SYLLABUS

FOR

POST GRADUATE COURSE

MATERIAL SCIENCE

(With effect from 2021-22)

Under Choice Based Credit System

with

Semester Pattern

DEPARTMENT OF MATERIAL SCIENCE

Maharaja Sriram Chandra Bhanjadeo University

Sriram Chandra Vihar

Takatpur, Baripada-757003

M.Sc. (Material Science) Examination

(Choice Based Credit System Semester Pattern)

1. The course is of two years duration comprising of four semesters.
2. There is an open elective paper MS 412, which is being offered in the second semester. The paper is open for students of other departments.
3. Each student has to carry out project work in Semester-IV and submit a dissertation at the end of the semester followed by presentation and Viva-Voce.
4. The student can opt one elective course having three options (any one can be chosen) in both 3rd and 4th semester.
5. The examination system for each theory paper consists of one IAE of 20 marks and one semester exam of 80 marks. The IAE shall be one hour duration and shall cover at least two units. The semester examination shall be 3-hour duration and the question paper shall be of unit pattern with two alternatives from each unit having equal weight.
6. The practical examination will be conducted comprising of 50 marks laboratory experiment, 30 marks for Viva-Voice, and 20 mark for practical record.
7. A candidate must secure at least 40% marks in a paper to pass the semester examination.
8. A student securing cumulative Grade Point Average (CGPA) 5.5 shall be declared as pass in the Post-Graduation Examination.
9. Candidate securing at least 6.75 CGPA (minimum 60% marks in aggregate) shall be declared as First Class. The First Class First student shall receive the University Gold Medal in the concerned regular P.G. Course provided that he/she has cleared all the papers of the semester examinations in a single attempt.
10. If the candidate passes all the four semester examinations he/she will be declared to have passed the M.Sc. examination in Material Science. Further, under no circumstance a candidate shall be allowed to appear any Semester Examination after completion of the twice the duration of the course.
11. The student has to secure at least 75% of attendance to be eligible to appear at the University examination.

Programme Outcomes:

- Material Science post graduates are enlightened with the knowledge of materials and their science & Engineering.
- Material Science post graduates are capable of formulating and analysing the scientific & engineering data.
- Material Science post graduates can identify, classify, and solve scientific and engineering problem.
- Material Science post graduates are capable of exploring the resources to collect the required data, analyse and solve critical problems.
- Material Science post graduates have skills in locating and applying modern tools to resolve the complex scientific and engineering problems.
- Material Science post graduates are competent to work in research, industrial sectors, and with multi-faceted team.
- Material Science post graduates have the capacity to design, plan, and execute complex processes adhering to environmental considerations and cost effectiveness.
- Material Science post graduates are capable to communicate effectively to scientific as well as engineering community and explain well to the society.
- Material Science post graduates have motivation for enduring education to maintain competency.
- Material Science post graduates have gained knowledge to adhere to the ethical considerations and play a key role in sustainable development.
- Material Science post graduates are capable to asses both persons and problems & take decisions independently.

PROGRAMME SPECIFIC OUTCOME

The M.Sc. in Material Science is designed to specifically achieve a few targets such as:

- Selecting student's career in core and emerging areas of Material Science and allied industries.
- Make students achieve timely progress towards higher degree in Materials, Engineering and related fields.
- To solve challenging industrial problems and serve effectively in globally competitive industrial environments with leadership skills.
- Train students to function as independent scientists and engineers.
- A deep understanding of the underlying principles of
    - the appropriate theories in their subject area.
    - the synthesis and preparation of their subject materials.
    - characterization of their subject materials.
    - processing of their subject materials.
- A deep understanding of interrelationships of structure, processing and properties of their subject materials.
- A broad knowledge of the preparation, characterization and processing of all types of materials.
- Enabling students to qualify the GATE entrance test for higher study.

P.G Syllabus for Material Science

Semester-I

Course Code	Course Title	Credit	Marks		
			Internal	Semester	Total
MS401	Mathematical Physics	05	20	80	100
MS403	Quantum mechanics	05	20	80	100
MS405	Crystallography and X-ray diffraction	05	20	80	100
MS407	Electronics	05	20	80	100
MS409	Practical (Morden Physics Experiments)	05	--	100	100
Total		**25**	**80**	**420**	**500**

Semester-II

Course Code	Course Title	Credit	Marks		
			Internal	Semester	Total
MS402	Numerical Methods and computer applications	05	20	80	100
MS404	Electromagnetic theory	05	20	80	100
MS406	Physics of Materials-I	05	20	80	100
MS408	Material preparation and Characterization-I	05	20	80	100
MS410	Practical (Morden Physics Experiments)	05	--	100	100
MS412	Open Elective **(Group Theory and Crystallography)**	05	20	80	100
Total		**30**	**100**	**500**	**600**

Semester-III

Course Code	Course Title	Credit	Marks		
			Internal	Semester	Total
MS501	Physics of Materials-II	05	20	80	100
MS503	Material Chemistry	05	20	80	100
MS505	Characterization techniques	05	20	80	100
MS507	Elective-I	05	20	80	100
MS509	Practical	05	--	100	100
Total		**25**	**80**	**420**	**500**

Semester-IV

Course Code	Course Title	Credit	Marks		
			Internal	Semester	Total
MS502	Nano Science and technology	05	20	80	100
MS504	Elective-II	05	20	80	100
MS506	Practical (elective)	05	--	100	100
MS508	Project	05	--	100	100
Total		**20**	**40**	**360**	**400**
GRAND TOTAL		**100**			**2000**

Elective: I

507-A: Solid state ionics

507-B: Nuclear Physics and reactor material

507-C: Corrosion Science and Engineering

Elective: II

504-A: Smart materials and structure

504-B: Bio materials

504-C: Advance Materials

SEMESTER-I

PAPER CODE: MS-401

PAPER : Mathematical Physics

PAPER OBJECTIVE:

1. To enrich logical understanding of the subject.
2. To enrich mathematical skill in students enabling them to apply mathematical methods and principle in solving problems related to Material Science.
3. To make students understand that Mathematics is the language of Science.

Unit: I: Matrices: Matrices as operators, Symmetric, Orthogonal, Hermitian and Unitary matrices. Eigen vales and Eigen vectors of a matrix. Similarity, Orthogonal, Unitary and Congruent transformation. Diagonalization of a real symmetric matrix.

General Curvilinear Co-ordinates: Expression for line, Surface and Volume elements in general curvilinear co-ordinates, Gradient, Curl, Divergence and Laplacian-Orthogonal curvilinear co-ordinates.

Tensors: Definition- Contravariant, Covariant and Mixed tensors. Sum, inner and outer Products-Contraction-Quotient law. The line element and metric tensors. Length of a vector. Raising and lowering of indices. Christoffel symbols and covariant differentiation of tensor. Stress and strain tensors.

Unit: II: Special Functions: Beta and Gamma functions, Bessel functions of the first kind-derivation of the basic form-Recurrence relation. Idea of Spherical Bessel function. Legendre functions- Recurrence relation and differential equation. Hermite functions- Recurrence relations-differential equations. (At least one application in each case)

Unit: III: INTEGRAL TRANSFORMS: Harmonic analysis, Fourier transformation-properties-transforms of simple functions and Derivatives-Convolution Theorems-

Applications-Laplace's Transform-Properties-Transform of simple function and derivatives-periodic functions- Convolution Theorems-Application to solve differential equations.

Unit: IV: Partial Differential Equations: Transverse vibration of string- wave equation-1D heat Conduction-Diffusion equations- 2D heat flow- Laplace's equations- Method of separation of Variables-Fourier series solution in Cartesian coordinates.

Complex Variables: Analytic functions. Series expansion- Laurent's Theorem. Residue Theorem. Theorem and evaluation of simple contour integrals. Evaluation of improper integrals and integrals involving trigonometric functions by method of residues.

Group Theory: basic Concepts- multiplication tables_- subgroups- direct product. Properties of groups. Representations of finite group- reducible and irreducible representation and examples of C4V group.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Students will demonstrate basic knowledge of Linear algebra, Calculus, Vector, complex variable, and Differential equations.
2. Students will show the understanding of impact of Mathematics on Material Science.
3. **Skill development for Teacher Education & Employability in data modelling R&D sector.**

References:

1. Mathematical Methods for Physics- G Arfken (Academic Press, 1986)
2. Kreyszig E; Advanced Engineering Mathematics, 7th edition, Jhon Wiley and Sons, Singapore, 1993.
3. Matrices and Tensors in Physics- A W Joshi (Wiley Eastern, 1975)
4. Tensor analysis- I S Sokolnikoff (Jhon Wiley, 1974)
5. Elements of Group Theory for Physicists- A W Joshi (Wiley Eastern, 1975)
6. Symmetry Groups and their applications- W Miller

SEMESTER-I

PAPER CODE: MS-403

PAPER: Quantum Mechanics

PAPER OBJECTIVE:

1. To impart the mathematical skills needed to develop theory of quantum mechanics
2. To enrich understanding of postulates of quantum mechanics and to acquire skill to apply them to solve some quantum mechanical systems.
3. To offer systematic methodology for the application of approximation methods to solve complicated quantum mechanical systems.

UNIT: I

Chronological evolution of quantum mechanics, Wave particle dualism, Uncertainly principle, Wave packets in space and time.

Formation of Quantum mechanics: Development of the wave equations, the Schrodinger wave equations, statical interpretation of the wave function, probability density and probability current density, Ehernfeet's Theorem ,stationary status ,energy Eigen function ,ID square well potential, parity.

UNIT: II

Some bound state problems: Linear harmonic oscillator, Spherically symmetric potential ,the Hydrogen atom, particle in spherical cavity.

UNIT: III

Operators and operator algebra, Eigen function and Eigen values, expectation values, Dirac brackets, completeness and closure property , matrix theory of harmonic oscillator. Matrix representation of angular momentum operators, Pauli matrices, addition of angular momentum, Clebsch –Garden coefficients.

UNIT: IV

Approximation Methods: Approximation Methods of bound states Stationary perturbation theory-non degenerate cases, Stark effect, LS and J-J coupling , spectroscopic notations strong and weak field Zeeman effect. Time dependent perturbation, transistion probabilities, semi- classical treatment of radiation. Intensity ratio of transition in alkali atoms.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Understand historical aspects of development of quantum mechanics.
2. Understand and explain the differences between classical and quantum mechanics.
3. Understand the central concepts and principles in quantum mechanics, such as the Schrodinger equation, the wave function and its statistical interpretation, the uncertainty principle, stationary and non-stationary states, time evolution of solutions, as well as the relation between quantum mechanics and linear algebra including understanding of elementary concepts in statistics, such as expectation values and variance. They will master the concepts of angular momentum and spin, as well as the rules for quantization and addition of these. Hence they will be able to solve the complex systems by approximation method.
4. **Skill development for all Physical-Science based organizations.**

References:

1. Applied X-rays- G W Cleark(Mc Graw Hill,1955)

2. Quantum Mechanics –LI Schiff (Mc Graw Hill,1968)
3. Quantum Mechanics – Sokolov (Holt Rinehart and WinstonInc.1966)
4. Quantum Mechanics – Mathews and Venkatesan (Tata Mc Graw Hill,1981)
5. Quantum Mechanics – Powel and craseman (Oxford and IBH,1985)

SEMESTER-I

PAPER CODE: MS-405

PAPER : Crystallography and X Ray Diffraction

PAPER OBJECTIVE:

The objective of the course is to present the basic concepts needed to understand the crystal structure of materials. Fundamental concepts including lattices, symmetries, point groups, and space groups will be discussed and the relationship between crystal symmetries and physical properties will be addressed. The theory of X-ray diffraction by crystalline matter along with the experimental x-ray methods used to determine the crystal structure of materials will be covered.

UNIT: I

Formation and Structure of Materials: Condensed state of matter –crystalline and amorphous. Ionic, covalent, metallic and molecular bonding –Bond angle, bond length and bond energy, Hybridization – Delocalized chemical bonding. Lattice energy – Madelung constant. Inert gas crystals- Vander Waals Interaction –Lenard Jones potential.

UNIT: II

Cristal Geometry and Structure Analysis- Crystal morphology – symmetry elements- crystal systems. Point group symmetry – derivation of point groups and Bravais lattices. Crystal planes and direction- miller indices- Interplanner separation. Simple crystal structures- sodium chloride, cesium chloride, diamond and Zinc Sulphide structure. Close packed structures- packing efficiency and density of materials.

UNIT: III

Structure analysis and Diffraction – Generation of X-rays, X-rays absorption , X-ray monochromators – X-ray detectors (principle only) . Atomic scattering factor, Laue conditions of diffraction and Braggs law. Geometrical structure factor- systematic absences. Reciprocal lattices of cubic systems, Ewalds construction , Laue rotation and power methods of X-ray analysis , interpretation of diffraction patterns, cell parameter determination , indexing, space group determination (qualitative only) , neutron and electron diffraction (qualitative only).

UNIT: IV

Crystal Imperfections: Point imperfection, configurational entropy, schotty and frenkel defects, equilibrium concentration. Line imperfection, edge and screw dislocation, Buerger' vector in cubic crystal. Surface imperfection – grin boundary- tilt and twin boundaries. Diffusion in Solids: Fich's law of diffusion – solutions to Fichs 2nd law- Gaussian error function solution. Determination of diffusion Coefficent- diffusion couple. Application based on second law. Kirkendal effect. Atomic model of diffusion – oter diffusion process- electrical conductivity of ionic crystals.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Understand interdisciplinary nature of Material Science.
2. Understand the Crystal structure and crystal system.
3. Understand the structure property relationship.
4. Understand the metallic materials, ceramics, alloys, and defects.
5. Symmetry and point group.
6. Understand X-ray diffraction.
7. **Skill development for employment in different R&D sectors, metallurgical, mineral, mining, and ceramics industries.**

References:

1. Elements of materials science and engineering- Lawrence H van Valick (Addision Wesly, 1975)
2. Materials science and Engineering – V raghavan(prentice Hall,1993)
3. Materials science and processing – B S Narang (CBS,1983)
4. Introduction to solid state Physics- C Kittel (II Ed. Asia publishing House,1965)
5. Introduction to solids- L V Azaroff (McGraw Hill,1960)
6. The structure and Properties of Materials- Vol. I- IV –Rose , Shepard and Wulff (Wiley eastern,1987)

SEMESTER-I

PAPER CODE: MS-407

PAPER : Electronics

PAPER OBJECTIVE:

The objective of this paper is to;

1. Give knowledge of some basic electronic components and circuits
2. To introduce basics of diode and transistor circuits
3. To understand working of some I C based circuits
4. To study logic gates and their usage in digital circuits.
5. To expose the students to working of some power electronic dev ices, transducers and application of transducers.

6. To introduce basic aspect of electronic communication systems

UNIT: I : Semiconductor Device: Special diodes – Zener, LED , Photodiode, Schotty diode, Dirac and Triac, Tunnel Diode- MOSFET , SCR, SCS, UJT,MIS diodes, CCDs, solar cells-phototransistors, integrated circuit technologies, overview of VLSI.

UNIT: II: Analog Electronics: Op- amp- Introduction – op amp based circuits- comparators and controls- mathematical operations- analog simulation –log and exponential amplifiers , oscillators using op-amp,555 Timer circuits, instrumentation amplifiers- active filters-composite transistor circuits, BJT and FET oscillators, relaxation oscillators. MOSFET Characteristics and application , FET and MOSFET Amplifiers.

UNIT: III : Digital Electronics: Combinational logic gates: Karnaugh mapping: methods or minimization (reduction) of product of Sum (Pos) and Sum of Products(Sop) expression of 2,3, and 4 variables Boolean expression, Logical implementation, revision of flip- flops, Conversion of Flip- Flops.

Resisters: Shift resistors, Serial in serial out, parallel in parallel out resistors, bi- directional and Universal resistors.

Counter: Sychronous and Asynchronous counter, moduio-counter, decade counter, ring counter, Up/down counter.

Multivibraters: Astable and Monostable (Principle, Circuits and Operations) using Transistors, Internal circuit of IC 555, Timer circuit with 555.

UNIT: IV

Digital Display: Seven Segment display system , developing of display system for decimal , octal number system.

Combinational Circuits: MUX, De MUX, Encoder, Decoder, comparator. A to D, and D to A conversion. Review of 8085 microprocessors, Internal structure, organization and assembly language. Microprocessor programming.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Understand basic electronic components and circuits.
2. Understand basics of diode and transistor circuits Understand X-ray diffraction, analyze, and interpret the data.
3. Understand working of some I C based circuits.
4. Students can design some power electronic devices, transducers and successfully find its application.
5. **Employability in different Electronic manufacturing Service Industries.**

References:

1. J.D.Ryder, Electronics and fundamentals and applications(PHI)
2. Gaykwad, operational Amplifier.
3. R P Jain , Modern digital electronics, Tata Mc Graw Hill.
4. Anad Kumar, Fundamentals of Digital Circuties ,PHI
5. Milman and Halkias- Microelectronics, Tata Me Graw Hill

SEMESTER-I

PAPER CODE: MS-409

PAPER : Practical-I

PAPER OBJECTIVE:

The objective of this paper is to;

1. Enable students to have hands on training on Metallography laboratories.
2. Preparation of metal sample for microscopic characterization

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Prepare sample for microscopic characterizations.
2. **Skill development & employability in different Industries.**

Semester-II

PAPER CODE: MS-402

PAPER : Numerical Methods and computer applications

PAPER OBJECTIVE:

1. To enrich logical understanding of the subject.
2. To enrich mathematical skill in students enabling them to apply mathematical methods and principle in solving problems related to Material Science.
3. To make students understand that Mathematics is the language of Science.

UNIT: I: System of Equations: Roots of equation – Methods of bisection and false position –Newton – Raphson method- solution of simultaneous linear algebraic equations- Gauss elimination – gauss Jordan methods- matrix inversion and LU decomposition method – Gauss-Seidel iterative method –Eigenvalues of matrices- power method and jacobis method.

UNIT: II: Interpolation, Curve Fitting and Error Analysis: Newtons forwards and backward interpolation formulae- Lagrange method – Lagrange's inverse interpolation – curve fitting –principal of least squares.

UNIT:III: Numerical Differentiation and Integration: Newton's forward and backward difference formulae –numerical integration : Trapezoidal and Simpsons rule- numerical

solution of ordinary differential Equation- Taylors Series-Eulers method, improved and modified methods –Runge-Kutta Method-Milines predictor-corrector method.

UNIT:IV: Probability, Statistics and Error Analysis: Probability Concepts: Binomial, Poisson , Exponential and Normal distribution- Test of hypothesis (small and large samples) based on students t and Chi-squire distribution –testing goodness of fit – Error analysis-Accuracy and precision –significant figures. Structure- pointers-types of variables- function (intrinsic and user defined) –arithmetic operation and shorthand notations-loops (do, for, if) –elementary examples of programs (three programme from each of the above units) sorting and some physics problems.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

3. Students will demonstrate basic knowledge of system of equation, interpolation, curve fitting, error analysis, differentiation, differential integration, probability, and statics.
4. Students will be able to understand the c-programme.
4. Students will show the understanding of impact of Mathematics on Material Science.
5. **Skill development & employability in different Industries.**

References:

1. M.K.Venkatraman, "Numerical Method in Science and Engineering" , Notional Publishing
   Company, Madras,1996
2. S.S.Sastry, "Introductory methods of Numerical Analysis '', Prentice Hall of India, New Delhi,1992
3. E.Walpore , R.M.Mayers and K. Ye, "Probability and Statistics for Engineers and Scientists, Pearson Education,2002
4. B.S. Grewal, Numerical Methods in Engineering and Science , Khanna Publishers, New Delhi,2006
5. P.Dey and M.Ghosh, "Programming inC" Oxford University Press,2007

Semester-II

PAPER CODE: MS-404

PAPER : Electromagnetic Theory

PAPER OBJECTIVE:

1. To introduce the basic mathematical concepts related to electromagnetic vector fields.
2. To impart knowledge on the concepts of electrostatics, electric potential, energy density and their applications.
3. To impart knowledge on the concepts of magneto-statics, magnetic flux density, scalar and vector potential and its applications.

4. To impart knowledge on the concepts of Faraday‘s law, induced emf and Maxwell‘s equations. To impart knowledge on the concepts of Concepts of electromagnetic waves and Transmission lines.
5. To introduce the concepts of different coordinate systems, Maxwell`s equations, static electric and magnetic fields and methods of solving for the quantities associated with these fields, time varying fields and displacement current, propagation of electromagnetic waves and their applications in practical problems.

UNIT: I : Maxwells Equations: Review of Gauss's law in electrostastatics and magnetism-Ampere's law-Faraday's law- displacement current- Maxwells equation- differential and integral form- scalar and vector potential and applications- potential due to nonuniformity charge sphere- magnetic induction due to current carrying wire.

UNIT: II: Electromagnetic Wave Propagation: Plane electromagnetic wave in free surface- Poyanting vector- characteristic impedance- wave equation in an isotropic medium-wave equation in insulators and good conductors – reflection by a perfect conductor – normal and oblique incidence – Fresnel equations for parallel and perpendicular polarization.

UNIT: III : Fields and radiation from a localized oscillating source and magnetic dipoles.

Wave guides: Cylindrical wave guides, modes in rectangular wave guides, capacity resonator.

UNIT: IV: Fundamental of Laser, population inversion, Three and four level lasers. Optical fiber and Characteristic-modes of propagation-losses in fibres-fibre optic communication, optoelectronic modulations and switching devices-optocoupler.

PAPER OUTCOME:

After completing the course, the students should be able:

1. Understand the basic mathematical concepts related to electromagnetic vector fields.
2. Apply the principles of electrostatics to the solutions of problems relating to electric field and electric potential, boundary conditions and electric energy density.
3. Apply the principles of magneto statics to the solutions of problems relating to magnetic field and magnetic potential, boundary conditions and magnetic energy density.
4. Understand the concepts related to Faraday‘s law, induced emf and Maxwell‘s equations.
5. Apply Maxwell‘s equations to solutions of problems relating to transmission lines and uniform plane wave propagation.
6. **Skill development & employability in different R&D Industry.**

References:

1. J.F.Nye,physical Properties of Crystals,Oxford University Press,New York,1985
2. 2.E.F.Jordan and K.G.Belmain,Electromagnetic waves and Radiating Systems,Prentice-Hall of India Pvt.Ltd.,New Delhi,1982.

3. 3.D.R. Corson and paul Lorrian ,Introduction to Electromagnetic fields and waves,D.B. Taraporevale Sons and Co.pvt.Ltd., Bombay ,1970.
4. A Yariv and P Yeh, Photonics , 6th Edition , Oxford University press, 2007

Semester-II

PAPER CODE: MS-406

PAPER : Physics of Materials-I

PAPER OBJECTIVE:

Materials science lies at the foundation of today's world. Most technological advances rely on new materials, such as carbon fibres for aircraft wings, novel semiconductors for self-driving car sensors, or high performance insulators in ski-wear. This course discusses the properties of materials that engineers need to be aware of. This includes mechanical, thermal, electrical, chemical and optical properties. All these properties are controlled by the microscopic structure of these materials, and this course will cover the quantum mechanics, atomic physics and thermodynamics that control what materials can do. The course will focus on the structure and properties of crystalline materials and on how these properties can be manipulated to create more capable materials.

Unit : I : Thermal Properties of Insulators: Vibrations of monoatomic and diatomic lattices – harmonic approximation – phonon frequencies and density of states – Einstein and Debye theories of lattice heat capacity and phonon dispersion curves – anharmonic effects – thermal expansion – thermal conductivity – normal and Umklapp process – scattering experiments.

UNIT: II: FREE ELECTRON THEORY: Drude theory –Wiedemann-Franz law and Lorentz number – free electron statistics (Fermi-Dirac) – density of states – Sommerfeld theory – concentration, chemical potential, Fermi energy and specific heat of free electrons – Boltzmann transport theory – electrical and thermal conductivity of electrons.

UNIT : III : PERIODIC POTENTIAL AND ENERGY GAPS: Bloch's theorem – nearly free electron approximation – formation of energy bands and gaps – Brillouin zones and boundaries – effective mass of electrons and concept of holes – classification into insulators, conductors, semiconductors and semimetals – Fermi surface – Cyclotron resonance.

UNIT: IV: Dielectric polarization and atomic forces – electronic polarization.Ionic polarization, orientational polarization.Static dielectric constant of materials.Lorentz internal field.Clausius-Mosotti relation.Polarization catastrophe.Electrochemical coupling – dielectric breakdown – electric energy stored in dielectric.General applications of dielectric materials. The complex dielectric constant, dielectric losess and relaxation time – Debye equations – optical phenomena in insulators,colour of crystals – Excitions – weakly bound and tightly bound excitions.

Ferroelectrics: General characteristics – piezoelectric, pyroelectric and ferroelectric materials – transducer and detector application. Zeroes and poles of the dielectric function – Lyddone-Sachs-Teller relation. Ferroelectric-domains. Thermodynamics of ferroelectric phase transitions. Remarks on anti-ferroelectric.

PAPER OUTCOME:

Upon successful completion, students will have the knowledge and skills to:

1. Describe the mechanical, electrical, thermal and optical properties of materials;
2. Analyze the importance of material properties for a wide variety of engineering situations;
3. Evaluate and select suitable materials for different practical applications;
4. Recall typical values of the properties of common practical materials;
5. Understand the micro-physics and chemistry responsible for material properties, and analyze how they can be modified.
6. **Skill development for employment in R&D Industry.**

References:

1. Introduction to solid state physics – C Kittel (II & IV Ed. Wiley & Sons, 1961 & 1964)
2. J Dekker, Solid State physics, Prentice Hall (1957)
3. HaraldIbach and Hans Lueth, Solid State Physics, 2nd edition Springer (1996)
4. M Ali Omar, Elementary Solid State Physics, revised printing Pearson Education (2000)
5. M. S. Rogalski and S. B. palmer, Solid State Physics, Gordon Breach Science
6. Y. K. Lim, Problems and solutions on Solid State Physics, Sarat Book publishers (2002)
7. N. W. Ashcroft and N. D. Mermin, Solid State Physics, Thomson Brrooks/Cole (1976)

Semester-II

PAPER CODE: MS-408

PAPER : MATERIAL PREPARATION AND CHRACTERIZATION-I

PAPER OBJECTIVE:

To develop an understanding of the basis of some material synthesis techniques, its requirement and the characterization thereof.

UNIT: I : CRYSTAL GROTH THEORY : Introduction to crystal growth- nucleation – Gibbs – Thomson equation – Kinetic theory of nucleation – limitations of classical nucleation theory – homogeneous and heterogeneous nucleation – different shapes of nuclei – spherical, cap, cylindrical and orthormbic.

CRYSTAL GROWTH TECHNIQUES: Bridgmantechnique- Czochralski methods – Verneuil technique – zone melting – gel growth – solution growth methods – low and high temperature solutions growth methods – vapour growth – epitaxial growth techniques.

UNIT : II : CERAMIC PROCESSING: Powder processing – precipitations, spray drying, sol-gel, solid state reaction technique other chemical methods, milling techniques – sintering techniques – standard pressure sintering, hot pressing, reaction bonded sintering, microwave sintering – surface finishing techniques.

STRUCTURAL CERAMICS: Oxide, carbide and nitride, borides,silicide ceramics; ceramic insulators and capacitors – ferroelectric ceramics, magnetic ceramics – spinel ferrites, zinc ferrites – superconducting ceramics – varistors and fuel cells.

UNIT : III : GLASS CERAMICS: Glass forming process – glass compositions, heat treatment schedule, crystal nucleation in glass, nucleation agent – high purity silica glass, laser glasses, fiber glasses, optical glasses, fiber glass, non-oxide glasses.

UNIT : IV : VACUM PRODUCTION : Low, high and ultra-high vacuum. Mechanical pumps – Diffusion pump – Turbo molecular pump, ion pump, measurement of vacuum – gauges – thin film vacuum coating unit – substrate cleaning.

THIN FILMS

Physical methods: Thermal evaporation – vapour sources – wire, crucible and electron beam gun – sputtering mechanism and methods – epitaxy – MBE.

Chemical Methods: Chemical vapour deposition and chemical solution deposition techniques - spray.

Thickness measurement and Monitoring: Multiple beam interface – quartz crystal – ellipsometric – stylus techniques.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Understand the crystal growth theory
2. Understand crystal growth technique.
3. Understand crystal growth technique ceramics and its processing.
4. Understand vacuum techniques.
5. Understand how to fabricate thin films.
6. **Skill development & employability in manufacturing Industry.**

References:

1. H.E. Buckley, Crystal growth, John Wiely and Sons, New York (1981).
2. D Elwell & H. J. Scheel, Crystal growth from high temperature solution, academic press, New York, 1995.

3. R. A. Laudise, The growth of single crystals, Prentice Hall, Englewood, 1970
4. P. Ramasamy& P. Santhanaraghavan, Crystal growth process and methods, KRU publications (2000).
5. W. D. Kingery, H. K. Bowen and D. R. Uhlmann, Introduction to ceramics, 2nd edition, John Wiley & Sons, New York, 1976.
6. D. W. Richerson, Modern Ceramic Engineering: Properties, processing and use in design, Marcel Dekker Inc, New York, 1992
7. J. S. Reed, Principle of Ceramics processing, John Wiley & Sons Inc, New York, 1995.
8. M. H. Lewis, Glasses and Glass Ceramics, Chapman and Hall, London, 1992.
9. Milton Ohring, The Material Science of Thin Films, Academic Press, 2001.
10. Donald L Smith, Thin Film Deposition: Principles and Practice, McGraw-Hill, 1995
11. K.L. Chopra, Thin Film Phenomena, McGraw-Hill, 1969
12. K. L. Chopra and I. J. Kaur, Thin Film Device Applications, Plenum Press, London, 1983.

Semester-II

PAPER CODE: MS-410

PAPER : Practical-II

PAPER OBJECTIVE:

The objective of this paper is to;

1. Enable students to have hands on training on material synthesis (oxide materials, thin films).
2. Preparation of metal sample for microscopic characterization.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Synthesize materials according to desired property.
2. **Skill development & employability in different Industries.**

Semester-II

PAPER CODE: MS-412

PAPER : Group Theory and Crystallography (Open Elective)

Paper Objective:

This course is designed by keeping an eye on the highly interdisciplinary nature of today's science and technology. An attempt has been made to make the students understand the nature by shading light on the subjects like Symmetry and group theory, Solid state Physics and Chemistry.

Unit: I: What is symmetry; why symmetry is important in understanding material design aspect; symmetry element; symmetry operations.

Unit: II: Finding types of symmetry in different molecules and structure, Point group, Character table, Matrix representation of Point group

Unit: III: Basics of solid state physics and chemistry, Defects, X-ray generation, Basics of X-ray diffraction

Unit: IV: Characterization of metals, alloys, ceramics, polymers, and composite by X-ray diffraction and data interpretation by using software's like XPERT High score, Maud etc, Rietveld refinement

Paper Outcome: After completion of this course students will be able to understand;

1. Symmetry, symmetry elements, and point group of any structure.
2. Structure property relationship of materials.
3. Crystal structure and geometry.
4. Crystal coordinate system, planes, directions.
5. Basics of X-ray diffraction and XRD characterization.
6. XRD data analysis.
7. Use of softwares like Xpert highscore, Maud etc.
8. **Skill development for employment in different R&D sectors, metallurgical, mineral, mining, and ceramics industries.**

Reference :

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).

Semester-III

PAPER CODE: MS-501

PAPER : Physics of Materials-II

PAPER OBJECTIVE:

This course is designed to enlighten the students with the concept of semiconducting material, different types of junctions, superconductor, and magnetic material.

UNIT: I : Semiconducting Materials : Electronic & Hole statistics in a semiconductor: Non degenerate & degenerate semiconductor, Intrinsic semiconductor, Ionization energy calculation, Distribution function over an impurity state,

UNIT: II: PN junction in equilibrium, Einstein Relation, Diffusion length, Derivation of diode equation, junction capacitance, Metal semiconductor junction, Equilibrium & Non-equilibrium, Photoconductivity & related device, Recombination via trap, Solar cell

UNIT : III : **Super conductor :** Zero electric resistance, Meissner effect, heat capacity, optical absorption by semiconductor,, entropy change, thermal conductivity, destruction of semi-conductivity by external magnetic fields Isotope effect, BCS theory, Role of electrons and phonons, application of electron band structure to calculate electron-phonon coupling constant, High Tc materials, Coherence length, expression for critical temperature Tc, critical field Hc, critical Jc, type I and II materials

UNIT : IV : Flux quantization, normal and Josephson tunneling, Superconducting magnets, Power generators, motors, transformers, power storage, power transmission, Josephson junction devices- IR sensors, SQUIDS, SLUGS, magnetically levitated trains, Computer storage elements.

Magnetic materials

Dia, Para, Ferro, Anti-ferro, and Ferri magnetic materials, Langevin and quantum theory of Dia magnetism, quantum theory of paramagnetism, Curie Weiss law and Neel temperature, Lande-g factor, quenching of orbital momentum, Bohr magneton, number og d and f group elements, Ferromagnetic materials.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Understand the basics of Semiconducting material.
2. Understand the basics of Superconductor and its application.
3. Understand the basics of magnetic material and its importance.
4. **Skill development & employability in different Industries.**

Reference:

1. Semiconductor Physics – Kireev
2. Introduction to Solid State Electronics- Streatman& Banerjee
3. Semiconductor – Smith
4. Solid State Physics- Dekker
5. Solid State Physics- C. Kittel

Semester-III

PAPER CODE: MS-503

PAPER : Material Chemistry

PAPER OBJECTIVE:

To provide a basic knowledge on Polymer science and Engineering.

UNIT: I: Introduction to polymer : Classification of polymers-copolymers- tacticity-geometric isomerism, molecular weight distribution and averages, measurement of molecular weight, synthesis of polymers, step growth polymerization, chain growth polymerization, polymerization techniques.

UNIT : II: Properties of polymers : Polymer confirmation and chain dimensions, freely orientated perpendicular chains, Gaussian model, amorphous state, glass transition temperature, the crystalline state, ordering of polymer chains, crystalline melting temperature, techniques to determine crystalline, mechanical properties, Introduction to viscoelasticity, dynamic mechanical analysis, mechanical models viscoelastic behavior, Boltzmann superposition principle, Introduction to rubber elasticity.

UNIT : III: Polymer processing and applications rheology : Basic processing operations, extrusion, molding, calendaring, coating, Introduction to polymer rheology, non Newtonian flow, analysis of simple flows, rheometry, capillary rheometer, Couetterheometer, cone and plate rheomete, applications conductivity polymers, bio polymers, liquid crystal polymers, photonic polymers, high temperature polymers

UNIT : IV: Introduction to composites: Types of composite materials, the concept of load transfer, matrix materials, polymers, metals and ceramics, fibers, glass, boron, carbon, organic and metallic fibers, fiber packing arrangements, particle reinforced composites, fibre reinforced composites, structural composites, applications.

Fabrication of Composites : Polymers matrix composites, liquid resin impregnation routes, pressurized consolidation of resin pre-pregs, consolidation of resin moulding compounds, injection moulding of thermoplastics, metal composites, squeeze infiltration, stir casting, spray deposition, powder blending and consolidation, diffusion bonding of foils, physical vapour deposition, ceramic composites, powder based routes, reactive processing, layered ceramic composites, carbon/carbon composites.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Basics of Polymer, its type, and properties.
2. Can synthesize different types of polymers.
3. Can synthesize polymer composites and its application.
4. **Skill development & employability in polymer Industries.**

References:

1. Polymer Science and Technology- Joel R. Fried
2. Introduction of Polymer Science- A. R. Gowarikar
3. Physics of Plastics: Processing, Properties and materials engineering- A. W. Birley, B. Haworth & J. Batchelor
4. Text Book of polymer science: F. N. Billmayer
5. An introduction to composite materials –D. Hull & T. W. Clyne
6. Composite Materials- K. K. Chawla
7. Ceramic Matrix Composites- K. K. Chawla
8. Fiber- Reinforced Composites: Materials, Manufacturing and Design- P. K. Mallick
9. Analysis of performance of fiber composites- B. D. Agaewal and L. J. Broutman
10. Mechanics of Composite Materials- R. M. Jones

Semester-III

PAPER CODE: MS-505

PAPER : Characterization techniques

PAPER OBJECTIVE:

To develop an understanding of the basis of various Material characterization techniques and its applications.

UNIT: I: Thermal Analysis : Introduction, thermogravimetric analysis (TGA), instrumentation, determination of weight loss and decomposition products, differential thermal analysis (DTA), cooling curves, differential scanning calorimetry (DSC), instrumentation, specific heat capacity measurements, determination of thermomechanical parameters.

UNIT:II: Microscopic Methods: Optical Microscopy: optical microscopy techniques, Bright field optical microscopy, Dark field optical microscopy, Dispersion staining microscopy, phase contrast microscopy, differential interference contrast microscopy, florescence microscope, confocal microscopy, scanning probe microscopy (STM, AFM) , scanning new field optical microscopy, digital holographic microscopy, oil immersion objectives, quantitative metallography, image analyzer

UNIT: III: Electron microscopy and optical characterization: SEM, EDAX, EPMA, TEM: working principle and instrumentation, sample preparation, data collection, processing and analysis, photoluminescence-light- matter interaction, instrumentation, electroluminescence, instrumentation, Application

UNIT:IV: Electrical methods: Two probe and four probe methods- vanderPauw method, Hall probe and instrument, scattering mechanism-C-V characteristics- Schottky barrier capacitance, impurity concentration- electrical C-V profiling- limitations.

Spectroscopy

Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, ESR, NMR, NQR, XPS, AES and SIMS- proton induced X-ray, Emssion spectroscopy (PIXE)- Rutherford Back Scattering (RBS) analysis- application.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Understand thermal characterization tools such as TGA, DTA, DSC.
2. Understand different Microscopic tools like Optical microscopy, electron microscopy i.e. SEM & TEM.
3. Understand different transport measurement tools such as two probe and four probe methods and their principle.
4. Understand different Spectroscopic tools such as UV-VIS, FT-IR, NMR, ESR, XPS, NQR , and AES.
5. **Skill development & employability in R&D sectors, manufacturing industries, metallurgical & material industries, polymer industries.**
6. **Research ethics in data production.**

References:

1. Growth and Characterization of semiconductors: Stradling, R. A. Klipstain, P. C.
2. Electron microscopy and microanalysis of crystalline material- J. A. Belk
3. Electron and Ion microscopy and microanalysis principles and application- Lawrence E. Murr
4. Analytical Chemistry- D. Kealey, & P. J. Haines

Semester-III

PAPER CODE: MS-507A

PAPER : Solid State Ionics

PAPER OBJECTIVE:

To provide in depth knowledge about Solid state ionics.

UNIT: I: Basic aspects of Solid State Physics : Type of bonding in solids –Fundamentals of Crystallography – simple Crystal structures , X-ray diffraction –band structures of metals semiconductor and Ionic and electronic conductivities.

UNIT : II : Solid State Ionics : Concept of solid state Ionics – Importance of super –ionic materials and structures Classification of super ionic solid Experimental probes pertaining

to solid state Ionics- Theoretical model s of fast to ion Transport – Applications of fast ionic solid . Hydrogen storage materials – Nano –ionic materials.

UNIT : III : Micro Batteries and Application : Concept of a thin film solid state battery - electrolyte thin films –flashes evaporation technique- pulsed Laser deposition technique applications- electromotive force reversible cells-free energy changes- capacity of a cell-power and energy density of a cell- polymer electrolytes- application of polymer electrolyte in micro batteries, Fuel cells –solid state battery – super capacitor.

UNIT : IV : Characterizations of New Cathode Materials : Phase identification- Thermal analysis- DTA-DSC-TG-Energy dispersive X-ray fluorescence spectroscopy(EDX)-Atomic absorption(AAS)-Rutherford Back scattering spectroscopy-X-ray photoelectron spectroscopy-Structural characterization-XRD Electron microscopy, local environment studies-Extended X-ray absorption fine structure-FTIR-Transport measurements-Electrical transport-transient transport.

Applications of Ionic Materials

Primary lithium batteries-lithium sulphur dioxide, Li-Vanadium Pentoxide, Secondary lithium batteries-Li-ion electrode materials-preparation and fabrication characterization of Li-ion cells-Comparison of Li-iodine and NiCd cells in CMOS-RAM applications.Applications of Lithium batteries in electronics devices, electric vehicle, fuel cells, sensors-Solar energy conversion devices.

PAPER OUTCOME:

At the end of this course, the students would be able to:

1. Calculate point defect concentrations using formation energies, develop Brouwer diagrams, describe several means of tailoring point defect concentrations through independent variables, and apply equilibrium thermodynamics to the case of defective solids.
2. Write point defect reactions in Kroger-Vink notation to describe defect processes, and apply a nonequilibrium thermodynamics and chemical kinetics framework to describe defect reactions and kinetic behaviour.
3. Describe operation of various solid state ionics applications (including open circuit cells, cells using current, and cells generating current.
4. **Skill development & employability in different Industries.**

References:

1. H.V. Keer, Principles of solid state physics, Wiley Eastern Ltd, New Delhi, 1993.
2. S.Chandra, Superionic solids-Principles and applications, North Holland Amsterdam(1981)
3. D.S.Clive, Modern Battery Technology, Alean International Ltd. Banbury, Elis Horwood Publishers, (1991)

4. T.R.Crompton, battery reference book, Reed Educational and Professional publishing Ltd, SAE International 1996
5. Ozin, Geoffrey.A, Arsenault, Andre C, Nanochemistry, A chemical approach to nanomaterials, Springer (2005).

Semester-III

PAPER CODE: MS-507B

PAPER : Nuclear Physics and reactor materials

PAPER OBJECTIVE:

To impart primary but wide theoretical knowledge about nuclear reactor and related topics.

UNIT : I : Nuclear Structure And Radioactivity : Nuclear charge, mass, spin, magnetic moment, electric quadruple moment, Binding energy, Semi-empirical mass formula-mass parabola-applications-Radioactivity-Soddy-Fajans law-Successive disintegration-transient and secular equilibrium.

UNIT : II : NUCLEAR MODELS, FORCES AND ELEMENTARY PARTICLES : Liquid drop model-shell model-compound nucleus model-Breit-wigner formula-Mesion theory-ground state of deutror-exchange forces-n-p, p-p scattering-spin dependence-classification of elementary particles-conservation laws-elementary idea about quarks, gluons and quantum chromodyamics.

UNIT: III: NUCLEAR FISSION AND FUSION: Types of fission-distribution of fission products-fissile and fertile materials-neutron emission in fission –spontaneous fission-Bohr-Wheeler theory-chain reaction-four factor formula-criticality condition- fusion-energy released –stella energy –controlled thermo nuclear reaction –plasma confinement.

UNIT : IV : NEUTRON AND REACTOR PHYSICS : Nuclear transmutation, Q-value, exoergic endoergic reactions-Nuclear cross section-neutron sources-classification of neutrons-thermalization-average logarithm decrement-thermal neutron diffusion-Fermi age equation

REACTOR DESIGN AND MATERIALS

Fuels, moderator, coolant, shielding-reactor size-radioactive waste disposal-radiation detection and measurements-film badge-TLD pocket dosimetry-application of radio isotopes –irradiation technology-radiation protection –units and dosage.

PAPER OUTCOME:

At the end of this course, the students would be able to:

1. Study the neutron moderation process.
2. Apply diffusion theory for fusion-fission dynamics.
3. Select materials relevant for reactor design and energy production.
4. Categorize different nuclear reactors.
5. Analyze fuel and waste management
6. **Skill development & employability in different Nuclear and atomic energy sectors.**
7. **Research in nuclear energy and its application ethics.**

References:

1. Evans, Atomic Physics, Tata McGraw Hill, New Delhi, 1986.
2. S.Glasstone, Principles of Nuclear Reactor Engineering, Van Nostrand Co, Inc., New York, 1985.
3. R.R. Roy and B.P. Nigam, Nuclear Physics, Wiley Easter, New Delhi, 1985.
4. D.S. Tayal Nuclear Physics Himalaya Publishers Bombay 1998.

Semester-III

PAPER CODE: MS-507C

PAPER : Corrosion Science and Engineering

PAPER OBJECTIVE:

To provide a practical knowledge about degradation of Material in particular, corrosion and its prevention in engineering field.

UNIT : I : Corrosion Process : Basic principle of electrochemistry and aqueous corrosion processes –Electrochemical thermodynamics and electrode potential-electro chemical kinetics of corrosion-cathodic and anodic behaviour-faradays law-Nernst equation; standard potentials Pourbaix diagram –Tafel equation-corrosion rate-Evans diagram –pitting crevice and exfoliation corrosion, influence of deposit and anaerobic conditions, corrosion control, high temperature oxidation, hot corrosion, corrosion/mechanical properties interactions

UNIT : II : Corrosion Prevention : Considerations in high temperature alloy design, prevention of high temperature corrosion -use of coatings. Hydrogen Damage-Sources, Types of damage, Mechanisms and preventive methods, Liquid metal attack - liquid metal embrittlement, preventive measures.

UNIT : III : Coating Manufacturing : Electrodeposition, flame and plasma spraying, thermal, HV of detonation gun, gas dynamic, physical vapour deposition (PVD), chemical vapour deposition, HIP surface treatment

UNIT : IV : Corrosion in selected environments : Amphotoric corrosion, corrosion in automobiles, corrosion in soils, corrosion of steel in concrete, corrosion in water, microbiologically induced corrosion, corrosion in the body, corrosion in the petroleum industry, corrosion in the aircraft industry, corrosion in the microelectronics industry

Corrosion Applications

Abrasive, erosive, and sliding wear, the interaction between wear and corrosion.Coating systems for corrosion and wear protection, new coating concepts including multilayer structure, functionally gradient materials, intermetallic barrier coating and thermal barrier coatings.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Do electro and electroless plating of Cu, Al alloys.
2. Determine the corrosion rate by weight loss method, electrical resistance method, potentiodynamic polarization experiment and atmospheric corrosion using color indicator method.
3. Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking.
4. Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness.
5. **Entrepreneurship & employability in Material Science Research firms and Metallurgical industries.**

References

1. D A Jones, Principles and Prevention of Corrosion, 2nd Ed, Macmilan publishing Co., 1995
2. JOM Bockris, BE Conway, E Yeager and White, Electrochemical Materials Science in Comprehenssive Treatise of Electrochemistry, Vol. 4, Plenum Press, 2001
3. 3.M G Fontana and N D Greene, Corrosion Engineering, McGraw Hill Publishing, 1978
4. I M Hutchings Tribology, Friction and Wear Engineering Materials CRC Press, Boca Raton, 1992 D O, Sprowds, Corrosion testing and evalution, Corrosion Metals Handbook, Vol. 13, 1986

Semester-III

PAPER CODE: MS-509

PAPER : Practical-III

PAPER OBJECTIVE:

The objective of this paper is to;

1. Enable students to get hands on training on corrosion property evaluation

PAPER OUTCOME:

After successfully completing this paper, student will be able to appreciate:

1. **Skill development & employability in different Industries.**
2. Evaluate the corrosion property of metals and alloys

Semester-IV

PAPER CODE: MS-502

PAPER : Nano Science and technology

PAPER OBJECTIVE:

To know the fundamental concepts of nanomaterials, synthesizing methods, their properties at nanosclae and possible technological applications in various fields of science and engineering.

UNIT:I :Nanoscale systems : Heterostructures and hand offset. Length, energy, and time scales-quantum confinement of electrons in semiconductor nanostructures. Quantum confinement in 1D, 2D, 3D and zero dimensional structures –size effect and properties of nanostructures –Landhuner /Buttikers formalism for conduction in confined geometric Top down and bottom up approach

UNIT:II : Basic properties of Nanoparticles : Size effect and properties of nanoparticles-particle size –particle shape-particle density-melting point-surface tension-wettability-specific surface area and pore size –reason for change in optical properties, electrical properties-mechanism properties and advantages

UNIT:III: Synthesis of Nanostructure materials : Gas phase condensation –vacuum deposition-physical vapour deposition (PVD)- chemical vapour deposition (CVD)-Laser ablation-sol gel-ball milling-Electrodeposition-spray pyrolysis-plasma based synthesis. Synthesis of nanowire by solvothermal process-template method (qualitative) –nanofibers-elecospining technique

UNIT: IV : Quantum dots : Excitions and excitonic Bohr radius –difference between nanoparticles and quantum dots-preparation through colloidal methods. Epitaxial methods-MOCVD and MBE growth of quantum dots-current/voltage characteristics-magneto tunneling measurements-spectroscopy of quantum dots: absorption and emission spectra-photoluminescence spectrum-optical spectroscopy-linear and non-linear microscopy

Nanotechnology Applications: Applications of nanoparticles, quantum dots, nanotubes and nanowires for Nano device fabrication-single electro-transistor-column blockade effects in ultra-small metallic tunnel junctions-nanoparticle based solar cells and quantum dots based white LED-CNT based transistors-principles of dip pen lithography

PAPER OUTCOME:

After successfully completing the course, student will be able to:

1. Understand the concepts of nanomaterials and their properties.
2. Learn different routes of synthesizing methods of nanomaterials.
3. Know the change in properties at the nanoscale level and their applications.
4. Understanding the risks on producing nanomaterials and safety precautions.
5. **Skill development & employability in different Industries.**

References:

1. Nanotechnology G Timp, editor, AIP press, Springer-Verlag, New York, 1999.
2. Nanostructured Materials and Nanotechnology, Concise Edition, editor-Hari Singh Nalwa, Academic Press, USA, 2002.
3. Hand book of Nanostructured Materials and Nanotechnology, Vol. 1-5 editor-Hari Singh Nalwa, Academic Press, USA, 2000.
4. Hand book of Nanoscience, Engineering, and Technology (The Electrical Engineering Hand book series, Kluwer Publishers, 2002).
5. Sol – gel Science, CJ Brinker and G W Scherer, Academic Press, Boston, 1994.
6. Nanoscale characterization of surface and interface, N John Dinardo, Weinheim Cambridge : Willy VCH 2nd ed., 2000.

Semester-IV

PAPER CODE: MS-504A

PAPER: Smart materials and structures

PAPER OBJECTIVE:

1. To study various types of smart materials used in engineering application.
2. To study processing of smart materials.
3. To study basics of sensors and its engineering application.
4. To study basics of actuators and its engineering application

UNIT: I : Light Weight Materials and Metallic foam: Classes of materials and their usage-intelligent /smart materials-Evalution of materials science-structural materials-functional materials-polyfunctional materials-generation of smart materials Introduction, properties, processing of Aerogels, Aerographite, Metallic Foams, Polymeric Foams, Metallic Microlattices

UNIT: II : Smart materials and structural systems : The principal ingredients of smart materials-thermal materials-sensing technology-microsensors-intelligent systems-hybrid smart materials-an algorithm for synthesizing smart materials-passive sensory smart structures-reactive actuators based smart structures-active sensing and reactive smart structures-smart skins-Aeroelastic tailoring of airfoils-synthesis of future smart systems

UNIT: III : Electrorehological (fluids) smart materials : Suspensions and electro-rheological fluids-Bingham body-Newtonian viscosity and non-Newtonian viscosity-principal characteristics of electro-rheological fluids-the electro-rheological phenomena-charge migration mechanism for the dispersed phase-electro-rheological fluid domain-electro-rheological fluid actuators-electro rheological fluid design parameters-Application of Electrorehological fluids

UNIT : IV : Piezoelectric smart materials: Background-electrostriction-pyrroelectricity—industrial piezoelectric materials-PZT-PVDF-PVDF film-properties commercial piezoelectric materials-properties piezoelectric films (explanation)-smart materials featuring piezoelectric elements-smart composite laminates with embedded piezoelectric actuators-SAV filters

Shape memory alloys based smart materials : Background on shape –memory alloys (SMA)-Nickel /Titanium alloys (Nitinol)-Materials characteristics of NitinolMartenstic transformations-Austenitic transformation-thermoplastic martensitic transformation-Cu based SMA-Applications of SMA-continuum applications of SMA fastner-SMA fibers-reaction vessels, nuclear reactor, chemical plants, etc-micro robot actuated by SMA-SMA memorization process (satellite antina application)-SMA blood clot filter-impediments to applications of SMA-SMA plastics-primary molding-secondary molding-potential applications of SMA plastics

PAPER OUTCOME:

At the end of this course, the students would be able to:

1. Understand various smart materials and its importance in engineering application.
2. Know various processing techniques of smart materials.
3. Get knowledge of use of smart material as sensors and actuators.
4. **Skill development & employability in different Industries.**

References:

1. MV Gandhi and BS Thomson, Smart Materials and structures , Chapman and Hall, London, First Ed., 1992.
2. T W Deurig, K N Melton, D Stockel, and C M Wayman, Enggineering aspects of Shape Memory Alloys, Butterworth-Heinemann,1990.
3. C R Rogers, Smart materials, Structure and Mathematical Issue, Technomic Publishing Co., USA, 1989.

Semester-IV

PAPER CODE: MS-504B

PAPER : Biomaterials

PAPER OBJECTIVE:

To know about various bio materials, its fabrication and applications.

UNIT : I : Biological performance of Materials : Biocompatibility-introduction to the biological environment-materials response-swelling and leaching-corrosion and dissolution, deformation and failure-friction and wear-host response the inflammatory process-coagulation and hemolysis approaches to thrombo-resistant materials development.

UNIT : II : Orthopaedic materials : Bone composition and properties-temporary fixation device-joint replacement-biomaterials used in bone and joint replacement: metals -, alloys, stainless steel , cobalt based alloys, titanium based alloy materials-ceramics: carbon, alumina, zirconia, bioactive calcium phosphate , bioglass and glass ceramics-polymers: PMMA, UHMWPE/HDPE, PTFE-bone cement-composites

UNIT : III Cardiovascular Materials : Blood clotting-blood rheology-blood vessels-the heart-aorta and valves-geometry of blood circulation-the lungs-vascular implants: vascular graft, cardiac valve prosthesis, cardiac pacemakers-blood substitutes-extracorporeal blood circulation device

UNIT : IV Dental materials : Teeth composition and mechanical properties-impression materials-bases, liners and varnishes for cavities-fillings and restoration materials-materials for oral and maxillofacial surgery-dental cements and dental amalgams-dental adhesives

Other materials: Biomaterials in ophthalmology-viscoelastic solutions, contact lenses, intraocular lens materials-tissue grafts-skin grafts-connective tissue grafts-suture materials-tissue adhesive-drug delivery: methods and materials-selection, performance and adhesion of polymeric encapsulants for implantable sensors

PAPER OUTCOME:

At the end of this course, the students would be able to:

1. Understand about basic of biomaterials, its synthesis, and application.
2. Understand performance of biomaterials.
3. **Skill development & employability in different bio material manufacturing industries**.

References:

1. Sujata V Bhat, Biomaterials, Narosa publication, New Delhi, 2002.
2. Jonathan Black, Biological performance of Materials: Fundamentals of Biocompatibility, Marcel Dekker Inc., New york, 1992.
3. D F Williams (editor) Materials Science and Technology: A comprehensive Treatment , Vol. 14, Medical and Dental Materials, VCH publishers, Inc New York, 1992.
4. F Silver and C Doillon Biocompatibility Interactions of biological and implanted materials, Vol. I polymers, VCH publishers, Inc New York, 1982.
5. LL Hench and E C Ethridge, Biomaterials: An Interfacial approach , Academic Press 1982.

Semester-IV

PAPER CODE: MS-504C

PAPER : Advance Materials

PAPER OBJECTIVE:

The course intends to present new, relevant and advanced topics within modern materials science and engineering.

UNIT : I : Nano-structural Material : Magnetism in particles of reduced size and dimensions- variations of magnetic moment with size – magnetism in clusters of non magnetic solids- magnetic behavior of small particles –diluted magnetic semiconductors (DMS)- Fe –DMS and IV- VI Mn DMS and their applications- intermettalic compounds- binary and ternaries and their magnetic properties

UNIT : II : Composite materials: Metal matrix composites- polymer matrix composites- ceramic matrix composites- reinforcements- whisker reinforced ceramics- carbon- carbon composites- design of composite materials –hybrid composites- angled plied composites- unidirectional fiber composites- discontinuous fiber composites- applications of composites in electrical components and nuclear industry.

UNIT : III : Light Weight High Strength material : Properties and structural of Titanium- alloying elements- manufacture of titanium wrought products- mechanical properties and micro structural correlation- alloys, aerospace and medical applications- yttrium based iron-chromium aluminium alloy, mechanical alloying process of MA 956 alloy- MAODS super alloys- high temperature and medical application

UNIT : IV : Injection luminescence and LEDs- LED materials –LED construction-double hetrojunction LED and related materials- edge emitter and super luminescent LED, material- liquid crystals- properties and structure- liquid crystal display- comparison between LED and LC displays- optical amplifier- erbium doped silica fiber. Electrets-properties and

applications- metallic glasses- properties and applications- SMART materials- piezoelectric, magnetostrictive, electrostrictive materials- shape memory alloys- rheological fluids- CCD device materials and applications- single crystalline solar cells- amorphous silica solar cells- thin film polycrystalline solar cells- surface acoustic wave and sonar transducer materials and applications

PAPER OUTCOME:

At the end of this course, the students would be able to:

1. Understand Nanostructure material.
2. Understand composite material.
3. Understand strengthe of material .
4. Understand display device and its basics.
5. **Skill development & employability in different Industries.**

References:

1. Hand book of Nanophase Materials- edited by Avery N. Goldstein, Maecel Dekker
2. Science and Technology of Nanostructured Magnetic Materials – George C. Hadjipanayis and Gary A. Prinz, NATO ASI series
3. Composite Materials- S. C Sharma
4. Heat Treatment Structure and properties of non- ferrous – Charlie Brooks. R
5. Optical Fiber Communications- John M. Senior
6. Microelectronic Materials- C. R. M. Grovenor, Adam Hilger, Bristol and Philadelphia

Semester-IV

PAPER CODE: MS-506

PAPER : PRACTICAL

PAPER OBJECTIVE:

The objective of this paper is to;

1. Enable students to get hands on training on material characterization by X-ray diffraction

PAPER OUTCOME:

At the end of this course, the students would be able to appreciate:

1. **The Skill development & employability in different Industries.**

Semester-IV

PAPER CODE: MS-508

PAPER : PROJECT WORK/DISSERTATION WORK

PAPER OBJECTIVE:

To know in depth exploration of a topic of special interest and to explain, apply relevant theories and laws in the chosen area.

PAPER OUTCOME:

At the end of this course, the students would be able to:

1. Interpret theories and doctrines, and give recommendations where appropriate
2. Acquire knowledge on the chosen topic and apply the knowledge, experience, and skills learned.
3. Produce a thesis of publishable quality.
4. Effectively present and defend research orally.
5. **Employability in any of the academic, Industrial and Research Organizations.**
6. **Research ethics.**