallurgy Principles, Robert E Reed Hill, Cengage Learning, Inc publications, 1992*