ITEM NO. FS 13.04(2)

ANNA UNIVERSITY CHENNAI :: CHENNAI-600 025

M. Phil (PHYSICS)
CURRICULUM 2009

SEMESTER I

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	PH911	Research Methodology	4	0	0	4
2	PH912	Characterisation of materials	4	0	0	4
3		ELECTIVE I	4	0	0	4
4		ELECTIVE II	4	0	0	4

SEMESTER II

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1	PH921	SEMINAR	0	0	2	1
2	PH922	PROJECT	0	0	32	16

Total Credits : 33

ELECTIVES FOR M.Phil. (PHYSICS)

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	PH951	Condensed Matter Physics	4	0	0	4
2	PH952	Ultrasonics	4	0	0	4
3	PH953	Radiation Physics	4	0	0	4
4	PH954	Crystal Structure Analysis	4	0	0	4
5	PH955	Nonlinear Optics	4	0	0	4
6	PH956	Medical Applications of Lasers	4	0	0	4
7	PH957	Advances in Crystal Growth and Characterisation	4	0	0	4
8	PH958	Physical Metallurgy	4	0	0	4
9	PH959	Superconductivity and applications	4	0	0	4
10	PH960	High Pressure Physics	4	0	0	4
11	PH961	Molecular biophysics	4	0	0	4
12	PH962	nonlinear science: solitons and chaos	4	0	0	4
13	PH963	fibre optics communications	4	0	0	4
14	PH964	stereotactic radiosurgery and radiotherapy	4	0	0	4
15	PH965	conformal radiotherapy	4	0	0	4
16	PH966	advanced materials science	4	0	0	4
17	PH967	laser theory and applications	4	0	0	4
18	PH968	crystal growth and structure determination	4	0	0	4
19	PH 969	advanced solid state theory	4	0	0	4
20	PH 970	advanced solid state ionics	4	0	0	4
21	PH 971	methods of the characterization of nanomaterials	4	0	0	4
22	PH 972	nanoscience andtechnology	4	0	0	4

PH911 RESEARCH METHODOLOGY

L T P C
4 0 0 4

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

OBJECTIVE:

To impart the knowledge on systems of equation, probability statistics and error analysis and programming concepts.

UNIT I RESEARCH METHODOLOGY 12

Defining research problem - research design - Important concepts - different research design - basic principles of experimental design – sampling design - steps in sampling design - criteria - characteristics - types of sample designs. Purpose and problem statements - Literature review - Frameworks – Research questions and hypotheses - Quantitative and qualitative designs - Multimethod research - Study validity and elements of good design.

UNIT II NUMERICAL INTERPOLATION, DIFFERENTIATION AND INTEGRATION 12

Newton's forward and backward interpolation formulae - Lagrange's interpolation formula for unequal intervals - Error in polynomial interpolation and Newton's interpolation formula - Numerical differentiation - Maximum and minimum of a tabulated function - Numerical integration - Trapezoidal rule - Romberg's method- Simpson's rule - Practical applications of Simpson's rule.

UNIT III NUMERICAL SOLUTION OF ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS 12

Solution by Taylor's series - Euler's method - Runge-Kutta method - Predictor - Corrector method - Milne's method - Adam Baschforth method - Numerical solution of partial differential equations - Finite equations - Elliptic equations - Laplace equation - Poisson's equation - Parabolic equations - Hyperbolic equations.

UNIT IV EMPRICAL LAWS AND CURVE FITTING 12

Linear law and laws reducible to linear law - Graphical method - method of group averages - principle of least squares - Fitting of straight line, parabola, exponential and power curves.

UNIT V C - PROGRAMMING 12

Variables, constants, strings - Arrays - arithmetic operations and statements - shorthand assignment - input and output statements (scanf, printf) - format specifications - relational operators - local expressions and operators - if / else, for, while loops - functions (library and user-defined) - simple programs using standard numerical methods from the above chapters (four different programs at least from each chapter).

Total: 60 Periods

REFERENCES

1. Kothari. C.R "Research Methodology", New Age International publishers, New Delhi, 2008
2. Balagurusamy. E "Programming in ANSI C", 4 th Edition 2007, Tata McGraw-Hill Publishing Company Limited, New Delhi.
3. Shastry. S.S., "Introductory methods of numerical analysis", Prentice Hall, New Delhi, 1984.
4. Pannerselvam,R, “Research Methodology”, Prentice Hall of India, New Delhi, 2007.

PH912 CHARACTERISATON OF MATERIALS

L T P C
4 0 0 4

AIM:

To introduce various methods available for characterizing the materials.

OBJECTIVE:

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

UNIT I THERMAL ANALYSIS 11

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 15

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

UNIT III ELECTRON MICROSCOPY AND OPTICAL CHARACTERISATION 11

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

UNIT IV ELECTRICAL METHODS 11

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

UNIT V X-RAY AND SPECTROSCOPIC METHODS 12

Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, ESR, NMR,NQR, XPS, AES and SIMS-proton induced X-ray Emission spectroscopy (PIXE) –Rutherford Back Scattering (RBS) analysis-application - Powder diffraction - Powder diffractormeter - interpretation of diffraction patterns - indexing - phase identification - residual stress analysis - Particle size, texture studies - X-ray fluorescence spectroscopy - uses.

L: 60

REFERENCES

1. Stradling, R.A; Klipstain, P.C; Growth and Characterization of semiconductors, Adam Hilger, Bristol,1990.
2. Belk, J.A; Electron microscopy and microanalysis of crystalline materials, Applied Science Publishers, London, 1979.
3. Lawrence 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.

PH951 CONDENSED MATTER PHYSICS

L T P C
4 0 0 4

AIM:

To expose the students with the theoretical concepts of Condensed Matter Physics.

OBJECTIVE:

To impart knowledge on crystal binding, electronic properties, lattice dynamics, dielectric & optical properties and atomic molecular structure of materials.

UNIT I CRYSTAL BINDING 12

Force between atoms - cohesive energy - calculation of cohesive energy - bonding in solids - ionic, covalent, metallic, molecular - hydrogen bonded crystals - binding energy of ionic crystals - madelung constant - Born Haber cycle.

UNIT II ELECTRONIC PROPERTIES 12

Free electron theory (Sommerfeld theory) - electronic specific heat - electrical and thermal transports - Hall effect and experiment - Bloch theorem - formation of energy bands - Effective mass and concept of hole - classification of solids based on band theory - Fermi surface - cyclitron resonance (deHass Van Alphen effect).

UNIT III LATTICE DYNAMICS 12

Reciprocal space - Brillouin Zones - vibration modes of mono and diatomic lattices - quantization of lattice vibration - Lattice specific heat theories (Einstein and Debye models) - phonon momentum - scattering of neutrons by phonons - neutron diffraction.

UNIT IV DIELECTRIC AND OPTICAL PROPERTIES 12

Index of refraction - damping constant - characteristic penetration depth - absorbance - reflectivity and transmissivity - point defect - colour centers - luminescence - exciton - polaron - interband - intra band transitions - dispersion relation.

UNIT V ATOMIC MOLECULAR STRUCTURE 12

Central field approximation - Thomas Fermi model and its application - Hartree and Hartree Fock equations - hydrogen molecule - Heitler London model - LCAO - hybridization.

REFERENCES

1. C.Kittel, "Introduction to Solid State Physics", 7th Edn., Wiley Eastern, 1996.
2. A.K.Chandra, "Quantum Chemistry", Prentice Hall 1990.
3. R.E.Hummel, "Electronic properties of materials", Narosa, 1993.
4. S.Raimes, "The wave mechanics of electrons in metals", North Holland, 1967.

PH952 ULTRASONICS

L T P C
4 0 0 4

AIM:

To study the basic concepts of Ultrasonics.

OBJECTIVE:

To provide the knowledge on propagation of ultrasonic waves in medium & determination of its velocity, ultrasonic transducers, absorption of ultrasonic radiation and applications of ultrasonics.

UNIT I ULTRASONIC PROPAGATION IN SOLIDS AND LIQUIDS 12

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

UNIT II DETERMINATION OF VELOCITY OF PROPAGATION OF ULTRASONICS 12

Pulse Echo methods – Phase comparison methods – Pulse superposition – Measurements at high Pressure and high temperature–Transducer Coupling materials.

UNIT III ULTRASONIC TRANSDUCERS 12

Piezoelectric and magnetostrictive transducers – Equivalent circuits – Efficiency – Transducer mounting – Linear and sector transducers – Variable frequency systems.

UNIT IV ABSORPTION OF ULTRASONIC RADIATION 12

Classical absorption due to viscocity – Absorption due to thermal conductivity – Relaxation processes – Evaluation of dispersion and absorption curves – Structural relaxation – Relation between collision frequency and relaxation time – Ultrasonic attenuation in solids.

UNIT V APPLICATIONS OF ULTRASONICS 12

Applications of Ultrasonics in NDT – Medical Applications – Biological effects of Ultrasound – Different modes of scanning – Doppler Ultrasound techniques - Ultrasonic transaxial tomogram (U.T.T.) – Acoustic microscope-Acoustic hologram.

L : 60

REFERENCES

1. Gooberman G.L., “Ultrasonics-Theory and Applications“, The English Universities Press Ltd., London, 1968.
2. Schreiber Edward, “Elastic Constants and their measurement”, Anderson and Soga, McGraw Hill Book Co., New Delhi 1973.
3. Lerski R.A. (Ed), “Practical Ultrasound”, IRL Press, Oxford, 1988.
4. Robert T.Beyer and Stephen V. Letcher, “Physical Ultrasonics”, Academic Press London, 1969.
5. Woodcock J.P., “Ultrasonics”, Adam Hilger Ltd., U.K., 1979.

PH953 RADIATION PHYSICS

L T P C
4 0 0 4

AIM:

To teach the students about the basic concepts of radiation physics.

OBJECTIVE:

To impart knowledge on radiation and interaction, principles of radiation detection and measurement, radiation therapy techniques, diagnostic radiology and radiation protection.

UNIT I RADIATION AND INTERACTIONS 12

Interaction of Electromagnetic radiation with matter - Photoelectric and Compton process - pair production - interaction of particles with matter - neutrons - heavy ions - nuclear reactions and production of radioisotopes - radiation sources - natural and artificial radio active for medical applications- Bethe- Bloch formula.

UNIT II PRINCIPLES OF RADIATION DETECTION AND MEASUREMENT 12

Radiation units and definitions - G.M. Counter - Scintillation detectors - Solid state detectors - Photofilm method - Pocket dosimeter - TLD - FBX dosimeters.

UNIT III RADIO THERAPY TECHNIQUES: **12**

Telegamma unit - accelerators for therapy - Iridium and cobalt needles - preparation of tracers and labeled compound - uses of radioisotopes (Gamma and beta) in brachytherapy. Dosimetry in medical applications - beta particles dose computation for biological models - dosimetry of internally administered isotopes Principles and overview of conformal radiotherapy, SRS, SRT and IMRT.

UNIT IV DIAGNOSTIC RADIOLOGY: **12**

The physical basis of diagnostic radiology - the diagnostic X-ray tube - electrical circuits - rating of the x-ray unit - factors on which quality and quantity of x-ray production depends - geometric factor which influences the radiographic image - fluoroscopy - tomography - radio isotopes in clinical medicine - rectilinear scanner - gamma camera.

UNIT V RADIATION PROTECTION 12

Philosophy behind radiation protection - basic concepts of MPD - recent ICRP recommendations - tissues at risk - risk factor - evaluation of internal and external radiation hazards - transport and waste disposal of radioactive materials.

L : 60

REFERENCES

1. Meredith and Massay. "Fundamental Physics of Radiology", John Wright & Sons Jones M.E. and Cunningham J, "Physics of Radiology", Charles C. Thomas, USA, 1984.
2. Knoll, "Radiation Detection and Measurement", John Wiley and Sons, New York, 1982.
3. Mould R.F, "Radiation Protection", Adam Hilger's Boston, 1985.
4. Govindarajan K.N, "Advanced Medical Radiation Dosimetry", Prentice Hall of India, New Delhi, 1992.

PH954 CRYSTAL STRUCTURE ANALYSIS

L T P C
4 0 0 4

AIM:

To teach the students about the concepts of crystal structure analysis.

OBJECTIVE:

To make the students to understand lattice, X ray generation & diffraction, structure analysis, powder diffraction and protein crystallography.

UNIT I SYMMETRY : LATTICE 12

Unit cell and Bravais lattices - crystal planes and directions - basic symmetry elements operations - translational symmetries - point groups - space groups - equivalent positions - Bragg's law - reciprocal lattice concept -Laue conditions - Ewald and limiting spheres diffraction symmetry - Laue groups.

UNIT II DIFFRACTION **12**

X-ray generation, properties - sealed tube, rotating anode, synchrotron radiation - absorption - filters and monochromators Atomic scattering factor - Fourier transformation and structure factor - anomalous dispersion - Laue, rotation/oscillation, moving film methods - interpretation of diffraction patterns - cell parameter determination - systematic absences - space group determination.

UNIT III STRUCTURE ANALYSIS **12**

Single crystal diffractometers - geometries - scan modes - scintillation and area detectors - intensity data collection - data reduction - factors affecting X-ray intensities - temperature and scale factor - electron density - phase problem - normalised structure factor - direct method fundamentals and procedures -Patterson function and heavy atom method - structure refinement - least squares method - Fourier and difference Fourier synthesis - R factor - structure interpretation - geometric calculations - conformational studies - computer program packages.

UNIT IV POWDER METHODS **12**

Fundamentals of powder diffraction - Debye Scherrer method - diffractometer geometries - use of monochromators and Soller silts - sample preparation and data collection - identification of unknowns - powder diffraction files (ICDD) - Rietveld refinement fundamentals - profile analysis - peak shapes - whole pattern fitting - structure refinement procedures - autoindexing - structure determination from powder data - new developments. Energy dispersive X-ray analysis - texture studies - crystallite size determination - residual stress analysis - high and low temperature and high pressure crystallography (basics only).

UNIT V PROTEIN CRYSTALLOGRAPHY **12**

Globular and fibrous proteins, nucleic acids - primary, secondary, tertiary and quaternary structures - helical and sheet structures - Ramachandran map and its significance - crystallation methods for proteins - factors affecting protein crystallisation - heavy atom derivatives - methods used to solve protein structures - anomalous dispersion methods.

L : 60

REFERENCES

1. Azaroff, L.V., "Elements of X-Ray Crystallography", McGraw-Hill, New York, 1968.
2. Blundel, T.L., Johnson, L., "Protein Crystallography", Academic Press, New York, 1986.
3. Cullity, B.D., "Elements of X-ray Diffraction", Addison-Wesley, Reading, MA.1990.
4. Glsker, J.P., Trueblood, K.N. Crystal Structure Analysis, A Primer", Oxford University Press, New York, 1994.
5. Ladd, M.F.C., Palmer, R.A., "Structure Determination by X-ray Crystallography", Plenum Press, New York, 3rd Edition, 1993.
6. Stout, G.H., Jensen, L."X-ray Structure Determination, A Practical Guide", Macmillan : New York, 1989.
7. Woolfson, M.M. "An Introduction to X-ray Crystallography" Cambridge University Press, New York, 1984.
8. International Tables for Crystallography, Volume A, Hahn, T., Ed., Reidel : 1983.
9. Internet side: www.iucr.org/cww-top/edu.index.html

PH955 **NONLINEAR OPTICS**

L T P C
4 0 0 4

AIM:

To enlighten the students with the concepts of nonlinear optics.

OBJECTIVE:

To make the students to understand the concepts of origin of optical nonlinearities, second harmonic generation & parametric oscillation, third order nonlinearities, electrooptic and photo refractive effects and stimulated scattering process.

UNIT I ORIGIN OF OPTICAL NONLINEARITIES **9**

Effects due to quadratic and cubic polarization – Response functions Susceptibility tensors – Linear, second order and n^{th} order susceptibilities – Wave propagation in isotropic and crystalline media – The index ellipsoid.

UNIT II SECOND HARMONIC GENERATION (SHG) AND PARAMETRIC OSCILLATION **9**

Optical SHG – Phase Matching – Experimental verification – Parametric oscillation – Frequency tuning – Power output and pump saturation – Frequency up conversion – Materials.

UNIT III THIRD ORDER NONLINEARITIES **9**

Intensity dependent refractive index – Nonlinearities due to molecular orientation – Self-focusing of light and other self-action effects - Optical phase conjugation – Optical bistability and switching - Pulse propagation and temporal solitons.

UNIT IV ELECTRO –OPTIC AND PHOTOREFRACTIVE EFFECTS **8**

Electro-optic effects – Electro-optic modulators - Photorefractive effect - Two beam coupling in Photorefractive materials – Four wave mixing in Photorefractive materials.

UNIT V STIMULATED SCATTERING PROCESSES **10**

Stimulated scattering processes – Stimulated Brillouin scattering – Phase conjugation – Spontaneous Raman effect – Stimulated Raman Scattering – Stokes – Anti-Stokes Coupling in SRS – Stimulated Rayleigh - Wing Scattering.

REFERENCES

1. Robert W. Boyd, “Non-linear Optics”, Academic Press, London, 1992. (Units II and IV)
2. A.Yariv, Opto Electronics, Third Edition, John Wiley and Sons , New York , 1990. (Unit II)
3. P.N.Butcher and D.Cotter, “The Elements of Nonlinear Optics”, Cambridge Univ. Press, New York, 1990. (Unit I & V)

PH956 MEDICAL APPLICATIONS OF LASERS

L T P C
4 0 0 4

AIM:

To teach the students about medical applications of lasers.

OBJECTIVE:

To make the students proficient in the areas of laser theory and medical lasers, fundamentals of laser-tissue interaction, thermal applications, non thermal applications and safety regulations.

UNIT I LASER THEORY AND MEDICAL LASERS 12

Fundamentals of Laser action- Relation between spontaneous and stimulated emission probabilities - Three Level and Four Level laser system - LASER systems in medicine: Ruby, Ar ion, Nd-YAG, CO_2, Eximer N2 Laser system – Beam characteristics Applied to Medicine -Beam delivery systems - Principles of Laser Power - energy meters.

UNIT II FUNDAMENTALS OF LASER-TISSUE INTERACTION 12

Laser characteristics as applied to medicine and Biology - Different types of Laser tissue interaction : Photochemical - Photothermal - Photoablative and Electromechanical effects - Tissue optics - Experimental methods and determining the optical properties of tissue - Theory of Integrating sphere.

UNIT III THERMAL APPLICATIONS 12

Surgical applications of Lasers - Evaporation and excision techniques - sterilization - homeostasis - clinical applications based on thermal effect: oncology - Gynecology - Dermatology - Ophthalmology - Dentistry.

UNIT IV NON-THERMAL APPLICATIONS 12

Principles of OCT – Laser Scanning confocal microscope - Principles of Photoradiation therapy - applications - Laser Spectroscopy techniques in medical diagnosis: Reflectance Fluorescence, Raman spectroscopy principles optical mammography-FLIM techniques.

UNIT V SAFETY REGULATIONS 12

Protection standards for lasers - Safety regulations - specific precautions - medical Surveillance

L: 60

REFERENCES

1. Martellucci.S.S. and Chester. A.N. "Laser Photobiology and Photomedicine", Plenum Press, New York, 1985.
2. Pratesi.R. and Sacchi.C.A., "Lasers in Photomedicine and Photobiology", Springer Verlag, West Germany, 1980.
3. Markolf H. Niemz "Laser - Tissue Interactions", Fundamentals and applications Springer verlag, Berlin -1996.
   William T. Silfvast "Laser Fundamentals", Cambridge University press, New Delhi, 1998

PH957 **ADVANCES IN CRYSTAL GROWTH AND CHARACTERISATION**

L T P C
4 0 0 4

AIM:

To introduce the knowledge on crystal growth and characterization.

OBJECTIVE:

To expose the students with theories of nucleation & crystal growth, crystal growth by from solution, melt and vapour phase and their characterization.

UNIT I CLASSICAL THEORY OF NUCLEATION **12**

Gibbs-Thomson equation- theory of nucleation - Energy of formation of a nucleus - Different possible shapes of nucleus - Homogeneous nucleation of Binary system - Heterogeneous nucleation - Free energy of formation of a critical heterogeneous - cap shaped -disc shaped nucleus - Heterogeneous nucleation of Binary vapour - Secondary nucleation.

UNIT II THEORIES OF CRYSTAL GROWTH **12**

Surface energy theory - Diffusion theory - Adsorption layer theory - Volmer theory -Bravais theory - Kossel theory - Stranski's treatment. Two dimensional nucleation theory

UNIT III CRYSTAL GROWTH BY MASS TRANSFER PROCESSES **12**

Bulk diffusion model - Surface diffusion growth theories - Physical modeling of BCF theory - BCF differential surface diffusion equation - single straight step - Multiple straight parallel steps - Temkins model of crystal growth. PBC theory of crystal growth

UNIT IV GROWTH OF CRYSTAL FROM MELT **12**

LEC growth of III - V materials - Growth of oxide materials. Growth of crystal from flux - Slow cooling method - Temperature difference method - High pressure method - Solvent evaporation method - Electro crystallization. - Crystal growth by hydrothermal method.

UNIT V GROWTH OF CRYSTALS FROM VAPOUR PHASE **12**

Vapour phase epitaxy (VPE) - Liquid phase epitaxy (LPE) -Molecular Beam Epitaxy (MBE) - Atomic layer Epitaxy (ALE) - Electroepitaxy - Metalorganic Vapour Phase Epitaxy (MOVPE) -Chemical Beam Epitaxy (CBE).

UNIT VI CRYSTAL CHARACTERISATION **12**

Single crystal diffraction techniques - Powder diffraction - indexing - Least square refinment - x-ray fluorescence - x-ray topography SEM and TEM studies - Electron probe Micro Analysis - Secondary Ion Mass Spectroscopy (SIMS) - Electron Spectroscopy for Chemical Analysis (ESCA) - Electrical conductivity - Measurement of electrical conductance - Measurement of dielectric constant - Microhardness - Etching studies

L : 60

REFERENCES

1. Modelling crystal growth rates from solution -by Makoto Ohara and Robert C. Reid, 1973, Prentice-Hall of India P.Ltd, New Delhi.
2. Crystal growth Processes - by J.C. Brice, John Wiley and sons, New York 1986.
3. Crystal Growth -by B.R. Pamplin , 1975,Pergamon press, London.

4. Material and Process Characterization for VLSI, 1988 (i CMPC' 88) - X.F. Zong, Y.Y. Wang, J. Chen, World Scientific, New Jersey(1988).
5. Synthesis, Crystal Growth & Characterization - Krishan Lal, North-Holland, Amsterdam(1982).
6. Growth of crystals from vapour by M.M.Faktor and I. Garret, Chapman and Hall, London , 1974.
7. A guide to Materials Characterisation and chemical Analysis, by Siblia J.P., VCH Publications 1988

PH958 PHYSICAL METALLURGY

L T P C
4 0 0 4

AIM:

To teach the students about the basic concepts of physical metallurgy.

OBJECTIVE:

To expose the students about the concepts of structure of alloys, phase diagrams, diffusion, mechanical properties and engineering alloys.

UNIT I STRUCTURE OF ALLOYS 12

Hume Rothery rules - Intermediate phases – Intermetallic compounds – Improvement in mechanical and electrical properties – metallography: Optical microscope – SEM – TEM – Determination of chemical composition – Electron probe microanalysis.-Structural stability of alloys-EXAFS measurements.

UNIT II PHASE DIAGRAMS 12

Free energy – Composition curves – Lever rule – Invariant reactions – Eutectic system – Property variations in eutectic systems –Peritectic and peritectoid systems-Non equilibrium solidification – Zone meting.

UNIT III DIFFUSION 12

Ficks laws – Mechanisms of diffusion – Solutions of diffusion equation – Kirkendal effect – Factors affecting diffusion – Applications of diffusion .

UNIT IV MECHANICAL PROPERTIES 12

Stress-strain curve – Compressibility – Plastic deformation mechanisms,Tensile strength – Creep – Fracture – Fatigue failures – Effect of grain size on mechanical properties-Hardness.

UNIT V ENGINEERING ALLOYS 12

Steels – High strength structural steels – tool materials – high temperature alloys – cast iron – light alloys – Al, Mg and Ti and their alloys – Copper based systems – brass and bronze.

L : 60

REFERENCES

1. Guy.A.G. and Hren.J.J., Physical Metallurgy, Oxford, IBH, 1980.
2. Raghavan.V., Physical Metallurgy, Prentice Hall, 1989.
3 .Westbrook.J. (Ed.), Intermetallics, Academic Verlag, 1995.
4. Taylor-X-ray metallography, Mentice Hall,1982.

PH959 SUPERCONDUCTIIVITY AND APPLICATIONS

L T P C
4 0 0 4

AIM:

To enlighten the students with the concepts of superconductivity.

OBJECTIVE:

To impart knowledge on superconducting materials, theoretical aspects and the applications of superconductors.

UNIT I BASIC EXPERIMENTAL ASPECTS 12

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 12

Elemental superconductors – superconducting compounds and its alloys – A15 compounds – chevral phase compounds

UNIT III HIGH TEMPERATURE SUPERCONDUCTORS 12

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 12

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 12

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

L : 60

REFERENCES

1. Narlikar. A.V. and Ekbote, "Introduction to superconductivity", South Asia publishers, 1983.
2. Tilley. D.R and Tilley. . "Superfluidity and superconductivity", Adam Hilger, 1986.
3. Hoi.S.Kowk and David T. Shaw (Eds.), "Superconductivity and its Applications", Elsevier Science Publishing, 1988.
4. Narlikar. A.V., "Studies on High temperature superconductors- Advances in research
and applications" Nova Scientific, New Delhi, 1990.

PH960 **HIGH PRESSURE PHYSICS**

L T P C
4 0 0 4

AIM:

To introduce the knowledge on high pressure physics.

OBJECTIVE:

To make the students understand general techniques of producing high pressure and their measurement, high pressure devices, high pressure physical, chemical mechanical properties & industrial applications and concept of dynamic pressures.

UNIT I GENERAL TECHNIQUES **12**

Definition of pressure – Hydrostaticity – generation of static pressure, pressure units – piston cylinder – Bridgmann Anvil – Multi anvil devices – Diamond anvil cell. Measurement of High Pressure Primary gauge – Secondary gauge – Thermocouple pressure gauge – Resistance gauge – fixed point pressure scale – Ruby fluorescence – Equation of state.

UNIT II HIGH PRESSURE DEVICES FOR VARIOUS APPLICATIONS **12**

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

UNIT III HIGH PRESSURE PHYSICAL AND CHEMICAL PROPERTIES **12**

PVT Relations in fluids – Properties of gases under pressure – Melting phenomena – viscosity – thermo emf – thermal conductivity. Electrical conductivity – phase transition phonons, superconductivity – Electronic structures of metals and semiconductors – NMR and magnetic properties. Liquid crystals – spectroscopic studies – Infra red, Raman, Optical absorption – EXAFS.

UNIT IV MECHANICAL PROPERTIES AND INDUSTRIAL APPLICATIONS **12**

Elastic constants – Measurements – Mechanical properties – Tension and compression – Fatigue – creep – Hydrostatic extrution, material synthesis – superhard materials – Diamond – oxides and other compounds – water jet.

UNIT V DYNAMIC PRESSURES **12**

Shock wave – generation – measurements - Effect of shock wave on metals – Applications of shock wave.

L : 60

REFERENCES

1. W. Bridgmann, The Physics of High Pressure, G. Bell and Sons Ltd., London, 1931.
2. B Vodar and Ph. Marteam, High Pressure Science and Technology, Vol I and II Pergamon Press, Oxford, 1980.
3. H.LI. D. Pugh, Mechanical Behaviour of Materials under Pressure,Elsevier Publishing Co., Ltd., New York, 1970.
4. M. I. Eremets, High Pressure Experimental methods, Oxford University press, New York, 1976.

PH961 MOLECULAR BIOPHYSICS

L T P C
4 0 0 4

AIM:

To study the basic concepts of molecular biophysics.

OBJECTIVE:

To make the students to understand the basic concepts of intermolecular interactions, structure of proteins, nuclei acids, polysaccharides and biomolecular assembly.

UNIT I INTRAMOLECULAR INTERACTIONS 12

Contact distance criteria - Van der Wall's interactions - Electrostatic interactions - Hydrogen bonding interactions - Distortional energies - Description of various interactions by potential functions.

UNIT II STRUCTURE OF PROTEINS 12

Peptide bond and peptide unit - cis and trans configuration - phi and psi conventions - stonic hindrance - Allowed conformations - Ramachandran diagram - Conformational maps for glycrine and other natural amino acids - Energy maps - Patterns of folding - Primary, Secondary, Ternary and quaternary structure - Super secondary and domain structure - Types of secondary structures - Alpha helx, beta sheet, reverse turns - Structure of fibrous and globular proteins - Collagen, hemoglobin and lysozyme.

UNIT III STRUCTURE OF NUCLEI ACIDS 12

Nucleosides and nucleotides - tautomeric equilibria of bases - ionisation equilibria of nucleosides and nucleotides - Conformation of nucleosides and nucleotides - Structure and conformation of oligonucleotides - Base pairing interactions - base stacking interactions - Double helical model of DNA - DNA polymorphism – S tructure of A, B and Z - DNA structure of TRNA.

UNIT IV STRUCTURE OF POLYSACCHARIDES 12

Monosaccharides - Stereoisomerism of hexapyranose sugars - Structure and conformation of maltose, cellobiose, cellulose amylose and chitin.

UNIT V BIOMOLECULAR ASSEMBLY 12

Molecular models for membranes structure and conformation of Phospolipids, membrane proteins - Structure of chromatin, nucleosomes, polynucleosomes and viruses.

L : 60

REFERENCES

1. Contor, C.R. and Schimmer.P.R., "Biophysical Chem. Vol.I-II", W.H.Freman and Co., San Fransisco, USA, 1980.
2. Senger W., "Principlesof Nucleic Acid Structure", Springer Verlag, Germany, 1984.
3. Schelz.G.E. and Schirmar.R.H., "Principlesof protein structure", Springer Verlag, West Germany, 1979.

PH962 **NONLINEAR SCIENCE: SOLITONS AND CHAOS**

L T P C
4 0 0 4

AIM:

To enlighten the students about the basic concepts of nonlinear science: solitons and chaos.

OBJECTIVE:

To impart knowledge on general mathematical concepts of partial differential equation, nonlinear waves, coherent structures, bifurcation and onset of chaos, chaos theory & characterization and applications.

1. GENERAL **12**

Linear waves-ordinary differential equations(ODEs)-Partial differential equations(PDEs)- Methods to solve ODEs and PDEs.- Numerical methods – Linear and Nonlinear oscillators-Nonlinear waves-Qqualitative features.

2. COHERENT STRUCTURES **12**

Linear and Nonlinear dispersive waves - Solitons – KdB equation – Basic theory of KdB equation – Ubiquitous soliton equations – AKNS Method, Backlund transformation, Hirota bilinearization method, Painleve analysis - Perturbation methods- Solitons in Optical fibres - Applications.

3. BIFURCATIONS AND ONSET OF CHAOS **12**

One dimensional flows – Two dimensional flows – Phase plane – Limit cycles – Simple bifurcations – Discrete Dinamical system – Strange attractors – Routes to chaos.

4. CHAOS THEORY AND CHARACTERISTION **12**

One dimensional maps – Duffing oscillators – Lorenz equations – BVP and DVP oscillators – Pendulum – Chaos in nonlinear circuits – Chaos in conservative system – characterization of chaos – Fractals.

5. APPLICATIONS **12**

Soliton based communication systems – Solition based computation – Synchronization of chaos – Chaos based communication – Cryptography – Image processing – Stochastic – Resonance – Chaos based computation – Time Series analysis.

L : 60

REFERENCES

1. M.Lakshmanan and S.Rajasekar, Nonlinear Dynamics: Integrability, Chaos and Patterns, Springer, Berlin 2003
2. A.Hasegawa and Y.Kodama, Solitons in Optical Communications, Oxford Press, 1995.
3. G.Drazin and R.S.Johnson, Solitons : An Introduction, Cambridge University Press,1989.
4. M.Lakshmanan and K.Murali, Chaos in Nonlinear Oscillators, World Scientific, Singapore, 1989.
5. S.Strogatz, Nonlinear Dynamics and Chaos, Addison Wesley, 1995.

PH963 FIBRE OPTICS COMMUNICATIONS L T P C
4 0 0 4

AIM:

To make the students understand the concepts of fibre optics communications.

OBJECTIVE:

To impart knowledge on basics fibre optical communication, instruments, signal propagation, optical networks & WDM concepts and dispersion compensation and solitons.

1. INTRODUCTION TO OPTICAL COMMUNICATION 12

Principles of light transmission in fibers - optical fiber modes and configuration - Mode theory for circular wave guides, single mode fibers, Multi – mode fibers, Numerical Aperture, Mode Field Diameter, V-Number - Optical power, polarization, bandwidth and signal quality measurements - Advance fiber design: Dispersion shifted , Dispersion flattened, Dispersion compensating fiber, Design optimization of single mode fibers. Advantages and disadvantages of the optical communication systems.

2. INSTRUMENTS 12

Optical sources - LEDs, LASER Diodes, Modal Reflection Noise, Power Launching & Coupling, Fiber splicing, optical connectors, photo detectors - PIN, Avalanche Detectors - Response Time, Avalanche Multiplication Noise - Optical Amplifiers – EDFA, semiconductor and Raman amplifiers.

3. SIGNAL PROPAGATION 12

Signal Degradation in optical fibers - Attenuation losses - signal distortion in optical wave guides - material dispersion - wave guide dispersion - chromatic dispersion - Intermodal dispersion - pulse broadening in graded-index fibers - mode coupling - Coherent optical fiber communication - Modulation Techniques - Line Coding: NRZ, RZ, Block codes, Error correction.

4. OPTICAL NETWORKS & WDM CONCEPTS 12

Optical networks- Basic networks-sonnet/ SDH-wavelength routed networks - Global networks – joining networks, terrestrial and long-distance systems - Regional networks – design of regional and metropolitan networks - Local networks – emerging services, passive networks, Gigabit Ethernet and Internet protocols, computer and phone networks – Principle of WDM – Passive Components – Couplers- Multiplexing and De-multiplexing – Tunable sources – Phase array based WDM Devices.

5. DISPERSION COMPENSATION AND SOLITONS 12

Limitations, Post-and Pre-compensation techniques, Equalizing filters, fiber based gratings, Broad band compensation - Nonlinear effects in fiber optic links. Concept of self-phase modulation, group velocity dispersion and solition based communication systems - design, High capacity and WDM soliton system – Dispersion –managed Solitons.

L : 60

REFERENCES

1. J.Keiser, Fibre Optic communication, McGraw-Hill, 2nd Ed. 1992.
2. J.E. Midwinter, Optical fibers for transmission, John Wiley, 1979.
3. J.Gowar, Optical communication systems, Prentice Hall India, 1987.
4. G. P. Agrawal, Nonlinear fibre optics, Academic Press, 2005.

PH964 STEREOTACTIC RADIOSURGERY AND RADIOTHERAPY

L T P C
4 0 0 4

AIM:

To expose the students with concepts of stereotactic radiosurgery and radiotherapy.

OBJECTIVE:

To provide the knowledge on stereotactic radiosurgery & stereotactic radiotherapy, clinical indications, radiobiology of radiation therapy-radiosurgery in particular, linac based radiosurgery and quality assurance.

UNIT I STEREOTACTIC RADIOSURGERY AND STEREOTACTIC RADIOTHERAPY 12

Introduction -Fundamentals of Radiation Physics -Interaction of Radiation with Matter- Radiosurgery and Stereotactic Radiotherapy-Gamma Knife and Linac based - Radiosurgery-Methods of immobilization, localization devices and potential for frameless steretaxy - Treatment Planning -Imaging and Evaluation - Treatment Delivery.

UNIT II CLINICAL INDICATIONS 12

Structure and Functioning of the brain. Clinical implications and malformations - AV AOVM, glioma, maningioma, acoustic schwanoma, pitutary adenoma and others.

UNIT III RADIOBIOLOGY OF RADIATION THERAPY-RADIOSURGERY IN PARTICULAR 12

Physical and Biological factors affecting cell survival-tumor regrowth and normal tissue response-Non conventional fractionation scheme and their effect of reoxygenation, repair redistribution in the cell cycle - High LET radiation therapy - TDF- LQ Model-Radiobiology of Radiosurgery - Radiobiology of fractionated Stereotactic Radiotherapy.

UNIT IV LINAC BASED RADIOSURGERY 12

Physical principles involved in the design of current Accelarators-Design and Characteristics - Modifications to the normal acclearators for Radiosurgery-Dosimetry of various collimators-3D calculation algorithms for noncoplanar fields-Quality assurance checks for radiosurgery-Image fusion in treatment planning and treatment evaluation.

UNIT V QUALITY ASSURANCE 12

Scope of Computers in Radiation Treatment planning-Factors to be incorporated in computational algorithms- Cost effectiveness of Treatment Planning System - Hardware and Software requirements-Periodic software and hardware Q.A cheeks - Installation and Quality Acceptance of TPS and Linac accessories for Radiosurgery.

L : 60

REFERENCES

1. Ahiuwalia-Tomographic methods in nuclear medicine:physical principles, instruments an(clinical applications- Boca Raton -1989.
2. Steve Webb - Physics of 3D Radiation Therapy - Institute of Physics Publishing - Bristol & Philadelphia.1993.
3. Mauch & Loffier - Radiation Oncology Technology and Biology - W.B.Saunders Company London.1994
4. Gordon Steel - Basic Clinical Radiobiology-Edward Arnold Publishers 1993

PH965 **CONFORMAL RADIOTHERAPY**

L T P C
4 0 0 4

AIM:

To expose the students with basic concepts of conformal radiotherapy.

OBJECTIVE:

To impart knowledge on three dimensional radiation therapy treatment planning, treatment optimization, conformal therapy with multileaf collimators, treatment machine features for conformal therapy, imaging for conformal radiotherapy planning.

1. THREE DIMENSIONAL RADIATION THERAPYTREATMENT PLANNING 12

Conformal radiotherapy treatment planning-Registration of two image datasets for 3D treatment planning -Summary and the NCI study of 3D therapy planning - Stages of Treatment Planning -Dosimetry-Beam data Acquisition, Dosimetry with special detectors, data analysis and Input into 3D planning system - Dose verification with Phantom measurements

2. TREATMENT OPTIMIZATION 12

General Considerations - The impossibility of true inverse Computed Tornography - The case of circularly- symmetric dose distribution -Primitive blocked rotation therapy. Methods for 2D and 3D optimization - Evaluation of Plans.-DVH

3. CONFORMAL THERAPY WITH MULTILEAF COLLIMATORS 12

Brahme's theory of orientation - Optimization of Beam Profiles, Dynamic Wedge of Linac.Wedges with MLC's. Linac's with Independent Collimators - Instrumentation: Radiation Detectors-ion chamber, Diode, Film, TLD - Electronic Portal Imaging-Digital.

4. TREATMENT MACHINE FEATURES FOR CONFORMAL THERAPY 12

Earliest treatment machine for conformal therapy with a Csl37 source-Tracking Units-A tracking LINAC with MLC and CT combination.-Universal Wedge-Dynamic Wedge-Wedges with MLC's-Linear Accelerators with independent collirnators-4.8)Two Dimensional tissue Compensators.

5. IMAGING FOR CONFORMAL RADIOTHERAPY PLANNING 12

Principles of imaging by computed topography - X-ray computed topography-Basic Principles. - Signal/Noise ratio considerations. Physical factors affecting Image Quality. - Parallel Beam and Fan beam systems - Magnetic Resonance lmaging-NMR theory.- Relaxation times. Image reconstruction techniques.- Ultrasound lmaging - Single photon emission Computed topography-SPECT - Positron Emission Topography-PET -CT imaging on radiotherapy simulator.

REFERENCE **L : 60**

1. Steve Webb- Physics of 3D Radiation Therapy- Institute of Physics Publishing- Bristol & Philadelphia-1993.
2. Peckharn, Pinedo & Veronesi-Oxford textbook of Oncology Vol.I-Oxford Medical Publications- London 1995
3. Gunnila G. Bentel-Radiation Therapy Planning -Macmillan Publishing Company-New York- 1992.
4. Griffiths, Short et al- Radiotherapy-Principles and Practice- Churchill Livingstone Publications London-1 994.

PH966 ADVANCED MATERIALS SCIENCE

L T P C
4 0 0 4

AIM:

To impart knowledge on various materials of technological importance.

OBJECTIVE:

To teach the students about semi conducting materials, ceramic materials, polymeric materials, optical materials and new materials.

1. SEMICONDUCTING MATERIALS 12

Semiconductor –direct and indirect bonding characteristics – Importance of quantum confinement – Quantum wires and dots – Fabrication process of integrated circuits – Dilute magnetic semiconductors – Characteristics and applications – Ferroelectric semiconductors – Applications.

2. CERAMIC MATERIALS 12

Ceramic superconductors – Preparation – Sol gel techniques – nanoparticles – Applications – High temperature superconductors – Superconducting magnets – High T_c Tapes – Applications of Composite materials – Fibre reinforced composites – Composite structure and manufacturing methods.

3. POLYMERIC MATERIALS 12

Polymer semiconductors – Photoconductive polymers – Composition and structure of polymers – Electrical conductivity – LEP's design and fabrication – Applications – Mechanical properties – nanoindentation techniques.

4. OPTICAL MATERIALS 12

Modern imaging materials, Principle of imaging – Superconducting, piezoelectric, acousto-optic and electro-optic materials – Optical storage materials – Photochromic, thermoplastic and Photoresist materials – Materials suitable for detecting toxic gases.

5. NEW MATERIALS 12

Smart materials-Shape memory alloys – Shape memory effect – Martensitic transformation – shape memory alloys – functional properties – processing – texture and its nature - application

L : 60

REFERENCES

1. Verdeyen.J, Laser Electronics, II Edition, Prentice Hall, 1990.
2. Turner.C.W. and Van Duzer.T, Principles of Superconductive Devices and Circuits, 1981
3. Reynolds and M.Pomeranty in Electroresponsive molecules and polymeric systems Ed. by Skotheim T. Marcel Dekker New York 1991.
4. Yariv.A, Principles of Optical Electronics, John Wiley, New York, 1984
5. Hull.B, and John.V, Non-Destructive Testing, McMillan Education Ltd., London, 1988.
6. Funakubo H Shape memory alloys Gordon & Breach New York 1984.

PH967 LASER THEORY AND APPLICATIONS

L T P C
4 0 0 4

AIM:

To expose the students with theoretical aspects of laser theory and its applications.

OBJECTIVE:

To provide the knowledge on laser theory, resonators and switching theory, gas & liquid lasers, solid state & semiconductor lasers and their applications.

1. LASER THEORY 12

Absorption - Spontaneous and stimulated emission - Einstein's coefficients - threshold conditions for laser action - Line broadening, Mechanism - Lorentzian and Doppler line shapes - Small signal gain - Gain coefficient - gain saturation - Rate equations for 3 and 4 level systems.

2. RESONATORS AND SWITCHING THEORY 12

Resonant cavity - Fox and Li - Boyd and Gorden's theory on resonators - modes - Spot size - Types of resonators - Mode selection - Q switching theory and technique - Mode locking theory and technique.

3. GAS AND LIQUID LASERS 12

He-Ne, Argon Ion, Carbon dioxide, Nitrogen - Metal vapour - Gas dynamics - Excimer - Free electron lasers - Dye lasers organic dyes - Pulsed and CW dye lasers - Threshold conditions - Puming configurations.

4. SOLID STATE AND SEMICONDUCTOR LASERS 12

Ruby, Nd : YAG, Nd : Glass, Ti-sapphire, Alexandrite, lasers - Semiconductor lasers - Homo function - Hetro function - Quantum well laser.

5. APPLICATIONS 12

Speckle, speckle interferometry - Holography - Holographic interferometry - Material processing - Surface treatment - welding, drilling - Laser ranging - Laser Doppler Velocimetry - Pollution monitoring - Medical applications.

L : 60

REFERENCES

1. Laser Fundamentals, William T. Silfvast, Cambridge University Press, 1999.
2. Oshea, Callen and Rhcdes, "An Introduction to Lasers and their Applications", Addison Wesley, 1985.
3. A.Yariv, "Quantum Electronics", Third Edn., Addison-Wesley 1990.
4. Hariharan, "Optical Holography", Academic Press, New York, 1983.
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PH968 CRYSTAL GROWTH AND STRUCTURE DETERMINATION

L T P C
4 0 0 4

AIM:

To provide knowledge on crystal growth and structure determination.

OBJECTIVE:

To impart knowledge on nucleation theory, various techniques of crystal growth, symmetry lattice and structure determination.

1. NUCLEATION CONCEPT **12**

Kinds of nucleation - Homogeneous nucleation – Heterogeneous nucleation - Energy of formation of a critical nucleus - Theories of crystal growth - Two dimensional nucleation theory - thermodynamics of nucleation - Free energy of formation of a two dimensional nucleus - Rate of nucleation - Mononuclear model - Polynuclear model - Birth and spread model - Modified Birth and spread model - Physical modeling of BCF theory - BCF differential surface diffusion equation - single straight step - Temkins model of crystal growth.

2. GROWTH OF CRYSTAL FROM MELT **12**

Bridgman method - Kyropolous method - Czochralski method - Verneuil method - Zone melting method

3. GROWTH OF CRYSTALS FROM VAPOUR PHASE **12**

Physical vapour deposition - Chemical vapour transport - Open and closed system - Growth of crystals from solutions - solvents and solutions - solubility - preparation of a solution - saturation and supersaturation - Low temperature solution growth - Slow cooling method - Mason-jar method - Evaporation method - Temperature gradient method - Electro crystallization - Crystal growth in gels - Experimental methods - Chemical reaction method - Reduction method - Crystal growth by hydrothermal method .

4. SYMMETRY LATTICE **12**

Unit cell and Bravais lattices - crystal planes and directions - basic symmetry elements, operations - translational symmetries - point groups - space groups - equivalent positions - Bragg's law - reciprocal lattice concept - Laue conditions - Ewald and limiting spheres - diffraction symmetry - Laue groups.

5. STRUCTURE DETERMINATION **12**

X-ray diffraction - Powder method - rotating crystal method - specimen preparation - measurement of d-values - indexing procedure for crystals - Single crystal diffractometer - double crystal diffractometer - triple crystal diffractometer - four crystal diffractometer - determination of unit cell and space group. X-ray topography(XRT) - Neutron diffraction

L : 60

REFERENCES

1. Modelling crystal growth rates from solution -by Makoto Ohara and Robert C.Reid, 1973, Prentice-Hall of India P.Ltd, New Delhi.
2. Modern crystallography - Vol. III, by A.A.Chernov, Nauka Publishing House , Moscow 1980.
3. Crystal growth Processes - by J.C. Brice, John Wiley and sons, New York 1986.
4. Crystal Growth -by B.R. Pamplin , 1975,Pergamon press, London.

5. Crystal Growth - an introduction , Ed. by P.Hartman,North-Holland Publication Co. Amsterdam , 1972 .
6. X-ray diffraction - L.A.Azarof et al, McGraw Hill Book Company(1974).
7. Elements of X-ray Crystallography - L.V.Azarof, McGraw-Hill Book Company(1968).
8. Material and Process Characterization for VLSI, 1988 (i CMPC' 88) - X.F. Zong, Y.Y. Wang, J. Chen, World Scientific, New Jersey(1988).
9. Synthesis, Crystal Growth & Characterization - Krishan Lal, North-Holland, Amsterdam.

PH969 ADVANCED SOLID STATE THEORY

L T P C
4 0 0 4

AIM:

To expose the students with theoretical aspects of solid state theory.

OBJECTIVE:

To provide the knowledge on band theory, lattice dynamics, transport properties, magnetic properties and super conductivity.

1. BAND THEORY 12

Free electron theory - Bloch's theorem - Band structure calculation - Augmented plane wave method - LMTO method - examples of Band structure calculation - Different exchange correlation schemes - total energy calculation - structural stability - equation of state - Experimental study of Band structure.

2. LATTICE DYNAMICS 12

Born - Oppenheimer approximation - Harmonic approximation - Brillouin zones - phonon dispersion in solids - phonon softening.

3. TRANSPORT PROPERTIES 12

Electrical conductivity - Thermal conductivity - Thermo electric power - Hall effect - Magneto resistance effect - Normal and umklapp processes.

4. MAGNETIC PROPERTIES 12

Ferromagnetic order - Curie point - exchange integral - saturation magnetization - origin of domains - magnons - dispersion relation - Band theory - spin Polarized band structure calculation - Hund's rule.

5. SUPERCONDUCTIVITY 12

BCS theory - role of electron and phonon - McMillan's formula - calculation of electron phonon coupling constant from band structure results - effect of pressure on the transition temperature - experimental and theoretical study of Fermi surface.

REFERENCES

1. H.L.Skriver The LMTO method, Springier Berlin 1984.
2. N.W. Ashcroft and N.D.Mermin, Solid State Physics Saunders 1976.
3. A.V.Narlikar 'Superconductivity' Plenium, 1994.
4. G.C.Fletcher Electron theory of solids, North Holland Pub.Co., 1980.

PH970 ADVANCED SOLID STATE IONICS

L T P C
4 0 0 4

AIM:

To expose the students with theoretical aspects of advanced solid state ionics and their applications.

OBJECTIVE:

To provide the knowledge on fundamentals of solid state physics, superionic materials and structures, experimental probes, applications of superionic solids and lithium batteries.

1. INTRODUCTION 8

Bonding types in solids - Fundamentals of Crystallography - Simple Crystal structures - X-ray crystal diffraction - bond structures of metals, semiconductors and insulators - Ionic and electronic conductivities.

2. SUPERIONIC MATERIALS AND STRUCTURES 9

Types of ionic solids - Superionic materials - Alkali metal ion conductors - silver ion conductors - Copper ion conductors - structural: principles for high silver and copper ion conductors - proton conductors - electronic conductors with ion transport - Hydrogen storage materials.

3. EXPERIMENTAL PROBES 9

Structural characterization - Thermodynamic properties - ion transport (macroscopic properties) - Ion dybnamics (microscopic properties) - Phoelectron spectroscopy - EXAFS (extended X-ray absorption fine structure) - Local environment studies - FTIR, Thermal analysis - DTA - DSC - TG. - Particle size analysis - SEM-TEM.

4. APPLICATION OF SUPER IONIC SOLIDS 9

Diffusion coefficient measurement in solids/liquids-sensor and partial pressure gauges - oxygen sensors (concentration cell type) - sulfur sensor (formation cell type) - Fuel cells - solid state battery - super capacitors.

5. LITHIUM BATTERIES 10

Principles and general background of ambient temperature lithium batteries - synthesis of nano materials for lithium batteries - properties, structure and conductivity of organic and inorganic electrolytes for lithium battery systems - thin film deposition - pulsed laser deposition of electrodes - preparation and fabrication - characterization of Li-ion cells - Comparison of lead acid-NiCd and Li-ion batteries - Application of Lithium batteries in electronic devices and electric vehicle - Solar energy conversion devices.

L : 45

REFERENCES

1. Superionic solids - Principles and applications, S. Chandra, North Holland Amsterdam (1981)
2. Principles of solid state physics, H.V.Keer, Wiley Eastern Ltd., New Delhi, 1993.
3. Modern Battery Technology, D.S.Clive, Alean International Ltd, Banbury, Elis Horwood Publishers, (1991)
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6. Nanochemistry, A chemical approach to nanomaterials, Ozin, Geoffrey.A, Arsenault Andre C, Springer (2005)

PH971 **METHODS OF THE CHARACTERIZATION OF NANOMATERIALS**

L T P C
4 0 0 4

AIM:

To expose the students with knowledge of understanding the basic characterization of nanomaterials

OBJECTIVE:

To make the understand the various necessary techniques used for analyzing the nanomaterials.

1. X-RAY ANALYSIS OF NANOMATERIALS **9**

Powder X-ray diffraction – powder diffraction techniques - Debye-Scherrer technique – indexing the powder pattern – calculation of particle size using Scherer method – problems associated with Scherer method –Weber-Fechner method for particle size analysis - Selected area diffraction - Low angle scattering - High resolution X-ray diffractometer (two and four crystal).

2. SURFACE ANALYTICAL TOOLS FOR NANO-MATERIALS **9**

UV and X-ray photoelectron spectroscopy; Auger electron spectroscopy; low energy electron diffraction and reflection high energy electron diffraction - secondary ion mass spectrometry - Rutherford backscattering - Medium energy ion scattering- Electron energy loss spectroscopy (EELS) and high resolution EELS. X-ray Photoelectron Spectroscopy, Auger photoelectron Spectroscopy.

3. NANOSCALE ELECTRICAL SPECTROSCOPY **9**

I-V/C-V; Hall, quantum Hall effects; transient charge spectroscopy. Optical spectroscopy: micro Photoluminescence; Absorption Spectroscopy, Excitation Spectroscopy, micro Raman Spectroscopy; Time domain spectroscopy.

4. ELECTRON MICROSCOPY **9**

Principle of SEM – EDAX analysis- standardization of elements - nanoSEM, basic principles- STM - STEM - sample preparation – nanoparticles – thin films - TEM - High resolution TEM -

5. NANO-IMAGING SPECTROSCOPY **9**

Basic principles - Scanning Tunneling Microscopy, Scanning Force Microscopy (SFM/AFM), scanning holographic microscopy -image interpretations; Scanning Near Field Optical Microscopy and scanning ion conductance microscopy.

L : 45

REFERENCES

1. G. Gao, Nanostructures and Nanomaterials, Imperial College Press, London, 2006

2. Y. Gogotsi, Nanomaterials Handbook, CRC Taylor and Francis, New York, 2006

PH972 INTRODUCTION TO NANOTECHNOLOGY

L T P C
4 0 0 4

AIM:

To introduce knowledge on basics of Nanotechnology

OBJECTIVE:

- To make the students understand the importance of Nanotechnology
- To make the students to understand the fundamental aspects of properties leading to technology

1. NANO SYSTEMS 9

Size effect and properties of nanoparticles - particle size - particle shape - particle density - melting point, surface tension, wettability - specific surface area and pore size – Reason for change in optical properties, electrical properties, and mechanical properties. Quantum confinement in 3D, 2D, 1D and zero dimensional structures - Size effect and properties of nanostructures- Top down and Bottom up approach.

2. SYNTHESIS OF NANOMATERIALS 9

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

3. NANOTUBES 9

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

4. CHARACTERIZATION 9

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

5. NANOTECHNOLOGY APPLICATIONS 9

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

L : 45

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1. “Nanotechnology” G. Timp. Editor, AIP press, Springer-Verlag, New York, 1999
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3. “Hand book of Nanostructured Materials and Technology’’, Vol.1-5, Editor:- Hari Singh Nalwa; Academic Press, USA (2000).
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5. Nanoscale characterization of surfaces & interfaces, N John Dinardo, Weinheim Cambridge: Wiley-VCH, 2nd ed., 2000.