ITEM NO. FS 13.04(3)

ANNA UNIVERSITY CHENNAI :: CHENNAI-600 025

M.PHIL CRYSTAL SCIENCE

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEROY						
1	CG 911	Research Methodology	4	0	0	4
2	CG 912	Theoretical and Experimental Aspects of Crystal Growth	4	0	0	4
3		Elective I	4	0	0	4
4		Elective II	4	0	0	4
		TOTAL	**16**	**0**	**0**	**16**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	CG 921	Seminar	0	0	2	1
2	CG 922	Project Work	0	0	32	16
		TOTAL	**0**	**0**	**34**	**17**

ELECTIVES

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	CG 951	Semiconductor Physics	4	0	0	4
2	CG 952	Semiconductor Devices	4	0	0	4
3	CG 953	Characterization of semiconductor crystals	4	0	0	4
4	CG 954	Fabrication and Characterizations of Solar Cells	4	0	0	4
5	CG 955	Characterizations Technique	4	0	0	4
6	CG 956	Ferroelectrics	4	0	0	4
7	CG 957	Biological Crystallization	4	0	0	4
8	CG 958	Nanomaterials and Nanotechnology	4	0	0	4
9	CG 959	Epitaxial Growth	4	0	0	4

CG 911 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.

1. RESEARCH DESIGN AND 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.

2. 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.

3. 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.

4. 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 and parabola.

5. 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

CG 912 THEORETICAL AND EXPERIMENTAL ASPECTS OF CRYSTAL GROWTH

L T P C
4 0 0 4

AIM:

To train the students in understanding important aspects related to the theory and experiments in Crystal growth and to prepare to take up research activity in the field of crystal growth.

OBJECTIVE:

- To provide information on the important aspects of nucleation mechanisms involved in the growth of crystals and to evaluate the existing theories of crystal growth
- To introduce the development and experimental aspects of crystal growth.
- To train the students in specific areas of growing techniques in making bulk single crystals related to Lasers, Electronics and Photovoltic activities.

UNIT - I **15**

Phase equilibria – Single component system – component systems – simple eutectic – Peritectic – Binary compounds with congruent melting – Solid solutions – Solid-liquid and liquid – vapour equilibria. Nucleation concept – Kinds of nucleation – Homogeneous nucleation – Equilibrium stability and metastable state – classical theory of nucleation – Gibbs-Thomson equation – Kinetic theory of nucleation – Energy of formation of a nucleus – Statistical theory of nucleation – Free energy of formation of nucleus considering translation, vibration and rotational energies. Homogeneous nucleation of Binary system – Induction period. Heterogeneous nucleation – Equilibrium concentration of embryos for different sizes – Energy of formation of a critical nucleus – Free energy of formation of a critical heterogeneous - cap shaped – disc shaped nucleus – Heterogeneous nucleation of Binary vapour – Secondary nucleation.

UNIT - II **12**

Theories of crystal growth - Surface energy theory - Diffusion theory - Adsorption layer theory - Volmer theory -Bravais theory - Kossel theory - Stranski's treatment - Two dimensional nucleation theory - thermodynamics of nucleation – Free energy of formation of a two dimensional nucleus – possible shapes – Correction to the two-dimensional nucleation theory – Rate of nucleation – Mononuclear model – Polynuclear model – Birth and spread model – Modified Birth and spread model. Crystal growth by mass transfer processes - Bulk diffusion model - Surface diffusion growth theories - Mobility of adsorbed molecules on a crystal surface Physical modeling of BCF theory - BCF differential surface diffusion equation - single straight step - Multiple straight parallel steps – Surface supersaturation and concentration near the step – PBC theory (qualitative) - Growth rate of an F-face, K-face and S-face - Giant dislocation steps – Temkin’s model of crystal growth – Computer simulation technique.

UNIT - III MELT GROWTH **12**

Growth of crystal from melt - Bridgman method - Kyropolous method - Czochralski method-Verneuil method - Zone melting method - LEC growth of III - V materials Growth of oxide materials. Growth of crystals from flux - Slow cooling method - Temperature difference method - High pressure method - Solvent evaporation method - Top seeded solution growth -Growth of superconducting single crystal.

UNIT – IV VAPOUR GROWTH AND EPITAXY 12

Growth of crystals from vapour phase - Physical vapour deposition - Chemical vapour transport - Open and closed system - Thermodynamics of chemical vapour deposition process - Physical, thermo-chemical factors affecting growth process.

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

UNIT - V SOLUTION GROWTH 12

Growth of crystals from solutions - solvents and solutions - solubility - preparation of a solution - saturation and supersaturation - Measurement of supersaturation - Expression for 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 - Complex decomposition method -Solubility reduction method - Growth of biologically important crystals - Crystal growth by hydrothermal method.

TOTAL : 60 PERIODS

TEXT BOOKS;

1. J.C. Brice, Crystal growth processes John Wiley and sons, New York, 1986.
2. A. Laudise- The Growth of single crystals. Prentice Hall, 1970.
3. Pamplin- Crystal Growth. Volume 16, Pergamon press.1973.

REFERENCES:

1. F.F. Abraham, Homogenous nucleation theory, Advances in Theoretical Chemistry, Academic Press, New York, 1974.
2. R.F. Strickland, Kinetics and Mechanism of Crystallization. , Academic Press, New York, 1968.
3. AM Alper, Phase Diagrams: Materials Science and Technology**,** Vol.I— VI, Academic Press, New York, 1970.

CG 951 SEMICONDUCTOR PHYSICS

L	T	P	C
4	0	0	4

AIM:

To inculcate the technology in the fundamental aspects of semiconductor physics with reference to the applications of semiconductors.

OBJECTIVE:

- To provide updated information on the evaluation of semiconductor physics.
- To enable the students to evaluate the usefulness of the physical properties for specific device applications.

UNIT - I INTRODUCTION TO SEMICONDUCTORS 12

Bonds and Bands in Semiconductor: Chemical band in semiconductor-The Semiconducting bond - Energy bands - Bond approach Vs Band Model - Elementary properties of semiconductors - Types of semiconductors - intrinsic and extrinsic semiconductors - p and n type semiconductors - Doping of semiconductors (High level and Low level) - Elementary theory of semiconductors - control of carrier concentration - Energy levels in crystalline solids - energy level diagrams - carrier concentration in thermal equilibrium - Free electron Theory - Transport properties. Junction Properties of semiconductors - Homogeneous, Inhomogeneous semiconductors - direct and induct bandgap semiconductor 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 OF SEMICONDUCTORS 12

Optical constants - Light absorption spectrum - Light absorption edge - Effect of free charge carriers on the absorption edge - Fundamentals of - Light absorption by free charge carriers - Intrinsic light absorber - Light absorption dependence on temperature, pressure, alloy composition and degeneracy - Transition between the valence and conduction, within the valence and conduction bands - ambient absorption spectrum - Photo resistive effect - Demper effect - Photovoltaic effect - Faraday effect.

UNIT – III ELECTRON TRANSPORT PHENOMENA 12

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 – Different scattering mechanisms - electron scattering by static defects - phonons - high fields effects - hot electron transport theory - dynamics of localized phonon modes - shallow impurity states in semiconductors - electronic states and structural properties of Deep Centers in semiconductors - impurity bands - the electronic structure of surfaces and interfaces - space charge layers at Semiconducting interfaces - the theory of surface waves.

UNIT - IV THERMAL EFFECT IN SEMICONDUCTOR 12

Thermal conductivity - Thermo-electric power - Thermo magnetic effects - condition of degeneracy - strong magnetic fields - relative magnitudes of the magnetic effects. Optical and High frequency effects in Semiconductor: Optical constants of semiconductors - the fundamental absorption - exciton absorption photoconductivity - the photo-magnetic effect - high frequency effects in magnetic field - impurity absorption - lattice absorption - Infra-red emission from semiconductors - diffusion of electron and positive holes.

UNIT - V APPLICATION OF SEMICONDUCTOR 12

Use of Semiconductors in electrical technology - Rectifiers - Transistors - Photodiode - Photo-electric power generator - Photo cells - Infra-red detectors - Infra-Red and Microwave modulators - Thermopiles - Thermo-electric refrigerators - Thermistors,Varistors and Other non-linear resistor.

TOTAL : 60 PERIODS

TEXT BOOKS:

1. S.M. Sze, Semiconductor Devices, Physics and technology, Wiley Publishers, New York, 1985.
2. Jasprit Singh-Electronic properties of Semiconductor structures, Cambridge University Press, 2003.

REFERNCES:

1. Pallab Bhattacharya, Semiconductor Optoelectronic Devices, Prentice- Hall of India, 1999.
2. Donald A.Neaman, Semiconductor Physics and devices, Tata McGrew-Hill Edition 2007

CG 952 SEMICONDUCTOR DEVICES

L	T	P	C
4	0	0	4

AIM :

To motivate the students in specific semiconductor devices based on the existing developments and to make the students understand the fundamentals in device structures.

OBJECTIVE :

- The selected concepts on device structures and fabrications will be introduced to the students to enable the students to understand the effective process and steps involved in device fabrications.
- To motivate the students in the technologically designed fabrications and devices such electrical and optical devices.

UNIT – I SEMICONDUCTOR PROPERTIES 12

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 Characterization - important processes for optoelectronic devices - Hetero junctions and Heterostructures materials and device configuration.

UNIT - II BIPOLAR DEVICES 12

Ion implantation : Ion implantor - general description - ion sources - range distribution - Theoretical approaches - sample holder - profiles - MeV implants ion damage - Annealing - Rapid thermal annealing - Laser annealing. Bipolar devices: p-n junction diode - basic device technology - depletion region and depletion capacitance - I-V and C-V Characteristics - junction breakdown - terminal functions - Heterojunction - 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 - III METAL –SEMICONDUCTOR CONTACTS 12

Unipolar devices: Metal-Semiconductor contacts - Energy - Band Relation - Schottky Effect - Characterization of Barrier Height - Device Structure - Ohmic Contact - JFET and MESFET - basic device characteristics - general characteristics - Microwave performance - MIS diode - Si-SiO2 MOS diode - Charge-Coupled Devices - MOSFET - basic device characteristic - Nonuniform doping and buried-channel devices - short-channel effect - MOSFET Structures - Nonvolatile memory devices.

UNIT- IV OPTICAL DEVICES 12

Special Microwave devices: Tunnel devices - tunnel diode - backward diode - MIS tunnel diode - MIS switch diode - MIM tunnel diode - tunnel transistor - IMMPATT and related transit-time diodes - static characteristics - dynamic characteristics - device design and performance - BARITT and DOVETT diodes - TRAPATT diodes - Transferred-electron devices - transferred- electron effect - modes of operation - device performances. Photonic Devices: Light Emitting diodes - LED for fiber optics - LED performance - reliability - Semiconductor Laser - Lasers for optical communication system - Photodetectors - Photoconductor - Photodiode - Avalanche Photodiode - Phototransistor - Solar cells - Thin film Solar cells.

UNIT - V APPLICATION OF SEMICONDUCTOR DEVICES 12

Applications of III-V Compounds: Semiconductor device processing for Integrated Circuits - Silicon Integrated Circuit Processing - Gallium Arsenide Digital Integrated Circuit Processing - Semiconducting Thin Films for electronic components - Solid State Sensors, Optical Sensors - Opto-electronic components - Semiconducting oxide thin films for solar cell fabrications - Semiconducting thin films for solar cell applications.

TOTAL : 60 PERIODS

TEXT BOOKS:

1. S.M.Sze, Physics of Semiconductor devices (2nd edition) Wiley Eastern Ltd., New Delhi, 1981.
2. D.A. Fraser, The Physics of Semiconductor devices Clarendon Press, Oxford, UK, 1986
3. M.S. Thyagi, Introduction to Semiconductor Materials and Devices, John Wiley & Sons, New York, 1991

REFERENCE:

1. Dieter. K. Schroder, Semiconductor Material and Device characterization, John Wiley & Sons Inc., New York, 1990.
2. David L. Pulfrey and N. Garry Tarr, Introduction to Microelectronic Devices, Prentice-Hall international editions, New Delhi, 1989.
3. Peter Gise & Richard Blanchard, Modern Semiconductor fabrication technology Prentice-Hall, New Jersey, 1986
4 Cheening Hu and Richard M. White, Solar Cells Basic to advanced Systems McGraw Hill Book Company, New York, 1983

CG 953 CHARACTERIZATION OF SEMICONDUCTOR CRYSTALS

L	T	P	C
4	0	0	4

AIM:

Evaluation of material properties is fundamental to the effective utilization of semiconductor crystals. Specific characterization techniques is to be exposed to the students to train them in the utilization of materials.

OBJECTIVE:

- To train the students on the fundamentals of structural characterization to enable the students to understand the usefulness of optical characterization.
- To provide information on the evaluation of the quality of the semiconductor crystals in terms of its structure, electrical and optical perfection.

UNIT – I X-RAY DIFFRACTION 12

X-ray diffraction - Powder method - rotating crystal method - specimen preparation - measurement of d-values - indexing procedure for cubic and tetragonal crystals - Single crystal diffractometer - double crystal diffractometer - triple crystal diffractometer - four crystal diffractometer

UNIT – I I STRUCTURAL AND ELECTRICAL CHARACTERISATION 12

X-ray topography(XRT) - Berg-Barret-Lang geometry - Crystal perfection analysis- Hall effect - Evaluation of Carrier Concentration - Hall Mobility - resistivity -. Deep Level Transient Spectroscopy (DLTS) - analytical technique for impurity/defect analysis.

UNIT - III MECHANICAL PROPERTIES 12

Evaluation of doped impurity segregation coefficient - Hardness - anisotropy - types of Hardness - Evaluation of the Cracks patterns - Mechanical properties-fracture toughness

UNIT–IV OPTICAL AND MORPHOLOGICAL STUDIES 12

Optical, Scanning Electron Microscope (SEM) - morphological studies -- Transmission Electron Microscope (TEM) - structural analysis - Luminescence - Photoluminescence(PL) - Thermoluminescence (TL) - Electroluminescence (EL) - Bulk Analysis.

UNIT - V QUALITY EVALUATION TECHNIQUES 12

Rutherford Back Scattering analysis(RBS) - principle of channeling semiconductor epilayers interface analysis - Impurity analysis. Dissolution - Etching - Mechanism of dissolution- Various types of Etching - Thermal etching - Chemical etching - Electrolytic etching - Photo-etching - Selective etching - Mechanism of selective etching - Etch pit - Model of etch-pit formation at dislocation sites - Hillock - calculation of Etch Pit Density and Hillock Density - types of Morphologies of etch figures - Semiconductor etchants - AB etchant - DSL etchant - DCL etchant - Applications of etching techniques.

TOTAL : 60 PERIODS

TEXT BOOKS:

1. S.M. Sze, Semiconductor Devices, Physics and technology, Wiley Publishers, New York,1985.
2. B.R. Pamplin, Progress in Crystal Growth Characterization, Pergamon Press Ltd., U.K, 1982.
3 Dieter.K. Schroder, Semiconductor Material and Device characterization, John Wiley & Sons Inc., New York, 1990.

REFERNCES:

1. B.D.Cullity, Element of X-ray Diffraction, Addison Wesley Publication, 1978.
2. C.R.Grovenor, Microelectronic Materials, Taylor and Francis Group, 1998.

CG 954 FABRICATION AND CHARACTERIZATION OF SOLAR CELLS

L	T	P	C
4	0	0	4

AIM:

To meet the growing technological demands in the utilization of solar cells,. the students will be prepared on the fundamental aspects of fabrications and characterization of solar cells.

OBJECTIVE:

- To provide information on the salient features of fabricating the solar cells to make the students understand the present technology available related to the processing of solar cell.

UNIT- I ENERGY SOURCE 12

Sources of energy - Solar cell energy conversion - Materials and material problems - Spectral distribution of solar radiation - The Sun and Sun Earth relative motion - Measurements of solar insulations - Solar simulation.

UNIT – II OPTICAL SOURCE 12

Photon absorption in semiconductors - Carrier transport across p-n junction solar cells - Heterojunction solar cells - Schottky barrier and MIS solar cells - Contacts and surface properties: Contact structures - Antireflection coatings - Surface texturing - Gird design - Etching - Solar cell arrays - Radiation damage on solar cells.

UNIT – III 12

The Calculation of solar efficiency -The ideal cell under illumination -The effects of series and parallel resistance - Other treatments of the calculation of the solar efficiency - The effect of temperature and illumination on solar cell efficiency - Loss analysis - Some common and emerging solar cells - Fabrication process and photovoltaic performance of some standard solar cells like Silicon, Gallium arsenide (GaAs), Indium phosphide(InP), Copper indium selenide($CuInSe_2$), Cadmium Telluride (CdTe), Cu_2S based solar cells and polycrystalline thin film silicon solar cells and amorphous silicon solar cells - photoelectrochemical cell.

UNIT – IV 12

Novel concepts in design of high efficiency solar cells - High intensity effects - Unconventional non-concentrator cells: Metal insulator semiconductor cells (MIS) - Induced junction cell and front surface field cell - Multiple pass cell - Liquid junction cells - Unconventional concentrator cells: parallel multiple vertical junction cells - Series multiple perpendicular junction cell - V grooved multifunction solar cell - Integrated back contact (IBC) cell - High low junction emitter cell - Graded band gap solar cell - Multiple cell systems: Spectrum splitting and cascade cells - Thermophotovoltaic (TPV) system - photoelectrolytic cell.

UNIT - V EVALUATION TECHNIQUES 12

Characterization techniques - Photovoltaic measurements I-V characteristics - Spectral response - Optical scanning - light beam induced current(LBIC) pictures and electron beam induced current(EBIC) micrograph for the direct determination of minority carrier diffusion length- junction analysis: I-V analysis - Capacitance measurements - DLTS Technique. Material characterization-X-ray diffraction – Reflection high energy electron diffraction (RHEED) - Scanning electron microscopy (SEM) - Scanning transmission electron microscopy (STEM) - Transmission electron microscopy (TEM) - Auger electron spectroscopy (AES) - Electron spectroscopy for chemical analysis (ESCA) - Secondary ion mass spectroscopy (SIMS).

TOTAL : 60 PERIODS

TEXT BOOKS:

1. Fahrenbruch and Bube, Fundamentals of solar cells Academic press, UK, 1983
2. K.L.Chopra and Suhit Ranjan das, Thin film solar cells, Plenum press, UK,1983
3. Cheuning Hu & Richard M.White, Solar cells - Basic to advanced system, McGraw Hill Company, New York, 1983.
4. H.H.Willard, D.L.Merrit, Dean and Settle, Instrumental methods of analysis, CBS Publishers. 1992.

REFERENCES:

1. R.K.Willardson, Albert C.Beer, Semiconductors and semimetals, Vol.8, Academic Press, New York, 1992.
2. Diter K.Schroder, Semiconducting materials and devices characterization, John Wiley & Sons Inc., New York, 1990.
3. M.K.Achuthan and K.N.Bhat, Fundamentals of Semiconductor Devices-Tata MeGraw Hill Publishing Company Ltd, New Delhi, 2007.

CG 955 CHARACTERISATION TECHNIQUES

L	T	P	C
4	0	0	4

AIM :

To train the students on the various aspects of characterization techniques related to study the properties of crystals.

OBJECTIVE :

- To provide information on the optical and X-ray techniques to characterize crystals.
- To make the students understand the salient features of characterization techniques including thermal analysis.

UNIT – I FUNDAMENTALS OF SPECTROSCOPY 12

Absorption and Emission spectroscopy - Nature of electromagnetic radiation - Atomic energy levels - Molecular electronic energy levels - vibrational energy levels - Raman effect - X-ray energy levels.

UNIT - II STRUCTURAL ANALYSIS 12

Infrared spectroscopy - Near IR - Mid IR - Far IR Region - Correlation of infrared spectra with molecular structure - structural Analysis - Radiation sources - Detectors - Thermal Detectors - Photon Detectors - Spectrophotometers - Fourier Transforms Interferometer - Sample handling.

UNIT – III SPECTROSCOPY STUDIES 12

Raman spectroscopy - Theory - Resonance Raman Spectroscopy - Comparison of Raman with Infrared Spectroscopy - Diagnostic - Structural Analysis - Polarization measurements - Instrumentation - Quantitative analysis.

UNIT – IV X-RAY ANALYSIS 12

X-ray methods - Production of X-rays and X-ray Spectroscopy - Instrumental units - Detectors for the measurements of radiation - Semiconductor detectors - Direct X-ray methods - Nuclear magnetic Resonance Spectroscopy - Basic principles - Quantitative analyses - Scanning Electron Microscopy - Electron Spectroscopy for Chemical Analysis - Electron Probe Micro Analysis.

UNIT – V THERMAL ANALYSIS 12

Thermal analysis - Differential Thermal Analysis - Instrumentation – Differential Scanning calorimetry - Thermogravimetry - Instrumentation - Methodology of Differential Scanning Calorimetry & Thermo Gravimetric Analysis - Conductance method - Electrical conductivity - Measurement of electrical conductance - Measurement of dielectric constant. Microhardness - Etching studies.

TOTAL : 60 PERIODS

TEXT BOOKS:

1. X.F. Zong, Y.Y. Wang, J. Chen, Material and Process Characterization for VLSI, World Scientific, New Jersey, 1988.
2. H.H.Willard, D.L.Merrit, Dean and Settle, Instrumental methods of analysis, CBS Publishers. 1992.

REFERENCES:

1. Dieter.K. Schroder, Semiconductor Material and Devices characterization, John Wiley & Sons Inc., New York, 1990

CG 956 **FERROELECTRICS**

L T P C
4 0 0 4

AIM:

To inspire the students with the theory and various important utilization aspects of ferroelectric crystals.

OBJECTIVE:

- To provide information on the various aspects of ferroelectric crystals and their properties.
- To introduce the students the usefulness of ferroelectric crystals and its applications.

UNIT – I FERROELECTRIC 12

Dielectrics - Dipole moment - Polarization - piezoelectric materials - polar materials - pyroelectric materials - Ferroelectric materials and their characteristic properties and polarizability - Ferroelectric domains - Hysteresis - First and second order transitions.

UNIT – II OPTICAL PROPERTIES 12

Optical and related properties - Refractive index and Birefringence - Optical dispersion - Thermooptic behavior - Elastooptic behavior - Electrooptic characteristics - Non-Linear optical effects - photo refractive effect - Light scattering effect - Absorption - Photoluminescence - Electroluminescence and Luminescence.

UNIT – III MODULATORS 12

The modulation of optical radiation - Electro optic effect – Electro optic Retardation – Electro optic Amplitude modulation - Phase modulation of light - Transverse Electro optic modulators - Electro optic beam deflection - The photoelastic effect - Bragg diffraction of light by Acoustic Waves - Deflection of light by sound - Bragg scattering in Naturally Birefringent crystals.

UNIT – IV NONLINEAR OPTICS 12

Nonlinear optics - wave propagation in nonlinear dielectrics - Electrooptic and Non-linear optic co-efficient - The nonlinear susceptibility - Optical second Harmonic generation – phase matching condition – higher order nonlinearity.

UNIT – V APPLICATION OF FERROELECTRICS 12

Order-Disorder Ferroelectrics - Triglycine Sulphate - Sodium nitrate - Displacive Ferroelectrics - oxygen Octahedran - Applications of Ferroelectrics - Pyroelectric detection - Memories and display.

TOTAL : 60 PERIODS

TEXT BOOKS:

1. C. Kittal, Introduction to Solid state Physics, John Wiley Publications, 7th Ed, New York, 1996.
2. A.J.Dekkar, Electrical Engineering Materials, Prentice Hall, New Delhi, 1996
3. E.Lines and A.M.Glass, Principles and applications of ferroelectrics materials Clarendon Press, Oxford, 1979.

REFERNCES:

1. Amnon Yariv, Quantum Electronics, John Wiley and sons Inc, New York, 1975
2. C. Burfoot, D. Van, Ferroelectrics, Nostrand Co Ltd, London, 1967.

CG 957 BIOLOGICAL CRYSTALLIZATION

L	T	P	C
4	0	0	4

AIM:

To provide the students, knowledge on the aspects related to biological crystals and to train them in the processing of crystal growth related to biological materials.

OBJECTIVE:

- Biological characterization is a specialized field and hence specific crystal growth techniques will be introduced to the students.
- To make students understand the important mechanisms involved in biological characterization.

UNIT – I BIOLOGICAL CRYSTALS 12

Crystal Growth from solution - Driving force for crystallization - solubility in biological fluids - Growth kinetics - Nucleation - Diffusion effects - Dissolution - Morphology in vivo & Invitro studies -Crystals responsible for the crystal deposition diseases – Mono sodium urate monohydrate - Calcium pyrophosphate dihydrate - Cholesterol - Steroids - Discalcium phosphate dihydrate - Hydroxy apatite - Calcium oxalate - Calcium hydrogen phosphate dihydrate - Lithium heparin crystals.

UNIT – II CRYSTAL AND JOINT DISEASES 12

Crystal deposition diseases - Deposition of crystals in joints - Crystals induced damage to joints - Crystals and its environment - Mechanism of crystals formation - Induced joint diseases - Actute inflammatory response - Protein binding - Causes for the initiation and termination for the acture inflammation - Chronic inflammation and fibrosis - Destruction of articular cartilage and bone – Gout - Introduction - History - Metabolism of uric acid - hyperuricaemia - Crystallization of urate - Gout crystal - monosdium urate monohydrate - Pathology of gout - Unanswered question regarding gout - Other purine disorders associated with crystals.

UNIT – III HYDROXYAPATITE 12

Introduction - Crystallization of hydroxy apatite - Hydroxy apatite deposition and joints - Relationship between the apatite deposition and osteoarthritis - Other calcium phosphate miscellaneous crystals and particles - Crystals deposited in synovial joints - Extrinsic crystals and particles found in synovial joints.

UNIT – IV STEROIDS 12

Steroids - The chemistry of sterols - Analysis of steroids and related steroids - steroids in biological membranes cholesterol and atherosclerosis - sterol storage diseases - cholesterol gallstones: Plasma cholesterol in liver disease - solubilization of cholesterol - conditions required for the formation of stones - Bile supersaturated with cholesterol - Origin of biliary lipids - The pathogenesis of supersaturated bile - Secretion rates of biliary lipids - Effect of removing the gallibladder - Medical treatment of gallstones - Dissolution of cholesterol stones by chenodeoxycholic acid - Experimental gallstones in animals - Plasma lipids - lipoproteins - the cause of hypercholesterolaemia - Lipid composition of blood cells - Xanthomas in biliary obstruction - parenchymatous liver diesease.

UNIT - V CRYSTALLISATION OF PROTEINS 12

Various crystallization technique- Hanging Drops-Sitting Drops-Sandwich Drops-Reverse Vapor Diffusion- pH Gradient Vapor Diffusion-Practical Tips for Vapor Diffusion -Dialysis-Batch Techniques -Micro batch -Protein Samples-Dynamic Light Scattering- Precipitants- Buffers and pH -Temperature-Crystallization Strategies-A Flexible Sparse Matrix Screen-An Alternative to Sparse Matrix Screens-Reverse Screen- Imperial College Grid Screen-Interpretation of the crystallization Drop Results-Seeding-Macro seeding –Oils for Crystals -Crystallization Cryo-Data Collection -Crystallization of Membrane Proteins

TOTAL : 60 PERIODS

TEXT BOOKS:

1. N.B.Myant The biology of cholesterol and related steroids, William
. Heinemann Medical Books Ltd, London, 1981
2. Paul Dieppe & Paul Calvert, Crystals & Joint disease, Chapman and Hall Ltd, London, 1983
3. Sujata V. Bhat, Biomaterials, Narosa Publishing House, New Delhi, 2002
4. Albert L.Lehninger, Principles of Biochemistry, CBS, Publishers, India, 1984.

REFERENCES:

1. Brain R. Pamlin, Inorganic Biological Crystal Growth, Pergamon Press Ltd., UK, 1988
2. A. Ducruix and R.Giege, Crystallization of Nucleic Acids and Proteins A Practical Approach, Oxford University Press, England, 1992
3. Terese M.Bergfor's, Protein Crystallization Techniques, Strategies and Tips, International University Line, 1999

CG 958 NANOMATERIALS AND NANOTECHNOLOGY

L T P C
4 0 0 4

AIM:

To provide the latest information related to Nanomaterials and Nano technology and to make the students appreciate the usefulness of nanomaterials and nanotechnology.

OBJECTIVE:

- To provide information on the various aspects of Nano materials preparations and related growth conditions.
- To train the students on the evaluation of nano materials and their specific applications.

UNIT – I INTRODUCTION TO NNOMATERIALS 12

Introduction to nanoscale materials-preparation of nano-structured materials, thin films, multiplier's, patterned nanostructures- Production of nano-particles- gas and liquid phases- Vapour deposition- Decomposition of supersaturated solid solutions-Controlled crystallization of glasses-Sol-gel processing - -Mechanical alloying and mechanical milling- Bulk Nan composite materials-Nanoporous materials. Thin films by Laser ablation-Carbon Nanotubes - Synthesis and applications -Nano composites.

UNIT – II SEMICONDUCTOR NANOSTRUCTURES 12

Semiconductor nanostructures-fabrication techniques-Electronic structure and physical processes in semiconductor nanostructures-semiconductor nanostructure based electronic and electro-optical devices - Semiconductor Quantum dots-Quantum cascade Lasers- Quantum dot optical memory-MEMS-MOEMS-NEMS-processing technology –Photolithography-Electron Beam lithography-Lithography instrumentation -Nano-phosphors- Sensors -industrial applications.

UNIT – III NANOMAGNETIC MATERIALS 12

Nanoscale magnetic materials and devices-nanostructure-fabrication and properties of nanostructure magnets-properties of nanomagnetics-applications and devices-Nanocomposite magnets-Nano ferroelectrics-Nano-domain engineering-Nanoarrays-Nanoparticles and Micro-organisms-Nano-materials in Bone Substitutes & Dentistry-Nanoparticles in Food and Cosmetic applications-Drug delivery and its applications-Biochips and analytical devices-Biosensors

UNIT – IV PROPERTIES OF NANOMATERIALS 12

Influence of nanostructuring on mechanical, optical, electronic, magnetic, and chemical properties-grain size effects on strength of metals-optical properties of quantum dots and quantum wires-electronic transport in quantum wires and carbon nanotubes -magnetic behavior of single domain particles and nanostructures-surface chemistry of tailored monolayers- self assembling.

UNIT – V CHARACTERISATION OF NANOMATERIALS 12

Optical microscope Surface Analytical Instrumentation Techniques for Nano-technology- Low Energy Electron Diffraction (LEED), RHEED, Scanning Probe Microscopy, SEM, EDAX, TEM, XRD (Powder), STM, XRF, -UV Photo electron spectroscopy ESCA-Auger, UV*PS.

Total Periods =60

TEXT BOOKS:

1. M C Petty, M R Bryce, D Bloor (eds.), 'Introduction to Molecular Electronics', Edward Arnold, London, 1995.
2. G Hadziioannou, P F van Hutten, 'Semiconducting Polymers: Chemistry, Physics, and Engineering', Wiley-VCH, 2000.
3. Nanomaterials: Synthesis, Properties and Applications, ed. A. S.Edelstein and R. C. Cammarata, IOP (UK), 1996.

REFERENCES:

1. Nanotechnology, ed. By Gregory Timp, Springer-Verlag, NewYork 1999.
2. "Fundamental Properties of Nanostructured Materials", Ed. D. Fiorani, G. Sberveglieri, World Scientific, 1994.
3. Handbook of Nanoscience, Engineering, and Technology (“HNET”), Ed. W. A. Goddard, D. W. Brenner, S. E. Lyshevski, G. J. Iafrate, CRC Press, New York, 2003.
4. Instrument Methods of Analysis H.W. Willard, L.L Merritt., J.A Dean and F.A. Settle (VI edition), East West Publishers (1992).
5. Microelectronic Materials, C.R.M. Grovenor, IOP Publishing Ltd, 1989.

CG 959 **EPITAXIAL GROWTH**

L	T	P	C
4	0	0	4

AIM:

To introduce students the important aspects of epitaxial growth related to experimental and device fabrications.

OBJECTIVE:

- To provide information on the principles of epitaxial techniques to enable the students to operate the epitaxial growth systems such as LPE, VPE and MOVPE.
- To make the students understand the usefulness of the epitaxial techniques in current day technology.

UNIT -1 LPE **12**

Phase diagrams of III-V compounds - LPE apparatus & procedure - tipping - dipping - sliding - homoepitaxy Heteroepitaxy - principle of LPE for growth of binary, ternary and quaternary system - limitations of LPE.

UNIT – II VPE **12**

Principle of method & Apparatus – growth of III-V compounds by Hydride VPE and Chloride VPE - Reactor design - substrate preparation and orientation - degreasing and etching - Dopant & impurities - epitaxial defects - application - Mechanism of vapour phase epitaxy - Nucleation kinetics of III-V compounds. Buried and regrowth of structures -selected area growth - growth of III-V compound Semiconductors - InP - GaAs - GaInAs - GaInAsP and other III-V compounds.

UNIT - III MOVPE **12**

Mechanism of MOVPE growth - Thermodynamic concepts - growth rate calculations - Low pressure MOCVD (LPMOCVD) applications of III-V materials grown from MOVPE – growth of As, P, N based binary, ternary, quaternary , III-V-compounds applications towards fabrication of solar cells, LED's – laser and high power and frequency of deliver (qualitative)

UNIT - IV MBE **12**

Molecular beam deposition - Apparatus - growth of GaAs - Experimental preparation - Thermodynamics considerations - Reaction Kinetics - Kinetics of alloy growth - Dopant incorporation in MBE grown films - principle of RHEED oscillations - applications. Chemical beam epitaxy (CBE) - Atomic layer epitaxy (ALE).

UNIT – V EPITAXY **12**

Nanostructures growth chemical beam epitaxy – atomic layer epitaxy –Design of ALE apparatus - Monolayer growth – growth late – ALE based MOVPE and MBE – Dip PEN lithography – atom manipulation by STM

TOTAL : 60 PERIODS

TEXT BOOKS:

1. Pallab Bhattacharya, Semicondutor Optoelectronic Devices, Pretice Hall of India, New Delhi, 1994.
2. D.W.Hees and K.F.Jensen, Microelectronics processing, American Chemical Society Washington DC, 1989.
3. David L.Pulfery & N.Garry Tarr, Introduction of Microelectronic Devices, Prentice Hall, New York, 1989.
4. T.Suntola and M.Simpson, Atomic Layer Epitaxy, Prentice Hall, New York, 1990.

REFERENCES:

1 LED's by Suji Nakamuna, **S. J. Pearton - 1997.**
2. MOCVD – G.B.String fellow J. Crystal. Growth 178, 1 (1997).