

COURSE-I
RESEARCH METHODOLOGY

UNIT :1 RESEARCH TECHNIQUES

Problem identification – Determining the mode of approach-literature survey-various sources-current status of the problem –impact and usefulness of the research topic-role of guide and scholar – Use of internet e-mail and www browsing-use of software packages MS office – Introduction to MATLAB.

UNIT :2 PREPARATION AND PRESENTATION OF SCIENTIFIC REPORTS

Writing a paper and preparing a poster-art of writing synopsis, dissertation and thesis-Illustrations and analysis of results.

UNIT :3 NUMERICAL ANALYSIS

Curve fitting –Least squares method –solution of equations :Graphical Method , simple iterative method-Jacobi's method-Gauss Serial method- Regula falsi method-Newton-Raphson method-Numerical Integration: Simpson's rule - Gaussian's integration- Differential equation: Taylor's series solution- Predictor corrector method-Eulers method - Runge-Kutta method.

UNIT :4 BASICS OF C PROGRAMMING

Introduction to C –Character set– Identifiers and keywords – Data types – constants – symbolic constants –Expressions – statements –Arithmetic, Relational, Logical and assignment operators, increment and decrement operators, conditional operators – Bitwise operator, special operator, library functions- input and output functions

Control statements – while, do-while, for, nested for, if – else, switch, break, continue and go to statements- arrays.

UNIT :5 RESEARCH EQUIPMENTS

Working principles and applications of UV, VIS, IR, FTIR, XRD, SEM, TEM, STEM, ESR, and NMR.

REFERENCES:

1. J. Anderson, and M. Poole. Assignment and Thesis Writing. 4th Edition. John Wiley and Sons Inc. (2002)
2. M.K. Venkataraman. Numerical Methods in Science and Engineering. The National Publishing Company, Madras. (1999).
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain , Numerical Methods for Scientific and Engineering Computation. 4th Edition. New Age International Publishers. New Delhi, India. (2005).
4. E. Balagurusamy. Programming in ANSI C. 6th Edition. Tata McGraw Hill Education Private Limited, New Delhi, India. (2012).
5. K. Ravichandran, K. Swaminathan, and B. Sakthivel. Introduction to Thin Films. Research India Publications. New Delhi. (2013).

Question Paper Pattern

Maximum: External – 60 Marks, Internal – 40 Marks

Section – A: Either or type Questions (5x6=30 Marks) (1 pair from each unit)

Section – B: 3 Out of 5 (3x10=30 Marks) (1 Question from each Unit)

Signature of the HOD

COURSE-II
THEORETICAL PHYSICS

UNIT :1 IMPERFECTION IN ATOMIC PACKING

Defects in solids-point defects-plane defects-dislocation-diffusion and ionic conductivity-color centers-photoconductivity-luminescence-types of luminescence-thermo and electro luminescence Glow curve-absorbtion and emission spectra.

UNIT :2 PREPARATION TECHNIQUES

CHEMICAL METHODS: Electroplating-ion plating-Chemical reduction plating-vapour phase growth. Anodisation-Vacuum evaporation-Evaporation theory-Sputtering methods-Reactive sputtering-RRF Sputtering-preparation technique of semiconducting Chalcogenide binary compounds.

High vacuum Technology: Vacuum Pump-Oil-sealed rotary pumps-Diffusion pump-pressure measurement-Thermal conductivity-Gauge-pressure gauges for high to ultra high vacuum.

UNIT :3 ULTRASONICS

Ultrasonic waves-different methods of production-behaviour - reflection and transmission at normal incidence-stationary waves and resonance.

Detection of Ultrasonic waves-Measurment technique of ultrasound-pulse echo overlap method –cross corelation method-phase slope method.

UNIT :4 ELECTRONICS AND CONTROL CIRCUITS

Electronics control circuits-Introduction to automatic control system open loop control system-closed loop control system-basic elements of servo mechanism-advantages of electronic control of devices-dc motor speed control-temperature control-illumination control-automatic water level indicator using SCR-Battery operated inverter circuit using power transistor.

UNIT :5 NON CONVENTIONAL ENERGY

Principle of conversion of solar radiation into heat-Green house effect-flat plate collectors- general characteristics-solar concentrators- parabolic and spherical systems-solar cells-characteristics –peak power point photovoltaic cell-types of solar cell applications -indirect sources of solar energy conversion- wind energy-Horizontal axis type wind mill.

REFERENCES:

1. Introduction to Solid state physics, Charles Kittel, Wiley International,6th Edition,(1986)
2. Ultrasonics-Benson Carlin Tata McGraw Hill Company,3rd Edition,(1949)
3. Hand Book of Thin film technology, L.T.Maissel and Glang McGraw Hill, (1970)
4. Thin film Phenomena, K.L.Chopra, Krieger Publishing Company, (1979) .
5. Solar energy utilization-G.D.Rai Khanna Publishers, (1987)
6. Fundamentals of Microprocessor 8085: Architecture Programming, and Interfacing, Viswanathan, S. Printers & Publishers Pvt Ltd,(2009)
7. Fundamentals of Microprocessor and computers by Badri Ram, Dhanpat Rai and sons, New Delhi,(1995.)
8. Industrial Electronics and Control S.K.Battarcharya,S.Chatterjee, Tata McGraw Hill,(2001)
9. Laser: Theory and Application, Thyagarajan, K.; Ghatak, A. K. New York, Plenum Press, (1981.)

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COURSE-III
NANO PHYSICS

UNIT: 1 IMPERFECTION IN ATOMIC PACKING AND TOOLS

Atomic structures-Molecular and atomic size-Bohr radius -Nucleation-Influence of nucleation rate on the size of the crystals- macroscopic to microscopic crystals and nanocrystals - large surface to volume ratio, top-down and bottom-up approaches-self assembly process-grain boundary volume in nanocrystals-defects in nanocrystals-surface effects on the properties.

Nano SEM - Scanning Conducting microscopy (SCM) - High-resolution Transmission Electron Microscopy (HRTEM) - single nanoparticle characterization – Scanning capacitance microscopy. Principle and working of Atomic Force Microscopy (AFM) and Scanning tunneling microscopy (STM) – Principle of Transmission Electron Microscopy (TEM) – applications to nanostructures – nanomechanical characterization – nanoindentation.

UNIT: 2 NANOMATERIALS AND SYNTHESIS ROUTES

Carbon Nanotubes (CNT) - Metals (Au, Ag) - Metal oxides (TiO₂, CeO₂, ZnO) - Semiconductors (Si, Ge, CdS, ZnSe) - Ceramics and Composites - Dilute magnetic Semiconductor -Metallic glasses- Shape Memory Alloys (SMA) - Bio Materials - Biological system - DNA and RNA - Lipids - Size dependent properties -Mechanical, Physical and Chemical properties.

New forms of Carbon- Types of nanotubes- formation of nanotubes- methods and reactants- arcing in the presence of Cobalt- Laser methods- Ball Milling-Chemical Vapour Deposition Methods- Catalytic route- Properties of Nano tubes- Plasma arcing electro deposition-Pyrolytic Synthesis.

UNIT: 3 NANO OPTICS AND NANO COMPUTING

Optics-Photonics of Nanotechnology –Properties of light and nanotechnology- interaction of light with nano systems- Absorbance- Surface Plasma excitation.

Nano computers -Types - Quantum computers - DNA computers - construction-working - molecular computing - optical computing.

UNIT: 4 NANO ELECTRONICS

Nano electronics -Nanofabrication-molecular electronics- Nano electronic devices-Nano circuitry- Nano electronics with tunneling devices and superconducting devices - Molecular electronics- Applications of superconducting devices-- Plastic electronics.

UNIT: 5 SENSORS AND ENERGY APPLICATIONS

Chemical and Molecular Sensors- Bio sensor-DNA Sensors-optical bio sensors- Displacement and motion sensors- Force nano sensors- pressure sensors- Thermal Sensors- Neural microsensing. Nanotubes based sensors, Fluid flow, gas temperature, Gas sensing (SnO_2) - LPG (sensor SnO_2 -Powder.) - Fuel cells - Solar cells.

BOOKS FOR STUDY & REFERENCES:

1. Understanding nanotech, Scientific American, editors at Scientific Wmer Books(2002)
2. Nanoelectronics and nanosystem: From transistors to molecular devices K.Goser, P.Glosekottert,J.Dienstuhl sringer 2004
3. Magnetic Materials: Fundamentals and device applications Nicola Am Spaldin, Cambridge University Press(2003) ISBN 0521016584.
4. Nanocomposite Science and Technology, Pulicket.M.Ajayan, Linda.S.Schadler Paul V.Braum,Willey-VCH Verlag, Weiheim(2003)

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ADVANCES IN CRYSTAL GROWTH AND APPLICATIONS TO NANOMATERIALS

UNIT :1 CLASSICAL THEORY OF NUCLEATION

Gibbs Thomson equation – theory of nucleation – energy of formation of a nucleus – different possible shapes of nucleus - homogenous nucleation of binary system – heterogeneous nucleation - free energy of formation of critical heterogeneous – cap shaped – disc shaped nucleus – secondary nucleation.

UNIT :2 THEORY OF CRYSTAL GROWTH

Surface energy theory – diffusion theory – absorption layer theory – Volmer theory – Bravais theory – Kossel theory – Straski's treatment – two dimensional nucleation theory.

UNIT :3 GROWTH OF CRYSTAL FROM MELT

Growth of III-V materials – growth of oxide materials – growth crystal from flux – slow cooling method- temperature difference method – high pressure method – solvent evaporation method – electro crystallization – crystal growth by thermal, hydrothermal method.

UNIT : 4 CRYSTAL CHARACTERIZATION

Single crystal diffraction techniques – power diffraction – indexing – least square refinement – X-ray fluorescence – X-ray topography – SEM and TEM studies – electron probe microanalysis – secondary ion mass spectroscopy (SIMS) – electron spectroscopy for chemical analysis (ESCA) – electrical conductivity – measurement of electrical conductance – measurement of dielectric constant – micro hardness – etching studies.

UNIT : 5 PROPERTIES OF NANOMATERIALS

Nanomaterials – method used to produce nanomaterials – Sol-Gel synthesis – applications of nanomaterials – Automobiles with greater fuel efficiency – Aero space components with enhanced performed characteristics – better and future weapons platforms – longer lasting satellites – longer lasting medical implants – ductile, machinable ceramics – large electrochromic display devices.

BOOKS FOR STUDY:

1. Modeling crystal growth rates from solution by Makoto Oharo and Robert C.Reid PHI Pvt. Ltd., New Delhi, 1973
2. Crystal Growth Process by J. C. Brice . John Wily and sons., NY 1986.

BOOKS FOR REFERENCE:

1. 1.Synthesis, crystal growth and characterization – Krishnan Lal, North Holland Amersterdam (1982).
2. A Guide to materials characterization and chemical analysis – John P. Sibia, Wiley VCH(1996)
3. Introduction to Nano Technology – Charles P. Pool Jr. and Frank J. Owens , John Wiley Sons., New Delhi 2006.

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THIN FILM PHYSICS

UNIT: 1 NUCLEATION THEORY AND DEPOSITION METHODS

Theories of nucleation- Four stages of film growth incorporation of defects during growth-Chemical methods: Liquid phase epitaxy– electrodeposition-Ion plating- Chemical reduction plating-Vapour phase growth - Anodisation-Vacuum evaporation- Evaporation theory-Sputtering methods- Reactive sputtering-RF sputtering- Preparation technique of semiconducting- Chalcogenide binary compounds - Molecular beam epitaxy (MBE).

UNIT 2: PRESSURE AND THICKNESS MEASUREMENTS

High vacuum Technology: Vacuum pump- Oil sealed Rotary pumps-Diffusion pump- pressure measurement- Thermal conductivity –Gauge –Pressure gauges for high to ultra high vacuum.

Thickness measurements: Electrical methods –microbalance monitors-optical interference methods multiple beam interferometry- Fizeau and FECO methods- Quartz crystal thickness monitor.

UNIT 3: INSULATING AND DIELECTRIC FILMS

Metal insulator contact –Ohmic-neutral, blocking contacts –two electrode system-conduction mechanism in insulator film- Photoconduction –Experimental techniques.

Dielectric properties –dielectric constant –dielectric loss capacitance – breakdown voltage – polarization – effect of temperature and frequency on dielectric properties.

UNIT 4: ELECTRICAL, OPTICAL AND MAGNETIC PROPERTIES

Sources of resistivity in metallic conductors – sheet resistance – TCR influence of thickness on the resistivity –Hall effect- influence of heat treatment – optical characterization by spectrophotometer (refractive index, Absorption Edge – Transmission and absorbance) – Energy band gap – Magneto resistance – Ferromagnetic Domain studies –Meissner effect –super conducting stage.

UNIT: 5 THIN FILM APPLICATIONS

Thin film passive components –Thin film battery –Thin film for Gas sensors and photovoltaic applications –Thin film flexible LED –CNT and its applications - Field Emission Display - Decorative and Barrier Coatings.

REFERENCES:

1. Hand Book of Thin Film Technology –L.T. Maissel and Glang McGraw Hill, NY (1983).
2. Thin film Fundamentals –A.Goswami New Age International ,New Delhi (2003).
3. Thin film Phenomena –K.L.Chopra McGraw Hill NY (1969).

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LIQUID STATE AND THIN FILM PHYSICS

UNIT :1 ULTRASONICS

Introduction – Generation of ultrasonic waves – piezo electric generator – magnetostriction – generator – applications of ultrasonic waves – ultrasonic communication – testing materials – separation of mixtures – thermal effect – physical and chemical effect- biological effect.

UNIT :2 ULTROSONIC STUDY OF LIQUID MIXTURES AND SOLUTIONS

Molecular interactions – Types – Ultrasonic study – Preparation of multi component mixtures – Measurement Techniques – Coefficient of absorption – Density , viscosity measurements – Theories of ultrasonic velocity in mixtures and solutions.

UNIT :3 INTERNAL PRESSURE AND FREE VOLUME

Theories of liquid state –inadequacy- Internal pressure – derivation – free energy – significance – thermodynamic equation of state – internal pressure , free volume- sound velocity – experimental determination.

UNIT : 4 PREPARATION TECHNIQUES

Chemical methods: Electroplating - ion plating – chemical reduction plating – vapour phase growth. Anodisation – vacuum evaporation – evaporation theory – sputtering methods – reactive sputtering – RF sputtering – preparation technique of semi conducting chalcogenide binary compounds.

High vacuum technology: Vacuum pump – oil sealed rotary pumps – diffusion pump – pressure measurement – thermal conductivity – Gauge – pressure gauges for high and ultra high vacuum.

UNIT : 5 THICKNESS MEASUREMENTS

Thickness measurements: Electrical methods – microbalance monitors – optical interference methods – multiple beam interferometer – Fizeau and FECO methods – Quartz crystal thickness monitor. Theories of nucleation – four stage film growth- incorporation of defects during growth.

REFERENCES:

1. Robert. T. Beyera and Stephen, GB., Physical Ultrasonics, Vol.32, Academic Press, New York.
2. Panaj and Sharma, Ultrasonics (G.B) (1991).
3. Barker J.A, Lattice Theories of Liquid state, Oxford, Pergaman (1963).
4. Eyring H., Jhon, M.S. Significant Liquid structure, New York, Wiley (1969).
5. L.T. Maissel and Glang, Hand book of Thin film Technology, McGraw Hill, New York, (1983).
6. A. Goswamy, Thin Film Fundamentals, New Age, New Delhi, (2003)
7. Thin Film Phenomena, K.L. Chopra, McGraw Hill NY(1969).

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X – RAY CRYSTALLOGRAPHY

UNIT : 1

Crystals Morphology - Miller Indices – Zones - Concept of Lattice – Periodicity - Seven Crystal Systems - 14-Bravais Lattices - Unit Cell Volume.

Symmetry - Symmetry elements – Non-existence of five-fold symmetry in crystal lattice - Proper and improper rotations - Point groups - Space groups - Systematic absences - Space group determination.

Concept of reciprocal lattice - Ewald's and limiting spheres.

UNIT : 2

Scattering of X-Rays - Atomic scattering factor - Molecular scattering factor - Structure factor - Scattering by crystals - Bragg's law.

Practicing film techniques - Weissenberg and Precession methods - Diffractometer measurements - 4-Circle Diffractometer - Data collection - Data reduction - Absorption correction - CCD.

UNIT : 3

Solution of Phase problem - Fourier synthesis - Patterson synthesis - Direct methods - Various steps involved in structure determination using direct methods – DIRDIF – SHELXS – SUPERFLIP – SIR.

UNIT : 4

Refinement of structures - Difference Fourier methods - Least Squares technique- F_o and F_o^2 refinement - Weighting schemes – R- indices – GOOF – SHELXL – CRYSTALS – OLEX2.

UNIT : 5

Structure interpretation - computation of bond lengths, bond angles, torsion angles - Conformational features – Packing – H-bonds - Other short contacts – PARST – PLUTON – PLATON – ORTEP – MERCURY.

REFERENCES:

1. Massa, W. Crystal Structure determination. Springer-Verlag, Berlin, Heidelberg, (2004)
2. Giacovazzo, C., Monaco, H. L., Artioli, G., Viterbo, D., Milanesio, M., Ferraris, G., Gilli, G., Gilli, P., Zanotti, G. & Catti, M. Fundamentals of Crystallography. Third Edition. Edited by C. Giacovazzo. IUCr, OUP, Oxford, (2011).

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PHYSICS OF DIELECTRIC MATERIALS

OBJECTIVE:

This paper provides detailed information about various dielectric parameters and molecular interaction in materials at high frequency electromagnetic fields.

Unit 1: THEORIES OF STATIC PERMITTIVITY

The molecular origins of permittivity and loss – Polarization types Debye's theory of static permittivity – Onsager's theory of the internal field and permittivity – Kirkwood's theory and Frohlich's theory for non-polarizable dipoles – relation between Kirkwood's and Frohlich's theory.

Unit 2: DIPOLE MOMENT STUDIES

Dipole moment – Experimental determination – Debye's method and Onsager's method – application to molecular structure – dipole moment of molecular complexes – Few and Smyth method- Huyskens method.

Unit 3: DIELECTRICS

Dielectrics and insulators – various polarization mechanisms – polarization and relaxation in solid and liquid dielectrics – Ceramics and Plastic dielectrics – power and distribution equipments – electronic equipments – Capacitors – Dielectric rectifiers and piezo electric transducers – Memory devices.

Unit 4: MICROWAVE FREQUENCY TECHNIQUES

X-band microwave bench – Principle – Von Hippel Method Experimental arrangement – Determination of dielectric parameters-Dielectric and conductivity measurements at microwave frequencies – Microwave devices fabrication - Dielectric relaxation – Higasi's and Cole-Cole plot methods – Rate theory of dielectric relaxation and viscosity –Time domain Reflectometry – Principle, Experimental arrangement- Procedure- Dynamic permittivity – Davidson – Cole model, Havariliak – Nagami model – Applications.

Unit 5: POLYMERS

Monomers – Polymers classification – Chain and step polymerization – Thermo plastic and thermosetting polymers – Mol.wt and degree of polymerization – Glassy solids and glass transition temperature with copolymers — Polymer dielectrics in power equipments – Conducting polymers –charge transfer complexes – Effect of doping on

polymers and its techniques – Optical properties of polymers –Effect of polymer-Structure on optical properties-clarity, transparency, haze, transmittance, reflectance and gloss-refractive indices of polymers by group contributions – polymer solar panels

REFERENCES:

- 1) Dielectric properties and molecular behaviour – Nora E Hill – Van Nostrand Co.London(1969).
- 2) Dielectric behaviour and molecular structure – C.P Smyth –McGraw Hill publication(1955).
- 3) Electric dipole moments – J.W.Smyth – Butterworth publications(1955).
- 4) Microwave Techniques and Laboratory manual – M.L Sisodia and G.S. Raguvanshi – Wiley Eastern Limited – (1987).
- 5) Hydrogen bonding - S.N. Vinogradov – Nostrand Reinhold (1971).
- 6) Polymer Science V.R. Gowariker, N.V. Viswanathan and Jayadev Sreedhar – New Age International (P) Ltd (1986).
- 7) Dielectric materials and applications – Von – Hippel A.R., John wiley and Sons Inc., New York (1974).
- 8) Dielectric Relaxation – Daniel V. E., Academic Press., London (1967).
- 9) Molecular interactions Vol(2) – Rataj C Zak and Orville –Thomas – Wiley Interscience(1982).
- 10) A special issue on conducting polymers – Indian journal of Chemistry Sec A – (1994).
- 11) Handbook of conducting polymers – Terje A. Skotheim – Marcel Dekkar Inc (1986).
- 12) Text book of Polymer Science-F.W. Bill Mayer-Wiley International Publications-(1984).

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CHEMICAL PHYSICS

Unit 1: THEORIES OF STATIC PERMITTIVITY

Molecular origins of permittivity and laws – polarization types – Debye's theory of static permittivity – Onsager's theory of the internal field and permittivity – Kirkwood's theory and Frolich theory for non-polarizable dipoles – Relation between and Kirkwood's and Frohlich theory.

Unit 2: DIPOLE MOMENT STUDIES

Dipole moment – Experimental determination – Debye's method and Onsager's method – application to - molecular structure – dipole moment of molecular complexes – Few and Symth method Huyskens method.

Unit 3: FREQUENCY DOMAIN AND TIME DOMAIN TECHNIQUES

X-band microwave bench – principle – experimental arrangement – dielectric relaxation – Higasi and Cole-Cole plot method – Rate theory of dielectric relaxations and viscosity – Time Domain Reflectometry - principle – Experimental arrangement – procedure – dynamic permittivity – Davidson –Cole method - Havariliak – Negami model – applications.

Unit 4: FUNDAMENTALS OF H - BONDING STUDIES

Nature of H-bonding – Model of Hydrogen bonding (Electrostatic model, (Quantum mechanical models) – potential energy curves and symmetrical hydrogen bonds – proton transfer and ion pair formation – thermodynamics of H-bonding – equilibrium constants.

Unit 5: IR SPECTRA AND H - BONDING

Applications of IR spectra in the study of H-bonding - determination of equilibrium constants – Nash method – Whetsal and Kagarise method - thermodynamic properties – dipole moment derivatives – enhancement of intensity in H-bonding system.

BOOKS FOR REFERENCES:

- 1) Dielectric properties and molecular behaviour – Nora E Hill – Van Nostrand Reinhold London.Ny-(1969).
- 2) Dielectric behaviour and molecular structure – C.P Smyth –McGraw Hill publication-(1955).
- 3) Electric dipole moments – J.W.Smyth – Butterworth publications London –(1955).
- 4) The IR spectra of complex molecules – L.J. Bellamy-Publisher-2nd edition, London, Chagman and Hall-(1980).
- 5) Hydrogen bond – G.C.Pimental and A.L.McClellan-Annual review of Physical Chemistry-(1971).
- 6) Hydrogen bonding - S.N. Vinogradov and R.H.Linnell- Van Nostrand Reinhold Co. London. (1971)
- 7) Microwave techniques and laboratory manual – M.L Sisodhia and G.S. Raguvanshi – Wiley Eastern Limited – (1987).
- 8) Molecular interactions Vol.(2) –H. Ratajczak and J.Orville –Thomas – Wiley Interscience-NY-(1982).
- 9) Dielectric materials and applications – VonHippel A.R., John Wiley and Sons. NY (1954).
- 10) Dielectric Relaxation – DanielVera., Academic Press.,1st Edition London (1967).

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