ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M. Sc. MATERIALS SCIENCE (2 YEARS)

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I. To make the students in mastering in the field of materials science and prepare them for research.

II. To provide students with a solid foundation in mathematical, scientific and fundamentals of Materials Science and to impart knowledge on preparation, processing, characterization and applications of various kinds of Materials.

III. To train students with good scientific and sound knowledge of Materials Science so as to comprehend, analyze, design, and provide solutions for the real life problems.

IV. To inculcate the students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate Materials Science aspects to broader social context.

V. To provide students an academic environment to develop excellence in leadership qualities, practice ethical codes and guidelines, and achieve life-long learning needed for a successful professional career.

PROGRAMME OUTCOMES (POs):

On successful completion of the programme,

1. The students will acquire a solid foundation in mathematical, scientific and fundamentals of basic Materials Science
2. The students will have a sound knowledge on preparation, processing, characterization and applications of various kinds of Materials.
3. Students will develop an ability to identify, formulate and solve problems related to Materials Science.
4. Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
5. Students will develop an ability to design and conduct experiments, analyze and interpret data.
6. Students will be able to prepare and characterize materials both at different length scales including micro and nanoscale and analyze various properties.
7. Students will demonstrate knowledge of professional and ethical responsibilities.
8. Students will be able to communicate effectively in both verbal and written form.
9. Students will show the understanding of impact of Materials Science on the society and also will be aware of contemporary issues.
10. Students will develop confidence for self education and ability for life-long learning.

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CURRICULA AND SYLLABI

SEMESTER - I

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MC7101	Classical Mechanics and Statistical Thermodynamics	FC	3	3	0	0	3
2.	MC7102	Electronics and Instrumentation	PC	3	3	0	0	3
3.	MC7103	Mathematical Physics	FC	4	4	0	0	4
4.	MC7104	Physics of Materials – I	PC	3	3	0	0	3
5.	ME7151	Engineering Graphics and Workshop Practice	PC	4	2	0	2	3
PRACTICAL								
6.	MC7111	Materials Science Laboratory - I	PC	6	0	0	6	3
			TOTAL	**23**	**15**	**0**	**8**	**19**

SEMESTER - II

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MC7201	Characterization of Materials	PC	3	3	0	0	3
2.	MC7202	Crystallography and Crystal Growth	PC	3	3	0	0	3
3.	MC7203	Electromagnetic Theory and Optics	PC	3	3	0	0	3
4.	MC7204	Numerical Methods for Materials Science	PC	4	4	0	0	4
5.	MC7205	Physics of Materials – II	PC	3	3	0	0	3
6.	MC7206	Quantum Mechanics	FC	3	3	0	0	3
PRACTICAL								
7.	MC7211	Materials Science Laboratory - II	PC	6	0	0	6	3
			TOTAL	**25**	**19**	**0**	**6**	**22**

SEMESTER - III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MC7301	Introduction to Nanoscience and Technology	PC	3	3	0	0	3
2.	MC7302	Physical Metallurgy	PC	3	3	0	0	3
3.	MC7303	Polymer and Composite Materials	PC	3	3	0	0	3
4.		Elective I	PE	3	3	0	0	3
5.		Elective II	PE	3	3	0	0	3
PRACTICAL								
6.	MC7311	Materials Science Laboratory – III and Mini Project	PC	6	0	0	6	3
7.	MC7312	Seminar	EEC	2	0	0	2	1
			TOTAL	**23**	**15**	**0**	**8**	**19**

SEMESTER - IV

SI.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective III	PE	3	3	0	0	3
2.		Elective IV	PE	3	3	0	0	3
3.		Elective V	PE	3	3	0	0	3
PRACTICAL								
4.	MC7411	Project Work	EEC	20	0	0	20	10
			TOTAL	**29**	**9**	**0**	**20**	**19**

TOTAL NO. OF CREDITS: 79

FOUNDATION COURSES (FC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Classical Mechanics and Statistical Thermodynamics	FC	3	3	0	0	3
2.		Mathematical Physics	FC	4	4	0	0	4
3.		Quantum Mechanics	FC	3	3	0	0	3

PROFESSIONAL CORE (PC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Electronics and Instrumentation	PC	3	3	0	0	3
2.		Physics of Materials – I	PC	3	3	0	0	3
3.		Engineering Graphics and Workshop Practice	PC	4	2	0	2	3
4.		Electromagnetic Theory and Optics	PC	3	3	0	0	3
5.		Numerical Methods for Materials Science	PC	4	4	0	0	4
6.		Characterization of Materials	PC	3	3	0	0	3
7.		Crystallography and Crystal Growth	PC	3	3	0	0	3
8.		Physics of Materials – II	PC	3	3	0	0	3
9.		Physical Metallurgy	PC	3	3	0	0	3
10.		Introduction to Nanoscience and Technology	PC	3	3	0	0	3
11.		Polymer and Composite Materials	PC	3	3	0	0	3
12.		Materials Science Laboratory - I	PC	6	0	0	6	3
13.		Materials Science Laboratory - II	PC	6	0	0	6	3
14.		Materials Science Laboratory – III and Mini Project	PC	6	0	0	6	3

PROFESSIONAL ELECTIVES (PE)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MC7001	Advances in Crystal Growth	PE	3	3	0	0	3
2.	MC7002	Advances in X-ray Analysis	PE	3	3	0	0	3
3.	MC7003	Biomaterials	PE	3	3	0	0	3
4.	MC7004	Ceramic Materials	PE	3	3	0	0	3
5.	MC7005	Composite Materials and Structures	PE	3	3	0	0	3
6.	MC7006	Corrosion Science and Engineering	PE	3	3	0	0	3
7.	MC7007	High Pressure Science and Technology	PE	3	3	0	0	3
8.	MC7008	Laser and Applications	PE	3	3	0	0	3
9.	MC7009	Materials Processing	PE	3	3	0	0	3
10.	MC7010	Nanoelectronics and Photonics	PE	3	3	0	0	3
11.	MC7011	Nanomaterials Preparation and Characterization	PE	3	3	0	0	3
12.	MC7012	Nanoscale Fabrication and Techniques	PE	3	3	0	0	3
13.	MC7013	Non-Destructive Testing	PE	3	3	0	0	3
14.	MC7014	Nonlinear Optics and Materials	PE	3	3	0	0	3
15.	MC7015	Nuclear Physics and Reactor Materials	PE	3	3	0	0	3
16.	MC7016	Semiconducting Materials and Devices	PE	3	3	0	0	3
17.	MC7017	Smart Materials and Structures	PE	3	3	0	0	3
18.	MC7018	Solid State Ionics	PE	3	3	0	0	3
19.	MC7019	Superconducting Materials and Applications	PE	3	3	0	0	3
20.	MC7020	Thin Film Science and Technology	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Seminar	EEC	2	0	0	2	1
2.		Project Work	EEC	20	0	0	20	10

MC7101 CLASSICAL MECHANICS AND STATISTICAL THERMODYNAMICS **L T P C 3 0 0 3**

OBJECTIVE

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

UNIT I CLASSICAL MECHANICS 9

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

UNIT II THERMODYNAMICS 9

Laws of thermodynamics- internal energy- Enthalpy- Entropy- Helmholtz and Gibbs free energies – Thermodynamic relations – Euler equation – Maxwell's relations and applications – Chemical Potential- Gibbs phase rule – phase equilibria (single and multicomponent systems) - Clausius – Clayperon equation – law of mass action – first order phase transition in single component systems – Second order phase transition.

UNIT III CLASSICAL AND QUANTUM STATISTICS 9

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

UNIT IV APPLICATION OF STATISTICS 9

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

UNIT V 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.

TOTAL: 45 PERIODS

OUTCOME

- The students will gain knowledge on classical theories of particle mechanics, thermo dynamical aspects and statistical functions.

REFERENCES

1. M.C.Gupta. Statistical Thermodynamics. Wiley Eastern Ltd., New Delhi, 1993.
2. T.Engel and P.Reid. Thermodynamics, Statistical Thermodynamics & Kinetics, Pearson Education, Inc. 2006.
3. H.B.Callen. Thermodynamics and an Introduction to Thermostatistics. Wiley India Pvt. Ltd. 2014.
4. H.Goldstein, C.P.Poole and J.Safko. Classical Mechanics. Pearson Education, Inc. 2011.
5. J.P.Holman. Heat transfer. Tata McGraw Hill, New Delhi, 2008.
6. F.Reif. Fundamentals of Statistical and Thermal Physics. McGraw Hill, 1995.
7. N.C.Rana and P.S.Joag. Classical Mechanics.Tata McGraw Hill, New Delhi, 2008.

MC7102 ELECTRONICS AND INSTRUMENTATION **L T P C 3 0 0 3**

OBJECTIVE

- Educating the students to understand the basic concepts of electronic devices including nanodevices and their applications

UNIT I ANALOG ELECTRONICS 9

Operational amplifiers: Introduction – differential amplifier – op-amp parameters – feedback-comparators – mathematical operations – analog simulation circuits - oscillators – active filters – instrumentation amplifiers – isolation amplifiers – active diode circuits – OTAs – sample & hold circuits. Voltage regulators: Principles and operations – Nonlinear electronics: Ideas, implications and applications. ‘.

UNIT II DIGITAL ELECTRONICS 9

Introduction – overview of logic functions and logic gates – combinational logic – flip-flops and related circuits – sequential logic – registers, counters, shift-registers and memory – microprocessor architecture – A/D and D/A conversion – DSP fundamentals.

UNIT III OPTOELECTRONICS 9

LEDs – semiconductor lasers – photodiodes – solar cells – photodetectors – optical fibers – communication – optoelectronic modulation and switching devices – optocoupler – optical data storage devices – display devices.

UNIT IV ELECTRONIC INSTRUMENTATION 9

Basics of instrumentation system – transducers – types of transducers – strain gauges – RTDs – LVDT – piezoelectric transducers – load cell – flow meters – signal conditioning – data acquisition and conversion – data transmission – digital signal processing.

UNIT V NANOELECTRONICS 9

MOSFETs - ‘electron transport in nanostructures - resonant tunneling diodes – single electron transfer devices – molecular switches and memory storage – nano-electromechanical systems - quantum dot cellular automata.

TOTAL: 45 PERIODS

OUTCOME

- The students will understand the working principles of various electronic devices, circuits, optoelectronic devices, electronic instrumentation and nanodevices.

REFERENCES

1. A.P.Malvino. Electronic principles. Tata McGraw-Hill, New Delhi, 2011.
2. T.L. Floyd. Electronic devices. Pearson Education Inc., New Delhi, 2012.
3. P.Horowitz and W.Hill. Art of electronics. Cambridge Univ.Press, New Delhi, 2006.
4. L.O.Chua, C.A.Desoer and E.S.Kuh. Linear and Nonlinear Circuits. McGraw-Hill, New Delhi, 1997.
5. M.Lakshmanan and K.Murali. Chaos in Nonlinear Oscillators. World Scientific, Singapore, 1996.
6. P.Bhattacharya. Semiconductor Optoelectronic Devices. Pearson Education Inc., New Delhi, 2002.
7. H.S.Kalsi. Electronic Instrumentation. Tata McGraw-Hill, New Delhi, 2004.
8. W.D.Cooper. Electronic Instrumentation and Measurement Techniques. Prentice Hall of India, 1991.
9. G.W.Hanson. Fundamentals of Nanoelectronics. Pearson Education Inc., New Delhi, 2009.

MC7103 MATHEMATICAL PHYSICS L T P C
4 0 0 4

OBJECTIVE

- To make the students understand the basic mathematical functions necessary for modeling physics problems

UNIT I VECTOR CALCULUS AND MATRICES 12

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

UNIT II SPECIAL FUNCTIONS 12

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.

UNIT III THEORY OF COMPLEX VARIABLES 12

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.

UNIT IV INTEGRAL TRANSFORMS 12

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.

UNIT V PARTIAL DIFFERENTIAL EQUATIONS AND GROUP THEORY 12

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.

TOTAL: 60 PERIODS

OUTCOME

- The students can understand the basics of mathematical functions and apply them in real problems.

REFERENCES

1. L.A.Pipes and Harvil. Applied Mathematics for Engineers and Physicists. McGraw-Hill Book Co., New York, 1980.
2. E.Kreyszig. Advanced Engineering Mathematics. Wiley India Pvt. Ltd., New Delhi, 2011.
3. E. Butkov. Mathematical Physics. Addison Wesley, New York, 1973.
4. B.S.Grewal. Higher Engineering Mathematics, Khanna Publishers, New Delhi, 2013.
5. Sathyapraksh. Mathematical Physics. S.Chand Co., New Delhi, 1994.
6. M.K.Venkatraman. Advanced Mathematics for Engineers and Scientists. National Publishing Co., Madras, 1994.
7. B.D.Gupta. Mathematical Physics. Vikas Publishing House Pvt Ltd, New Delhi, 2004

MC7104 PHYSICS OF MATERIALS – I L T P C

3 0 0 3

OBJECTIVE

- To understand the theoretical concepts of Physics of Materials

UNIT I CRYSTAL STRUCTURE AND BONDING 9

Crystalline solids - crystal systems - Bravais lattices –coordination number – packing factors – cubic, hexagonal, diamond structure, Sodium Chloride Structure – lattice planes – Miller Indices – interplanar spacing – directions. Types of bonding - lattice energy - Madelung constants – Born Haber cycle – cohesive energy.

UNIT II FREE ELECTRON THEORY 9

Drude theory – Wiedemann-Franz Law and Lorentz number –Quantum state and degeneracy-density of states, concentration - free electron statistics (Fermi-Dirac), Fermi energy and electronic Specific heat, Electrical conductivity of metals, – Boltzmann transport theory – electrical and thermal conductivity of electrons.

UNIT III LATTICE DYNAMICS 9

Mono atomic and diatomic lattices – anharmonicity and thermal expansion- phonon –Momentum of phonons, Inelastic scattering of photons by long wavelength phonons, Local phonon model – Einstein and Debye model, density of states, Thermal conductivity of solids- due to electron-due to phonons – thermal resistance of solids – phonon-phonon interaction-normal and Umklapp processes - scattering experiments.

UNIT IV PERIODIC POTENTIALS AND ENERGY BANDS 9

Bloch's theorem – Kronig-Penney model-Construction of Brillouin Zones-Effective mass of electron-nearly free electron model – Tight binding approximation-Construction of Fermi Surfaces-density of states curve-electron, holes and open orbits-Fermi surface studies-Cyclotron resonance, classification into metals, insulators and semiconductors.

UNIT V PHYSICS OF SEMICONDUCTORS AND SUPERCONDUCTIVITY 9

Semiconductors – direct and indirect gaps – carrier statistics (intrinsic and extrinsic) – law of mass action– electrical conductivity and its temperature variation - III - V and II – VI compound semiconductors. 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.

TOTAL: 45 PERIODS

OUTCOME

- The students will gain knowledge on crystal structure, electron transport and classification of solids.

REFERENCES

1. M.A.Wahab. Solid State Physics: Structure and Properties of Materials. Narosa Book Distributors Pvt. Ltd., 2009.
2. S.L.Gupta and V.Kumar. Solid State Physics. K.Nath & Co.,1995.
3. M.Ali Omar. Elementary Solid State Physics. Pearson Education, 2002.
4. M.S.Rogalski and S.B.Palmer. Solid State Physics. Gordon Breach Science Publishers, 2000.
5. N.W.Ashcroft and N.D.Mermin. Solid State Physics, Cengage Learning, 2003.
6. A.J Dekker. Solid State Physics. Macmillan India, 2000.

ME7151 ENGINEERING GRAPHICS AND WORKSHOP PRACTICE L T P C
2 0 2 3

OBJECTIVE

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

1. ENGINEERING GRAPHICS 30

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.

TOTAL: 60 PERIODS

OUTCOME

- The students will be able to understand the concept on basic drawing / graphics, and concept on CNC to provide on hand exposure on CNC and various machine tools usage.

REFERENCES

1. N.D.Bhatt. Elementary Engineering Drawing. Charater Publishing Co. 1990.
2. H.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, 2001.
4. S.Kalpajion and S.R.Schmid. Manufacturing Engineering and Technology, Prasson Education, Inc., 2002.
5. Radhakrishnan. C.N.C. Machines. New Central Book Agency, 1992
6. B. Hodges. CNC Part programming work book, City and Guilds. MacMillan, 1994
7. S.K.Hajra Choudry. Elements of Workshop Teaching, Vol.I and II. Tata McGraw Hill Publishing Co., New Delhi, 1992.

MC7111	MATERIALS SCIENCE LABORATORY – I	L T P C
		0 0 6 3

OBJECTIVE

To carry out experiments to determine the elastic, dielectric and magnetic properties of the materials. Also, to expose the students with basic electronics experiments.

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

TOTAL: 90 PERIODS

LABORATORY EQUIPMENTS REQUIREMENTS:

1. X-Y translation microscope

2. Thermostats
3. Ultrasonic generator
4. Multimeters
5. IC's transistors and resistors

OUTCOME

The students will get a better understanding of the concepts studied by them and correlate both the theory and experiment.

MC7201 CHARACTERISATON OF MATERIALS L T P C
3 0 0 3

OBJECTIVE

- To introduce various methods available for characterizing the materials

UNIT I THERMAL ANALYSIS 9

Introduction – thermogravimetric analysis (TGA) – instrumentation – determination of weight loss and decomposition products – differential thermal analysis (DTA)- cooling curves - differential scanning calorimetry (DSC) – instrumentation – specific heat capacity measurements – determination of thermomechanical parameters .

UNIT II MICROSCOPIC METHODS 9

Optical Microscopy: optical microscopy techniques – Bright field – Dark field optical microscopy – phase contrast microscopy -differential interference contrast microscopy - fluorescence microscopy - confocal microscopy - Metallurgical microscope.

UNIT III ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY 9

SEM- FESEM- EDAX,- HRTEM: working principle and Instrumentation – sample preparation – scanning probe microscopy - STM – AFM - working principle, Instrumentation and modes of operation.

UNIT IV ELECTRICAL AND OPTICAL METHODS OF CHARACTERISATION 9

Two probe and four probe methods- van der Pauw method – Hall probe and measurement – scattering mechanism – C-V, I-V characteristics – Schottky barrier capacitance – impurity concentration – electrochemical C-V profiling – limitations - Photoluminescence – light – matter interaction – instrumentation – electroluminescence – instrumentation – Applications.

UNIT V SPECTROSCOPY 9

Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, ESR, NMR, NQR, ESCA and SIMS- proton induced X-ray Emission spectroscopy (PIXE) – application – mass spectroscopy.

TOTAL: 45 PERIODS

OUTCOME

- The students are exposed with thermal, microscopic, electrical and spectroscopic methods of characterization.

REFERENCES

1. R.A.Stradling and P.C.Klipstain. Growth and Characterization of semiconductors. Adam Hilger, Bristol, 1990.
2. J.A.Belk. Electron Microscopy and Microanalysis of Crystalline Materials. Applied Science Publishers, London, 1979.
3. L. E.Murr. Electron and Ion microscopy and Microanalysis principles and Applications. Marcel Dekker Inc., New York, 1991.
4. D.Kealey & P.J.Haines, Analytical Chemistry, Viva Books Private Limited, New Delhi, 2002.
5. Banwell, Fundamentals of Molecular Spectroscopy, McGraw-Hill Education, Pvt. Ltd., 2013.

MC7202 **CRYSTALLOGRAPHY AND CRYSTAL GROWTH** **L T P C**
3 0 0 3

OBJECTIVE

- To introduce crystal symmetry, basics of X-ray diffraction and growth of crystals

UNIT I CRYSTAL SYMMETRY AND STRUCTURES 9

Symmetry operations, elements - translational symmetries - point groups - space groups - equivalent positions – close packed structures - voids - important crystal structures – Pauling's rules - defects in crystals – polymorphism and twinning.

UNIT II X-RAY DIFFRACTION 9

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)

UNIT III SINGLE CRYSTAL AND POWDER DIFFRACTION 9

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.

UNIT IV CRYSTAL GROWTH THEORY 9

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.

UNIT V CRYSTAL GROWTH TECHNIQUES 9

Bridgman technique - Czochralski method - Verneuil technique - zone melting – gel growth – solution growth methods – low and high temperature solution growth methods – vapour growth - epitaxial growth techniques- LPE – MOCVD - MPE

TOTAL: 45 PERIODS

OUTCOME

- The students can understand the basics crystalline materials, X-ray diffraction and methods of growing single crystals.

REFERENCES

1. H.E.Buckley. Crystal growth. John Wiely & sons, New York,1981.
2. D.Elwell and H.J.Scheel. Crystal growth from high temperature solution. Academic Press, New York,1995.
3. R.A.Laudise. The growth of single crystals. Prentice Hall, Englewood,1970.
4. P.Ramasamy and P.Santhanaraghavan. Crystal growth processes and methods. KRU Publications, 2000.
5. L.V.Azaroff. Elements of X-ray crystallography. Techbooks, 1992.
6. J.A.K.Tareen and T.R.N.Kutty. A basic course in crystallography. University Press, 2001.
7. C.Hammond. The Basics of Crystallography and Diffraction, IUCr-Oxford University Press, 2009.

MC7203 **ELECTROMAGNETIC THEORY AND OPTICS** **L T P C**
3 0 0 3

OBJECTIVE

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

UNIT I MAXWELL'S EQUATIONS 9

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.

UNIT II ELECTROMAGNETIC WAVE PROPAGATION 9

Plane electromagnetic waves in free surface - Poynting vector - characteristic impedance - wave equation in an isotropic medium - wave equation in insulators and conductors - reflection by a perfect conductor - normal and oblique incidence - Fresnel equations for parallel and perpendicular polarisation - Hollow rectangular wave guide.

UNIT III CRYSTAL OPTICS 9

Crystal symmetry-Light propagation in anisotropic media – Maxwell's equations: the constitutive relation -Index ellipsoid – walk off – wave plates – Biaxial media: Optic axes – positive and negative crystals - Electrical conductivity tensor- - stress optic tensors - third rank tensors – piezoelectricity- Linear Electro-optic effect - Fourth rank tensors: third order susceptibility tensor and Kerr effect.

UNIT IV OPTICAL ACTIVITY 9

Kerr and pockel effect - applications - Harmonics and sum & frequency generation stimulated Brillouin scattering - stimulated Raman scattering – SERS – combination of lenses

UNIT V NONLINEAR OPTICS 9

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

TOTAL: 45 PERIODS

OUTCOME

- The students gain knowledge on Maxwell's equation, wave propagation, linear and nonlinear optical properties of materials with theoretical background.

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 P.Lorrain, Introduction to Electromagnetic Fields and Waves, D.B.Taraporevale Sons & Co. Pvt. Ltd., Bombay, 1970.
4. A.Yariv and P.Yeh. Photonics. Oxford University Press, 2007
5. G. New, Introduction to Nonlinear Optics, Cambridge University Press, New Delhi, 2011.

MC7204 **NUMERICAL METHODS FOR MATERIALS SCIENCE** **L T P C**
4 0 0 4

OBJECTIVE

- To expose the students with various mathematical methods for numerical analysis and use of software tools

UNIT I MATLAB/SCILAB PROGRAMMING 12

Overview of Matlab – data types and variables – operators – flow control – functions – input-output – array manipulation – writing and running programs – plotting – overview of simulink environment.

UNIT II SYSTEM OF EQUATIONS 12

Linear equations: Introduction – linear systems – Gaussian elimination – singular systems – Jacobi iteration - Gauss-Seidel iteration. Nonlinear equations: Introduction – bisection method – rule of false position – Secant method – Newton-Raphson method – Comparison of methods for a single equation – Seidel and Newton's methods for systems of nonlinear equations.

UNIT III INTERPOLATION & CURVE FITTING AND ERROR ANALYSIS 12

Polynomial interpolation theory - Newton's forward and backward interpolation formulae - Lagrange's method - Lagrange's inverse interpolation – piecewise linear interpolation – interpolation with cubic spline – least-squares line - curve fitting – Fourier series and trigonometric polynomials.

UNIT IV NUMERICAL DIFFERENTIATION AND INTEGRATION 12

Numerical differentiation: Finite difference approximations – Richardson extrapolation – derivatives by interpolation. Numerical integration: introduction to quadrature – composite Trapezoidal and Simpson's rule – recursive rules and Romberg integration – Gaussian integration.

UNIT V DIFFERENTIAL EQUATIONS SOLVING AND STATISTICS 12

Initial value problems: Euler method - Taylor series method – Runge-Kutta methods – stability and stiffness – adaptive Runge-Kutta method – Predictor- corrector method – system of differential equations – phase-plane analysis: chaotic differential equations. Boundary value problems:finite-difference method. Statistics: random variable – frequency distribution – expected value, average and mean – variance and standard deviation – covariance and correlation. Generating random numbers – Monte Carlo integration.

TOTAL: 60 PERIODS

OUTCOME

- The students gain knowledge on a systems of equations, probability statistics, error analysis and programming concepts using various software tools.

REFERENCES

1. A. Kharab and R.B. Guenther. An Introduction to Numerical Methods: A MATLAB Approach. CRC Press, Boca Raton, 2012.
2. J. H. Mathews and K. D. Fink. Numerical Methods using MATLAB. Pearson, New Delhi, 2006.
3. C. Woodford and C. Phillips. Numerical Methods with worked examples: MATLAB edition. Springer, Berlin, 1997.
4. M.K.Venkatraman, Numerical Methods in Science and Engineering. National Publishing Company, Madras, 1997.
5. S.S.Sastry. Introductory Methods of Numerical Analysis. Prentice Hall of India, New Delhi, 1992.

MC7205 PHYSICS OF MATERIALS J **II** **L T P C**
3 0 0 3

OBJECTIVE

- To impart knowledge on various properties of materials with examples

UNIT I 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.

UNIT II DIELECTRIC PROPERTIES 9

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

UNIT III MAGNETIC PROPERTIES 9

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

UNIT IV 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.

UNIT V ADVANCED 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 nanoscale materials and their properties.

TOTAL: 45 PERIODS

OUTCOME

- The students are exposed to the mechanical, dielectric, magnetic and optical properties of materials.

REFERENCES

1. V.Raghavan, Materials Science and Engineering: A First Course. PHI Learning, 2013.
2. S.O.Kasap. Principles of Electronic Materials and Devices. Tata McGraw-Hill, New Delhi, 2007.
3. C.Suryanarayana and A.Inoue. Bulk Metallic Glasses, CRC Press, 2011.
4. K.Otsuka and C.M.Wayman. Shape Memory Materials, Cambridge University Press, 1998.

MC7206 QUANTUM MECHANICS L T P C
3 0 0 3

OBJECTIVE

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

UNIT I 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.

UNIT II 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.

UNIT III 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.

UNIT IV 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.

UNIT V 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.

TOTAL: 45 PERIODS

OUTCOME

- The students will be exposed with basic formulation, potential problems, approximation methods and scattering theories.

REFERENCES

1. N.Zettili. Quantum Mechanics: Concepts and Applications, John Wiley & Sons, 2009.
2. V. Devanathan, Quantum Mechanics. Narosa Publishing House Pvt. Ltd, New Delhi, 2005.
3. L.Schiff, Quantum Mechanics, Mc Graw-Hill Book Co., New York, 1996.
4. P.M.Mathews and K.Venkatesan, A Text book of Quantum mechanics, Tata Mc Graw-Hill, New Delhi, 1977.
5. J.J.Sakurai, Modern Quantum Mechanics, Addison Wesley, Tokyo, 1994.

MC7211 MATERIALS SCIENCE LABORATORY – II L T P C
0 0 6 3

OBJECTIVE
To do experiments to determine the electrical, magnetic and various mechanical properties of the materials, and also to grow single crystals by various methods.

LIST OF EXPERIMENTS 45
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 loop
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

Laboratory equipments requirements:

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

TOTAL: 90 PERIODS

OUTCOME

The students will learn about the various methods to determine the strength of the materials, electrical and magnetic properties. They will also become familiar with crystal growth techniques.

MC7301 INTRODUCTION TO NANOSCIENCE AND TECHNOLOGY L T P C
3 0 0 3

OBJECTIVE

- To introduce knowledge on basics of nanoscience and technology

UNIT I NANOSCALE SYSTEMS 9

Length, energy, and time scales - Quantum confinement in 3D, 2D, 1D and zero dimensional structures - Quantum confinement of electrons in semiconductor nanostructures- Size effect and properties of nanostructures- Top down and Bottom up approach.

UNIT II 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 – carbon nanotubes and graphene synthesis

UNIT III QUANTUM DOTS 9

Excitons and excitonic Bohr radius – nanoparticles and quantum dots - Preparation through colloidal methods - Epitaxial methods- MOCVD and MBE growth of quantum dots - Absorption and emission spectra - photo luminescence spectrum - optical spectroscopy – linear and nonlinear optical spectroscopy.

UNIT IV CHARACTERIZATION 9

Crystallite size analysis using Scherrer formula - Particle size measurement using DLS and HRTEM - Atomic Force Microscopy (AFM) and Scanning tunneling microscopy (STM) - applications to nanostructures – Nanomechanical characterization – Nanoindentation – femotosecond laser.

UNIT V 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.

TOTAL: 45 PERIODS

OUTCOME

- The students can understand the importance of nanoscience and technology, and the fundamental concepts behind size reduction.

REFERENCES

1. G.Timp. Nanotechnology. AIP press, Springer-Verlag, New York, 1999.
2. Hari Singh Nalwa. Nanostructured materials and nanotechnology. Academic Press, USA, 2002.
3. Hari Singh Nalwa. Hand book of Nanostructured Materials and Technology. Vol.1-5. Academic Press, USA, 2000.
4. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate. Handbook of Nanoscience, Engineering and Technology (Electrical Engineering Handbook), CRC Press, 2012.
5. C.J. Brinker and G.W. Scherrer. Sol-Gel Science. Academic Press, Boston, 1994.
6. N John Dinardo. Nanoscale Characterization of Surfaces & Interfaces. Weinheim Cambridge: Wiley-VCH, 2000.

MC7302 PHYSICAL METALLURGY L T P C
3 0 0 3

OBJECTIVE

- To impart knowledge of the formation of alloys

UNIT I PHASE DIAGRAMS 9

Composition and classification of pig iron and cast iron – iron ores - manufacture of wrought iron and steel - The phase rule - Types of Binary Diagrams,– invariant reactions- eutectic, eutectoid, peritectic and peritectoid reactions – Thermodynamics, Solution theory - free energy composition curves – Experimental determination of equilibrium diagram-grain size analysis, grain size measurement - effect of grain size on properties of metals and alloys

UNIT II 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

UNIT III HEAT TREATMENT 9

Recovery, recrystallisation and grain growth: property changes, annealing twins, textures in cold worked and annealed alloys,-TTT diagrams – CCT 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.

UNIT IV PHASE TRANSFORMATIONS 9

Types of phase changes – Driving forces, N-G aspects, diffusion in solids – solidification – pearlitic transformations – martensitic transformations – kinetics of transformation - precipitation and age hardening.

UNIT V ENGINEERING ALLOYS 9

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

TOTAL: 45 PERIODS

OUTCOME

- The students will be able to understand phase diagrams, alloys, heat treatment methods and phase transformations.

REFERENCES
1. V.Raghavan, Physical Metallurgy: Principles and Practice, Prentice-Hall of India, New Delhi, 2009.
2. A.G.Guy and J.Hren, Elements of Physical Metallurgy, Oxford Univ. 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. Metallurgy and Materials Science, 1995
6. W.F.Smith, Structural Properties of Engineering Alloys, McGraw Hill Publications, 1993.
7. Y.Lakhtin, Engineering Physical Metallurgy, Mir Publishers, 1998.

MC7303 POLYMER AND COMPOSITE MATERIALS L T P C
3 0 0 3

OBJECTIVE
- To introduce knowledge on polymers and composite materials and its applications

UNIT I 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.

UNIT II PROPERTIES OF POLYMERS 9
Polymer conformation and chain dimensions – Freely jointed chains- 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

UNIT III POLYMER PROCESSING, RHEOLOGY AND APPLICATIONS 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 rheometer - applications-conducting polymers-biopolymers-liquid crystal polymers-photonic polymers-high temperature polymers.

UNIT IV INTRODUCTION TO COMPOSITES 9
Classification 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 – interface region –bonding mechanisms – mechanical behavior of composites.

UNIT V 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.

TOTAL: 45 PERIODS

OUTCOME
- The students will be able to understand different processing methods of polymers and composite materials and impart knowledge on properties and applications of the above materials.

REFERENCES
1. Joel R.Fried, Polymer Science and Technology, Phi Learning Pvt. Ltd., 2009.
2. V.R. Gowarikar, N.V.Viswanathan & J.Sreedhar, Polymer Science, New Age International, 2011.
3. R.J.C.Crawford, Plastics Engineering, Butterworth-Heinemann, 1998.
4. D.Hull & T.W.Clyne, An Introduction to Composite Materials, Cambridge University Press, 2008.
5. P.K.Mallick, Fiber-Reinforced Composites: Materials, Manufacturing and Design, CRC Press, Boca Raton, 2008.

MC7311	MATERIALS SCIENCE LABORATORY - III & MINI PROJECT	L T P C
		0 0 6 3

OBJECTIVE

To expose the students to various materials characterization techniques and to carry out a mini project.

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: 45+45 PERIODS

OUTCOME

The students will learn about various materials characterization techniques and analysis. The students will also be able to perform mini project.

MC7001 ADVANCES IN CRYSTAL GROWTH **L T P C**
3 0 0 3

OBJECTIVE

- To introduce the concepts of advances in crystal growth techniques

UNIT I NUCLEATION 9

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

UNIT II THEORIES OF CRYSTAL GROWTH 9

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

UNIT III MELT GROWTH 9

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

UNIT IV SOLUTION GROWTH 9

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

UNIT V VAPOUR GROWTH 9

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

TOTAL: 45 PERIODS

OUTCOME

- The students will be able to understand the various theories of crystal growth and growing crystals using different techniques.

REFERENCES

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

MC7002 ADVANCES IN X-RAY ANALYSIS **L T P C**
3 0 0 3

OBJECTIVE

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

UNIT I EXPERIMENTAL METHODS 9

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

UNIT II SINGLE CRYSTAL METHODS 9

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).

UNIT III POWDER METHODS 9

Powder cameras: Seeman-Bohlin, Back-reflecton and Guinier cameras - Bragg-Brentano geometry - sample preparation and step data collection – indexing – phase indentification - ICDD powder diffraction file – quantitative phase analysis: external and internal standard methods, direct comparison method. The Rietveld method – fundamentals - peak shapes – profile fitting - structure refinement procedures – R factors – structure determination from powder data – computer programs.

UNIT IV APPLICATIONS 9

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.

UNIT V OTHER STUDIES 9

Wide-angle diffraction, small angle scattering (qualitative study) - Wavelength dispersion and energy dispersion – spectrometers – intensity and resolution - X-ray fluorescence – applications - high pressure diffraction methods – high and low temperature diffraction methods.

TOTAL: 45 PERIODS

OUTCOME

- The students will be able to understand different advanced methods of materials characterization using X-rays and also its application in synthesis of materials.

REFERENCES

1. G.H.Stout and L.Jensen, X–ray Structure Determination: A Practical Guide, Macmillan, New York, 1989.
2. M.M.Woolfson, An introduction to X-ray crystallography, Cambridge Univ. Press, New York, 1997.
3. M. F. C. Ladd and R.A.Palmer, Structure Determination by X-ray Crystallography, Springer, 2003.
4. B.D.Cullilty and S.R.Stock, Elements of X-ray diffraction, Pearson Education Ltd., 2013.
5. R.A.Young, The Rietveld method, IUCR-Oxford University Press, 1995.
6. C.Giacovazzo, Fundamentals of Crystallography, IUCR-Oxford University Press, 2002.

MC7003 BIOMATERIALS L T P C

3 0 0 3

OBJECTIVE

- To introduce the basic concepts about biomaterials

UNIT I 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

UNIT II 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.

UNIT III 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

UNIT IV 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

UNIT V SOFT TISSUE 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

TOTAL: 45 PERIODS

OUTCOME

- The students can understand importance and properties of biomaterials and their applications.

REFERENCES

1. Sujata V. Bhat. Biomaterials, Narosa Publishing House, New Delhi, 2010.
2. J.Park & R.S.Lakes. Biomaterials: An Introduction. Springer, 2007.
3. J. Black. Biological Performance of Materials: Fundamentals of Biocompatibility, Marcel Dekker Inc, New York, 1992.
4. D.F.Williams (editor). Materials Science and Technology: A Comprehensive treatment, Volume 14. Medical and Dental Materials, VCH Publishers Inc, New York, 1992.
5. L.L.Hench and E.C.Ethridge. Biomaterials: An Interfacial Approach, Academic Press, 1982.

MC7004 CERAMIC MATERIALS

L	T	P	C
3	0	0	3

OBJECTIVE

- To introduce knowledge on ceramic materials and its applications

UNIT I CERAMIC PROCESSING 9

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

UNIT II STRUCTURAL CERAMICS 9

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

UNIT III ELECTRONIC CERAMICS 9

Ceramic insulators and capacitors – ferroelectric ceramics – barium titanate, PZT, PLZT materials – properties and applications of electronic ceramics - magnetic ceramics – spinel ferrites, zinc ferrites – applications - garnets – superconducting ceramics – varistors – oxides and non-oxide varistors and fuel cells.

UNIT IV REFRACTORY CERAMICS 9

Refractories – types of refractories - special refractories - silica, alumina, mullite, zirconia, cordierite - carbide based and nitride based refractories – Fusion cast refractories – ceramic fibers – high temperature applications.

UNIT V GLASS CERAMICS 9

Glass forming processes – Glass transition – Glass transformation range - Heat treatment schedule, crystal nucleation in glass, nucleation agent – high purity silica glass, laser glasses, fiber glasses, optical glasses and non-oxide glasses.

TOTAL: 45 PERIODS

OUTCOME

- The students can understand different processing methods of ceramic preparation and impart knowledge on different ceramics such as structural, electronic, refractory and glass.

REFERENCES

1. D.W.Richerson. Modern Ceramic Engineering: Properties, Processing and Use in design. Taylor and Francis Group, New York, 2005.
2. J.S.Reed. Principles of Ceramic Processing. John Wiley & Sons Inc, NY, 1995.
3. M.H.Lewis. Glasses and Glass Ceramics. Chapman and Hall, London, 1992.
4. M.Cable and J.M.Parker. High Performance Glasses. Chapman and Hall, London, 1992.
5. J.H.Chester. Refractories, Production and Properties. Iron and Steel Institute, London, 1992.

MC7005 COMPOSITE MATERIALS AND STRUCTURES L T P C
3 0 0 3

OBJECTIVE

- To introduce the basic aspects of composite materials and structures

UNIT I 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.

UNIT II 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.

UNIT III 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.

UNIT IV 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.

UNIT V 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.

TOTAL: 45 PERIODS

OUTCOME

- The students will be able to understand the importance of composite materials, their properties and applications.

REFERENCES

1. D.Hull and T.W.Clyne. An Introduction to Composite Materials. Cambridge University Press, 2008.
2. K.K.Chawla. Composite Materials: Science and Engineering. Springer-Verlag, New York, 2010.
3. K.K.Chawla. Ceramic Matrix Composites. Chapman & Hall, London, 1993.
4. P.K.Mallick. Fiber-Reinforced Composites: Materials, Manufacturing and Design. CRC Press, Boca Raton, 2008.
5. B.D.Agarwal and L.J.Broutman. Analysis and Performance of Fibre Composites. John Wiley & Sons, 1980.
6. R.M.Jones. Mechanics of Composite Materials. McGraw Hill Co., 1975.

MC7006 CORROSION SCIENCE AND ENGINEERING L T P C
3 0 0 3

OBJECTIVE

- To introduce the importance of corrosion science and engineering

UNIT I CORROSION PROCESSES 9

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.

UNIT II CORROSION TESTING 9

Materials and specimens – surface preparation – measuring and weighing – linear polarization – AC impedance – in vivo corrosion – paint tests – seawater tests.

UNIT III COATING MANUFACTURE 9

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

UNIT IV CORROSION IN SELECTED ENVIRONMENTS 9

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

UNIT V COATING APPLICATIONS 9

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.

TOTAL: 45 PERIODS

OUTCOME

- The students can understand the principles behind corrosion science, various corrosion processes and engineering applications.

REFERENCES
1. D.A.Jones. Principles and Prevention of Corrosion. 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.
3. M.G.Fontana. Corrosion Engineering, Tata McGraw-Hill, 2010.
4. I.M.Hutchings. Tribology: Friction and Wear of Engineering Materials. CRC press, Boca Raton, 1992.
5. D.O. Sprowds. Corrosion Testing and Evaluation. Corrosion Metals Hand book, Vol. 13, 1986.

MC7007 HIGH PRESSURE SCIENCE AND TECHNOLOGY L T P C
3 0 0 3

OBJECTIVE
- To introduce the aspects of High pressure science and the technology

UNIT I METHODS OF PRODUCING HIGH PRESSURE 9
Definition of pressure – Hydrostaticity – generation of static pressure, pressure units – piston cylinder – Bridgmann Anvil – Multi-anvil devices – Diamond anvil cell.

UNIT II MEASUREMENT OF HIGH PRESSURE 9
Primary gauge – Secondary gauge – Merits and demerits – Thermocouple pressure gauge – Resistance gauge – fixed point pressure scale – Ruby fluorescence – Equation of state.

UNIT III HIGH PRESSURE DEVICES FOR VARIOUS APPLICATIONS 9
X-Ray diffraction, Neutron diffraction – Optical studies – Electrical studies – Magnetic studies – High and low temperature applications – Ultra high pressure anvil devices.

UNIT IV HIGH PRESSURE PHYSICAL PROPERTIES 9
PVT Relation in fluids – Compressibility 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.

UNIT V MECHANICAL PROPERTIES UNDER PRESSURE 9
Elastic constants – Measurements – mechanical properties – Tension and compression – Fatigue – Creep – Hydrostatic extrusion. Material synthesis – Superhard materials – Diamond – Oxides and other compounds – water jet.

TOTAL: 45 PERIODS

OUTCOME
- The students will be able to understand the basic concepts of the high pressure and various technological applications of high pressure.

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 and 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.

MC7008 LASERS AND APPLICATIONS L T P C
3 0 0 3

OBJECTIVE

- To introduce knowledge on basics of lasers

UNIT I PRINCIPLES OF LASERS 9

Spontaneous emission, Stimulated emission, Einstein coefficients, ratio of rates of stimulated and spontaneous emission – Threshold condition for laser action – Rate equations – Population inversion in three level and four level systems.

UNIT II OPTICAL RESONATORS 9

Resonant cavities, Gaussian beam characteristics, resonator modes, spot size – Types of resonators, geometries, quality factor of an optical resonator – Q-switching and Modelocking concepts and techniques.

UNIT III LASER SYSTEMS 9

Gas lasers: He-Ne laser, Carbon dioxide gas laser, Nitrogen gas laser, Argon ion gas laser – Solid state lasers: Ruby laser, Nd-YAG laser, fiber laser, Ti-Sapphire- Semiconductor Laser– homojunction and heterojunction lasers- Liquid Lasers: Dye lasers

UNIT IV MATERIALS PROCESSING 9

Laser 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.

UNIT V APPLICATIONS 9

Metrology - interferrometric techniques - Laser ranging and tracking - Laser Doppler velocimetry - Ring laser and rotation sensing - Pollution monitoring - Holography and speckle in displacement and deformation measurements – ions – Medical applications.

TOTAL: 45 PERIODS

OUTCOME

- The students can understand the principle involved in laser action and importance of resonator cavity. The gain knowledge on the principle and working of different types of lasers and applications of lasers.

REFERENCES

1. W.T.Rhodes, W.R.Callen and D.C.O'Shea. An Introduction to Lasers and their Applications. Addison Wesley Professional, 1977.
2. J. Verdeyen. Laser Electronics. Prentice Hall, 1990.
3. S.S. Charchan. Lasers in Industry. Van Nostrand Reinhold Co., 1975.
4. B.B.Laud. Laser and Non-Linear Optics. New Age International (P) Ltd. 2011
5. M.Steen William. Laser Material Processing. Springer, 2008.

MC7009 MATERIALS PROCESSING L T P C
3 0 0 3

OBJECTIVE

- To introduce knowledge on processing of materials used in industries

UNIT I 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.

UNIT II 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.

UNIT III WELDING PROCESSES 9

Various processes of welding, fusion welding, pressure welding, oxyacetelene welding, resistance welding, spot welding, thermit welding, hermetic 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.

UNIT IV 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.

UNIT V 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.

TOTAL: 45 PERIODS

OUTCOME

- The students are able to understand the physics of materials processing and principles behind the different processing techniques.

REFERENCES

1. T.V.Rajan, C.P.Sharma and A. Sharma, Heat treatment-Principles and Techniques, Prentice Hall of India Pvt. Ltd. New Delhi, 1995.
2. M.K.Muralidhara, 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. R.B.Gupta. Materials Science and Processes. Satya Prakashan, New Delhi, 1995.

MC7010 NANOELECTRONICS AND PHOTONICS L T P C
3 0 0 3

OBJECTIVE

- To expose the students to the introductory concepts of nanoelectronics and nanophotonics

UNIT I MATERIALS FOR NANOELECTRONICS 9

Introduction – semiconductors – crystal lattices: bonding in crystals – electron energy bands – semiconductor heterostructures – organic semiconductors – carbon nanomaterials: graphene, nanotubes, and fullerenes.

UNIT II ELECTRON TRANSPORT IN SEMICONDUCTORS & NANOSTRUCTURES 9

Introduction – time and length scales of the electron in solids – statistics of the electrons in solids and nanostructures – density of states of electrons in nanostructures – electron transport in nanostructures.

UNIT III ELECTROMIGRATION 9

Introduction – electro-migration (EM) – wire morphology – electron wind – EM induced stress in nanodevice – current-induced heating in nanowire device – diffusion of material – importance of surfaces – failure of wires – wire heating – EM consequences for nanoelectronics.

UNIT IV LOW-DIMENSIONAL STRUCTURES AND NANODEVICES 9

Introduction – Quantum confinement: Quantum wells, wires and dots – Uses of quantum structures – band gap of nanomaterials. Tunneling – Single electron phenomena: Coulomb blockade – uncertainty - resonant-tunneling diodes – field-effect transistors – single-electron transfer devices. Molecular electronic devices.

UNIT V NANOPHOTONICS 9

Light-matter interaction: Review of Maxwell's equations – dispersion in materials – optical properties of insulators, semiconductors and metals – electromagnetic properties of molecules, microscopic and nano particles – photonic crystals: introduction – basic properties of electromagnetic effects in periodic media – photonic crystal waveguides – photonic devices.

TOTAL: 45 PERIODS

OUTCOME

- The students will gain knowledge on the basics of nanoelectronics, nanoelectronic devices and nanophotonics.

REFERENCES

1. G.W.Hanson. Fundamentals of Nanoelectronics. Pearson, New Delhi, 2009.
2. C.Durkan. Current at the Nanoscale. Imperial College Press, London, 2007.
3. V.V. Mitin, V. A. Kochelap and M.A. Stroscio, Introduction to nanoelectronics. Cambridge University Press, 2008.
4. Supriyo Datta. Quantum Transport: Atom to transistor. Cambridge University Press, Cambridge, 2005.
5. B.Rogers, S.Pennathur and J. Adams. Nanotechnology: Understanding small systems. CRC Press, Boca Raton, 2008.

MC7011 NANOMATERIALS PREPARATION AND CHARACTERIZATION L T P C
3 0 0 3

OBJECTIVE

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

UNIT I BASIC PROPERTIES OF NANOPARTICLES 9

Size effect and properties of nanoparticles - particle size - particle shape - melting point, surface tension, wettability - specific surface area and pore size – Reason for change in optical properties, electrical properties, and mechanical properties - advantages

UNIT II NANOTUBES 9

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

UNIT III NANOWIRES AND NANOFIBERS 9

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

UNIT IV CHARACTERIZATION 9

FESEM - 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)

UNIT V 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 - Millipede for storage – nano-material sensors

TOTAL: 45 PERIODS

OUTCOME

- The students will understand the principle involved in preparation and characterization of nanostructures and fabrication of nanodevices.

REFERENCES

1. Masuo Hosokawa, Kiyoshi Nogi, Makio Naito, Toyokazu Yokoyama, Nanoparticle Technology Handbook, Elsevier Publishers, 2007.
2. A.S.Edelstein (Editor), Nanomaterials Synthesis, properties and applications, IOP Publishing, UK, 1996.
3. Hari Singh Nalwa (Editor), Nanostructured materials and nanotechnology, Academic Press, USA, 2002.
4. Hari Singh Nalwa (Editor), Hand book of Nanostructured Materials and Technology, Vol.1-5, Academic Press, USA, 2000.
5. T.W.Ebbesen (Editor), Carbon nanotubes: preparation and properties, CRC Press, USA, 1997.
6. Zhon Ling Wang, Characterization of nanophase materials, Wiley-VCH Verlag GmbH, 2000.

MC7012 NANOSCALE FABRICATION AND TECHNIQUES L T P C
3 0 0 3

OBJECTIVE

- To introduce the aspects of nanoscale fabrication techniques.

UNIT I 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.

UNIT II CLEAN ROOM 9

Clean room and its importance – Types of clean rooms – maintenance of different types of clean rooms – standardization – peripherals - oxidization and metallization- masking and patterning

UNIT III 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.

UNIT IV NANO-FABRICATION 9

Etching technologies - wet and dry etching - photolithography – Drawbacks of optical lithography for nanofabrication - electron beam lithography – ion beam lithography - strain-induced self-assembly for Nanofabrication of quantum dots and molecular architectures - Polymer processing for biomedical applications

UNIT V 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.

TOTAL: 45 PERIODS

OUTCOME

- The students will understand the basic aspects of various lithographic techniques and the importance of clean room facility. They also understand various device characterization techniques.

REFERENCES

1. T.R.Hsu. MEMS & Microsystems Design and Manufacture.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. Springer-Verlag, 2004.
5. J.A.Pelesko and D.H.Bernstein. Modeling MEMS and NEMS. Boca Raton, Chapman &Hall/CRC, 2003.

MC7013 NON-DESTRUCTIVE TESTING L T P C
3 0 0 3

OBJECTIVE

- To introduce the importance of non-destructive testing

UNIT I INTRODUCTION AND SURFACE NDT METHODS 9

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.

UNIT II RADIOGRAPHIC TESTING 9

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 – neutron radiography.

UNIT III ULTRASONIC TESTING 9

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.

UNIT IV EDDY CURRENT TESTING 9

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.

UNIT V THERMAL AND OPTICAL METHODS 9

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

TOTAL: 45 PERIODS

OUTCOME

- The students will understand the principles behind various non-destructive testing methods and applications of various non-destructive testing methods.

REFERENCES

1. B.Hull and V.John. Nondestructive Testing. Mc Millan Education Ltd., London, 1988.
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.

MC7014 NONLINEAR OPTICS AND MATERIALS L T P C
3 0 0 3

OBJECTIVE

- To expose the students to the concept of nonlinear optics and different types of nonlinear optical materials.

UNIT I ELECTROMAGNETIC THEORY 9

Maxwell equations – wave equations in various media and its propagation – origin of complex refractive index – classical theory of optical absorption (electron oscillator model) and dispersion (Lorenz oscillator model) – classical theory of anharmonic oscillators.

UNIT II OPTICAL SUSCEPTIBILITIES 9

Wave equation description of nonlinear optical susceptibilities – quantum mechanical treatment of nonlinear optical susceptibilities – frequency and intensity dependence of polarization – and dielectric susceptibility – first and higher order susceptibilities.

UNIT III SECOND-ORDER NONLINEARITIES 9

Second harmonic generation – sum and difference frequency generation – parametric processes – simple theory and calculations of nonlinear polarization – various phase matching techniques in second harmonic generation (SHG).

UNIT IV THIRD-ORDER NONLINEARITIES 9

Third harmonic generation – four-wave mixing – Kerr nonlinearity – intensity dependent effect – self-phase modulation – cross-phase modulation. Stimulated Raman scattering – stimulated Brillioun scattering. Parametric gain – parametric amplification and oscillation -. Applications of frequency mixing and up-conversion – difference frequency generation – optical phase conjugation: theory and applications – Photorefractive effect and applications – solitons: theory and applications – optical bistability.

UNIT V NONLINEAR OPTICAL MATERIALS 9

Nonlinear optics of organic materials and polymers – liquid crystals – photorefractive materials – organic doped glasses – rare earth doped glasses and crystals – semiconductors – optical fibers and photonic crystal fibers – ferroelectric materials and other novel optical materials.

TOTAL: 45 PERIODS

OUTCOME

- The students will be able to understand nonlinear optics and different types of materials used to observe nonlinearity and construction of devices.

REFERENCES

1. R.W.Boyd. Non-linear Optics. Academic Press, London, 2008.
2. Y.V.G.S.Murti and C.Vijayan. Essentials of Nonlinear Optics. Wiley (2014).
3. Y.R.Shen. Principles of Nonlinear optics. Wiley-Interscience, New York ,2003.
4. N. Bloembergen. Nonlinear Optics. World Scientific, Singapore, 2005.
5. G.S.He and S.H.Liu. World Scientific, Singapore, 1999.
6. N.B.Singh. Growth and characterization of nonlinear optical materials. Pergamon Press, 1990.

MC7015 NUCLEAR PHYSICS AND REACTOR MATERIALS **L T P C**
3 0 0 3

OBJECTIVE

- To introduce the importance of and properties of nuclear materials

UNIT I 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.

UNIT II 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 chromodynamics.

UNIT III 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.

UNIT IV NEUTRON AND REACTOR PHYSICS 9

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

UNIT V 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.

TOTAL: 45 PERIODS

OUTCOME

- The students will understand the physics of nuclear reactors and properties of nuclear reactor materials.

REFERENCES

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

MC7016 SEMICONDUCTING MATERIALS AND DEVICES **L T P C**
3 0 0 3

OBJECTIVE

- To study the properties of materials being used for semiconductor devices and to understand device fabrication process steps to realize transistor, LED's and sensors

UNIT I INTRODUCTION 9

Introduction: Properties of semiconductors - Free electron Theory - Transport properties. Bonds and Bands in Semiconductor: - Electronic band structure - Junction Properties of semiconductors - Recombination mechanism - Electron, Hole recombination through traps - Junction properties of p-n, n+-n, p+-p junctions - Surface recombination - Recombination with donors and acceptors at low temperatures - Quantum theory of junction devices - Generation of recombination processes in junction devices

UNIT II OPTICAL PROPERTIES 9

Optical properties of semiconductors - Optical constants - Light absorption spectrum - Light absorption edge - Effect of free charge carriers on the absorption edge - Fundamentals of absorption and reflection - Electron transport phenomena: Theory of electron transport in crystalline semiconductors - Boltzmann's transport equation for Bloch states - relaxation time - relaxation time approximation to the low field transport coefficients - scattering mechanism - Thermal effects in Semiconductors: Thermal conductivity - Thermo-electric power - Thermomagnetic effects - condition of degeneracy - strong magnetic fields - relative magnitudes of the magnetic effects. Optical and High frequency effects in Semiconductor.

UNIT III TRANSPORT PROPERTIES 9

Basic Process in Semiconductor Devices: Equilibrium properties - electrons and holes - impurities in semiconductors - carrier concentration as a function of temperature - High doping effects - Non-equilibrium phenomena - carrier transport - Transport properties in high fields - recombination and generation processes - breakdown mechanism - Basic equations for Semiconductor devices - equations for the interior of devices - boundary conditions - Systems, Material preparation - Material Characterisation - important processes for optoelectronic devices - Hetero junctions and Heterostructures.

UNIT IV FABRICATION OF TRANSISTORS AND THYRISTORS 9

Unipolar devices: Metal-Semiconductor contacts - Energy - Band Relation - Schottky Effect - Characterization of Barrier Height - Device Structure - Ohmic Contact - JFET and MESFET - basic device characteristic - general characteristic - Microwave performance - related field-effect devices - MIS diode - Si-SiO2 MOS diode - Charge-Coupled Device - MOSFET - basic device characteristic - Nonuniform doping and buried-channel devices - short-channel effect - MOSFET Structures - Nonvolatile memory devices. Bipolar transistor - Static characteristics - microwave transistor - power transistor - switching transistor - related device structures - Thyristors - basic characteristics - Schottky diode - Three terminal thyristor - related power thyristor - Unijunction transistor and trigger thyristor - Field-controlled thyristor.

UNIT V FABRICATION OF LED'S AND SENSORS 9

Photonic Devices: Light Emitting diodes - LED for fiber optics - LED performance - reliability - Semiconductor Laser - Lasers for optical communication system - future trends in Fiber optic communications - Photodetectors - Photoconductor - Photodiode - Avalanche Photodiode - Phototransistor - Solar cells - Thin film solar cells - solid state sensors, optical Sensors - optoelectronic components.

TOTAL: 45 PERIODS

OUTCOME

- Upon completion of this course, the students will understand different properties of semiconductors, the properties of materials being used for semiconductor devices and different fabrication steps involved in realizing transistors, LED's and sensors.

REFERENCES
1. S.M.Sze. Physics of Semiconductor devices. Wiley India, New Delhi, 2008.
2. S.P.Keller. Handbook on Semiconductors, Vol. 1-4. T.S. Moss, Ed., North-Holland, Amsterdam, 1980.
3. C.M.Wolfe, J.R.N.Holonyak and G.E.Stillman. Physical Properties of Semiconductors. Prentice Hall International Inc., London, 1989.
4. P.N.Butcher, N.H.March and M.P.Tosi. Crystalline Semiconducting materials and devices. Plenum Press New York and London, 1986.
5. D.A.Fraser. The Physics of Semiconductor devices. Clarendon Press, Oxford, 1986.
6. D.K.Schroder. Semiconductor Material and Device Characterization. John Wiley & Sons Inc., New York,1990.
7. D. L. Pulfrey and N.Garry Tarr. Introduction to Microelectronic Devices. Prentice-Hall international editions, New Delhi,1989.
8. P. Gise & R. Blanchard. Modern Semiconductor Fabrication Technology. Prentice-Hall, New Jersey, 1986

MC7017	SMART MATERIALS AND STRUCTURES	L T P C
		3 0 0 3

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

UNIT I INTRODUCTION 9
Classification of materials and their uses – 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.

UNIT II 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.

UNIT III 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.

UNIT IV 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.

UNIT V SHAPE – MEMORY 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- SMA blood clot filter – Impediments to applications of SMA – SMA plastics – primary molding – secondary molding – Potential applications of SMA plastics.

TOTAL: 45 PERIODS

OUTCOME

- The students will understand the importance and structure of smart materials and applications of smart materials.

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.

MC7018 SOLID STATE IONICS L T P C 3 0 0 3

OBJECTIVE

- To introduce the basic concepts about solid state ionics

UNIT I 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.

UNIT II 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.

UNIT III 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.

UNIT IV 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.

UNIT V 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.

TOTAL: 45 PERIODS

OUTCOME

- The students will understand the concepts behind solid state ionic materials and their use in battery fabrication.

REFERENCES
1. H.V.Keer. Principles of Solid State Physics. Wiley Eastern Ltd, New Delhi, 1993.
2. S.Chandra. Superionic Solids-Principles and applications. North Holland Amsterdam, 1981.
3. D.S.Clive, Modern Battery Technology, Alean International Ltd, Banbury, Elis Horwood Publishers, 1991.
4. T.R.Crompton. Battery reference book, Reed Educational and Professional Publishing Ltd, SAE International, 1996.
5. Ozin, Geoffrey.A, Arsenault, Andre C, Nanochemistry, A chemical approach to nanomaterials, Springer, 2005.

MC7019 SUPERCONDUCTING MATERIALS AND APPLICATIONS **L T P C**
3 0 0 3

OBJECTIVE
To introduce the aspects of the superconductivity

UNIT I 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.

UNIT II SUPERCONDUCTING MATERIALS **9**
Elemental superconductors – superconducting compounds and its alloys – A-I5 compounds – chevral phase compounds

UNIT III 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.

UNIT IV 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.

UNIT V 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.

TOTAL: 45 PERIODS

OUTCOME
- The students will understand the basic concepts of superconductivity and superconducting materials. They also understand various technological application of the superconductivity.

REFERENCES
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2. D.R.Tilley and Tilley. Superfluidity and Superconductivity. Adam Hilger, 1986.
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MC7020 THIN FILM SCIENCE AND TECHNOLOGY L T P C
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OBJECTIVE

- To introduce the basic concepts of various thin film deposition techniques and their applications

UNIT I HIGH VACUUM PRODUCTION 9

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

UNIT II PREPARATION METHODS 9

Physical methods: thermal evaporation - vapour sources - Wire, crucible and electron beam gun - sputtering mechanism and methods - Pulsed laser deposition (PLD), photochemical deposition (PCD) - Chemical methods: chemical vapour deposition and chemical solution deposition techniques - spray pyrolysis - laser ablation.

UNIT III 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 -

UNIT IV GROWTH AND STRUCTURE OF FILMS 9

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

UNIT V 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

TOTAL: 45 PERIODS

OUTCOME

- The students will gain the knowledge of different thin film deposition techniques, growth aspects and their applications.

REFERENCES

1. M. Ohring. The Materials Science of Thin Films. Academic Press, 2001.
2. D. L.Smith. Thin-Film Deposition: Principles and Practice. McGraw-Hill, 1995.
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5. L.I. Maissel and R. Glang (Eds.), Handbook of Thin film Technology, McGraw- Hill, 1970.
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