UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY CHENNAI : : CHENNAI 600 025

REGULATIONS - 2009

CURRICULUM I TO IV SEMESTERS (FULL TIME)

M. Sc. MATERIALS SCIENCE

SEMESTER – I

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	ML 9111	Mathematical Physics	3	1	0	4
2	ML 9112	Physics of Materials – I	3	0	0	3
3	ML 9113	Classical Mechanics and Statistical Thermodynamics	3	0	0	3
4	ML 9114	Electronics and Instrumentation	3	0	0	3
5	ML 9115	Engineering Graphics and Workshop Practice	1	1	2	3
PRACTICAL						
6	ML 9116	Materials Science Laboratory - I	1	0	3	3
		TOTAL	**14**	**2**	**5**	**19**

SEMESTER - II

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	ML9121	Numerical Methods for Materials Science	3	1	0	4
2	ML9122	Physics of Materials – II	3	0	0	3
3	ML9123	Quantum Mechanics	3	0	0	3
4	ML9124	Electromagnetic Theory and Optics	3	0	0	3
5	ML9125	Crystallography and Crystal Growth	3	0	0	3
6	ML9126	Characterization of Materials	3	0	0	3
PRACTICAL						
7	ML9127	Materials Science Laboratory - II	0	0	6	3
		TOTAL	**18**	**1**	**6**	**22**

SEMESTER - III

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
	ML9131	Physical Metallurgy	3	0	0	3
	ML9132	Ceramic Materials	3	0	0	3
	ML9133	Polymer and Composite Materials	3	0	0	3
	ML9134	Seminar	0	1	0	1
	E1	Elective-I	3	0	0	3
	E2	Elective-II	3	0	0	3
PRACTICAL						
	ML9135	Materials Science Laboratory - III & Mini project	0	0	6	3

	TOTAL	**15**	**1**	**6**	**19**

SEMESTER - IV

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	E3	Elective-III	3	0	0	3
2	E4	Elective-IV	3	0	0	3
3	E5	Elective-V	3	0	0	3
PRACTICAL						
4	ML9141	Project	0	0	20	10
		TOTAL	**9**	**0**	**20**	**19**

TOTAL CREDITS : 79

ELECTIVES

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	ML9151	Advances in X-ray analysisl	3	0	0	3
2	ML9152	Lasers and Applications	3	0	0	3
3	ML9153	Advanced Crystal Growth	3	0	0	3
4	ML9154	Materials Processing	3	0	0	3
5	ML9155	Introduction to Nanoscience and technology	3	0	0	3
6	ML9156	Nanomaterial: Preparation and characterization	3	0	0	3
7	ML9157	Nanoscale fabrication and techniques	3	0	0	3
8	ML9158	Thin film Science and Technology	3	0	0	3
9	ML9159	High Pressure Science and Technology	3	0	0	3
10	ML9160	Super conducting Materials and Applications	3	0	0	3
11	ML9161	Structure and Properties of Alloys	3	0	0	3
12	ML9162	Smart materials and Structures	3	0	0	3
13	ML9163	Biomaterials	3	0	0	3
14	ML9164	Solid State Ionics	3	0	0	3
15	ML9165	Nuclear Physics and Reactor Materials	3	0	0	3
16	ML9166	Advanced Materials	3	0	0	3
17	ML9167	Composite Materials and Structures	3	0	0	3
18	ML9168	Corrosion Science and Engineering	3	0	0	3
19	ML9169	Non-Destructive Testing	3	0	0	3
20	ML9170	Ultrasonics and Applications	3	0	0	3
21	ML9171	Microprocessor Based Instrumentation	3	0	0	3
22	ML9172	Measurement and Instrumentation	3	0	0	3

ML 9111 **MATHEMATICAL PHYSICS** **L T P C**
3 1 0 4

AIM:

To make the students understand the basic mathematical functions necessary for modeling, Physics problems.

OBJECTIVE:

To provide the information in a way that the student can understand the basics of mathematical functions and apply them in real problems

1. VECTOR CALCULUS AND MATRICES **9**

Laplacian-Vector operators in curvilinear coordinates Gauss, Green and Stokes theorems-Applications - Vector spaces-Linear dependence and independence - Eigenvalue problem - Diagonalisation -Similarity transformation.

2. SPECIAL FUNCTIONS **9**

Beta and Gamma functions-Bessel, Legendre, Hermite, Chebyshev and Laguerre functions and their properties-Series solutions-Recurrence relations-Rodrigue's formulae, Orthogonality, Generating functions-Applications-Dirac delta function.

3. THEORY OF COMPLEX VARIABLES **9**

Functions of complex variables-Cauchy Riemann conditions-Analytic functions-Conformal mapping-Simple and Bilinear transformations-Applications-Cauchy's Integral Theorem and Integral Formula-Taylor's and Laurent's series-Singularities-Zeros, Poles and Residues-Residue theorem-Contour integration with circular and semicircular contours.

4. INTEGRAL TRANSFORMS **9**

Harmonic analysis, Fourier transform-properties-transforms of simple functions and derivatives-Convolution theorems-Applications-Laplace's transform-properties-Transform of simple functions and derivatives-periodic functions-Convolution theorem-Application to solve differential equation.

5. PARTIAL DIFFERENTIAL EQUATIONS AND GROUP THEORY **9**

Transverse vibration of a string - Wave equation - One dimensional heat conduction - Diffusion equation - Two dimensional heat flow - Laplace's equation - Method of separation of variables -Fourier series solution in cartesian coordinates. Definition of group - symmetry elements -Reducible and irreducible representation - Orthogonality theorem.

L : 45; T : 15 = 60

REFERENCES:

1. Pipes L.A. & Harvil, Applied Mathematics for Engineers and Physicists, McGraw-Hill Book Co., New York, 1980.
2. Kreyszig E., Advanced Engineering Mathematics, 7th edition, John Wiley & Sons, Singapore, 1993.
3. Butkov E. Mathematical Physics, Addison Wesley, New York, 1973.
4. Grewal B.S., Higher Engineering Mathematics, Khanna Publishers, New Delhi, 1998.
5. Sathyapraksh, Mathematical Physics, S.Chand Co., New Delhi, 1994.

6. M.K.Venkatraman, Advanced Mathematics for Engineers & Scientists, National Publishing Co., Madras, 1994.
7. Gupta, B.D., Mathematical Physics 3rd Edition, Vikas Publishing House Pvt Ltd, New Delhi, 2004

ML9112 PHYSICS OF MATERIALS – I

L T P C
3 0 0 3

AIM:

To understand the theoretical concepts of Physics of Materials

OBJECTIVE:

To provide the knowledge on crystal structure, electron transport and Classification of solids

1. CRYSTAL STRUCTURE AND BONDING 9

Crystalline solids - crystal systems - Bravais lattices –corordination number – packing factors – cubic, hexagonal, diamond structures – lattice planes – Miller indices – interpalanar distances – directions. Types of bonding - lattice energy - Madelung constants – Born Haber cycle – cohesive energy .

2. FREE ELECTRON THEORY 9

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.

3. LATTICE DYNAMICS 9

Mono atomic and diatomic lattices – harmonic approximation - phonon frequencies and density of states – Einstein and Debye theories of lattice energies and phonon dispersion curves – anharmonic effects - thermal expansion - thermal conductivity - normal and Umklapp processes - scattering experiments.

4. PERIODIC POTENTIALS AND ENERGY BANDS 9

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.

5. PHYSICS OF SEMICONDUCTORS AND SEPERCONDUCTIVITY 9

Semiconductors – direct and indirect gaps – carrier statistics (intrinsic and extrinsic) – law of mass action and chemical potential of semiconductors – electrical conductivity and its temperature variation - III - V and II – VI compound semiconductors – excitons and polarons. Superconductivity – critical parameters – anomalous characteristics – isotope effect, Meissner effect – type I and II superconductors - BCS theory (elementary) - Josephson junctions and tunneling – SQUID - High temperature superconductors - applications.

REFERENCES:

1. Harald Ibach and Hans Lueth, Solid State Physics, 2nd edition Springer (1996)
2. H.P.Myers, Introductory Solid State Physics, 2nd edition, Viva Books Pvt. Ltd (1998)
3. M.Ali Omar, Elementary Solid State Physics, revised printing Pearson Education (2000)
4. M.S. Rogalski and S.B. Palmer, Solid Statae Physics, Gordon Breach Science Publishers (2000)

5. Y.K. Lim, Problems and solutions on Solid State Physics, Sarat Book Publishers (2002)
6. N.W. Ashcroft and N.D. Mermin Solid State Physics, Thomson Brrooks/Cole (1976)
7. A.J Dekker, Solid State Physics, Prentice Hall (1957).

ML 9113 CLASSICAL MECHANICS AND STATISTICAL THERMODYNAMICS **L T P C 3 0 0 3**

AIM:

To make the students to understand the mechanical aspects of systems and the statististical distribution of particle system

OBJECTIVE:

To provide the knowledge on classical theories of particle mechanics, thermo dynamical aspects and statistical functions

1. LAGRANGIAN DYNAMICS **9**

Virtual work - Generalised coordinates –– d'Alembert's principle – Lagranges equation of motion – Cyclic co-ordinates and conservation laws - Euler Lagrange equation - Rutherford's scattering - Hamiltonian dynamics – Hamilton's equations of motion – Principle of least action – Canonical transformation – Poisson brackets.

2. CHEMICAL POTENTIAL **9**

Helmholtz and Gibbs free energies – Thermodynamic reactions – Euler equation – Maxwell's relations and applications – Gibbs phase rule – phase equilibria (single and multicomponent sysems - Clausius – Clayperon equation – law of mass action – first order phase transition in single component systems.

3. ENSEMBLES **9**

Microcanonical, canonical and grand canonical ensembles – Maxwell – Boltzmann, Bose- Einstein and Fermi-Dirac statistics – Comparison of MB, BE and FD statistics.

4. APPLICATION OF STATISTICS **9**

Stefan-Boltzmann law – Einstein model of a solid – Bose condensation – Classical partition function and classical ideal gas – Equipartition theorem – Semiconductor statistics – Statistical equilibrium of free electrons in semiconductors.

5. HEAT AND MASS TRANSFER **9**

Basic concepts of conduction, convection and radiation – Hydrodynamics - Dimensionless numbers – Rayleigh's number-Reynold's number - Heat balance equation – Mass transfer convective flow – diffusion - Fick's law - diffusion coefficient-mass transfer coefficient - Application to melt growth.

L : 45

REFERENCES

1. M.C.Gupta, Statistical Thermodynamics, Wiley Eastern Ltd., New Delhi, 1993
2. B.K.Agarwal and Melvin Eisner, Wiley Eastern Ltd., New Delhi –1988.
3. Herbert B.Callen, Thermodynamics, John Wiley and Sons, New York 1960.
4. H.Goldstein, Classical mechanics, Narosa Publising House, New Delhi, 1989.

5. Novak and R.Bialecki, Advanced Computational Methods in Heat Transfer, ISBN. 1853(125911) 1998.
6. J.P.Holman,Heat transfer, Tata McGraw Hill,New Delhi, Ninth edition,2008.
7. Reif, F., Funamentals of Statistical and Thermal Physics, McGraw Hill, 1995.
8. N.C. Rana, P.S.Joag-Classical Mechanics, Tata McGrawHill, New Delhi, 2008.-

ML 9114	ELECTRONICS AND INSTRUMENTATION	L T P C
		3 0 0 3

AIM:

To make the students to understand the basic concepts of electronic devices and their applications

OBJECTIVE:

To provide the knowledge on the construction of various electronic devices, circuits, optoelectronic devices and instrumentation.

1. SEMICONDUCTOR DEVICES **9**

Special diodes-Zener, LED, Photodiode, Schottky diode, Diac and Triac, Tunel diode – MOSFET, SCR, SCS, UJT, MIS diodes, CCDs, Solar cells - phototransistors, Integrated circuit technologies, overview of VLSI

2. ANALOG ELECTRONICS **9**

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.

3. DIGITAL ELECTRONICS **9**

Introductory digital concepts – overview of logic functions and logic gates – combinational logic - flip-flops and related devices – registers, counters, shift registers and memory units - introduction to microprocessors, computer architectures. A/D and D/A conversion.

4. OPTOELECTRONICS **9**

Semiconductor lasers – optical fiber and characteristics – modes of propagation – losses in fibres - fibre optic communication, optoelectronic modulation and switching devices – optocoupler – magnetic and optical data storage techniques.

5. INSTRUMENTATION **9**

Qualities of measurements – digital instruments – transducers, strain gauge, LVDT. load cell, piezo electric transducers, temperature transducers, flow meters - recorders and transducers – signal conditioning – data acquisition, conversion and transmission – digital signal processing.

L: 45

REFERENCES:

1. B.G. Stretman and S. Banerjee, 'Solid state electronic devices', (5th Edition), Pearson Education Inc., New Delhi, (2000).
2. A.P. Malvino, 'Electronic principles', (6th Edition), Tata McGraw Hill Publ.Co.Ltd., New Delhi (1999).
3. T.L.Floyd, Electronic Devices (6th Edition), Pearson Education Inc., New Delhi, 2003
4. P.Bhattacharya, Semiconductor Optoelectronic Devices, 2nd Edition, Pearson Education Inc., New Delhi, 2002.

5. H.S.Kalsi, Electronic Instrumentation, 2nd Edition, Tata McGraw Hill Publishing Co., New Delhi 2004.
6. William David Cooper, Electronic Instrumentation and Measurement techniques – Prentice Hall of India Pvt. Ltd., 1991.
7. A.K.Sawhney, Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Sons, New Delhi, 1990.

ML 9115 ENGINEERING GRAPHICS AND WORKSHOP PRACTICE L T P C
1 1 2 3

AIM:

Creating awareness on fundamentals of graphics, engineering drawing and handling of machine tools including CNC machines with the following objectives.

OBJECTIVE:

To make the students to understand the

- Concept on basic drawing / graphics
- Concept on CNC To provide
- on hand exposure on CNC and various machine tools usage

1. ENGINEERING GRAPHICS 15

Drawing Instruments and their uses, lines, lettering and dimensioning – orthographic projections – section of solids, Isometric projections – Isometric views of simple objects such as square, cube and rectangular blocks – Free hand sketching of nuts, bolts, rivets and washers with dimensions, from samples – BIS standards and codes (Elementary treatment)

2. WORKSHOP PRACTICE 30

a) Demonstration of basic manufacturing process like Welding, Frundry and sheet metal
b) Lathe: Apron mechanism, different work holding devices, different operation, Machining time calculations.
c) Milling machine: Mechanism - different work holding devices, different operation, calculations part
d) Drilling machine: Mechanism – Operations – Calculation part
e) Shaper Machines: Quick return mechanism – Different work holding Devices – Different operations – Calculation part.
f) Process planning and cost estimation of simple components – Elementary treatment.
g) Introduction to CNC Machines – Machining centres and turning centres.

L:15 + T:15 = P:30

REFERENCES:

1. N.D.Bhatt, Elementary Engineering drawing, Charater publishing co. 1990.
2. Hajra Choudhry, Elements of Workshop Technology, Vol. I and II, Media Promoters and publishers Pvt. Ltd., Mumbai, 2001.
3. R.K.Jain and S.C.Gupta, Production Technology, Khanna Publishers, 16th Edition, 2001.
4. Serope Kalpajion, Stevan R. Schmid, Manufacturing Engineering and Technology, Prasson Education, Inc., 2002 (Second Indian Print).
5. Radhakrishnan, C.N.C. Machines, New Central Book Agency, 1992

6. Bernard Hodges, CNC Part programming work book, City and Guilds. MacMillan, 1994
7. Hajra Choudry, S.K., Elements of Workshop Teaching, Vol.I and II, Tata McGraw Hill Publishing Co., New Delhi, 1992.

ML 9116 MATERIALS SCIENCE LABORATORY –I **L T P C**
1 0 3 3

LIST OF EXPERIMENTS

Any fifteen experiments

1. Band gap determination
2. Determination of elastic constants – Hyperbolic fringes
3. Determination of elastic constants – Elliptical fringes
4. Determination of dielectric constant
5. Ultrasonic diffractometer - Ultrasonic velocity in liquids
6. Magnetostriction measurements
7. Study of crystal lattices
8. Strain gauge meter – Determination of Young's modulus of a metallic wire
9. Conductivity of ionic crystals
10. Instrumentation Amplifier
11. Regulated power supply
12. 555 Timer – Astable multivibrator
13. Operational amplifier - characteristics and applications.
14. Active filter
15. RC Phase Shift Oscillator (FET)
16. AD/DA convertor
17. Viscosity of liquid - Meyer's disc

P: 90

LABORATORY EQUIPMENTS REQUIREMENTS:

1. X-Y translation microscope
2. Thermostats
3. Ultrasonic generator
4. Multimeters
5. IC's transistors and resistors

ML 9121 NUMERICAL METHODS FOR MATERIALS SCIENCE

L T P C
3 1 0 4

AIM:
To expose the students with various mathematical methods for numerical analysis and use of computational tools.

OBJECTIVE:

To impart the knowledge on a systems of equations, probability statistics, error analysis and programming concepts

1. SYSTEM OF EQUATIONS 9

Roots of equations - 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 methods - Gauss-Seidel iterative method-Eigenvalues of Matrices-Power method and Jacobi's method.

2. INTERPOLATION & CURVE FITTING AND ERROR ANALYSIS 9

Newton's forward and backward interpolation formulae - Lagrange's method - Lagrange's inverse interpolation - curve fitting - principle of least squares.

3. NUMERICAL DIFFERENTIATION AND INTEGRATION 9

Newton's forward and backward difference formulae - numerical integration - Trapezoidal rule and Simpson's rule - numerical solution of ordinary differential equations - Taylor series - Euler's method, improved and modified methods - Runge-Kutta methods - Milne's predictor -corrector method.

4. PROBABILITY, STATISTICS AND ERROR ANALYSIS 9

Probability concepts – Binomial, Poisson, exponential and Normal Distribution - Tests of hypothesis (small and large samples) based on Student's 't' and Chi-square distribution – Testing Goodness of fit - Error analysis – Accuracy and precision – Significant figures.

5. C-PROGRAMMING 9

Structure – pointers – types of variables-arrays-functions (intrinsic and user defined) – arithmetic operations and shorthand notations – loops (do, for, if loops) – elementary examples of programs (three programs at least from each of the above units)

L : 45 + T15 : 15 = 60

REFERENCES

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

ML 9122 **PHYSICS OF MATERIALS - II** **L T P C**
3 0 0 3

AIM:
To impart knowledge on various properties of materials with examples

OBJECTIVE:
To make the students to understand the mechanical, dielectric, magnetic and optical properties of materials

1. MECHANICAL PROPERTIES 9

Factors affecting mechanical properties - mechanical tests - tensile, hardness, impact, creep and fatigue - Plastic deformation by slip - shear strength - work hardening and recovery - fracture - Griffith's theory - slip and twinning - creep resistant materials - diffusion – Fick’s law.

2. DIELECTRIC PROPERTIES 9

Dielectric constant and polarizability - different kinds of polarization - Internal electric field in a dielectric -Clausius- Mossatti equation - dielectric in a ac field - dielectric loss - ferroelectric - types and models of ferro electric transition - electrets and their applications – piezoelectric and pyroelectric materials.

3. MAGNETIC PROPERTIES 9

Classification - dia, para, ferro, antiferro and ferrimagnetism – Langevin and Weiss theories - exchange interaction - magnetic aniostrophy - magnetic domains - molecular theory – hysterisis - hard and soft magnetic materials - ferrite structure and uses - magnetic bubbles - magnetoresistance - GMR materials - dilute magnetic semiconductor (DMS) materials.

4. OPTICAL PROPERTIES 9

Optical absorption in insulators, semiconductors and metals – band to band absorption – luminescence - photoconductivity. Injection luminescence and LEDs - LED materials - superluminescent LED materials - liquid crystals - properties and structure - liquid crystal displays-comparison between LED and LC displays.

5. TECHNOLOGICAL MATERIALS 9

Metallic glasses - preparation, properties and applications - SMART materials - piezoelectric, magnetostrictive, electrostrictive materials - shape memory alloys - rheological fluids - CCD device materials and applications - solar cell materials (single crystalline, amorphous and thin films) - surface acoustic wave and sonar transducer materials and applications - introduction to nanophase materials and their properties.

L: 45

REFERENCES:

1. V.Raghavan, Materials Science and Engineering, Prentice Hall,2003.
2. D.R.Tilley and J.Tilley, Superfludity and superconductivity, 3rd Edition, Hilger,1990.
3. Charles Kittel, Introduction to solid state physics, Wiley 7th edition, 1996.
4. K.V.Keer, Principles of solid state physics, Wiley - Eastern, 1993.
5. Microelectronic Materials - C.R.M.Grovenor, Adam Hilger, Bristol and Philadelphia,1989.

ML 9123 **QUANTUM MECHANICS** **L T P C**
3 0 0 3

AIM:

To inspire the students with knowledge on the quantum mechanical concepts.

OBJECTIVE:

To expose with basic formulation, potential problems, approximation methods and scattering theories.

1. BASIC FORMULATION **9**

Inadequacy of Classical Mechanics - Postulates of quantum mechanics-wave function, probabilistic interpretation, observables and operators -Eigenvalues and Eigenfunctions, Expectation values-Commutators-Bra & Ket vectors, completeness, orthonormality, Basic theorems-Uncertainty principle-Ehrenfest's theorem-Schrodinger wave equation-stationary state solutions.

2. POTENTIAL PROBLEMS **9**

Free particle in three dimensions, particle in a box-one dimension and three dimension-potential step, potential barrier, tunnel effect, square well potential, periodic potential, linear harmonic oscillator, rigid rotator, the hydrogen atom, atomic orbitals.

3. ANGULAR MOMENTUM **9**

Rotation operators, angular momentum operators, commutation rules, Eigenvalues of angular momentum operator, matrix representations, addition of two angular momenta, Clebsch-Gordon coefficients, properties-Pauli matrices.

4. APPROXIMATION METHODS **9**

Time-independent perturbation theory, non degenerate and degenerate cases, Examples of Anharmonic oscillator and Stark effect, The variation method, Application to the deutron and helium atom, Time dependent perturbation theory, Harmonic perturbation.

5. SCATTERING THEORY **9**

Centre of mass and Laboratory systems-Scattering amplitude and cross sections-Scattering of a wave packet-Born approximation-validity-partial wave analysis-phase shifts.

L: 45

References

1. L.Schiff, Quantum Mechanics, Mc Graw-Hill Book Co., New York, 1996.
2. K.Ziock, Basic Quantum Mechanics, John Wiley & Sons, New York, 1969.
3. Sathyaprakash, Quantum Mechanics, Kedarnath Ramnath & Co., Meerut, 1994.
4. Chatwal and Anand, Quantum Mechanics, Himalaya Publishing House, New Delhi, 1993.
5. P.M.Mathews and K.Venkatesan, A Text book of Quantum mechanics, Tata Mc Graw-Hill, New Delhi, 1977.
6. J.J.Sakurai, Modern Quantum Mechanics, Addison Wesley, Tokyo, 1994.
7. E.Merzbacher, Quantum Mechanics, Wiley International, New York, 1970.
8. A.K.Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill, New Delhi, 1983.
9. Kakani S.L. and Chandalia H.M., Quantum mechanics, Sultan Chand & sons, New Delhi, 1994.

ML 9124 ELECTROMAGNETIC THEORY AND OPTICS **L T P C**
3 0 0 3

AIM:

To inspire the students with electromagnetic wave propagation and optical properties of materials

OBJECTIVE:

To impart knowledge on Maxwell's equation, wave propagation, linear and nonlinear optical properties of materials with theoretical background.

1. MAXWELL'S EQUATIONS **10**

Review of Gauss's law in electrostatics and magnetism - Ampere's law - Faraday's law - displacement current - Maxwell's equations - differential and integral forms - scalar and vector potentials and applications - Potential due to a nonuniformly charged sphere - magnetic induction due to a current carrying wire.

2. ELECTROMAGNETIC WAVE PROPAGATION **10**

Plane electromagnetic waves in free surface - Poynting vector - characterstic 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 polarisation - Hollow rectangular wave guide.

3. CRYSTAL OPTICS **10**

Definition of a tensor - second rank tensors - transformations - principal axes - quadric - permittivity tensor - Index ellipsoid - Electrical conductivity tensor, stress and strain tensors - third rank tensors - piezoelectricity - Fourth rank tensors - Modulus of elasticity.

4. OPTICAL ACTIVITY **5**

Kerr and pockel effect - applications - Harmonics and sum & frequency generation - stimulated Brillouin scattering - stimulated Raman scattering.

5. NONLINIEAR OPTICS **10**

Theory and applications of non-linear effects - frequency conversion - optical switching - phase conjugation - optical bistability - nonlinear optical materials - NLO crystals, properties and applications.

L: 45

REFERENCES:

1. J.F.Nye, Physical Properties of Crystals, Oxford University Press, New York, 1985.
2. E.F,Jordan and K.G.Belmain, Electromagnetic waves and Radiating Systems - Prentice-Hall of India Pvt. Ltd., New Delhi, 1982.
3. D.R.Corson and Paul Lorrain, Introduction to Electromagnetic fields and waves,
   D.B. Taraporevale Sons & Co. Pvt. Ltd., Bombay, 1970.
4. Yariv, A and Yeh, P, Photonics, 6th Editition, Oxford University Press, 2007

ML 9125 CRYSTALLOGRAPHY AND CRYSTAL GROWTH **L T P C**
3 0 0 3

AIM:

To introduce the knowledge on the growth of crystals and understand the crystalline solids.

OBJECTIVE:

To make the students to understand crystalline systems and expose with growing single crystals

1. CRYSTALLOGRAPHY **8**

Symmetry elements, operations - translational symmetries - point groups - space groups - equivalent positions –close packed structures - voids - important crystal structures – Paulings rules - defects in crystals, – polymorphism and twinning - polarizing microscope and uses.

2. CHARACTERISTIC X-RAYS **8**

Generation of X-rays - laboratory sources – X-ray absorption – X-ray monochromators - X-ray detectors (principles only) - diffraction by X-rays - Bragg's law - reciprocal lattice concept - Laue conditions - Ewald and limiting spheres - atomic scattering factor - anomalous scattering - neutron and electron diffraction (qualitative only)

3. SINGLE CRYSTAL DIFFRACTION **7**

Laue, rotation/oscillation methods - interpretation of diffraction patterns - cell parameter determination – indexing – systematic absences - space group determination (qualitative only). Powder diffraction: Debye-Scherrer method – uses.

4. CRYSTAL GROWTH THEORY **10**

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 orthorhombic – Temkins model – physical modeling of BCF theory.

5. CRYSTAL GROWTH TECHNIQUES **12**

Bridgman technique - Czochralski methods - Verneuil technique - zone melting – gel growth – solution growth methods – low and high temperature solution growth methods – vapour growth - epitaxial growth techniques.

L:45

REFERENCES:

1. Buckley, H.E., Crystal growth, John Wiely and sons, New York,1981.
2. Elwell,D & Scheel, H.J., Crystal growth from high temperature solution, Academic Press, New York,1995.
3. Laudise, R.A. The growth of single crystals, Prentice Hall, Englewood,1970.
4. Ramasamy, P. & Santhanaraghavan. P. Crystal growth processes and methods, KRU Publications, 2000.
5. Azaroff, L.V. Elements of X-ray crystallography, McGraw-Hill,NY,1968.
6. Tareen, J.A.K & Kutty, T.R.N, A basic course in crystallography, University Press, 2001.

ML 9126 **CHARACTERISATON OF MATERIALS** **L T P C**
3 0 0 3

AIM:

To introduce various methods available for characterizing the materials.

OBJECTIVE:

To expose the students with thermal, microscopic, electrical and spectroscopic methods of characterization.

1. THERMAL ANALYSIS 8

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 .

2. MICROSCOPIC METHODS 12

Optical Microscopy: optical microscopy techniques – Bright field optical microscopy – Dark field optical microscopy – Dispersion staining microscopy - phase contrast microscopy -differential interference contrast microscopy - fluorescence microscopy - confocal microscopy - scanning probe microscopy (STM, AFM) - scanning new field optical microscopy - digital holographic microscopy - oil immersion objectives - quantitative metallography - image analyzer.

3. ELECTRON MICROSCOPY AND OPTICAL CHARACTERISATION 8

SEM, EDAX, EPMA, TEM: working principle and Instrumentation – sample preparation – data collection, processing and analysis- Photoluminescence – light – matter interaction – instrumentation – electroluminescence – instrumentation – Applications.

4. ELECTRICAL METHODS 8

Two probe and four probe methods- van der Pauw method – Hall probe and measurement – scattering mechanism – C-V characteristics – Schottky barrier capacitance – impurity concentration – electrochemical C-V profiling – limitations.

5. SPECTROSCOPY 9

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

L: 45

REFERENCE:

1. Stradling, R.A; Klipstain, P.C; Growth and Characterization of semiconductors, Adam Hilger, Bristol,1990.
2. Belk, J.A; Electron microscopy and microanalysis of crystalline materials, Applied Science Publishers, London, 1979.
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4. D.Kealey & P.J.Haines, Analytical Chemistry, Viva Books Private Limited, New Delhi 2002.

ML 9127 MATERIALS SCIENCE LABORATORY – II **L T P C**
0 0 6 3

LIST OF EXPERIMENTS **14**

Any ten experiments:

1. Electrical conductivity of metals and alloys with temperature-four probe method
2. Hall effect
3. Magnetic susceptibility-Quincke's method
4. Crystal Growth-Solution technique
5. Crystal Growth-Gel technique
6. Determination of melt flow index of polymers
7. Creep characteristics of a metallic wire
8. Particle size determination-laser - Determination of wave length of He-Ne laser-Diffraction method
9. Ultrasonic interferometer – ultrasonic velocity in liquids
10. Ferroelectricity – Hysteresis loss
11. Arc spectrum – Identification of elements
12. Fraunhofer diffraction - using laser

STRENGTH OF MATERIALS LABORATORY **45**

1. Tensile test on mild steel rod
2. Compression test on wood
3. Torsion test on mild steel rod
4. Impact test
5. Compression test on helical spring
6. Deflection test on Carriage spring
7. Double shear test
8. Hardness shear test
9. Deflection test on metal beams
10. Tension test on helical spring

Total : 59 hours

Laboratory equipments requirements:

1. Four probe
2. Electromagnet
3. Laser source
4. Melt flow index device
5. Ultrasonic interferometer
6. Universal testing machine

ML 9131 **PHYSICAL METALLURGY**

L T P C
3 0 0 3

AIM:

To impart knowledge of the formation of alloys.

OBJECTIVE:

To expose with topics related to phase diagrams, alloys, heat treatment methods and phase transformations.

1. PHASE DIAGRAMS **9**

Composition and classification of pig iron and cast iron – iron ores - manufacture of wrought iron and steel The phase rule – binary equilibrium diagrams – invariant reactions- eutectic, eutectoid, peritectic and pertectoid reactions – free energy composition curves – micro structural changes during cooling – metallurgical microscope, grain size analysis, grain size measurement - effect of grain size on properties of metals and alloys

2. SOLID SOLUTION **9**

Types of solid solution – solid solution factors governing substitutional solubility – Hume-Rothery rules- intermediate phases -solid solution alloys –Vegards law – Lever rule - mechanical mixtures- - Iron-Carbon equilibrium diagram – Aluminum alloys – Copper alloys – Effect of alloying elements – Experimental determination of equilibrium diagram.

3. HEAT TREATMENT **9**

Cold working and hot working - Recovery, recrystallisation and grain growth.T-T-T diagrams – C-C-T diagrams – heat-treatment processes – annealing, normalising, quenching and tempering – baths used in heat treatment – hardenability – Jominy's end quench test – martempering and austempering – case hardening – induction, flame, laser - carburising, cyaniding, nitriding, carbo nitriding.

4. PHASE TRANSFORMATIONS **9**

Types of phase changes – diffusion in solids – Nucleation and growth – solidification – pearlitic transformations – martensitic transformations – kinetics of transformation - precipitation and age hardening –

5. ENGINEERING ALLOYS **9**

Low carbon steels – mild steels – high strength structural steels – tool materials – stainless steels – super alloys – light alloys – shape memory alloys – applications

L : 45

REFERENCES

1. V.Raghavan, Physical metallurgy, Prentice-Hall of India, New Delhi, 1983
2. A.G.Guy and J.Hren, Elements of Physical Metallurgy, Oxford University Press, 1984.
3. S.H.Avener, Physical Metallurgy, Mc Graw Hill, 1974
4. Robert.E.Reed-Hill, Physical Metallurgy Principles, D.Van Norstrand Inc., 1964
5. I.S.Polmear, Light Alloys, Third Edition, Metallurgy and Materials Science, 1995
6. William F.Smith, Structural Properties of Engineering Alloys, Mc Graw Hill Publications, 1993.
7. R.K.Rajput, Materials Science and Engineering, S.K.Kataria & Sons, New Delhi, 2002.

ML 9132 **CERAMIC MATERIALS** **L T P C**
3 0 0 3

AIM:

To introduce knowledge on ceramic materials and its applications

OBJECTIVE:

To make the students understand different processing methods of ceramic preparation and impart knowledge on different ceramics such as structural, electronic, refractory and glass.

1. CERAMIC PROCESSING **9**

Powder processing – precipitation, spray drying, freeze drying, sol-gel, CVD, SHS – milling techniques – forming – die processing, slip casting, injection moulding, doctor blade processing – sintering techniques – standard pressure sintering, hot pressing, HIP, reaction bonded sintering, microwave sintering – surface finishing techniques.

2. STRUCTURAL CERAMICS **9**

Oxide ceramics – zirconia, alumina, silica, magnesia and, titania, mullite – carbides – silicon carbide, boron carbide, tungsten carbide, titanium carbide – nitrides – silicon nitride, boron nitride, titanium nitride, borides, silicides, - sialon.

3. ELECTRONIC CERAMICS **9**

Ceramic insulators and capacitors – ferroelectric ceramics – barium titanate, PZT, PLZT materials – magnetic ceramics – spinel ferrites, zinc ferrites, garnets – superconducting ceramics – varistors and fuel cells.

4. REFRACTORY CERAMICS **9**

Silica, alumina –Bioceramic materials-high temperature applications-silica refractories – special refractories – alumina, mullite, carbide based and nitride based refractories, cordierite, zirconia, fusion cast refractories – ceramic fibers.

5. GLASS CERAMICS **9**

Glass forming processes – glass composition, heat treatment schedule, crystal nucleation in glass, nucleation agent – high purity silica glass, laser glasses, fiber glasses, optical glasses, fiber glass, non-oxide glasses.

L : 45

REFERENCES:

1. Kingery, W.D., Bowen, H.K. and Uhlmann, D.R. Introduction to Ceramics, 2nd Edition, John Wiley & Sons, New York, 1976.
2. Richerson, D.W., Modern Ceramic Engineering: Properties, Processing and Use in design, Marcel Dekker Inc, New York, 1992.
3. Reed, J.S., Principles of Ceramic Processing, John Wiley & Sons Inc, NY, 1995.
4. Lewis, M.H., Glasses and Glass Ceramics, Chapman and Hall, London, 1992.
5. Cable, M. and Parker, J.M., High Performance Glasses, Chapman and Hall, London, 1992.
6. Chester, J.H., Refractories, Production and Properties, Iron and Steel Institute, London, 1992.
7. Hench, L.L. and West, J.K., Principles of Electronic Ceramics, John Wiley, New York, 1990.

ML 9133 POLYMER AND COMPOSITE MATERIALS L T P C
3 0 0 3

AIM:

To introduce knowledge on polymers and composite materials and its applications.

OBJECTIVE:

To make the students understand different processing methods of preparation of polymers and composite materials and impart knowledge on properties and applications of above materials **.**

1. INTRODUCTION TO POLYMERS 9

Classification of polymers – copolymers – tacticity – geometric isomerism – molecular weight distribution and averages –Measurement of molecular weight – synthesis of polymers – step growth polymerisation – chain growth polymerisation – polymerisation techniques .

2. PROPERTIES OF POLYMERS 9

Polymer conformation and chain dimensions – Freely oriented perpendicular chains-Gaussian model – amorphous state – glass transition temperature – the crystalline state – ordering of polymer chains – crystalline melting temperature – techniques to determine crystallinity –Mechanical properties – Introduction to viscoelasticity – dynamic mechanical analysis – mechanical models of viscoelastic behaviour – Boltzmann superposition principle – Introduction to rubber elasticity.

3. POLYMER PROCESSING AND APPLICATIONS RHEOLOGY 9

Basic processing operations – extrusion, molding, calendaring, coating – Introduction to polymer rheology – non-Newtonian flow – analysis of simple flows – rheometry – capillary rheometer, Couette rheometer, cone and plate rheomete-applications-conductive polymers-bio polymers-liquid crystal polymers-photonic polymers-high temperature polymers.

4. INTRODUCTION TO COMPOSITES 9

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.

5. FABRICATION OF COMPOSITES 9

Polymer matrix composites – liquid resin impregnation routes, pressurized consolidation of resin pre-pregs, consolidation of resin moulding compounds, injection moulding of thermoplastics, hot press 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.

L:45

References

1. Joel R.Fried, Polymer Science and Technology, Prentice-Hall, New Jersey, 1995
2. A.R. Gowarikar, Introduction to Polymer Science, TMH India, 1996
3. A.W.Birley, B.Haworth & J.Batchelor, Physics of Plastics: Processing, properties and materials engineering, Hanser Publishers, Munich, 1992.
4. F.N.Billmayer, Text Book of polymer science, John Wiley & Sons, New York, 1994
5. D.Hull & T.W.Clyne, An Introduction to composite materials, Cambridge University Press, 1996.
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8. P.K.Mallick, Fiber-Reinforced Composites:Materials, Manufacturing and Design,Marcel Dekker Inc., 1988.
9. B.D.Agarwal and L.J.Broutman, Analysis and Performance of Fibre Composites, John Wiley & Sons, 1980.
10. R.M.Jones, Mechanics of Composite Materials, McGraw Hill Co., 1975.

ML 9135 MATERIALS SCIENCE LABORATORY - III & MINI PROJECT

L T P C
0 0 4 2

A. MATERIALS SCIENCE LABORATORY – III

LIST OF EXPERIMENTS

Any ten experiments

1. Density measurements – organic materials and polymers
2. NDT – Ultrasonic flaw detector
3. Resistivity measurements
4. Faraday effect
5. X-ray powder method – Identification of unknown elements
6. X -ray powder method – indexing and cell determination
7. Charge density, atomic scattering factor calculations.
8. Kerr effect
9. Laser coherence, divergence measurement
10. Optical absorption – spectrophotometer
11. Identification of phases.
12. Preparation of buffer solutions and pH measurements.
13. Laser Raman - sample preparation, recording and analysis
14. FTIR studies - sample preparation, recording and analysis
15. Etch pattern of single crystals

B. MINI PROJECT

Total: 60 Periods

ML 9151 **ADVANCES IN X-RAY ANALYSIS**

L T P C
3 0 0 3

AIM:

To introduce knowledge on recent developments in X-ray analysis.

OBJECTIVE:

To make the students to understand different advanced methods of materials characterization using X-rays and also its application in synthesis of materials.

1. EXPERIMENTAL METHODS **10**

X-ray sources – synchrotron radiation – X-ray optics – monochromatization, collimation and focusing – Neutron sources – nuclear reactors – pulsed neutron sources – neutron optics – X-ray and neutron detectors – point, linear and area detectors - physical and geometrical factors affecting X-ray intensities.

2. SINGLE CRYSTAL METHODS **10**

Single crystal diffractometers – geometries and scan modes - structure factors - systematic absences and space group determination – electron density – phase problem - structure solution – direct method (basics only) - Patterson function and heavy atom method. Structure refinement – Least-squares method - difference Fourier synthesis - R factor - structure interpretation – geometric calculations - computer program packages (qualitative only).

3. POWDER METHODS **10**

Powder cameras: Seeman-Bohlin, Guinier geometries - diffractometer geometries: Debye, transmission and reflection – Bragg-Brentano geometry - monochromator geometry and Soller slits - sample preparation and step data collection – qualitative and quantitative phase analysis – indexing - ICDD powder diffraction file – uses. The Rietveld method - Principles and fundamentals - peak shapes – profile fitting - structure refinement: procedures adopted – R factors – auto indexing - structure determination from powder data – computer programs.

4. APPLICATIONS **8**

Orientation and quality of single crystals: transmission and back-reflection methods – defect analysis: x-ray topographic methods – crystallite size analysis: grain and particle size – strain and line width – texture studies: fiber and sheet textures - residual stress analysis: uniaxial and biaxial – special diffractometers and cameras..

5. OTHER STUDIES **7**

Wavelength dispersion and energy dispersion – spectrometers – intensity and resolution - X-ray fluorescence – applications - EXAFS and XANES (qualitative study) - high pressure diffraction methods – high and low temperature diffraction methods.

L:45

REFERENCES:

1. Stout, G.H. Jensen, L. X-ray structure determination, A Practical Guide, Macmillan, Newyork,1989.
2. Woolfson, M.M. An introduction to X-ray crystallography; Cambridge university press, Newyork 1984.
3. Ladd, M.F.C. Palmer, R.A. Structure determination by X-ray crystallography, Plenum Press, Newyork, 3rd edition, 1993.
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7. Giacovazzo. C., Fundamentals of Crystallography, IUCR-Oxford University Press, 2002.

ML 9152 LASER THEORY AND APPLICATIONS

L T P C
3 0 0 3

AIM:

To introduce knowledge on basics of lasers

OBJECTIVE:

1. To make the students understand the principle involved in laser action and importance of resonator cavity.
2. To teach the principle and working of different types of lasers and explain the different applications of lasers

1. PRINCIPLES OF LASERS 9

Einstein coefficients, ratio of rates of stimulated and spontaneous emission – Threshold condition for laser action – Small signal gains of a laser – Population inversion in three level and four level systems –

2. OPTICAL RESONATORS 9

Resonant cavities, resonator modes, spot size – Types of resonators, geometries, alignment charcteristics, stability criterion, quality factor of an optical resonator – Q-switching and Modelocking concepts and techniques.

3. LASER SYSTEMS 9

Gas lasers: He-Ne laser, Carbondioxide gas laser, Nitrogen gas laser, Argon ion gas laser – Solid state lasers: Ruby laser, Nd-YAG laser, Semiconductor Laser– Liquid Lasers: Dye lasers

4. MATERIALS PROCESSING 9

Gaussian beam characteristics - Spot size - Power density - Welding - Fusion depth and welding geometry - Welding speeds - Advantages and uses of laser welding - Drilling hole geometry - Advantages and uses of laser drilling - Micromachining resistor trimming - Capacitor adjustment and fabrication, Scribing - Controlled fracturing.

5 APPLICATIONS 9

Laser ranging and tracking - Laser Doppler velocimetry - Ring laser and rotation sensing - Pollution monitoring, Alignment monitoring - Holography and speckle in displacement and deformation measurements - Biological and medical applications - Laser for communication with fiber optics as channel.

L: 45

REFERENCES:

1. C.O. Shea, W.R. Callen and N.T. Rhodes, 'An Introduction to Lasers and their Applications', Addison Wesley, 1969.
2. J. Verdeyen, 'Laser Electronics', Second Edition, Prentice Hall, 1990.
3. S.S. Chandran, 'Laser in Industry', Van Nostrand Reinhold Co., 1975.
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5. B.B. Laud, 'Laser and Non-Linear Optics', Second Edition, New Age International (p) Limited publishers, 1996.

ML 9153 **ADVANCED CRYSTAL GROWTH**

L T P C
3 0 0 3

AIM:

To introduce the concepts of advances in crystal growth techniques

OBJECTIVE:

To make the students to understand the various theories of crystal growth
To teach the principle and growth of crystals using different techniques

1. NUCLEATION THEORY **7**

Nucleation concept – Homogeneous, heterogeneous nucleation – classical theory – Energy of formation of nucleus – kinetic theory of nucleation – statistical theory of nucleation – nucleation rate – induction period.

2. THEORIES OF CRYSTAL GROWTH **8**

Two dimensional nucleation theory – Temkins model of crystal growth – limitations of Temkins model – BCF surface diffusion theory – solution of BCF surface diffusion equation. Atmospheric nucleation - condensation of vapour droplets – ice formation – nucleation agents – artificial rain making.

3. MELT GROWTH **12**

Temperature measurement and control – Starting materials and purification – conservative and non-conservative process – Bridgman method – Czochralski method – Verneuil method – Zone melting – Skull melting – Fluid flow analysis in melt growth – theory and experiment.

4. GROWTH FROM SOLUTIONS **10**

Measurement of supersaturation – Low temperature solution growth – High temperature solution growth – Accelerated crucible rotation technique (ACRT) – Electrocrystallization – Crystal growth in gel – Growth of biological crystals – Hydrothermal technique – Sol-gel growth – Chemical bath deposition (CBD) – Photochemical deposition (PCD) – unidirectional growth of crystals from solution.

5. VAPOUR GROWTH **8**

Physical vapour transport –chemical vapor transport. Epitaxial growth techniques – Liquid phse epitaxy - vapour phase epitaxy: chloride, hydride, metalorganic - molecular beam epitaxy - chemical beam epitaxy.

L : 45

REFERENCE:

1. Nucleation, Ed.by A.C.Zxettlemoyer, Marcel – Dekker Publishers, 1969.
2. Modelling Crystal Growth rates from solution – by Makoto Ohara and Robert C. Reid, 1973.
3. Crystal Growth Processes – by J.C.Brice, John Wiley and sons, New York 1986.
4. Crystal Growth – by B.R.Pamplin, 1975, Pergamon press, London.
5. Advance Crystal Growth – Edited by P.M.Dryburgh, B.Cockayane and K.G.Barraclough, Prentice – Hall, London, 1986.

ML 9154 **MATERIALS PROCESSING**

L T P C
3 0 0 3

AIM:

To introduce knowledge on processing of materials used in industries

OBJECTIVE:

To make the students understand the physics of materials processing
To teach the principle behind the different processing techniques.

1. BASIC MANUFACTURING PROCESSES **9**

Fundamental analysis of Manufacturing processes, casting, casting processes, forging, methods of forging, extrusion, rolling, spinning, turning, planing and shaping, milling, grinding.

2. SURFACE TREATMENT PROCESSES **9**

Necessity for surface modification, surface cladding, surface alloying, hard facing, shock hardening, conventional methods, carburising, nitriding, cyaniding, advantages of laser surface treatment over conventional methods, typical laser variables used in surface alloying, laser cladding, experimental set up.

3. WELDING PROCESSES **9**

Various processes of welding, fusion welding, pressure welding, oxyacetelene welding, resistance welding, spot welding, thermit welding, projection welding, seam welding, butt welding, thermal effects of welding, effects on grain size and microstructure, internal stresses effect, corrosion effect, high energy beam welding, laser beam and electron beam welding, key hole effect.

4. MECHANICAL WORKING OF METALS **9**

Hot working, cold working, normalising, full annealing, tempering, theory of tempering, effect of tempering temperature on mechanical properties of carbon steels, different tempering process, deformation of metals, elastic deformation, plastic deformation, slip, twinning.

5. POWDER METALLURGICAL PROCESS **9**

Production of powders, powder mixing, compacting, types of presses, sintering, soaking, finishing process, limitations and advantages of powder metallurgy, applications , production of cemented carbide cutting tools, self lubricating bearings, magnets, cermets, ultrasonic ceramic transducers.

L: 45

REFERENCES:

1. Rajan T.V, Sharma C.P and Ashok Sharma Heat treatment - Principles and Techniques, Prentice Hall of India Pvt. Ltd. New Delhi, 1995.
2. Muralidhara, M.K., Materials Science and Processes, Dhanpat Rai Publishing Co., New Delhi, 1998.
3. Rykalin, Uglov A, Kokona, A Laser and Electron beam material processing hand book, MIR Publishers, 1987.
4. Gupta, R.B. Materials Science and Processes, Satya Prakashan, New Delhi, 1995.

ML 9155 INTRODUCTION TO NANOSCIENCE AND TECHNOLOGY

L T P C
3 0 0 3

AIM:

To introduce knowledge on basics of Nanoscience and technology

OBJECTIVE:

1. To make the students understand the importance of Nanoscience and technology
2. To make the students to understand the fundamental concepts behind size reduction

1. NANOSCALE SYSTEMS: 9

Length, energy, and time scales - Quantum confinement of electrons in semiconductor nanostructures: Quantum confinement in 3D, 2D, 1D and zero dimensional structures -Size effect and properties of nanostructures- Landauer-Buttiker formalism for conduction in confined geometries - Top down and Bottom up approach.

2. QUANTUM DOTS: 9

Excitons 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 - photo luminescence spectrum - optical spectroscopy - linear and nonlinear optical spectroscopy.

3. SYNTHESIS OF NANOSTRUCTURE MATERIALS: 9

Gas phase condensation – Vacuum deposition -Physical vapor deposition (PVD) - chemical vapor deposition (CVD) – laser ablation- Sol-Gel- Ball milling –Electro deposition- electroless deposition – spray pyrolysis – plasma based synthesis process (PSP) - hydrothermal synthesis

4. CHARACTERIZATION: 9

Principle and working of Atomic Force Microscopy (AFM) and Scanning tunneling microscopy (STM) - near-field Scanning Optical Microscopy – Principle of Transmission Electron Microscopy (TEM) – applications to nanostructures – nanomechanical characterization – nanoindentation

5. NANOTECHNOLOGY APPLICATIONS: 9

Applications of nanoparticles, quantum dots, nanotubes and nanowires for nanodevice fabrication – Single electron transistors, coulomb blockade effects in ultra-small metallic tunnel junctions - nanoparticles based solar cells and quantum dots based white LEDs – CNT based transistors – principle of dip pen lithography.

L: 45

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 Technology'', Vol.1-5, Editor:- Hari Singh Nalwa; Academic Press, USA (2000).
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5. "Sol-Gel Science", C.J. Brinker and G.W. Scherrer, Academic Press, Boston (1994).
6. Nanoscale characterization of surfaces & interfaces, N John Dinardo, Weinheim Cambridge: Wiley-VCH, 2nd ed., 2000.

ML 9156 NANOMATERIALS: PREPARATION AND CHARACTERIZATION

L T P C
3 0 0 3

AIM:

To introduce the basic aspects of preparation of nanomaterials and their related characterization techniques.

OBJECTIVE:

1. To make the students understand the principle involved in preparation and characterization of nanostructures.
2. To teach the principle and fabrication of nanodevices.

1. BASIC PROPERTIES OF NANOPARTICLES: **9**

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, and mechanical properties - advantages

2. NANOTUBES: 9

Single walled and Multi walled Nanotubes (SWNT and MWNT) - synthesis and purification - synthesis of carbon nanotubes by pyrolysis techniques - arc-discharge method - nanotube properties – Nanowires – methods of preparation of nanowires – VLS mechanism

3. NANOWIRES AND NANOFIBERS: 9

Semiconductor and oxide nanowires –preparation –solvothermal – electrochemical – PVD –Pulse laser deposition – template method (qualitative)- nanofibers –electro spinning technique

4. CHARACTERIZATION: 9

Nano SEM - Scanning Conducting microscopy (SCM) - near-field Scanning Optical Microscopy - High-resolution Transmission Electron Microscopy (HRTEM)- Absorption and emission spectra – PL spectrum - single nanoparticle characterization –Scanning capacitance microscopy – capillary electrophoresis-laser induced fluorescence (CE-LIF)

5. NANODEVICES: 9

Magnetic storage: magnetic quantum well; magnetic dots - magnetic date storage - high density quantized magnetic disks - magnetic super lattices – MRAMS - MTJs using nanoscale tunneling junctions – nanomaterial sensors

L: 45

REFERENCES:

1. “Nanoparticle Technology Handbook”, Masuo Hosokawa, Kiyoshi Nogi, Makio Naito, Toyokazu Yokoyama, Elsevier Publishers (2007).
2. “Nanomaterials Synthesis, properties and applications”, Editor:- A.S Edelstein, IOP Publishing, UK (1996).
3. “Nanostructured materials and nanotechnology’’, Concise Edition, Editor:- Hari Singh Nalwa; Academic Press, USA (2002).
4. “Hand book of Nanostructured Materials and Technology’’, Vol.1-5, Editor:- Hari Singh Nalwa; Academic Press, USA (2000).
5. “Carbon nanotubes: preparation and properties”, Editor: - T.W. Ebbesen, CRC Press, USA (1997).
6. Zhon Ling Wang, Characterization of nanophase materials, ISBN: 3527298371, Wiley-VCH Verlag GmbH (2000)

ML 9157 NANOSCALE FABRICATION AND TECHNIQUES **L T P C**
3 0 0 3

AIM:

To introduce the aspects of Nanoscale fabrication techniques.

OBJECTIVE:

To make the students understand the basic aspects of various lithographic techniques and the importance of clean room facility.
To enable the student to understand various device characterization techniques.

1. Scaling laws in miniaturization **9**

Heat conduction in micro- and nano- systems: heat conduction equation, Newton's cooling law, heat conduction in multilayered thin films, heat conduction in submicron scale - Quantum phenomena in nano-systems: photonic band gap structure, quantum states in nano-sized structures, quantum transport

2. Clean room: **9**

Need for a clean room – Types of clean rooms – maintenance of different types of clean rooms – oxidization and metallization- masking and patterning

3. Preparation techniques: **9**

Basic micro- and nano-fabrication techniques: thin film deposition, ion implantation, diffusion, oxidation - surface micromachining, LIGA process -Packaging: die preparation, surface bonding, wire bonding, sealing, assembly Measurement techniques : scanning tunneling microscope, atomic force microscope, focused ion beam technique- nanoindentation, nanotribometer

4. Nano-fabrication: principles and techniques: **9**

Etching technologies - wet and dry etching - photolithography – Drawbacks of optical lithography for nanofabrication - electron beam lithography – ion beam lithography - dip-pen nanolithography, stamping techniques, strain-induced self-assembly for Nanofabrication of quantum dot and molecular architectures - Polymer processing for biomedical applications

5. Applications and devices **9**

Mechanics for micro- and nano-systems: bending of membrane and cantilever, resonance vibration, fracture, stress, nano Tribology -Fluid dynamics for micro- and nano- systems: surface tension, viscosity, continuity equation -laminar fluid flow, fluid flow in submicron and nanoscale- Surface acoustic wave (SAW) devices, microwave MEMS, field emission display devices, nanodiodes, nanoswitches, molecular switches, nano-logic elements- Super hard nanocomposite coatings and applications in tooling- Biochemistry and medical applications: lab-on-a-chip systems.

L: 45

REFERENCES

1. T.R. Hsu, MEMS & microsystems design and manufacture, Boston, McGraw Hill, 2002.
2. S.E. Lyshevski, Nano- and microelectromechanical systems, Boca Raton, CRC Press, 2001.
3. R. Waser (ed.), Nanoelectronics and information technology, Aachen, Wiley-VCH, 2003.
4. B. Bhushan, Springer handbook of nanotechnology, Berlin, Springer-Verlag, 2004.
5. J.A. Pelesko and D.H. Bernstein, Modeling MEMS and NEMS, Boca Raton, Chapman &Hall/CRC, 2003.

ML 9158 THIN FILM SCIENCE AND TECHNOLOGY **L T P C**
3 0 0 3

AIM:

To introduce the aspects of Nanoscale fabrication techniques.

OBJECTIVE:

1. To make the students understand the basic aspects of various lithographic techniques and the importance of clean room facility.
2. To enable the student to understand various device characterization techniques.

1. HIGH VACUUM PRODUCTION **9**

Mechanical pumps - Diffusion pump - measurement of vacuum - gauges - production of ultra high vacuum - thin film vacuum coating unit - substrate cleaning

2. PREPARATION METHODS **9**

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 pyrolysis - laser ablation.

3. THICKNESS MEASUREMENT AND MONITORING **9**

Multiple beam interference - quartz crystal - ellipsometric - stylus techniques. Characterization: X-ray diffraction - electron microscopy - high and low energy electron diffraction - ESCA - EPMA - Auger emission spectroscopy.

4. GROWTH AND STRUCTURE OF FILMS **9**

General features - Nucleation theories - Post-nucleation growth – Thin film structures- Structural defects

5. PROPERTIES OF THIN FILMS **9**

Optical - reflection and anti-reflection coatings - interference filters - thin film solar cells - electrophotography. Electrical and dielectric behaviour of thin films - components - thin film diode and transistor - strain gauges and gas sensors. Anisotropy in magnetic films - domains in films - computer memories - superconducting thin films - SQUID - mechanical properties: testing methods - adhesion - surface and tribological coatings

L : 45

REFERENCES:

1. Milton Ohring, The Materials Science of Thin Films, Academic Press, 2001.
2. Donald L. Smith, Thin-Film Deposition: Principles and Practice, McGraw-Hill, 1995.
3. K.L. Chopra, Thin Film Phenomena, McGraw-Hill, 1969.
4. K.L. Chopra and I.J. Kaur, Thin Film Device Applications, Plenum Press, London, 1983.
5. L.I. Maissel and R. Glang (Eds.), Handbook of Thin film Technology, McGraw-Hill, 1970.
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7. George Hass, Physics of Thin Films: Volumes 1 -12, Academic Press, 1963.

ML 9159 HIGH PRESSURE SCIENCE AND TECHNOLOGY

L T P C
3 0 0 3

1. METHODS OF PRODUCING HIGH PRESSURE 8

Definition of pressure – Hydrostaticity – generation of static pressure, pressure units – piston cylinder – Bridgmann Anvil – Multi-anvil devices – Diamond anvil cell.

2. MEASUREMENT OF HIGH PRESSURE 7

Primary gauge – Secondary gauge – Merits and demerits – Thermocouple pressure gauge – Resistance gauge – fixed point pressure scale – Ruby fluorescence – Equation of state.

3. HIGH PRESSURE DEVICES FOR VARIOUS APPLICATIONS 10

X-Ray diffraction, Neutron diffraction – Optical studies – Electrical studies – Magnetic studies – High and low temperature applications – Ultra high pressure anvil devices.

4. HIGH PRESSURE PHYSICAL PROPERTIES 10

PVT Relation in fluids – Compressibilities of solids – properties of gases under pressure - Melting phenomena – viscosity – thermo emf – thermal conductivity. Electrical conductivity – phase transitions phonons superconductivity – Electronic structure of metals and semiconductors – NMR and magnetic properties. Liquid crystals – spectroscopy studies –Infrared, Raman Optical absorption – EXAFS.

5. MECHANICAL PROPERTIES UNDER PRESSURE 10

Elastic constants – Measurements – mechanical properties – Tension and compression – Fatigue – Creep – Hydrostatic extrusion. Material synthesis – Superhard materials – Diamond – Oxides and other compounds – water jet.

L: 45

REFERENCES:

1. P.W. Bridgmann, The Physics of High Pressure, G. Bell and SONS Ltd., London, 1931.
2. B.Vodar and Ph. Marteam, High Pressure Science and Technology, Vol.I and II, Pergamon Press, Oxford,1980
3. H. LI. D. Pugh, Mechanical Behaviour of Materials under Pressure, Elsevier Publishing Co., Ltd., New York, 1970.
4. M.I. Eremets, High pressure Experimental methods, New York, 1996.

ML 9160 SUPERCONDUCTING MATERIALS AND APPLICATIONS

L T P C
3 0 0 3

1. BASIC EXPERIMENTAL ASPECTS 9

Zero electrical resistance – Meissner effect – a.c. diamagnetic susceptibility – heat capacity – optical absorption by superconductor – entropy change –thermal conductivity – destruction of superconductivity by external magnetic fields – type I and type II materials – superconducting behaviour under high pressures –flux quantisation – normal and Josephson tunneling.

2. SUPERCONDUCTING MATERIALS 9

Elemental superconductors – superconducting compounds and its alloys – A-I5 compounds – chevral phase compounds

3. HIGH TEMPERATURE SUPERCONDUCTORS 9

La-Ba-Cu-O, Y-Ba-cu-O, Bi-Sr-Ca-Cu-O and new systems and their crystal structures – Experimental studies on the new materials – organic superconductors –fullerenes.

4. THEORETICAL ASPECTS 9

Isotope effect – BCS theory – Role of electrons and phonons – applications of electron band structure results to calculate electron-phonon coupling constant McMillan's formula – GLAG theory – recent theories on high Tc materials, Coherence length, expression for critical temperature Tc, critical field Hc, critical current Jc – heavy fermion superconductivity.

5. APPLICATIONS 9

Superconducting magnets – power generators, motors, transformers, power storage, power transmission – Josephson junction devices – IR sensors – SQUIDS –SLUGS – magnetically leviated trains – computer storage elements.

L : 45

References

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3. Hoi.S.Kowk and David T. Shaw (Eds.), "Superconductivity and its Applications", Elsevier Science Publishing, 1988.
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ML 9161 **STRUCTURE AND PROPERTIES OF ALLOYS**

L T P C
3 0 0 3

AIM:

To introduce the basic aspects of structure and properties of alloys.

OBJECTIVE:

1. To enable the students understand importance of phase diagrams and their relationship with properties of alloys
2. To make the students understand the basic structure and property relationship of the alloys

1. SOLID SOLUTIONS **9**

Concept of solid solution-solid solutions of Copper and Iron - Cu-Ni phase diagram - cast cupro nickel microstructures -properties of annealed copper solid solution alloys -soft magnetic alloys-stainless steels.

2. EUTECTIC ALLOYS **9**

Pb-Sb phase diagram and microstructure - Pb-Sn phase diagram - Cu:O system - ternary Pb-Sn-Sb phase diagram - characteristic properties of eutectic system alloys -applications of Pb-Sn and Pb-Sn-Sb alloys.

3. CAST AND WROUGHT ALLOYS **9**

Al-Si phase diagram - Al-Cu phase diagram -coherency theory of age hardneing - microstructures -cast aluminium alloy -properties-residual stresses and relaxation.

4. TWO PHASE ALLOYS **9**

Cu-Zn phase diagram – Cu-Zn alloy structure - Cu-Sn and Cu-Al alloy systems and their microstructures -properties of brasses, tin brasses and aluminium bronzes.

5. IRON-CARBON ALLOYS **9**

Fe-Fe_3C phase diagram - solubility of carbon in austenite and ferrite-terminology-equilibrium and non equilibrium - microstructures-properties of normalised steels - grain size of steels-engineering applications of low carbon steels and low alloy high strength steels

L: 45

REFERENCES:

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2. Solid State Physics - Structure and properties of materials, M.A.Wahab, Narosa publishing house, New Delhi, 1999.
3. Heat Treatment - Principle and Techniques, T.V.Rajan, C.P.Sharma and Ashok Sharma, Prentice Hall of India pvt. Ltd., New Delhi, 1995.
4. Materials Science and Processes, M.K.Muralidhara, Dhanpat Rai publishing company, New Delhi, 1998.
5. Charlie Brooks, R,Heat Treatment, Structure and properties of non ferrous alloys, American Society for Metals, U.S.A, 1984.

ML 9162 SMART MATERIALS AND STRUCTURES

L T P C
3 0 0 3

AIM:

To introduce the basic aspects and importance of smart materials and structures

OBJECTIVE:

1. To enable the students understand importance and structure of smart materials
2. To make the students understand the applications of smart materials

1. INTRODUCTION AND HISTORICAL PERSPECTIVE 9

Classes of materials and their usage – Intelligent /Smart materials – Evaluation of materials Science – Structural material – Functional materials – Polyfunctional materials – Generation of smart materials – Diverse areas of intelligent materials – Primitive functions of intelligent materials – Intelligent inherent in materials – Examples of intelligent materials, structural materials, Electrical materials, bio-compatible materials etc. – Intelligent biological materials – Biomimetics – Wolff's law – Technological applications of Intelligent materials.

2. SMART MATERIALS AND STRUCTURAL SYSTEMS 9

The principal ingredients of smart materials – Thermal materials – Sensing technologies – Micro sensors – Intelligent systems – Hybrid smart materials – An algorithm for synthesizing a smart material – Passive sensory smart structures– Reactive actuator based smart structures – Active sensing and reactive smart structures – Smart skins – Aero elastic tailoring of airfoils – Synthesis of future smart systems.

3. ELECTRO-RHEOLOGICAL (FLUIDS) SMART MATERIALS 9

Suspensions and electro-rheological fluids – Bingham-body model – Newtonian viscosity and non-Newtonian viscosity – Principal characteristics of electro rheological fluids – The electro-rheological phenomenon – Charge migration mechanism for the dispersed phase – Electro-rheological fluid domain – Electrorheological fluid actuators – Electro-rheological fluid design parameter – Applications of Electrorheolgoical fluids.

4. PIEZOELECTRIC SMART MATERIALS 9

Background – Electrostriction – Pyroelectricity – Piezoelectricity – Industrial piezoelectric materials – PZT – PVDF – PVDF film – Properties of commercial piezoelectric materials – Properties of piezoelectric film (explanation) – Smart materials featuring piezoelectric elements – smart composite laminate with embedded piezoelectric actuators – SAW filters.

5. SHAPE – MEMORY (ALLOYS) SMART MATERIALS 9

Background on shape – memory alloys (SMA) Nickel – Titanium alloy (Nitinol) – Materials characteristics of Nitinol – Martensitic transformations – Austenitic transformations – Thermoelastic martensitic transformations – Cu based SMA, chiral materials – Applications of SMA – Continuum applications of SMA fastners – SMA fibers – reaction vessels, nuclear reactors, chemical plants, etc. – Micro robot actuated by SMA – SMA memorisation process (Satellite antenna applications) SMA blood clot filter – Impediments to applications of SMA – SMA plastics – primary molding – secondary molding – Potential applications of SMA plastics.

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REFERENCES:

1. M.V.Gandhi and B.S. Thompson, Smart Materials and Structures Chapman and Hall, London, First Edition, 1992
2. T.W. Deurig, K.N.Melton, D.Stockel and C.M.Wayman, Engineering aspects of Shape Memory alloys, Butterworth –Heinemann, 1990
3. C.A.Rogers, Smart Materials, Structures and Mathematical issues, Technomic Publising Co., USA, 1989.

ML 9163 BIOMATERIALS

L T P C
3 0 0 3

AIM:

To introduce the basic concepts about biomaterials

OBJECTIVE:

1. To enable the students understand importance of and properties of biomaterials
2. To make the students understand applications of various biomaterials

1. BIOLOGICAL PERFORMANCE OF MATERIALS 9

Biocompatibility- introduction to the biological environment – material 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

2. ORTHOPAEDIC MATERIALS 9

Bone composition and properties - temporary fixation devices - joint replacement – biomaterials used in bone and joint replacement: metals and alloys – stainless steel, cobalt based alloys, titanium based materials – ceramics: carbon, alumina, zirconia, bioactive calcium phosphates, bioglass and glass ceramics – polymers: PMMA, UHMWPE/HDPE, PTFE – bone cement – composites.

3. CARDIOVASCULAR MATERIALS 9

Blood clotting – blood rheology – blood vessels – the heart – aorta and valves – geometry of blood circulation – the lungs - vascular implants: vascular graft, cardiac valve prostheses, cardiac pacemakers – blood substitutes – extracorporeal blood circulation devices

4. DENTAL MATERIALS 9

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

5. OTHER MATERIALS 9

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

L:45

REFERENCES:

1. Sujata V. Bhat. Biomaterials, Narosa Publication House, New Delhi, 2002.
2. Jonathn Black. Biological Performance of Materials: Fundamentals of biocompatibility, Marcel Dekker Inc, New York, 1992.
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ML 9164 **SOLID STATE IONICS**

L T P C
3 0 0 3

AIM:

To introduce the basic concepts about solid state ionics

OBJECTIVE:

1. To enable the students understand concepts behind solid state ionic materials
2. To make the students understand applications of ionic materials for battery applications

1. BASIC ASPECTS OF SOLID STATE PHYSICS **9**

Types of bonding in solids-Fundamentals of Crystallography-Simple Crystal structures, X-ray diffraction-band structures of metals, semiconductors and insulators-Ionic and electronic conductivities.

2. SOLID STATE IONICS **9**

Concept of solid state ionics- Importance of super-ionic materials and structures-Classification of Superionic solids- Experimental probes pertaining to solid state ionics- Theoretical models of fast ion transport- Applications of fast ionic solids-Hydrogen storage materials- Nano-ionic materials.

3. MICRO BATTERIES AND APPLICATION **9**

Concept of a thin film solid state battery- electrolyte thin films- flash 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 electrolytes in micro batteries, Fuel cells-solid state battery-super capacitors.

4. CHARACTERIZATION OF NEW CATHODE MATERIALS **9**

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.

5. APPLICATIONS OF IONIC MATERIALS **9**

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 electronic devices, electric vehicle, fuel cells, sensors -Solar energy conversion devices.

REFERENCES:

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3. D.S.Clive, Modern Battery Technology, Alean International Ltd, Banbury, Elis Horwood Publishers,(1991)
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ML 9165 NUCLEAR PHYSICS AND REACTOR MATERIALS L T P C
3 0 0 3

AIM:

To introduce the importance of and properties of nuclear materials

OBJECTIVE:

To enable the students understand the physics of nuclear reactor
To make the students understand properties of nuclear reactor materials

1. NUCLEAR STRUCTURE AND RADIOACTIVITY 9

Nuclear charge, mass, spin, magnetic moment, electric quadrupole moment, Binding energy, Semi-empirical mass formula – mass parabola – applications – Radioactivity – Soddy-Fajans law – Successive disintegration – transient and secular equilibrium.

2. NUCLEAR MODELS, FORCES AND ELEMENTARY PARTICLES 9

Liquid drop model – shell model-compound nucleus model – Breit-wigner formula – Mesion theory – ground state of deutron – exchange forces – n-p, p-p scattering-spin dependence – classification of elementary particles – conservation laws – elementary idea about quarks, gluons and quantum chromodyamics.

3. NUCLEAR FISSION AND FUSION 9

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 – stellar energy – controlled thermo nuclear reaction – plasma confinement.

4. NEUTRON AND REACTOR PHYSICS 9

Nuclear transmutation, Q value – exoergic – endoergic reactions – Nuclear cross sections – neutron sources – classification of neutrons – themalisation – average logarithmic decrement – thermal neutron diffusion – Fermi age equation.

5. REACTOR DESIGN AND MATERIALS 9

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

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REFERENCE:

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.
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4. D.S.Tayal, Nuclear Physics, Himalaya Publishers, Bombay, 1998.

ML 9166 **ADVANCED MATERIALS**

L T P C
3 0 0 3

AIM:

To introduce the students about the importance of advanced materials

OBJECTIVE:

1. To enable the students understand structure and properties of advanced materials
2. To make the students understand applications of various advanced materials

1. NANOSTRUCTURAL MATERIALS **9**

Magnetism in particles of reduced size and dimensions - variations of magnetic moment with size - magnetism in clusters of non magnetic solids - magnetic behaviour of small particles - diluted magnetic semiconductors (DMS) - Fe- DMS and IV -VI Mn DMS and their applications - intermetallic compounds - binary and ternaries and their magnetic properties.

2. COMPOSITE MATERIALS **9**

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.

3. LIGHT WEIGHT HIGH STRENGTH MATERIALS **9**

Properties and structure of Titanium - alloying elements- manufacture of titanium wrought products - mechanical properties and microstructure correlation - α,β and $\alpha+\beta$ alloys, aerospace and medical applications - yttrium based iron-chromium aluminum alloy- mechanical alloying process of MA 956 alloy - MAODS super alloys - high temperature and medical applications

4. OPTO ELECTRONIC MATERIALS **9**

Injection luminescence and LEDs - LED materials - LED construction - double heterojunction LED and related materials - edge emitter and superluminescent LED materials-liquid crystals-properties and structure-liquid crystal displays-comparison between LED and LC displays-optical amplifier - erbium doped silica fiber.

5. ENGINEERING MATERIALS **9**

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.

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1. Hand book of Nanophase Materials - edited by Avery N.Goldstain Marcel Dekker Inc, NewYork, 1997.
2. Science and Technology of Nanostructured Magnetic Materials, Ed. George C.Hadjipanayis and Gary A.Prinz, NATO ASI series, Plenum Press, New York,1991.
3. Composite Materials, S.C.Sharma, Narosa Publishing House, New Dellhi,2000.
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6. Microelectronic Materials - C.R.M.Grovenor, Adam Hilger, Bristol and Philadelphia,1989.

ML 9167 COMPOSITE MATERIALS AND STRUCTURES

L T P C
3 0 0 3

AIM:

To introduce the basic aspects of composite materials and structures

OBJECTIVE:

To enable the students understand importance of composite materials
To make the students understand properties and applications of various composite materials

1. FIBERS AND MATRICES 9

Types of composite materials – the concept of load transfer - fibers – glass, boron, carbon, organic, ceramic and metallic fibers – the strength of reinforcements – volume fraction and weight fraction- fiber packing arrangements – long fibers – laminates, woven, braided and knitted fiber arrays – short fibers – fiber orientation and length distributions – matrix materials – polymers, metals and ceramic matrices.

2. THE INTERFACE REGION 9

Bonding mechanisms – adsorption and wetting, interdiffusion and chemical reaction, electrostatic attraction, mechanical keying – experimental measurements of bond strength – single fiber pull out, push-out and push-down tests – three-point bend test - control of bond strength – coupling agents, toughness reducing coatings, diffusion barrier coatings, interfacial chemical reaction, the interphase region.

3. FABRICATION 9

Polymer matrix composites – liquid resin impregnation routes, pressurized consolidation of resin pre-pregs, consolidation of resin moulding compounds, injection moulding of thermoplastics, hot press 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.

4. MICROMECHANICS AND MACROMECHANICS 9

Prediction of elastic constants – micromechanical approach - Halpin Tsai equations – transverse stresses – mechanics of load transfer from matrix to fiber – macromechanics – elastic constants of an isotropic material – elastic constants of a lamina – Analysis of laminated composites.

5. STRENGTH AND TOUGHNESS OF COMPOSITES 9

Failure modes of long fiber composites axial and transverse tensile failure, shear and compression failure – strength of laminates – fracture mechanics – contributions to work of fracture – sub-critical crack growth – Applications of composite materials.

REFERENCES:

1. D.Hull & T.W.Clyne, An Introduction to composite materials, Cambridge University Press, 1996.
2. K.K.Chawla, Composite Materials, Springer-Verlag, New York, 1987.
3. K.K.Chawla, Ceramic Matrix Composites, Chapman & Hall, London, 1993.
4. P.K.Mallick, Fiber-Reinforced Composites:Materials, Manufacturing and Design,Marcel Dekker Inc., 1988.
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6. R.M.Jones, Mechanics of Composite Materials, McGraw Hill Co., 1975.

ML 9168 CORROSION SCIENCE AND ENGINEERING **L T P C**
3 0 0 3

AIM:

To introduce the importance of corrosion science and engineering

OBJECTIVE:

To enable the students understand principles behind corrosion science and
To make the students understand various corrosion processes and engineering applications

1. CORROSION PROCESSES **12**

Basic principles of electrochemistry and aqueous corrosion processes - Electrochemical Thermodynamics and Electrode Potential - Electrochemical Kinetics of Corrosion Cathodic and anodic behavior - Faraday's Law - Nernst equation; standard potentials Pourbaix diagram - Tafel equations, corrosion rate - Evans diagram - pitting, crevice and exfoliation corrosion; influence of deposits and anaerobic conditions; corrosion control; high temperature oxidation and hot corrosion; corrosion/mechanical property interactions.

2. ANALYTICAL TECHNIQUES **9**

X-ray diffraction, TEM, SEM and EDX, WDX analysis, surface analysis by AES, XPS and SIMS, overview of other techniques.

3. COATING MANUFACTURE **9**

Electrodeposition; flame and plasma spraying; thermal, **HV of** detonation gun, gas dynamic……, physical vapour deposition; chemical vapour deposition; HIP surface treatments.

4. CORROSION IN SELECTED ENVIRONMENTS **7**

Atmospheric 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

5. COATING APPLICATIONS **8**

Abrasive, erosive and sliding wear. The interaction between wear and corrosion. Coating systems for corrosion and wear protection; new coating concepts including multi-layer structures, functionally gradient materials, intermetallic barrier coatings and thermal barrier coatings.

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REFERENCES

1. D.A. Jones, Principles and Prevention of Corrosion, 2nd Edition, Macmillan Publishing Co., 1995.
2. J.O.M. Bockris, B.E. Conway, E. Yeager and White, Electrochemical Materials Science in Comprehensive Treatise of Electrochemistry, Volume 4, Plenum press, 2001.
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4. I.M. Hutchings, Tribology: Friction and Wear of Engineering Materials, CRC press, Boca Raton, 1992 D.O. Sprowds, Corrosion Testing and Evaluation, Corrosion Metals Hand book, vol. 13, 1986

ML 9169 NON-DESTRUCTIVE TESTING L T P C
3 0 0 3

AIM:

To introduce the importance of non-destructive testing

OBJECTIVE:

To enable the students understand the principles behind various non-destructive testing methods

To make the students understand applications of various non-destructive testing methods

1. INTRODUCTION AND SURFACE NDT METHODS 7

Definition of terms, discontinuities and defects/flaws – fracture mechanics concept of design and the role of NDT – life extension and life prediction – penetrant testing and magnetic particle testing, basic principle of penetrant testing – limitations and advantages – basic principle involved in magnetic particle testing – development and detection of large flux – longitudinal and circular magnetization – demagnetization.

2. RADIOGRAPHIC TESTING 12

Electromagnetic spectrum – X-ray and gamma ray sources – X-ray generation – The spectrum of X-rays – Equipment controls – gamma ray sources – properties of X-rays and gamma rays – attenuation and differential attenuation – interaction of radiation with matter – Principle of radiographic testing and recording medium – films and fluorescent screens – nonimaging detectors – film radiography – calculation of exposure for X-ray and gamma rays – quality factors – Image quality indications and their use in radiography.

3. ULTRASONIC TESTING 10

Ultrasonic waves – velocity, period, frequency and wavelength – reflection and transmission – near and far field effects and attenuation – generation – piezoelectric and magnetostriction methods – normal and angle probes – methods of Ultrasonic testing – Principle of pulse echo method – Equipment – examples – rail road inspection, wall thickness measurement – range and choice of frequency.

4. EDDY CURRENT TESTING 6

Introduction – Principles of eddy current inspection – conductivity of a material – magnetic properties – coil impedance – lift off factor and edge effects – skin effect – inspection frequency – coil arrangements – inspection probes – types of circuit – Reference pieces – phase analysis – display methods – typical applications of eddy current techniques.

5. OTHER METHODS 10

Imaging – principle and applications – testing of composites – acoustic emission testing – application of AET – on-line monitoring or continuous surveillance and applications in materials science – Optical methods of NDT – photo elasticity – evaluation procedure – Holographic NDT procedure – speckle phenomenon – speckle interferometry – speckle shear interferometry – Fourier optics – Fourier filtering techniques for non-destructive testing

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REFERENCES:

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2. Metals Hand Book, Vol.2, 8^{th} Edition, ASTM, Metals Park, Ohio.
3. Dainty, Laser Speckle & Related Phenomena, Springer-Verlag, New York, 1984.
4. Mc Gonnagle, W.J. Non-destructive testing methods, Mc Graw Hill Co., NY, 1961.

ML 9170 ULTRASONICS AND APPLICATIONS **L T P C**
3 0 0 3

AIM:

To introduce the basic principles of ultrasonics and its applications

OBJECTIVE:

To enable the students understand basics of ultrasonics
To make the students understand applications of ultrasonics for various applications

1. ULTRASONIC TRANSDUCERS **9**

Piezoelectric and magnetostrictive transducers - equivalent circuits - Efficiency - Transducer mounting - Mechanical and Electronics, linear and sector transducers - variable frequency systems.

2. ABSORPTION OF ULTRASONIC RADIATION **9**

Classical absorption due to viscosity - Absorption due to thermal conductivity - Relaxation process - Evaluation of dispersion and absorption curves - structural relaxation - relation between collision frequency and relaxation time - Ultrasonic attenuation in solids.

3. ULTRASONIC PROPAGATION IN SOLIDS AND LIQUIDS **9**

Propagation of Ultrasonic waves in solids - Plane wave propagation - Relation between velocity of sound and Elastic properties - Adiabatic and Isothermal elastic constants - Ultrasonic propagation in liquids - Internal pressure and free volume calculations.

4. DETERMINATION OF VELOCITY OF PROPAGATION OF ULTRASOUND **9**

Transit time method - Pulse Echo methods - Acoustic Interferometry - Measurements at high pressure and high temperature - Transducer coupling materials.

5. APPLICATION OF ULTRASONICS **9**

Industrial applications - Medical Applications - Acoustic microscope - Acoustic hologram - ultrasonic transaxial tomography.

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REFERENCES:

1. G.L.Gooberman, Ultrasonics - Theory and Applications, - The English Universities Press Ltd., London, 1968.
2. Schreiber, Anderson and Soga, Elastic Constants and Their Measurement, Mc Graw Hill Book Co., New Delhi, 1973.
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6. W.J.McGonnagle, Nondestructive Testing Methods, McGraw Hill Book Co., New York, 1961.

ML 9171 MICROPROCESSOR BASED INSTRUMENTATION

L T PC
3 0 0 3

AIM:

To introduce the basic concepts microprocessor based instrumentation

OBJECTIVE:

To enable the students understand principles behind microprocessors
To make the students understand microprocessor based applications for various instrumentation

1. MICROPROCESSOR ARCHITECTURE AND PROGRAMMING 12

Introduction to microprocessors and microcomputers, tristate logic, buffers, transreceivers, bus structure of microcomputers, 8086-8088 microprocessors: introduction, internal architecture, assembly language programming, examples involving basic data transfer, arithmetic operations, code conversions: binary, BCD, ASCII, timing, delay generation, sorting of numbers and names, etc. 8086/8088 hardware features, minimum and maximum modes of operation, clock generator, bus interface devices, memory decoding, I/O decoding schemes: machine cycle, instruction cycle, fetch and execution cycle etc.

2. INTERFACING TECHNIQUES 10

Principle of interfacing, data transfer schemes, port operation, I/O techniques (memory mapped & I/O mapped). Peripheral chips 8255,8253-8254,8279,8259,8250,8251 etc. Programme development tools, top-down design, assemblers, editors, compilers, interpreters, in-circuit emulators (IE)

3. SIGNAL TRANSMISSION AND DISPLAYS 12

Interfacing using single board computers and PC's, basic input, output operations using ports, interfacing LED's, 7-segment LED displays, LCD alphanumeric displays (dot matrix), stepper motor, DC motor with and without feedback control, opto-isolation, interfacing data converters, DAC's ADC's, digital gain control , multiplexing, signal conditioning using sample/hold circuits, data acquisition systems (DAS).

4. INTERFACING STANDARDS AND APPLICATIONS 6

Bus standards, serial and parallel buses (RS232C and IEEE 488 and later modifications), modems, brief introduction to LAN. Interfacing with reference to specific experiments in the Physics Laboratory, a few case studies: PC-based crystal growing furnace, temperature control, crystal pulling schemes and Biomedical instrumentation applications.

5. MICRO CONTROLLERS 5

Single chip controllers (80848,8051,8096 families): one of them in detail with a specific prototype. Sensors and transducers in physical measurements: optical, mechanical, magnetic, displacement, temperature, pressure etc.

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ML 9172 MEASUREMENT AND INSTRUMENTATION L T P C
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AIM:

To introduce the basic concepts about measurement principles and instrumentation

OBJECTIVE:

To enable the students understand the importance of measurements
To make the students understand the principle behind instrumentation for measurement

1. PHYSICAL MEASUREMENT (7)

Measurement – result of a measurement – uncertainty and experimental error – systematic error – random error – repeated measurements – data distribution functions; mathematical description, derivation and properties – propagation error – analysis of data – multiparameter experiments.

2. INSTRUMENTATION SYSTEM DESIGN (8)

Experiment design – transducers – characteristics of transducers – selection of transducer – modeling external circuit components – instrument probes – power measurements – measurement methods – dc and ac bridge measurements – LCR bridges – Q meter – Megger.

3. BRIDGES, RECORDERS AND TRANSDUCERS (12)

Wheatstone's bridge – Kelvin's bridge – double bridge – bridge controlled circuits – digital readout bridges – AC bridges – bridges for capacitance and inductance comparison – Wien bridge – resonance bridge – types of detectors – strip chart recorders – X-Y recorders – digital data recording – recorder specifications – applications – electrical, resistive transducers – strain gauges – RTD – thermistor – LVDT – pressure inductive transducers – capacitive transducer (pressure) – load cell (pressure cell) – piezo electric, photoelectric and photo-voltaic transducers – photo diode and photo transistor – temperature and frequency generating transducers – flow measurements.

4. INSTRUMENTATION ELECTRONICS (8)

Op-amps – instrumentation amplifier – signal conditioning – filters - analog signal processing – high speed A/D conversion – D/A conversion – digital logic levels – digital instrumentation – frequency measurements – FFT – sampling time and analyzing – IEEE 488 interface bus – LabView (basics) – nuclear instrumentation.

5. ADVANCED MEASUREMENTS (10)

Spectroscopic instrumentation – visible and IR spectroscopy – spectrometer design – refraction and diffraction – lenses and refractive optics – dispersive elements – lasers – fiber optics – X-ray fluorescence: line spectra and fine structure – absorption and emission processes – X-ray production – X-ray diffraction and crystallography – neutron diffraction – TEM – SEM – atomic force and tunneling scanning microscope.

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