Master of Technology (M.Tech) in Material Science Syllabus

Department of Material Science, Central University of Tamil Nadu Thiruvarur – 610101

Master of Technology (M.Tech) in Material Science

The Materials Science master's programme is a competitive education program that specialises students in the area of new materials. The big leap of advances in modern technologies and products in recent decades relies to a large extent on the development of materials science and technology.

The importance of advanced materials in today's technology is best exemplified by the highly purified semiconductor crystals, which are the basis of the "electronic age". Future implementations and applications of materials in electronics and photonics involve nano-scaled physics, molecular electronics and non-linear optics etc.

This M.Tech. programme has been proposed to offer students high level interdisciplinary education and training in novel materials and its technological applications.

The M.Tech. (Materials Science) programme to be offered by CUTN is inter-disciplinary in nature, with students joining from diverse backgrounds. The programme emphasises the comprehension of scientific principles and the development of personal and professional skills in solving practical engineering problems. The studies begin with some mandatory courses on materials science and its technological applications, in order to provide students with a solid knowledge foundation for modern materials science and nanotechnology. The subjects on Material Science include metallic materials, engineering materials, ceramic materials, polymers & composites, magnetic & electronic materials and synthesis and characterization techniques. The students are particularly encouraged to get a feel for the latest developments in engineering materials.

Starting with the second year a large variety of elective courses are planned to offer in close connection to cutting-edge technologies in order to give students a broad perspective of today's materials science and links to applications in semiconductor technology, functional materials, optoelectronics, bioengineering (biocompatibility), chemical and biosensors, energy storage and mechanical applications. Students will also be instructed through the in-depth project courses to develop abilities for creative thinking and problem solving.

At last students will complete a thesis project in the area of materials science and nanotechnology, either in a research group in-house or in industry.

Duration of Course: 2 years (4 semester)

Intake / Seats: 24 Seats

Eligibility Criteria / Entry Requirements

M.Sc. Physics/Chemistry/Applied Physics/Applied Chemistry/Material Science/Nano Science/Nano Technology
or

B.E /B.Tech. (Except Computer Science/IT).

Career Opportunities:

This M.Tech programme provides students with knowledge and skills required for modern science and technology. Graduates will be prepared for careers within academia or industry in materials-related research and development. The demand for talents in this field is large both in research institutes and industries. For example, wide-bandgap semiconductors, high-performance soft matters, advanced multifunctional materials as well as hybrid smart materials are of high interest in the industries in India and other countries.

Central University of Tamilnadu

Departement of Materials Science

M.Tech. MATERIALS SCIENCE

Curriculum for I TO IV Semestres (FULL TIME)

SEMESTER I

Sl No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MSN1511	Introduction to Materials Science	4	0	0	4
2.	MSN1512	Nanomaterials and Nanotechnology	4	0	0	4
3.	MSN1513	Synthesis and Characterization of Materials	4	0	0	4
4.	MSN1514	Thermodynamics and Kinetics of Materials	4	0	0	4
5.	MSN1515	Quantum Mechanics and Electromagnetic Theory	4	0	0	4
PRACTICAL						
6.	MSN1516	Synthesis and Characterization of Materials Lab	0	0	3	2
		TOTAL CREDIT	**20**	**0**	**6**	**22**

SEMESTER II

Sl No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MSN1521	Computational Materials Science	4	0	0	4
2.	MSN1522	Metals, Alloys and Composite Materials	4	0	0	4
3.	MSN1523	Polymer and Biomaterials	4	0	0	4
4.	MSN1524	Physical Metallurgy	4	0	0	4
5.	MSN1525	Advanced Characterization Techniques	4	0	0	4
PRACTICAL						
6.	MSN1526	Properties of Materials Lab	0	0	3	2
7.	MSN1527	Computational Materials Science Lab	0	0	3	2
		TOTAL CREDIT	**20**	**0**	**6**	**24**

SEMESTER III

Sl No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MSN1531	Materials for Energy Applications	4	0	0	4
2.	MSN15E1	Elective I	3	0	0	3
3.	MSN15E2	Elective II	3	0	0	3
4.	MSN15E3	Elective III	3	0	0	3
PRACTICAL						
6.	MSN1532	Nanostructures and Nanoparticles Lab	0	0	3	2
7.	MSN1533	Strength and Testing of Materials Lab	0	0	3	2
8.	MSN1534	Internship	0	0	0	2
		TOTAL CREDIT	**13**	**0**	**6**	**19**

SEMESTER IV

Sl No	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1.	MSN1541	Project & Viva	0	0	16	16
		TOTAL CREDIT	**0**	**0**	**16**	**16**

SUMMARY OF CREDITS

SEMESTER	Semester I	Semester II	Semester III	Semester IV	**Total**
CREDITS	22	24	19	16	**81**

ELECTIVES

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MSN15E	Nanotechnology for Agriculture and Environment	3	0	0	3
2	MSN15E	Nanotechnology for Clean Energy Technology	3	0	0	3
3	MSN15E	Powder Metallurgy	3	0	0	3
4	MSN15E	Nanophotonics	3	0	0	3
5	MSN15E	Nanosensors and Nanodevices	3	0	0	3
6	MSN15E	Spectroscopic Techniques for Materials	3	0	0	3
7	MSN15E	Hydrogen Storage and Fuel Cell Technology	3	0	0	3
8	MSN15E	Batteries and Supercapacitors	3	0	0	3
9	MSN15E	Lasers and Applications	3	0	0	3
10	MSN15E	Advanced Crystal Growth	3	0	0	3
11	MSN15E	Materials Processing	3	0	0	3
12	MSN15E	Nanoscale fabrication and techniques	3	0	0	3
13	MSN15E	Thin film Science and Technology	3	0	0	3
14	MSN15E	High Pressure Science and Technology	3	0	0	3
15	MSN15E	Superconducting Materials and Applications	3	0	0	3
16	MSN15E	Structure and Properties of Alloys	3	0	0	3
17	MSN15E	Smart materials and Structures	3	0	0	3
18	MSN15E	Biomaterials	3	0	0	3
19	MSN15E	Solid State Ionics	3	0	0	3
20	MSN15E	Advanced Materials	3	0	0	3
21	MSN15E	Composite Materials and Structures	3	0	0	3
22	MSN15E	Corrosion Science and Engineering	3	0	0	3
23	MSN15E	Non-Destructive Testing	3	0	0	3
24	MSN15E	Ultrasonics and Applications	3	0	0	3
25	MSN15E	Microprocessor Based Instrumentation	3	0	0	3
26	MSN15E	Measurement and Instrumentation	3	0	0	3

INTRODUCTION TO MATERIALS SCICENCE

COURSE CODE	L	T	P	C
MSN1511	4	0	0	4

Unit-1: Introduction and structure of materials, why study properties of materials? Structure of atoms - Quantum states-Atomic bonding in solids-binding energy-interatomic spacing - variation in bonding characteristics - Single crystals – polycrystalline - Non crystalline solids - Imperfection in solids – Vacancies – Interstitials - Geometry of dislocation - Schmid´s law - Surface imperfection - Importance of defects - Microscopic techniques - grain size distribution

Unit-2: Solid solutions and alloys - Phase diagrams - Gibbs phase rule - Single component systems – Eutectic phase diagram – lever rule - Study of properties of phase diagrams - Phase transformation - Nucleation kinetics and growth

Unit-3: Band model of semiconductors - carrier concentrations in intrinsic, extrinsic semiconductors – organic semiconductors - Fermi level - variation of conductivity, mobility with temperature – law of mass action - Hall effect - Hall coefficients for intrinsic and extrinsic semiconductors – Hall effect devices. Application of diffusion in sintering, doping of semiconductors and surface hardening of metals.

Unit-4: Mechanical properties - Stress, Strain, Elastic properties – Deformation – elasticity – hardness - Optical properties - Light interaction with solids - Atomic, electronic interaction, non – radiative transition - refraction, reflection, Absorption, Transmission, Insulators, luminescence

Unit-5: Magnetic properties - paramagnetism - ferromagnetism - domain theory - magnetic hysteresis, Weiss molecular field theory, Heisenberg's theory - magnetic anisotropy - domain walls - Exchange energy –antiferromagnetism

REFERENCES

1. W. D. Callister, "Materials Science and Engineering: An Introduction", John Wiley & Sons, 2007.
2. K. Vijayamohanan Pillai and Meera Parthasarathi Functional Materials: A Chemist's Perspective by, Orient Blackswan (21 November 2013)
3. C. Kittel, "Introduction to Solid State Physics" Wiley Eastern Ltd, 2005.
4. V. Raghavan, "Materials Science and Engineering: A First Course", Prentice Hall, 2006
5. A.J. Dekker, "Solid State Physics", Macmillan & Co, 2000.
6. Michael Shur, "Physics of Semiconductor Devices", Prentice Hall of India, 1995.
7. Charles P Poole Jr., and Frank J. Ownes, Introduction to Nanotechnology, John Wiley Sons, Inc., 2003
8. H. S. Nalwa (Ed.), "Encyclopedia of Nanoscience & Nanotechnology", American Scientific Publishers, California, 2004.
9. C. Kittel, "Introduction to Solid State Physics", Wiley Eastern Ltd., 2005.
10. V.R.Gowariker, "Polymer science ",New age international Publishers, 1986

NANOMATERIALS AND NANOTECHNOLOGY

COURSE CODE	**L**	**T**	**P**	**C**

MSN1512	4	0	0	4

Unit-1: Introduction to nanotechnology, physics of low-dimensional materials, quantum effects, 1D, 2D and 3D confinement, Density of states, Excitons, Coulomb blockade, Zero-, One-, Two- and Three- dimensional structure, Size control of metal nanoparticles and their properties: optical, electronic, magnetic properties; surface plasmon resonance, change of bandgap; Application: catalysis, electronic devices

Unit-2: Importance of size distribution control, size measurement and size selection, assembling and self-organization of nanostructures, 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,

Unit-3: Advantages of nano electrical and electronic devices, micro and nano-electromechanical systems – sensors, actuators, optical switches, bio-MEMS diodes and nano-wire transistors - data memory lighting and displays, filters (IR blocking) – quantum optical devices – batteries - fuel cells and photo-voltaic cells – electric double layer capacitors – lead-free solder – nanoparticle coatings for electrical products

Unit-:4 Nanocatalyts, smart materials, heterogenous nanostructures and composites, nanostructures for molecular recognition (quantum dots, nanorods, nanotubes) – molecular encapsulation and its applications – nanoporous zeolites – self-assembled nanoreactors - organic electroluminescent displays

Unit-5: Drug deliveries, drug delivery system, nanoparticle in drug delivery-available applications, nanotechnology future application understanding for treatment. manufacture of nanoparticles, nanopowder and nanocrystals, targeting ligands applications of nanoparticle in drug delivery, cancer treatment, tissue regeneration, growth and repair, impact of drug discovery and development.

REFERENCES

1. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005
2. Nanolithography and patterning techniques in microelectronics, David G. Bucknall, Wood head publishing 2005
3. Transport in Nanostructures, D.K. Ferry and S.M. Goodmick, Cambridge university press 1997.
4. Optical properties of solids, F. Wooten, Academic press 1972
5. Micro and Nanofabrication, Zheng Cui, Springer 2005
6. Nanostructured materials, Jackie Y. Ying, Academic press 2001

7. Nanotechnology and nanoelectronics, W.R, Fahrner, Springer 2005
8. Nanoengineering of structural, functional and smart materials, Mark J. Schulz, Taylor & Francis 2006.
9. Hand book of Nanoscience, Engineering, and Technology, William A. Goddard, CRC press 2003.
10. Nanoelectronics and Information Technology, Rainer Waser, Wiley-VCH 2003.
11. The MEMS Handbook Frank Kreith, CRC press 2002.
12. Pradeep T "Nano: The Essentials", Mc Graw Hill Publishing Co. Ltd., 2007
13. Mick Wilson et al, "Nanotechnology", Overseas Press (India) Pvt. Ltd., 2005.
14. Charles P. Poole, Jr., Frank J. Owens, "Introduction to nano technology", Wiley, 2003.
15. Gunter Schmid, "Nanoparticles: From Theory to Applications", Wiley-VCH Verlag GmbH & Co., 2004.

SYNTHESIS AND CHARACTERIZATION OF NANOMATERIALS

COURSE CODE	L	T	P	C
MSN1513	4	0	0	4

Unit-1: Top down and bottom up synthesis approach, physical and chemical techniques for nanomaterial synthesis, sol-gel, hydrothermal, freeze drying, intercalation, attrition, mechanical alloying and mechanical milling, ion implantation, Gas phase condensation, Chemical vapour deposition, fundamentals of nucleation growth, controlling nucleation & growth

Unit-2: Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, clusters, colloids, zeolites, organic block copolymers, emulsion polymerization, templated synthesis, and confined nucleation and/or growth. Biomimetic Approaches: polymer matrix isolation, and surface-templated nucleation and/or crystallization. Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition.

Unit-3: Vapor deposition and different types of epitaxial growth techniques-pulsed laser deposition, Magnetron sputtering - Micro lithography (photolithography, soft lithography, micromachining, e-beam writing, and scanning probe patterning).

Unit-4: Preparation of nanomaterials like gold, silver, different types of nano-oxides, Al_2O_3, TiO_2, ZnO etc. nanotube and wire formation, carbon nanotubes, graphene preparation properties and applications

Unit-5: Principle, Theory, Working and Application; X-Ray Diffraction, X-Ray Reflectivity, Scanning Electron Microscopy, Transmission Electron Microscopy, High Resolution Transmission Electron Microscopy, Field Emission Scanning Electron Microscopy, Atomic Force Microscopy, Scanning Tunnelling Spectroscopy / Microscopy, Photoluminescence Spectroscopy, Electrochemical Impedance Spectroscopy, Polarized neutron Reflectivity, Differential thermal and Gravimetric Analysis, Dynamic Mechanical Analysis, Universal Testing Machine, Vibrating sample Magnetometer, Vector network Analyzer, Vibrating Sample Magnetometer, Brunauer-Emmett Teller surface areas, Zeta sizer, Environmental mode.

REFERENCES

1. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
2. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002.
3. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.
4. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications , Imperial College Press, 2004.
5. J. George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.
6. B. D. Cullity, “Elements of X-ray Diffraction”, 4^{th} Edition, Addison Wiley, 1978.
7. M. H. Loretto, “Electron Beam Analysis of Materials”, Chapman and Hall, 1984.

THERMODYNAMICS AND KINETICS OF MATERIALS

COURSE CODE	L	T	P	C
MSN1514	4	0	0	4

Unit-1: Introduction to thermodynamics and kinetics – different approaches – emphasis on metallurgical thermodynamics, transport phenomena and applications

Unit-2: Law of thermodynamics and related applications, Concepts of free energy and entropy, criteria for spontaneity.

Unit-3: Introduction to solutions – partial molar entities – Gibbs Duhem relations - thermodynamic aspects of metallic solutions and salt melts – Raoult’s Law and Henry’s Law - regular and quasi chemical models

Unit-4: Thermodynamic aspects of phase diagrams – similarity in thermodynamic approach towards different classes of materials – thermodynamic aspects of defect formation in metals and ceramics – approaches used in chemical modeling

Unit-5: Principles of metallurgical kinetics – reaction rates and reaction mechanisms – overview of mass transfer, heat transfer and fluid flow – related applications in metallurgical processes – role of transport phenomena in mathematical and physical modelling.

REFERENCES
1. Gaskell, David R., 'Introduction to Metallurgical Thermodynamics', McGraw Hill, 1973
2. Mohanty, A. K., "Rate Processes in Metallurgy", Prentice Hall of India (EEE), 2000
3. Upadhayaya, G.S., and Dube, R.K., Problems in metallurgical thermodynamics and kinetics, Pergamon
4. Darken, L.S., and Gurry, R.W., Physical chemistry of Metals, McGraw Hill

QUANTUM MECHANICS AND ELECTROMAGNETIC THEORY

COURSE CODE	L	T	P	C
MSN1515	4	0	0	4

Unit-1: Basics of Quantum Mechanics, Planck's formula of black-body radiation. Photoelectric effect. Bohr atom and quantization of energy levels. de Broglie hypothesis. Electron double-slit experiment. Compton effect, Davisson-Germer experiment, Heisenberg's uncertainty principle (statement) with illustrations.

Unit-2: Concept of wave function as describing the dynamical state of a single particle. Group and phase velocities, classical velocity of a particle and the group velocity of the wave representing the particle. Principle of superposition. Schrodinger equation. Probabilistic interpretation; equation of continuity, probability current density. Boundary conditions on the wave function.

Unit-3: One dimensional potential well and barrier, boundary conditions, bound and unbound states. Reflection and transmission coefficients for a rectangular barrier in one dimension – explanation of alpha decay. Free particle in one dimensional box, box normalization, momentum eigen functions of a free particle. Linear harmonic oscillator, energy eigenvalues from Hermite differential equation, wave function for ground state, parity of wave function.

Unit-4: Displacement Current, Maxwell’s Field Equations, Wave equation for electromagnetic (EM) field and its solution – plane wave and spherical wave solutions, transverse nature of field, relation between E and B; energy density of field, Poynting vector and Poynting’s theorem, boundary conditions.

Unit-5: Wave equation, reflection and refraction at plane boundary, reflection and transmission coefficients, Fresnel’s formula, change of phase on reflection, polarization on reflection and Brewster’s law, total internal reflection. Equation of motion of an electron in a radiation field : Lorentz theory of dispersion – normal and anomalous; Sellmeier’s and Cauchy’s formulae, absorptive and dispersive mode, half power frequency, band width.

REFERENCES

1. Quantum Mechanics – J. L. Powell and B. Crasemonn, (Oxford, Delhi).
2. Quantum Mechanics – F. Schwabl (Narosa).
3. Quantum Mechanics – A. K. Ghatak and S. Lokenathan (Macmillan, Delhi).
4. Introductory Quantum Mechanics - S. N. Ghoshal (Calcutta Book House).
5. A Textbook of Quantum Mechanics – P. M. Mathews and K. Venkatesan (Tata Mc Graw Hill).
6. Modern Quantum Mechanics – Sakurai (Persian Education)
7. Introduction to Electrodynamics – D. J. Griffith, (Prentice Hall, India Pvt. Ltd).
8. Classical Electrodynamics – J.D> Jackson (Wiley India)
9. Berkeley Series Vol II (Electricity and Magnetism) E.M. Purcell (Tata McGraw-Hill).
10. The Feynman Lectures on Physics – Vol. II (Addison – Wesley).
11. Electricity and Magnetism - J. H. Fewkes and J. Yarwood (Oxford Univ. Press, Calcutta).
12. Electricity and Magnetism – Chatterjee and Rakshit.
13. Electricity and Magnetism – A. S. Mahajan and A. A. Rangwala (Tata McGraw-Hill).

COMPUTATIONAL MATERIALS SCIENCE

COURSE CODE	**L**	**T**	**P**	**C**
MSN1521	4	0	0	4

Unit–1: Introduction and Basic concepts, Theoretical Background, Basic equations for interacting electrons and nuclei, Coulomb interaction in condensed matter, Independent electron approximations, Exchange and correlation, Periodic solids and electron bands, Structures of crystals: lattice + basis, The reciprocal lattice and Brillouin zone, Excitations and the Bloch theorem

Unit-2: Time reversal and inversion symmetries, Integration over the Brillouin zone and special points Density of states Uniform electron gas and simple metals. Non-interacting and Hartree-Fock approximation, The correlation hole and energy. Density functional theory: foundations, Thomas-Fermi-Dirac approximations: example of a functional. The Hohenberg-Kohn theorems, constrained search formulation of density functional theory, Extensions of Hohenberg-Kohn theorems, The Kohn-Sham ansatz. Replacing one problem with another: The Kohn-Sham variational equations Exc, Vxc and the exchange correlation hole meaning of the eigenvalue. Intricacies of exact Kohn-Sham theory.

Unit-3: Functionals for exchange and correlation, The local spin density approximation (LSDA), Generalized-gradient approximation (GGAs) , LDA and GGA expressions for the potential Vxc(r), Non-collinear spin density, Non-local density formulations: ADA and WDA, Orbital dependent functionals I: SIC and LDA+U. Orbital dependent functional II: OEP and EXX, Hybrid functionals , Tests of functionals Solving Kohn-Sham equations – Self-consistent coupled Kohn.Sham equations - Total energy functionals, Achieving self-consistency – Numerical mixing schemes, Force and stress.

Unit-4: Determination of electronic structure – Atomic sphere approximation in solids, Plane waves and grids: basics - The independent particle Schrodinger equation in a plane wave basis. The Bloch theorem and electron bands - Nearly free-electron-approximation - Form factors and structure factors. Plane-wave method - 'Ab initio' pseudopotential method - Projector augmented waves (PAWs) - Simple crystals: structures, bands, - Supercells: surfaces, interfaces, phonons, defects - Clusters and molecules. Localized orbitals: tight-binding – Tight-binding bands: illustrative examples - Square lattice and CuO_2 planes - Examples of bands: semiconductors and transition metals - Electronic states of nanotubes. Localized orbitals: full calculations – Solution of Kohn-Sham equations in localized bases. Analytic basis functions: gassians - Gassian methods: ground state and excitation energies - Numerical orbitals - Localized orbitals: total energy, force, and stress - Applications of numerical local orbitals - Green's function and recursion methods - Mixed basis.

Unit-5: Augmented plane waves (APW's) and 'muffin-tins' – Solving APW equations: examples Muffin-tin orbitals (MTOs). Linearized augmented plane waves (LAPWs) - Applications of the LAPW method - Linear muffin-tin orbital (LMTO) method - Applications of the LMTO method - Full potential in augmented methods - Molecular dynamics (MD): forces from the electrons - Lattice dynamics from electronic structure theory - Phonons and density response functions - Periodic perturbations and phonon dispersion curves - Dielectric response functions, effective charges - Electron-phonon interactions and superconductivity.

REFERENCES

1. H.Skriver, The LMTO Methods, Springer (1984).
2. Electronic Structure Basic Theory and Practical Methods Richard M. Martin, Cambridge University Press (2004).
3. Modeling Materials Continuum, Atomistic and Multiscale Techniques ELLAD B. TADMOR, Cambridge University Press (2012).
4. Atomic and Electronic Structure of Solids, Efthimios Kaxiras, Cambridge University Press (2003).
5. Computational Chemistry of Solid State Materials, *Richard Dronskowski*, WILEY-VCH (2005).
6. Mizutani U. Introduction to the Electron Theory of Metals (CUP,2001).
7. Roessler U. Solid State Theory.. An Introduction (2ed., Springer, 2009)

METALS, CERAMICS AND COMPOSITE MATERIALS

COURSE CODE	L	T	P	C
MSN1522	4	0	0	4

Unit-1: Atomic structure and bonding, crystal structures lattices, indices etc with examples of atomic structures and bonding types, order and disorder, diffusion mechanisms, deformation mechanisms, classes of metals, point defects, line defects, surface and volume defects, strengthening mechanisms, simple alloys and intermetallics.

Unit-2: ceramic crystal structures, Atomic defects including intrinsic and extrinsic point defects, Electrical properties including ferroelectrics, thermistors, electrical conductors, dielectrics, Magnetic properties including ferromagnetic and ferromagnetic materials.

Unit-3: Dielectrics, ferroelectrics and magnetoceramics, Magnetism; Dia-, Para, Ferro-, Antiferro-, Ferri-magnetism, Magnetic properties; Gaint magnetoresistance, Tunneling magnetoresistance, Colossal magnetoresistance, Superparamagnetism High Tc materials: YBCO and Bi-systems (Brief idea), Superconducting nano-materials & their properties and applications.

Unit-4: Solid state sintering, densification and coarsening processes, grain boundary mobility, porosity evolution (stability/entrapment). Thermal properties including thermal expansion, creep, and thermal stresses. Mechanical properties including strength, toughness, and microstructural design.

Unit-5: Composite Interfaces, Bonding Mechanisms, other Interfacial properties, Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Composite Strengths; Fibers as reinforcements.

REFERENCES

1. Introduction to Materials Science and Engineering, William J Callister, John Wiley & Sons, Inc.
2. K. Vijayamohanan Pillai and Meera Parthasarathi Functional Materials: A Chemist's Perspective by, Orient Blackswan (21 November 2013)
3. Physical Metallurgy Principles Reed-Hill - R. E., and R. Abbaschian, 3rd ed. Boston: PWS-Kent, 1992.
4. Structure and Properties of Engineering Alloys - Smith, W. F., McGraw-Hill, 1981.
5. Introduction to Ceramics W.D. Kingery, H.K. Bowen, D.R. Ulhmann.
6. Treatise on Inorganic Chemistry, Vol. II: Subgroups of the periodic table and general topics, Preparation of Metals - H. Remy, Elsevier, 1956.
7. Synthesis of Advanced Ceramic Materials David Segal.
8. Fundamentals of Polymer Science: An Introductory Text - P. Painter and M. Coleman, Technomic, 1997
9. Composite Materials: Engineering and Science - F. L. Matthews and R. D. Rawlings, Chapman & Hall 1994
10. Ceramic Processing and Sintering - M.N. Rahman, Marcel Dekker, Inc.
11. Handbook of Advanced Ceramics Vol.II, Processing and Their Applications - Shigeyuki Somiya, Elsevier Acadmic press.
12. Mechanical properties of ceramics Watchman, J. B., John Wiley New York, 1996
13. Advanced Composite Manufacturing - Gutowski, Wiley.
14. Physics of Magnetism - S. Chikazumi and S.H. Charap.
15. Magnetostriction and Magnetomechanical Effects - E.W. Lee.
16. Richerson D. W., 'Modern Ceramic Engineering - Properties Processing and Use in Design, 3rd Edition, CRC Press, 2006
17. Chiang Y.M., Birnie D. P., Kingery W.D., Physical Ceramics: Principles for Ceramic Science and Engineering, John Wiley, 1997
18. Norton F. H., ' Elements of Ceramics' 2nd Edition, Addison Wesley, 1974

POLYMER AND BIOMATERIALS

COURSE CODE	L	T	P	C
MSN1523	4	0	0	4

Unit-1: Historical developments in polymeric materials, Basic concepts & definitions: monomer & functionality, oligomer, polymer, repeating unites, degree of polymerization, molecular weight & molecular weight distribution.

Unit-2: Natural Polymers: Chemical & Physical structure, properties, source, important chemical modifications, applications of polymers such as cellulose, lignin, starch, rosin, shellac, latexes, vegetable oils and gums, proteins etc. Molecular weight and its distribution determination (Mn to Mz & MWD), carothers equation, states of polymers, transition temperatures such as Tg, Tc, Tm, solubility parameter, solution properties, temperature, good/ bad solvent,

Unit-3: Raw material for synthetic polymers: Manufacturing of various fractions of crude petroleum important for polymer industry for (a) Raw Materials such as ethylene, propylene, butadiene, vinyl chloride, vinylidene dichloride, styrene, acrylic monomers like acrylic acid, acrylonitrile, methacrylic acid, methacrylates, acrylamide etc, (b) solvents such as alcohols, toluene, xylene, acetone, ketones, terpenes, chloromethanes etc. Evaluation of raw materials and reactants for synthesis & manufacturing of polymers. (c) Polyacids such as phthalic acid, terephthalic acid, isomers and anhydrides etc. (d) phenols, polyols and their modifications, (e) Isocyanates, (f) Amino Compounds, (g) Other petroleum based material

Unit-4: Introduction to biomaterials for biomedical applications, Chemical structure and property of biomaterials, Degradation of biomaterials, Polymeric biomaterials: Introduction, preparation, hydrogel biomaterials, Bioconjugation techniques, Biomaterials for drug delivery application (small molecules, gene and protein)

Unit-5: Biocompatibility, Biomaterials implantation, Evaluation of biomaterials, Nanobiomaterials, Biomaterials for imaging and diagnosis, Cell-Biomaterials interaction, Biomaterial and tissue engineering

REFERENCES

1. Billmeyer F, ‘Textbook of Polymer Science’, Wiley Interscience, 1994
2. Principles of Polymer Science, Bahadur and Sastry, Narosa Publishing House 2002.

3. Polymer Science , Gowarikar, Johan wiley and Sons 1986.
4. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
5. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
6. Polymer Chemistry , Malcolm P. Stevens, Oxford University Press, Inc, 1990.
7. Text book of polymer Science, Billmeyer, John Wiley ans Sons 1984.
8. Principles of Polymer Systems, Rodriguez, Hemisphere Publishing Corpn, 1982.
9. Introduction to Polymer Science and Technology, H. S. Kaufman and J. J. Falcetta,
10. Wiley – Interscience Publication, 1977
8. Polymer Science and Technology of Plastics and Rubbers, P. Ghosh,
9. Tata McGraw-Hill Publishing Company 1990.
10. Textbook of Polymer Science, P. Nayak and S. Lenka, Kalyani Publishers, 1986.
11. Fundamentals of Polymer Science an introductory text, P. Painter and M. Colman, Technomic publishing Co Inc,1994.
12. Textbook of Polymer Science and Engg Anilkumar and Gupta, tata McGraw-Hill Publishing Co, Ltd., 1978.
13. Polymer Science and Technology by J. R. Fried, Prentice-Hall, Inc 1995.
14. Polymer chemistry, Seymour and Carraher, Marcel Dekker, 2003.
15. Fundamentals of Polymer Processing, S. Middleman, Houghton Mifflin Compony, 1997.
16. Materials Science & Engineering, WD Callister, (Wiley: New York).
17. Biomaterials : An Introduction, J B Park & RS Lakes, (Plenum Press : New York).
18. Principles of Polymer Engineering, McCrum NG, Buckley CP, Bucknall CB Oxford University Press.
19. Plastics Materials, Brydson JA Butterworth, London

PHYSCICAL METALLURGY

COURSE CODE	L	T	P	C
MSN1524	4	0	0	4

Unit-1: Concept of stress and strain in three dimensions and generalized Hooke’s law; Young’s modulus; Tension test of mild steel and other materials: true and apparent stress, ultimate strength, yield stress and permissible stress; Stresses in prismatic & non prismatic members and in composite members; Thermal stresses; Shear stress, Shear strain, Modulus of rigidity, Complementary shear stress; Poisson's ratio, Volumetric strain, Bulk modulus, relation between elastic constants; Stresses in composite members, Compatibility condition

Unit-2: Compound Stress: Two dimensional stress system: stress resultant, principal planes and principal stresses, state of pure shear maximum shear stress, Mohr's circle & its application. Moment of Inertia: Polar and product moment of inertia, Principal axes and principal moment of inertia

Unit-3: Columns: Short and long columns, slenderness ratio, crushing and buckling of column, short column subjected to axial and eccentric loads; Euler's theory and its limitation, concept of effective length of columns; Rankine & Secant formulae, Membrane Analysis: Stress and strain in thin cylindrical & spherical shells under internal pressures

Unit-4: Bending of Beams: Types of supports, support reactions, determinate and indeterminate structures, static stability of plane structures Bending moment, Shear force and Axial thrust diagrams for statically determinate beams subjected to various types of loads and moments, Point of Contra-flexure, relation between load, SF and BM

Unit-5: Theory of simple bending: Distribution of bending and shear stresses for simple and composite sections Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of nanoindentation load-displacement curves-Nanoindentation data analysis methods-Hardness testing of thin films and coatings- MD simulation of nanoindentation.

REFERENCES

1. Mechanics of Structures Vol. I & II by S.B Junarkar, Charotar Publishing House,
2. Strength of Materials & Mechanics of Structures: Vol. I, II by Dr. B.C. Punmia Laxmi Publications (p) Ltd.
3. Strength of Material by Singer and Pytel, Harper Collins Publishers.
4. Elements of Strength of Materials by Timoshenko & Young, Mc Graw Hill Book Co.
5. Mechanics of Structures by Timoshenko & Gere, CBS Publishers and Distributers.
6. R. M. Rose, L.A.Shepard and J.Wulff, "The Structure and Properties of Materials", Wiley Eastern Ltd,
7. B.W.Mott, "Micro-Indentation Hardness Testing", Butterworths, London, 1956.
8. Raghavan, V.,, Phase transformations, Prentice Hall
9. Smallman, R.E., Modern physical metallurgy

10.Reed Hill, R.E., Principles of physical metallurgy, Affiliated East West Press.

ADVANCED CHARACTERIZATION TECHNIQUES

COURSE CODE	L	T	P	C
MSN1525	4	0	0	4

Unit-1: X-ray diffraction. Diffraction under non-ideal conditions. Atomic scattering and Geometrical structure factors. Factors influencing the intensities of diffracted beams. Powder X-ray diffractometer. Applications of XRD in ceramic materials.

Unit-2: Study of the morphology, aggregation, size and microstructure of ceramic materials using. Optical microscope, quantitative phase analysis. Principle of electron microscopy. Construction and operation of Transmission Electron Microscope and Scanning Electron Microscope. Electron diffraction by crystalline solids; selected area diffraction.

Unit-3: Atomic Force Microscope. Mechanism of image formation in SEM and its processing. Electron microprobe analysis (EDAX and WDS). Preparation of samples for electron microscopic studies. ESCA and PES.

Unit-4: Spectrophotometric analysis of materials: Basic laws of spectrophotometry and its application in micro analysis in UV/ Visible range, effect of reflectance factor on optical analysis, construction and working principle of spectrophotometer, importance of additive absorbances in multiple analysis of materials. Infrared spectrophotometry: General aspects of IR spectroscopy and its application in structural analysis of systems, sources of IR radiations, Optical systems and operation of FTIR spectrophotometers. Samples preparation, IR analysis and structural co-relations.

Unit-5: Fluorescence and Phosphorescence spectroscopy: Basic principle, geometrical optics, construction, working principle and use of fluorescence spectrometers in materials analysis. XRF and on-line analysis of ceramic materials. Electron Spin Resonance spectroscopy in ceramic systems. DTA, TGA and DSC with suitable examples of glass and ceramic materials.

REFERENCES:

1. Sam Zhang, Lin Li and Ashok Kumar, Materials Characterization Techniques, CRC Press, (2008)
2. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Wiley & Sons (2008)
3. Elton N. Kaufmann, Characterization of Materials, Vol.1, Wiley & Sons (2003)

4. R.A. Laudise, Growth of Single Crystals, Prentice Hall, (1973)
5. G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley (Eds.), Springer Handbook of Crystal Growth, Springer-Verlag (2010)
6. Peter E.J. Flewitt and R.K. Wild, Physical Methods of Materials Characterization, 2nd Edition, Taylor & Francis (2003)
7. Willard, Merritt, Dean, Settle, Instrumental Methods of Analysis, CBS publishers & Distributors, Delhi, Sixth Edition, 1986.
8. Colin N. Banwell and Elaine M. McCash, Molecular Spectroscopy, Mcgraw-Hill College; 4 Sub edition (June 1, 1994), ISBN-10: 0077079760

MATERIALS FOR ENERGY APPLICATIONS

COURSE CODE	L	T	P	C
MSN1531	4	0	0	4

Unit-1: Materials for hydro power generation**:** Introduction: India' vast potential of hydro power; problem of high silt content of Himalayan rivers and its associated erosion damage, and high velocity streaming water causing cavitation. Size and shape of particles, hardness of particles and its concentration in water. Chemical composition, microstructure, mechanical properties like hardness, ductility, tensile strength, work-hardening rate and toughness.

Unit-2: Materials for thermal power generation: Introduction to the constraints that are currently placed on power generation plant in terms of environmental impact and developing of high efficiency, low emission systems. Measures to improve the efficiency of a power plant- Increasing the temperature and the pressure of the steam entering the turbine.

Unit-3: Batteries and Super capacitors for electrochemical energy storage: Batteries – primary and secondary batteries, Lithium, Solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries, Super capacitors for energy storage. Role of carbon nanomaterials as electrodes in batteries and super capacitors.

Unit-4: Materials for energy storage: Synthesis of nanomaterials, top-down and bottom-up approaches, mechanical milling, solgel method, chemical vapour deposition (CVD), Carbon Nano-Tubes (CNT), Carbon Nano-Fibres (CNF), graphene, preparation of graphene. Fabrication of CNTs and CNFs, CNTs and CNFs for hydrogen storage

Unit-5: Fuel Cells and its applications: Fuel Cells, components of fuel cells, Types of fuel cells, Acid/alkaline fuel cells, polymer electrolyte fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, Types of solid oxide fuel cells: High temperature, intermediate temperature Single chamber solid oxide fuel cells, Problems with fuel cells, applications of fuel cells, difference between batteries and fuel cells, principle of working of fuel cell, performance characteristics of fuel cells, efficiency of fuel cell, fuel cell stack, description of some commercially available fuel cell stacks, fuel cell cars and buses, overview on research activities.

REFERENCES

1. Dieter, G. E., "Mechanical Metallurgy", 3rd Ed., 1988,McGraw Hill,.
2. Reed-Hill, R.E. and Abbaschian, R., "Physical Metallurgy Principles", 1992, The PWS-KENT Series in Engg.
3. Hutchings, I.M. "Tribology - Friction and Wear of Engineering Materials", 1992, Edward Arnold Publications Ltd.
4. Linden D. and Reddy Thomas B., "Handbook of Batteries", 2001, McGraw Hill Publications
5. Larminie and A. Dicks, Fuel Cell Systems Explained, 2nd Edition, Wiley (2003)
6. Xianguo Li, Principles of Fuel Cells, Taylor and Francis (2005)
7. S. Srinivasan, Fuel Cells: From Fundamentals to Applications, Springer (2006)
8. O'Hayre, S. W. Cha, W. Colella and F. B. Prinz, Fuel Cell Fundamentals, Wiley (2005)
9. A. J. Bard and L. R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd Edition, Wiley, 2000
10. A. Faghri and Y. Zhang, Transport Phenomena in Multiphase Systems, Elsevier 2006

PRACTICALS

SYNTHESIS AND CHARACTERIZATION OF MATERIALS LAB

COURSE CODE	L	T	P	C
MSN1516	0	0	3	2

PROPERTIES OF MATERIALS LAB

COURSE CODE	L	T	P	C
MSN1526	0	0	3	2

COMPUTATIONAL MATERIALS SCIENCE LAB

COURSE CODE	L	T	P	C
MSN1527	0	0	3	2

NANOSTRUCTURES AND NANOPARTICLES LAB

COURSE CODE	L	T	P	C
MSN1532	0	0	3	2

STRENGTH AND TESTING OF MATERIALS LAB

COURSE CODE	L	T	P	C
MSN1533	0	0	3	2