ANNA UNIVERSITY: : CHENNAI - 25

FACULTY OF SCIENCE & HUMANITIES

Approved Special Electives for

M.S. / Ph.D. Degree Programs

(upto 17th AC 27.04.2012)

ANNA UNIVERSITY : : CHENNAI – 600 025.

SPECIAL ELECTIVES FOR FACULTY OF SCIENCE AND HUMANITIES

COURSE CODE	COURSE TITLE	L	T	P	M/C
PH 761 / CG101	Crystal Growth Theory **	3	1	0	4
PH 762 / CG102	Crystal Growth Experimental Techniques**	3	1	0	4
PH 763 / CG001	Epitaxial Growth** (Code revised on 22.08.2011)	3	0	0	3
PH 764 / CG002	Semiconductor Physics**	3	0	0	3
PH 765 / CG003	Characterization of Semiconductor Crystals**	3	0	0	3
PH 766 / CG004	Imperfection in Crystals**	3	0	0	3
PH 767 / CG005	Semiconductor Devices** (Code revised on 22.08.2011)	3	0	0	3
PH 768 / CG006	Fabrication and Characterization of Solar Cells**	3	0	0	3
PH 769 / CG007	Characterization Techniques**	3	0	0	3
PH 770 / CG008	Biological Crystallization**	3	0	0	3
PH 771 / CG009	Crystal Growth-Gel Medium **	3	0	0	3
PH 772 / CG010	Liquid Phase epitaxy**	3	0	0	3
PH 773 / CG011	Oxide Crystals – Growth Properties and Applications**	3	0	0	3
PH 774 / CG012	Ferroelectrics**	3	0	0	3
PH 775 / CG013	Superconducting Material Preparation and Characterization**	3	0	0	3
PH 776 / CG014	Numerical Methods and Computer Programming **	3	0	0	3
PH 777 / CG015	X-ray Crystallography**	3	0	0	3
PH 778 / CG016	Growth of Crystals From Vapour Phase**	3	0	0	3
PH 779 / CG017	Semiconductor Device Fabrication**	3	0	0	3
PH780 / CG018	Special Characterization Techniques**	3	0	0	3
FS1911	Organic Synthesis	3	0	0	3

FS1912	Asymmetric Synthesis	3	0	0	3
FS1913	Biosensors and Instrumentation	3	0	0	100
FS1914	Domination in graphs	3	0	0	100
FS1915	Domination related functions in graphs	3	0	0	100
FS1916	Crystal growth and spectroscopy	3	0	0	100
FS 1917	Reservoir Sedimentation	3	0	0	3
FS 1918	Genetic Engineering	3	0	0	3
FS 1919	Analytical Technique in Biotechnology	3	0	0	3
FS 1920	Key Components for All-optical Networks	3	0	0	3
FS 1921	Biomimetic Oxidation Chemistry	3	0	0	3
FS1922	Bose Einstein Condensation	3	0	0	3
FS1923	ICT for Development	3	0	0	3
FS 9001	Finite volume method	3	0	0	3
FS 9002	Neural networks, fuzzy logic systems and genetic algorithms	3	0	0	3
FS 9003	Vibrational Spectroscopy	3	0	0	3
FS 9004	Quantum mechanical computation of molecular models	3	0	0	3
FS9005	Differential Subordination	3	0	0	3
FS9006	Polymers in Drug Delivery and Tissue Engineering Applications	3	1	0	4
FS 9007	Epitaxial Growth	3	0	0	3
FS 9008	Semiconductor Devices	3	0	0	3
FS 9009	Fluid Dynamics	3	0	0	3
FS 9010	Fuel Cells for Energy Sources	3	0	0	3

**** PH code used by Ph.D. Students / CG code used by M. Phil.Students**

PH 761 (Old Code: CG101) CRYSTAL GROWTH THEORY L T P C
3 1 0 4

Aim: To introduce the fundamentals and theoretical concepts of crystal growth
To enhance the understanding of the phenomena of nucleation and crystal growth

Objectives:

- To provide the basic understanding of the crystal growth of technologically important crystals
- To understand the concepts of homogeneous and heterogeneous nucleation
- To formulate the modeling of crystal based on various theories of crystal growth.

UNIT I **(9)**

Phase equilibria -Single component system - multicomponent system - 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 rotation energies

UNIT II **(9)**

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 III **(9)**

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.

UNIT IV **(9)**

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 - Growth rate of an F-face - Giant dislocation steps –Description, Derivation, and interpretation of Temkin's model of crystal growth - PBC theory of crystal growth - Computer simulation technique

UNIT V **(9)**

Effect of impurities on growth processes - thermodynamics and structure of solutions - adsorption - Dependence of growth and morphology on the concentration of impurities - Creation of defects – slip Plane and Twinning - Inclusions - Inclusions of the mother liquor - Inclusions of foreign particles - Dislocations from a seed - Creation of dislocations in surface processes - Orientation of Dislocations - Thermal stresses - Dislocations related to vacancies and impurities - Grain boundaries.

TOTAL PERIODS = 45

REFERENCES:

1. T.Nishinaga, Advances in the understanding of crystal growth mechanisms Elsevier, 1997
2. Boyan Mutaftschiev, Fundamentals and Crystal Growth. Springer-Verlag New York, 2001
3. A.Chernov, Modern crystallography:III,- Crystal Growth, Springer Series in Solid State, New York, 1984.
   K.Sangwal, Elementary Crystal Growth, Saaan Publiser, UK, 1994
4. J.C. Brice, Crystal growth processes John wiley and sons, New York, 1986.
5. P. Santana Ragavan, P.Ramasamy, Crystal Growth and Processes, KRU Publications, Kumbakonam, 2000

PH 762 (Old Code: CG102) CRYSTAL GROWTH EXPERIMENTAL TECHNIQUES **L T P C 3 1 0 4**

AIM: To introduce the basic concepts of various types of crystal growth methods and characterisation techniques

OBJECTIVES:

- To study the different types of crystal growth methods
- To provide the concepts of melt, vapor, solution and epitaxial growth technique
- To develop the knowledge on characterisation of grown crystal

UNIT I **(9)**

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 crystal from flux - Slow cooling method - Temperature difference method - High pressure method - Solvent evaporation method - Top seeded solution growth -Growth of superconducting single crystal.

UNIT II **(9)**

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 .

UNIT III **(10)**

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 biological crystals - Crystal growth by hydrothermal method.

UNIT IV **(9)**

Epitaxy - 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 V **(8)**

X-ray diffractogram - X-ray diffraction - Powder method – Laue method - Absorption & Emission spectroscopy - Infrared spectroscopy - Near IR - Mid IR - Far IR Region - Raman spectroscopy - Thermal analysis – DTA – TGA – DSC – SEM - TEM - Electron Spectroscopy for Chemical Analysis - Electron Probe Micro Analysis

TOTAL PERIODS = 45

REFERENCES:

1. Alberto Pimpinelli, Jacques Villain, Physics of Crystal Growth, Cambridge University
   Press, 1998.
2. Hans J. Scheel, Tsuguo Fukuda, Crystal Growth Technology, John Wiley & Sons, Ltd, 2003
3. K.Sangwal, Elementary Crystal Growth - Saaan Publiser, UK,1994
4. M.M. Faktor, I. Garret, Growth of Crystals from Vapor, Chapmann and Hall, 1988
5. P. Santhana Ragavan, P.Ramasamy, Crystal Growth And Processes, KRU Publications, Kumbakonam, 2000
6. P.Ramasamy, ISTE Summer school Lecture Notes, Crystal Growth Centre, Anna University, Chennai, 1991.
7. J.C.Brice, Crystal Growth Process, John Wiley publications, New York, 1986.
8. A.A.Chernov, Modern crystallography:III,- Crystal Growth, Springer Series in Solid State, New York, 1984.

PH 763 (Old Code: CG001) EPITAXIAL GROWTH L T P C

3 0 0 3

AIM: To introduce the fundamentals of various types of epitaxy.
To enhance the understanding of the phase diagrams, epitaxial growth processes and instrumentation of epitaxial techniques.

OBJECTIVES: On completion of the course the student would be in position

- To understand the concepts of homoepitaxy and heteroepitaxy
- To derive the expressions for the kinetically controlled and thermodynamically controlled growth regimes in epiatxy
- To design the various reactor models in LPE, VPE, MOCVD, MBE, CBE and ALE

UNIT I (10)

Phase diagrams of III-V semiconducting compounds - experimental - apparatus & procedure - tipping - dipping - sliding - homoepitaxy - principle of LPE for growth from two component solution - Heteroepitaxy - uses & limitations of LPE.

UNIT II (10)

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.

UNIT III (9)

Principle of method and apparatus - reactor design - growth of III-V compound Semiconductors - InP - GaAs - GaInAs - GaInAsP and other III-V compounds.

UNIT IV (6)

Mechanism of MOCVD growth - Thermodynamic concepts - growth rate calculations - applications of III-V materials grown from MOCVD - Low pressure MOCVD (LPMOCVD)

UNIT V (10)

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

TOTAL PERIODS = 45

REFERENCES:

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. A.B.Balderschi and C.Paorici, Epitaxial electronic Materials, World Scientific Publishers, London, 1986
4. P.R.Vaya, Lecture notes on Technology and characterisation of epitaxial Semiconductor films and devices, IIT, Madras, 1987
5. David L.Pulfery & N.Garry Tarr, Introduction of Microelectronic Devices, Prentice Hall, New York, 1989
6. T.Santola and M.Simpson, Atomic Layer Epitaxy, Prentice Hall, New York, 1990.

PH 764 (Old Code: CG002) SEMICONDUCTOR PHYSICS L T P C
3 0 0 3

AIM: To prepare the student for the understanding of the optical and electrical properties of semiconductor

OBJECTIVES:

- Introduce the fundamental concepts of semiconductor physics
- Evaluate the significant advantages in semiconductors for the use in optical and electrical devices
- Create an awareness of the usefulness of advanced semiconductors

UNIT I (9)

Introduction: Elementary properties of semiconductors - Types of semiconductors - intrinsic and extrinsic semiconductors - p,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 - chemical binding in semiconductors - carrier concentration in thermal equilibrium - Free electron Theory - Transport properties. Bonds and Bands in Semiconductor: The Semiconducting bond - Energy bands - Bond approach Vs Band Model - The general Octet rule - The Aufbau-principle of the crystal structure of semiconductors - Electronic band structure - Two different strategies for band structure calculations - Tight binding method - Orthogonalized plane wave method - Green's function method - Pseudopotential method - Junction Properties of semiconductors - Homogeneous, Inhomogeneous semiconductors - Recombination mechanism - Electron, Hole recombination through traps - Junction properties of p-n, n+-n, p+-p junctions - Surface recombination - Recombination with donors and acceptors at low temperatures - Quantum theory of junction devices - Generation of recombination processes in junction devices

UNIT II (9)

Optical properties of semiconductors - Optical constants - Light absorption spectrum - Light absorption edge - Effect of free charge carriers on the absorption edge - Fundamentals of absorption and reflection - Absorption of light by lattice - 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 (9)

Electron transport phenomena: Theory of electron transport in crystalline semiconductors - Boltzmann's transport equation for Bloch states - relaxation time - relaxation time approximation to the low field transport coefficients - scattering mechanism - 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 **(9)**

Thermal effects in Semiconductors: Thermal conductivity - Thermo-electric power - Thermomagnetic effects - condition of degeneracy - strong magnetic fields - relative magnitudes of the magnetic effects. Optical and High frequency effects in Semiconductor: 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. Methods of determining of characteristic properties of Semiconductors: The minimum energy gap - mobility of electrons and holes - carrier concentration - effective mass - energy levels in the forbidden band due to impurities - thermal methods - optical methods - minority carrier lifetime - injection ratio.

UNIT V **(9)**

Application of semiconductors: 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 PERIODS = 45

REFERENCES:

1. S.M. Sze, Semiconductor Devices, Physics and technology, Wiley Publishers, New York,1985
2. S.P.Keller, Handbook on Semiconductors, Vol. 1-4, T.S. Moss, Ed., North-Holland, Amsterdam, 1980.
3. R.K.Willardson andA.C.Beer, Semiconductors & Semimetals Vol.2, 24, 27 - Raymond Dingle, Academic Press Inc., New York, 1987
4. Charles M. Wolfe, Nick Holonyak, JR, Gregory E. Stillman, Physical Properties of Semiconductors - Prentice Hall International Inc., London, 1989.
5. Adir Bar. Lev, Semiconductors & Electronic Devices Prentice Hall of India, New Delhi, 1987.
6. Paul.N.Butcher, Norman.H.March and Mario.P.Tosi, Crystalline Semiconducting materials and devices Plenum Press New York and London, 1986.
7. L. Aleksandarov, Growth of Crystalline Semiconductor Materials on Crystal Surfaces, Elsevier, Amsterdam, 1984.

Faulty of Science and Humanities (Approved in 3RD AC 22.11.2003) **ITEM NO.3.4 (2(5))**

PH 765 (Old Code: CG003) CHARACTERIZATION OF SEMICONDUCTOR CRYSTALS **L T P C 3 0 0 3**

AIM: To interduce the relevant aspects of semiconductor crystals evaluation and identify the factors responsible for the performance of the devices

OBJECTIVES:

- Detailed understanding of the structural characterisation techniques related to X-ray diffraction
- Evaluation of the optical techniques to characterize the semiconductor crystals
- Discussion of the relevant characteristion techniques to estimate the usefulness of the semiconductor crystals for application purpose.

UNIT I **(9)**

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 - determination of unit cell and space group.

UNIT II **(9)**

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

UNIT III **(8)**

Evaluation of doped impurity segregation coefficient - Hardness - anisotropy - types of Hardness - Evaluation of the Microstructure patterns - Mechanical properties.

UNIT IV **(9)**

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

UNIT V **(10)**

Rutherford Back Scattering analysis(RBS) - principle of channeling - 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 PERIODS = 45

REFERENCES:

1. X.F. Zong, Y.Y. Wang, Material and Process Characterization for VLSI, World Scientific, New Jersey, 1988.
2. S.M. Sze, Semiconductor Devices, Physics and technology, Wiley Publisers, New York,1985
3. B.R. Pamplin, Progress in Crystal Growth Characterization, Pergamon Press Ltd., U.K, 1982.
4. P.J.Dean, A.G.Cullisand, A.M.White, Characterization and Properties of Semiconductors, North-Holland, 1980.
5. Dieter.K. Schroder, Semiconductor Material and Device characterization, John Wiley & Sons Inc., New York, 1990.

PH 766 (Old Code: CG004) IMPERFECTION IN CRYSTALS L T P C
3 0 0 3

AIM: Comprhensive understanding of imperfection in crystals

OBJECTIVES:

- Evaluation of the different types of imperfections
- Understanding the process of defect dynamics
- To study the limitations imposed by imperfections on materials

UNIT I **(9)**

Crystal Symmetry: Point group and space group symmetry operations - Space group diagrams - international notations - special positions - asymmetric unit and its importance - molecular weight determination - reciprocal lattice concept - interpretation of Bragg's law - Laue condition

UNIT II **(10)**

Theory of Crystal Structure Analysis: Fourier analysis of electron density - Patterson function and its properties - location of heavy atom - heavy atom method in structure analysis. Defects and Dislocations: Types of imperfections - defects - impurities - interstitial atoms - vacancies - energy to form a vacancy - energy to form a interstitial atom - mobility of defects - dislocation - polygonization - dislocation walls - general properties of dislocations - translation dislocations - rotation dislocations - elastic theory of dislocations - screw dislocations - edge dislocations - energies - center of dislocation - change of density due to dislocations - the tensor of dislocation density - stress due to a distribution of dislocations

UNIT III **(9)**

Line tension - polygonal dislocations - force on a dislocation - the Peach and Coheler formula - interaction between dislocations - interaction between two parallel dislocations - Inclusions - Inclusions of the mother liquor - Inclusions of foreign particles - dislocation from a seed - propagation of dislocations - creation of dislocations in surface processes - orientation of dislocations - Thermal stresses - Dislocations related to vacancies and impurities - Grain boundaries.

UNIT IV **(8)**

Imperfect Dislocations - Stacking faults and twins - Schottky dislocations - Frenkel dislocations - origin of growth dislocations - creep -cleavage - interaction of dislocations with other defects - interaction energy - elastic interaction - electrostatic interaction - Screw dislocations - interaction of dislocations with electrical properties and thermal properties of metals and semiconductors.

UNIT V **(9)**

Motion of Dislocations: Glide - slip lines - conservative and non-conservative motions - dislocation glide - Schmid's law - Peierl's-Nabarro force - polygonal dislocations:kinks - jogs -kinetics of glide.

TOTAL PERIODS = 45

REFERENCES:

1. F.R.N.Nabarro, Dislocations in Solids Vol. 1-7, North-Holland, New York, 1986.
2. J. Chikawa, K.Sumino & K. Wada, Defects & Properties of Semiconductors and Defect Engineering, KTK Scientific Publishers, Tokyo, 1987
3. P.J.Dean, A.G.Cullisand, A.M.White, The structure and properties of Materials Vol.I, II, III, and IV, Wiley Eastern Limited, New Delhi, 1991
4. A.A. Urusoskaya, K. Sangwal, Mechanical Properties of Crystalline and Non Crystalline Solids, Politechnika Lubelsha, 2001
5. R.J.D. Tilley, Defect Crystal Chemistry and its application, Chapman and Hall, New York, 1987
6. S.G. Roberts, D.B. Holt & P.R. Wilshaw, Structure & Properties of dislocations Semiconductors - Proceedings on 6th Symposium at Oxford University 5-8 April 1989 No.104 - Institute of Physics, New York, 1989

PH 767 (Old Code: CG005) SEMICONDUCTOR DEVICES L T P C
3 0 0 3

AIM: To impart sound knowledge of working principles of various types of electron and optical semiconductor devices.

OBJECTIVES:

- To understand different types of heterostructures in devices.
- To develop the skills in electron devices using ion implantation
- To know the concepts of unipolar and bipolar electron devices
- To develop the knowledge in microwave and optical devices
- To gain the knowledge of integrated circuits and sensors

UNIT I **(8)**

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

UNIT II **(3)**

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 **(6)**

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

UNIT IV **(7)**

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 - future trends in Fiber optic communications - Photodetectors - Photoconductor - Photodiode - Avalanche Photodiode - Phototransistor - Solar cells - Thin film Solar cells.

UNIT V **(9)**

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 PERIODS = 45

REFERENCES:

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

PH 768 (Old Code: CG006) FABRICATION AND CHARACTERIZATION OF SOLAR CELLS **L T P C 3 0 0 3**

AIM: To expose the students on the fundamentals and experimental aspects of solar cell fabrication and evaluation

OBJECTIVES:

- Conceptual understanding of the fundamentals involved in the solar cell fabrication process.
- Evaluation methodologies in estimating the efficiency of solar cells
- Expose the researchers to the actual fabrication process and to the need specific design issues of solar cell fabrication

UNIT I **(8)**

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 insolations - Solar simulation.

UNIT II **(8)**

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 **(9)**

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 **(10)**

Novel concepts in design of high efficiency soalr 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: parallal multiple vertical junction cells - Series multiple perpendicular junction cell - V grooved multijunction solar cell - Integrated back contact (IBC) cell - High low junction emitter cell - Graded band gap solar cell - Multiple cell systems: Spectrum spliting and cascade cells - Thermophotovoltaic (TPV)system - photoelectrolytic cell.

UNIT V **(10)**

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 PERIODS = 45

REFERENCES:

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. Willard , Merrit, Dean and Settle, Instrumental methods of analysis, CBS publishers and distributors, India, 1986
5. R.K.Willardson, Albert C.Beer, Semiconductors and semimetals , Vol.8, Academic press, New York, 1992.
6. Diter K.Schroder, Semiconducting materials and devices characterization, John Wiley & Sons Inc., New York, 1990.

PH 769 (Old Code: CG007) CHARACTERIZATION TECHNIQUES L T P C
3 0 0 3

AIM: To enable the students to understand the importance of materials characterization
To expose the students on Advanced Characterization Techniques

OBJECTIVE:

- Through this course, the students would be exposed to Advanced
- Materials Characterization Techniques to understand the structural, optical, mechanical and defect characteristics of the materials.

UNIT I **(9)**

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

UNIT II **(8)**

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 **(9)**

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

UNIT IV **(10)**

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 **(9)**

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 PERIODS = 45

REFERENCES:

1. X.F. Zong, Y.Y. Wang, J. Chen, Material and Process Characterization for VLSI, World Scientific, New Jersey, 1988
2. S.M. Sze, Semiconductor Devices, Physics and technology, John Wiley Publishers, New York, 2000
3. B.R. Pamplin, Progress in Crystal Growth Characterization, Pergamon Press Ltd., U.K 1982
4. Dieter.K. Schroder, Semiconductor Material and Device characterization, John Wiley & Sons Inc., New York , 1990

PH 770 (Old Code: CG008) BIOLOGICAL CRYSTALLIZATION L T P C
3 0 0 3

AIM: To introduce the subject of biomineralisation.
To introduce Crystallization of biological macromolecules and their application to Structural Biology.

OBJECTIVE:

- To expose the students to the basic science of crystallisation of biological molecules like proteins, enzymes etc., and their application to structural biology & drug designing.
- To understand the importance of the study of Biominerals to Materials Technology.
- To study the synthesis of Hydroxyapatite which is a bone and dental replacement material.

UNIT I (9)

Crystal Growth from solution - Driving force for crystallization - solubility in biological fluids - growth kinetics - Nucleation - Diffusion effects - Dissolution - Morphology in vivo & In vitro studies - Crystals responsible for the crystal deposition diseases - Mono sodium urate monohydrate - Calcium pyrophosphate dihydrate - Cholesterol - Steroids - Dicalcium phosphate dehydrate - hydroxyapatite - Calcium oxalate - Calcium hydrogen phosphate dihydrate crystals.

UNIT II (8)

Crystallochemical Strategies in Biomineralization - Nucleation Strategies - Molecular Complementarity - spatial Charge Distribution - Symmety Requirements in epitaxial Matching chiral Interfaces - Stereochemical Requirements - Cooperativity - Growth Strategies - Morphology - Spatial Control- Growth Modifiers - flux Control - Biocomposites.

UNIT III (10)

The functional forms of Biominerals - Methods of Study - Biominerals viewed as structures - Physico-Chemical Character - Vesicles and Polymer Matrices - Growth of Minerals - Nucleation - Crystal Growth - Amorphous precipitation - Ripening - Biological Single Crystals as Probes of Cell Morphology - Protein Assemblies - Membranes - Acantharia - Desmids ($BaSO_4$) - Loxedes ($BaSO_4$) - Magnetotactic Bacteria - Coccolithiderae - Radiolaria - Biominerals Outside Cells - Exocytosis of Minerals - The Relationship Between Biominerals, Proteins and Membranes - Sensors - Hydroxyapatite- a bone and dental replacement material- structure of Hydroxyapatite-properties of Hydroxyapatite-manufacture of Hydroxyapatite- Crystallisation and synthesis of nano hydroxyapatites.

UNIT IV (9)

Crystallization of proteins - purification of proteins - crystallization condition - choice of crystallization techniques - various crystallization techniques - selection of solvent - precipitant - protein concentration - protein / detergent ratio - Additives - effect of pH - temperature - Gravity - Natural fields and forces - Crystallization under Microgravity, Magnetic field, High pressure.

UNIT V (9)

The Importance of the Study of Biominerals to Materials Technology - Materials Development - the Scope of Biominerals - Problems in Materials Technology and Insights from Biology- An Interfacial Problem - Adhesion - The Toughness of Inorganic Materials -

Strong Inorganic Materials - The control of Crystallization - Technological Uses for Siliceous Phytoliths - Advanced ceramics.

TOTAL PERIODS = 45

REFERENCES:

1. Crystals & Joint diseases by Paul Dieppe & Paul Calvert, Chapman and Hall Ltd, London, 1983.
2 Davidson's principles and Practice of medicine by John Macheod, Christopher Edwards, Ian Boucheir, ELBS edition, UK, 1952.
3. Principles of Biochemistry by Albert L.Lehninger, CBS publishers, India, 1984.
4. Biomineralization Edtby S.Mann, J.webb, R.J.P.Williams, VCH publishers, Newyork, 1989.
5. Crystallization of Nucleic Acids and Proteins Edtby A.Ducruix and R.Giege, Oxford university press, Oxford, 1992.
6. Biomaterials Science and Engineering by Joon Bu Park, Plenum Press, New York

PH 771 (Old Code: CG009) CRYSTAL GROWTH-GEL MEDIUM L T P C
3 0 0 3

AIM: To expose the students to the gel method of crystallization and its application to biomacromolecular crystallization and microgravity experiments

OBJECTIVE:

- To study about different types of gels and their ssuitability to grow organic and inorganic crystals

UNIT I (9)

History & Nature of the gel method – Different gel medium - specific gravity - Silica gel - Agar gel - Gelatin getl - poly acrylamide gel - tetra methoxy Silane gel - Tetra Ethoxy Silane gel - Basic growth procedures - Doble Diffusion Technique - Single Diffusion Technique - Reaction Method - Chemical Reduction method - Decomplexing method - Solubility Reduction method - doping.

UNIT II (8)

Gel structure & properties - Gel preparation and properties - Cooling of a sol - Chemical reaction – Precipitating agents - incompatible solvents - Gelling mechanism & Structure of silica gels - Gels as diffusion media.

UNIT III (10)

Growth mechanism - Diffusion patterns & single crystal growth rates - Functions of the gel - Advantages of the gel growth - Habit modifications - Concentration of feed solution - Crystallization temperature - Gel structure - Addition of various impurities - Various types of gels - Spacial distribution.

UNIT IV (9)

Nucleation - Evidence for homogenous nucleation - Nucleation control - Suitable reactants - Gels prepared with various acids - changing the gel structure - Intermediate neutral gel - effect of concentration variation.

UNIT V (9)

Liesegang rings - Qualitative features - Spiral formation - Radiation effects - Effects of gravity - Effect of electric field - Sol coagulation models - Conditions of quasi stability - Effect of growth rate -Chemical reaction method - Complex dilution method - Solubility reduction method.

TOTAL PERIODS = 45

REFERENCES:

1. Heinz K.Henisch, Crystals in gels & Liesegang rings, Cambridge University Press, UK,1988.
2. J.C. Brice, Crystal growth processes John Wiley and Sons, New York, 1986
3. P.Ramasamy, UGC Summer School, Lecture notes, Crystal growth Centre, Anna University, Chennai , 1991
4. Mann S., Biominerallisation: Chemical & Biomedical Perspectives, VCH Publishers, New York, 1989.

PH 772 (Old Code: CG010) LIQUID PHASE EPITAXY L T P C
3 0 0 3

AIM: To enhance in-depth knowledge in the fundamentals and applications of Liquid Phase epitaxy.

OBJECTIVES:

- To make the students to understand the concepts of liquid phase epitaxy and should be in a position to fabricate Liquid Phase Epitaxial system for the growth of heterostructures of elemental and compound semiconductors.

UNIT I (9)

Introduction to Epitaxy - Phase equlibria - Basic concept of LPE growth process - Impurity segregation - Substrate surface preparation - Operational consideration - Physical principles of the LPE process - Equilibrium cooling - Step cooling - Super cooling - Two phase solution cooling - Electroepitaxy - Advantages and disadvantages of LPE as a growth technique for device materials

UNIT II (10)

Properties and Phase diagrams - Properties and phase diagrams of Binary, ternary and quarternary compounds semiconductors - Gallium arsenide - Gallium phosphide - Gallium antimonide - Indium phosphide - Indium antimonide - Indium arsenide - Gallium aluminium arsenide - - Indium gallium arsenide - Indium arsenide phosphide - Gallium arsenide antimonide - Gallium arsenide phosphide - Indium arsenide antimonide - Aluminium gallium phosphide - Indium gallium arsenide phosphide

UNIT III (9)

Apparatus and Methodology - Boat designs: Tip system - Dip system - Horizontal sliding boat system - Rotary slider - Wipingless growth system - Multi slice boat designs - Furnace design – Theory - Diffusion limited growth theory - Solid liquid phase diagram - Impurity incorporation model - Phase diagram - Homoepitaxy - Heteroepitaxy - Device application of LPE growth

UNIT IV (9)

Properties and Characterization - Band gap - Electrical properties - Optical properties - Crystal perfection - Layers thickness control - Abrupt junctions - Selective area and structured substrate growth - Composition control

UNIT V (8)

Device applications -Opto electronic devices - Light emitting diode - Lasers - Photodetectors - Optoelectronic integrated circuits - Solar cells -Microwave devices – Gunn devices - Field Effect Transistors - Heterojunction bipolar transistors - Impact Avalanche Transit Time (IMPATT) - Transferred electron devices.

TOTAL PERIODS = 45

REFERENCES:

1. D.W.Hees and K.F.Jensen, Microelectronics processing, American Chemical Society, Washington DC, 1989
2. B.M.Arora Growth of III-V compounds by Liquid Phase Epitaxy, TIFR, Bull.material Science Vol.13 Nos 1 & 2, Mumbai, 1990
3. S.M. Sze, Semiconductor Devices, Physics and technology, John Wiley Publishers, New York, 2000.

PH 773 (Old Code: CG011) OXIDE CRYSTALS – GROWTH PROPERTIES AND APPLICATIONS

L	T	P	C
3	0	0	3

AIM: To enable the students to study the fundamental properties of oxide materials and the crystal growth of oxide materials

OBJECTIVE:

- The explore the fundamental issues with regard to the growth of oxide single crystal and the associate difficulties, various crystal growth techniques for the growth of oxide crystals and the technological applications of oxide crystals.

UNIT I **(8)**

Growth of oxide single crystals - Experimental set up - Czochralski technique - Verneuil technique - Flux technique.

UNIT II **(9)**

Growth of Lithium borate, Lithium molybdate, Lithium vanadate, Lithium niobate, Lithium tungstate, Lead molybdate, Lead germanate, Lead tungstate, Lead germanium vanadate, Bismuth molybdate, Yttrium vanadate, Zinc tungstate - Growth, properties and applications - Photorefractive materials.

UNIT III **(9)**

Difficulties encountered - Growth of oxide crystals - Bubble formation and incorporation in the crystals - Growth of bubble free crystals - Fluid flow analysis - Forced convection - Free convection - Middle danger rotation rate - Interface discontinuity - Interface inversion - Effect of melt depth.

UNIT IV **(10)**

Characterization of grown crystals - X-ray Laue, powder diffraction and oscillation photographs - IR spectra analysis - ESCA - SEM and EPMA studies - TGA and DTA to analyse thermal properties - Study of lasing action in crystals - Phase conjugation studies - Holographic materials.

UNIT V **(9)**

Single Crystals for Radiation Detectors - Introduction - Scintillation characteristics in general - Survey of typical scintillation crystals - Crystal growth of scintillation detectors - Scintillation characteristics - Radiation damage of scintillation crystals - Applications of high-Z scintillators.

TOTAL PERIODS = 45

REFERENCES:

1. Alexander A.Kaminskii, Laser Crystals - Their Physics and Properties, 2nd ed., Springer -Verlag, Berlin Heidelberg, 1981.
2. P.Gunter and J.P.Huignard Photorefractive Materials and their Applications I&II, Ed., Springer-Verlag , Berlin Heidelberg, 1988
3. J.C.Brice, Crystal Growth Process, New York, 1986.

PH 774 (Old Code: CG012) **FERROELECTRICS** **L T P C**
3 0 0 3

AIM: To enhance the understanding of the Ferroelectric materials, which are the special class of electronic materials.

OBJECTIVE:

- To explore the importance and applications of Ferroelectric materials
- Study of domain structure and domain kinetics of Ferroelectrics, electrical and switching characteristics of Ferroelectric materials.

UNIT I **(9)**

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 **(10)**

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

UNIT III **(8)**

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

UNIT IV **(9)**

Non-linear optics - wave propagation in Non-linear dielectrics - Electrooptic and Non-linear optic co-efficients -The nonlinear susceptibility - Optical second Harmonic generation.

UNIT V **(9)**

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

TOTAL PERIODS = 45

REFERENCES:

1. C. Kittal, Introdution 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.
4. Amnon Yariv , Quantum mechanics, John Wiley and sons Inc, New York, 1975
5. C. Burfoot, D. Van, Ferroelectrics, Nostrand Co Ltd, London, 1967.

PH 775 (Old Code: CG013) SUPERCONDUCTING MATERIAL PREPARATION AND CHARACTERIZATION

L	T	P	C
3	0	0	3

AIM: To enhance theoretical and modern technological aspects of Superconductivity and Superconducting materials.

OBJECTIVE:

- To explore the fascinating field of superconductivity, to study the mechanism of superconductivity, growth of superconducting single crystals, magnetic and electrical properties, to explore the applications of these materials.

UNIT I **(9)**

Historical development - Perfect Conductivity and Critical Magnetic Field - The Meissner Effect - the reversibility line - Mechanism for superconducting - The Penetration depth - London equations - The Coherence length - BCS Theory - Cooper Pairs - Josephson effect.

UNIT II **(9)**

Growth of Single crystals of superconducting materials - LSCO, YBCO, BSCCO, TlBCCO - Resistivity - Susceptibility measurements - Field dependence of Resistivity and Susceptibility - Anisotropy in Resistivity and susceptibility - Measurement of the Critical current density Jc - flux pinning effect - techniques to improve Jc - Thin films - sputtering - RF sputtering - Magnetron sputtering.

UNIT III **(9)**

Structure of LSCO - YBCO - BSCCO - TlBCCO - Domain structure - superstructure formation - structure modulation in superconducting materials

UNIT IV **(8)**

Characterization of superconducting materials - X-ray - STM - EPMA - Surface morphology - whiskers growth - Growth of twin free crystals.

UNIT V **(10)**

Fullerenes - Making of fullerenes - deposition of graphitic soot - Isolation of Buckminster fullerenes C60 and higher fullerenes - Superconductivity in fullerenes - effects of different dopants - enhancement of Tc values - resistivity and susceptibility measurements - Growth of C60 single crystals.

TOTAL PERIODS = 45

REFERENCES:

1. J.G.Bednorz and K.A. Muller, Earlier and Recent Aspects of Superconductor, Springer Verlag, Berlin, 1989
2. Ginsberg, Physical Properties of High Temperature Superconductors, South Asian Publishers Pvt. Ltd., Delhi, 1988
3. A.V.Narlikar and S.N.Ekbote Superconductivity and superconducting materials, South Asian Publishers Pvt. Ltd., Delhi, 1983
4. R.A.Barrio, T.Akachi and J.Taguana Proceedings of the IX Winter meeting on Low Temperature Physics of High Temperature Superconductors, World Scientific Publishers, Singapore, 1988.

PH 776 (Old Code: CG014) **NUMERICAL METHODS AND COMPUTER PROGRAMMING** **L T P C 3 0 0 3**

AIM: To introduce the fundamentals of various types of numerical simulation techniques

To enhance the understanding of the numerical simulation in crystal growth by using computation methods

OBJECTIVES: On completion of the course the student would be in position

- To understand the basic concepts of numerical simulation
- To solve the heat and mass transfer related problems in crystal growth

UNIT I **(9)**

System of equations: Roots of equations – Method of bisection and false position – Newton-Rapson method – Solution of simultaneous linear algebraic equations – Gauss elimination – Gauss Jordan methods - matrix inversion and LU decomposition methods – Gauss-Seidel iterative method-Eigen values of matrices – Power method and Jacobi's method.

UNIT II **(10)**

Interpolation, curve fitting and statistics: Finite difference operator - Newton's forward and backward interpolation formula - lagrange's Interpolation – Lagrange's inverse interpolation – curve fitting - principle of least squares –Linear correlation and regression analysis – sampling distributions - small and large samples – tests of hypothesis – students distribution – F-dstribution - chi square distribution

UNIT III **(9)**

Numerical Differentiation and Integration: Newton's forward and backward difference formula – numerical integration – Trapezoidal rule – simpson's $1/3^{rd}$ rule – numerical solutions of ordinary differential equation – Taylor's series – Euler's method, improved and modified methods – Runge kutta method of 4^{th} order– Milne's predicator - corrector method.

UNIT IV **(8)**

C programming: Introduction, operator, expressions, variables, input, output statements, control statements, functions, arrays, pointers, structures, unions – simple applications.

UNIT V **(9)**

Applied numerical simulation in crystal growth – Heat and Mass transfer in CZ growth of Si crystal – diffusion simulation in LPE growth of semiconductor – partial pressure simulations of crystal growth systems (VPE GaN) – Numerical Simulation of MBE growth of semiconductors – 2D simulation in solution growth – Thermodynamic simulations of CVT – Heat transport analysis of closed ampoule in Bridgman technique – Numerical simulation of heat transport in high temp furnaces

TOTAL PERIODS = 45

REFERENCES:

1. M.K. Venkatraman, Numerical methods in science and engineering, National publishing company, Chennai, 1996.
2. S.S. Sastry, Introductory methods of numerical analysis, Prentice Hall of India, New Delhi, 1992.
3. B.S. Gottfried, Programming with C, Tata McGraw Hill, Delhi, 2000.
4. B. Stroustrup, The C^{++} Programming language, Pearson Education (Singapore) Pvt.Ltd, Delhi, 2001
5. S.G. Advani and Christoph Beckermann, Heat and Mass Transfer in Solidification Processing, American Society of Mechanical, 1991

PH 777 (Old Code: CG015) X-RAY CRYSTALLOGRAPHY L T P C
3 0 0 3

AIM: To enhance the theoretical and experimental understanding of X-ray crystallography and structural characterization of materials

OBJECTIVE:

- Through this course the students would be exposed to the X-ray diffraction analysis of material properties including structural analysis, determination of lattice parameters, symmetry properties and Texturing aspects of crystalline materials.

UNIT I (9)

Crystallography - Lattice – unit cell and Bravis lattices – crystal planes and directions – basic symmetry elements, operations – translation symmetries – point group – space groups – equivalent positions – cubic structures – packing factor, co-ordination number – atomic radii/cell parameter relationship – important crystal structures – Bragg's law – reciprocal lattice concepts – Laue's conditions – Ewald and limiting spheres – diffraction symmetry – Laue groups

UNIT II (8)

X-ray generation, properties – sealed tube, rotating anode, synchrotron radiation – absorption – monochromators – X-ray detectors – diffraction by X-rays, neutron and electron (qualitative only). Atomic scattering factor – scattering factor – scattering by solids, liquids and gases – radial distribution function – anomalous scattering

UNIT III (10)

Single crystal – Laue, rotation/oscillation, moving film methods – Debye-Scherrer method, Seemann-Bohlin, Guinier cameras, interpretation of diffraction patterns – Cell parameter determination – indexing – systematic absences – space group determination (qualitative only) – use of powder diffraction files – identification of unknown compounds.

UNIT IV (9)

Powder Diffraction: Basics- diffractometer geometries – use of monochromators and Soller slits – sample preparation and data collection – single and multiple qualitative analysis – Rietveld refinement – fundamentals – step data collection – profile analysis – peak shapes – whole pattern fitting – structure refinement – procedures adopted – quantitative multiphase analysis – autoindexing – structure determination from powder data.

UNIT V (9)

Protein Crystallography: Principles on protein and nucleic acids structure – globular and fibrous proteins primaries, secondary, tertiary and quaternary structures – helical and sheet structures – Ramachandran map and its significance – crystallization methods for proteins – methods used to solve protein structures – anomalous dispersion methods.

TOTAL PERIODS = 45

REFERENCES:

1. B.D. Cullty, Elements of X-ray diffraction, Addison – Wesley reading, MA, 1978
2. L.V. Azroff, Elements of X-ray crystallography, McGraw Hill, New York, 1968.
3. M.M. Woolfson , An introduction to X-ray crystallography, Cambridge University press, New York, 1987.

PH 778 (Old Code: CG016) **GROWTH OF CRYSTALS FROM VAPOUR PHASE** **L T P C 3 0 0 3**

AIM: To study the fundamentals of various types of nucleation processes during vapour growth process

To learn the optimum conditions for the growth of technologically important materials from vapor phase and the methods of epitaxial growth techniques.

OBJECTIVES: On completion of the course the student would be in position

- To do independent work on the growth of crystals from vapour phase
- To design the various reactors for the growth of crystals using CVT, PVT, CVD, PVD techniques

UNIT I **(10)**

Methods of vapour phase growth – Physical Vapor Transport (PVT) – Physical Vapor Deposition (PVD) – Chemical Vapor Deposition (CVD) – Chemical Vapour Transport (CVT) – reaction types - thermodynamics, kinetics - transport processes - Thermodynamics of Chemical vapor deposition process – physical, thermo – chemical factors affecting growth process.

UNIT II **(10)**

Nucleation processes during vapour growth – one component system – multicomponent system – basic steps of crystal growth from vapour – Generation of reactants – Transport of reactants – Boundary layer transport – the growth surfaces – Kossel, Stranski, Volmer (KSV) theory – Burton, Cabrera, Frank (BCF) theory – Periodic bond chain theory – modelling of vapour growth.

UNIT III **(8)**

Chemical vapour growth – Principles – Experimental techniques – flow methods – diffusion methods – Gas motion by thermal convection relationship between gas diffusion and reaction speed – transport of rate – chemical reaction with a transport agent – chemical reaction with out a transport agent.

UNIT IV **(8)**

Advantages and Limitations of Chemical Vapor Transport (CVT) – stationary temperature profile (STP) – linearly time varying temperature profile (LTVTP) – oscillating temperature profile (OTP) – the role of chemical and geometrical parameters on CVT – determination of thermodynamic values – LPCVD – VPE – MOVPE.

UNIT V **(9)**

The transport of solid substances and its special applications – metal transport with vapor, hydrogen halides and volatile halides – oxides transport with water vapor, hydrogen halides, oxygen and volatile halides – introduction of impurities by transport-Growth of II-VI and I-III-VI_2 compounds from vapour phase.

TOTAL PERIODS = 45

REFERENCES:

1. A.W. Vere, Crystal Growth, Principles and Progress, Plenum Press, New York, 1987.
2. A.C. Zettlmoyer, Nucleation, Manced, Dekker, New York, 1972
3. M.M. Fakfor and I.Garrett, Growth of Crystals from the vapour, Chapman and Hall, London, 1974.
4. P. Santhana Raghavan, P. Ramasamy, Crystal Growth and Processess, KRU publications, Kumbakonam, 2000.

Faulty of Science and Humanities (Approved in 3RD AC 22.11.2003) **ITEM NO.3.4 (2(19))**

PH 779 (Old Code: CG017)	**SEMICONDUCTOR DEVICE FABRICATION**	**L T P C 3 0 0 3**

AIM: To disseminate the knowledge of semiconductor device processing and to deliver the functional devices.

OBJECTIVES:

At the end of the course the student should be in a position to meet the following objectives.

- Preparation of semiconductor structures for processing
- Deposition of oxides, masking and etching
- Applications and limitations of optical lithography and electron lithography
- Metallization, liftoff and annealing
- Dicing, bonding and packing of devices.

UNIT I **(9)**

Wafer Preparation : Bulk Crystal Growth - Cutting and Polishing - Surface Cleaning - Etching for oxide layer removal - Controlled dissolution of surfaces - Identification for batch processing.

UNIT II **(10)**

Deposition: Deposition processes - Silicon dioxide - Silicon nitride - Other materials - Plasma assisted deposition - Plasma Enhanced Chemical Vapour Deposition (PECVD) - Oxidation: Growth mechanism and kinetics - Oxidation techniques and systems - Oxide properties - Redistribution at interface - Oxidation induced defects.

UNIT III **(10)**

Ion Implantation and Etching : Impurity diffusion - Ion implantor - Ion ranges - Disorder production - Ion channelling - Annealing of implanted dopant impurities - Shallow junctions - Minority carrier effects. Etchants - Selective etchants - Dry etching - Advantages and disadvantages of dry etching. Lithography : The lithographic process - Optical lithography - Electron beam lithography - X-ray lithography - Pattern transfer - Other lithographic techniques.

UNIT IV **(8)**

Metallization : Methods of physical vapour deposition - Selected metals for metal-semiconductor contacts - Problems encountered in metallization - Metallization failure - Silicides for gates and interconnections - Corrosion and bonding.

UNIT V **(8)**

Assembly Techniques and packaging : Wafer separation and sorting - Die interconnections - Package types and fabrication technology - Special package considerations.

TOTAL PERIODS = 45

REFERENCES:

1. Hong H.Lee, Fundamentals of Microelectronics Processing, McGraw-Hill Book Company, Singapore (1990)
2. 2. D.W.Hees and K.F.Jensen, Microelectronics Processing, American Society, Wasington, DC, 1989
3. Stephen L.Long and Steven E.Butner, Gallium Arsenide Digital Integrated Circuit Design McGraw-Hill Publishing Company, Singapore (1990)
4. S.M. Sze, VLSI Technology,McGraw-Hill Publishing Company, 2nd Ed. Singapore(1988).
5. S.M.Sze, Physics of Semiconductor devices (2nd edition),Wiley Eastern Ltd.,New Delhi (1991)

PH 780 (Old Code: CG018) **SPECIAL CHARACTERIZATION TECHNIQUES** **L T P C 3 0 0 3**

AIM: To enable the students to study the special characterization Techniques of very high sophistication.

OBJECTIVE:

- To enable the students to study the special characterization techniques with respect to technologically important materials to study the surface features, domain structure and to estimate the composition.

UNIT I **(9)**

Scanning Electron Microscopy - Basic design of the scanning electron microscopy – Modes of operation – Backscattered electrons – Secondary Electrons – X-Rays – Typical forms of contrast – Resolution and Contrast – enhancement – Specimen Preparation – various application of SEM in the field of Crystal Growth – EDAX – WDAX – EPMA.

UNIT II **(9)**

Transmission Electron Microscopy -The Intrument – Modes of operation - Specimen preparation – Initial preparation and final thinning – Replicas – Informations – from the diffraction in imperfect crystals – Dislocations – precipitates- Structure of Grains boundaries and interfaces

UNIT III **(9)**

X- ray Diffraction -Powder, Laue and rotating crystal methods – use of X- ray diffraction for the measurement of the lattice parameters – single crystallinity – Xray topography – double circle and four circle diffractometers

UNIT IV **(8)**

Optical Microscopy - Use of polarized light microscopy, phase contrast microscopy and interference microscopy – hot stage microscopy – surface morphology – Etch pit density – Hardness Measurements

UNIT V **(10)**

Surface Analytical Techniques - Introduction – electron spectroscopy for chemical analysis (ESCA) – Low Energy Electron Diffractionm (LEED) – High energy Electron Diffraction (HEED) - Reflection High energy Electron Diffraction (RHEED) –Secondary Ion Mass Spectroscopy (SIMS)- Rutherford Back Scattering Spectroscopy (RBS)- Field Ion Microscopy (FIM) – X ray photoelectron Spectroscopy

TOTAL PERIODS = 45

REFERENCES:

1. Physical Metallurgy, R.W. Cahn and P. Haassen, Ed.., 3rd North – Holland, 1983.
2. Elements of X – ray Characterisation, B.D. Cullity, Adddison Wesly Publising Co., Philippines, 1978.
3. Optical Microscopy of Materials , R. Haynes, D.P. Woodruff and T.A. Talchar, Cambridge University Pree, 1986.

FS1911 (Old Code CY 081) ORGANIC SYNTHESIS L T P C
3 0 0 3

UNIT I PRINCIPLES OF ORGANIC SYNTHESIS 9

Basic principles - Convergent and linear synthesis - Concept of retrosynthetic analysis – Synthons and synthetic equivalents - Stereoselectivity, Stereospecifity, Regio selectivity and Chemoselectivity.

UNIT II FUNCTIONAL GROUP PROTECTION 9

Functional group interconversions – Protection and deprotection – Latent functionality – Reverse polarity (Umpolung) - One group C-X disconnection.

UNIT III FUNCTIONAL GROUP DISCONNECTION 9

Two group disconnection -1,2-Difunctional compounds, 1,3-Difunctional compounds and 1,4 - Difunctional compounds.

UNIT IV PERICYCLIC REACTIONS 9

Pericyclic reactions in organic synthesis - Radical reactions in organic synthesis – Suzucki, Heck and other organometallic reactions.

UNIT V PHOTOCHEMICAL REACTIONS 9

Olefin metathesis - Heterocyclic ring synthesis - Photochemical reactions in organic synthesis.

TOTAL : 45 PERIODS

REFERENCES:

1. Stuart Warren, Designing Organic Syntheses, A programmed introduction to the synthon approach, Wiley, New york, 1978.
2. Stuart Warren, Organic Synthesis: The Disconnection Approach, John Wiley & Sons, New York, 1982.
3. Francis A.Carery and Richard J.Sundberg, Advanced Organic Chemistry, Part B, 4th Edition, Plenum Press.
4. E.J.Corey and X.M.Cheng, The logic of chemical synthesis, Wiley, New york, 1989.
5. T.Lindberg, Strategies and tactics in organic synthesis, Academic Press, New york, 1984.
6. W.Carruthers, Some modern methods of organic synthesis, Second Edition, Cambridge University Press, 1978.
7. H. O House, Modern synthetic reactions, Second Edition, Benjamin, Menlo Park, 972.
8. I.Fleming, Some selected synthesis, Wiley-interscience, New York, 1973.
9. S.Nogradi, Stereoselective synthesis, Verlag Chemie, Weinheim, 1987.

FS1912 (Old Code CY 082) ASYMMETRIC SYNTHESIS L T P C
3 0 0 3

UNIT I STEREOCHEMISTRY 9

Stereoselectivity, enantioselectivity and diastereoselectivity- Cram's rule and Felkin-Anh model-Addition to carbonyl compounds - Organo magnesium, Organo copper, Organo cadmium, Organo zinc, Organo tin and Organo indium compounds.

UNIT II CHIRAL SYNTHESIS 9

Alpha substitution using chiral enolates – chiral auxiliary approach – chiral Auxiliaries derived from amino acids and simple carbohydrates - Asymmetric aldol reactions.

UNIT III ADDITION REACTIONS 9

Addition to C-C double bonds – asymmetric Diels - Alder reactions – asymmetric 2,3 cycloaddition reactions - Chirality transfer and pericylic reactions.

UNIT IV ASYMMETRIC SYNTHESIS REACTIONS 9

Asymmetric cycloproponations- asymmetric Michael additions – Asymmetric reduction of ketones by chiral Binap and chiral boranes- Chiral transfer hydrogenations –enzymatic reduction of ketones.

UNIT V ASYMMETRIC OXIDATION 9

Asymmetric oxidations asymmetric hydroxylation of enolates Asymmetric dihydroxylation of C-C double bonds – asymmetric epoxidation of allylic alcohols and olefins.

TOTAL: 45 PERIODS

REFERENCES:

1. Gary Proctor, Asymmetric synthesis, Oxford Science Publications, Oxford Science Press, 1999.
2. AriKoskinen, Asymmetric synthesis of natural products, Wiley , 1993
3. Robert E.Gawley and Jeffrey Aube, Principles of asymmetric synthesis, Pergamon, 1996.
4. Guo-Qiang Lin, yue-Ming Li and Albert S.C.Chan, Principles and applications of asymmetric synthesis, Wiley Interscience, 2001
5. Asymmetric synthesis, Volume 1 to 5, edited by James D.Morrison, Academic Press Inc., 1985
6. Catalytic asymmetric synthesis, edited by Iwao Ojima, wiley VCH, 2000.

FS1913 BIOSENSORS AND INSTRUMENTATON L T P M
3 0 0 100

UNIT I INTRODUCTION
Concepts and components of a biosensor - principles of operation, integration of biosensor in instrumentation.

UNIT II PREPARATION OF BIOSENSOR
Biomolecules used in biosensors and their properties, general Immobilization techniques for (Optical-detection biosensor, thermal-detection biosensor, electrochemical biosensor etc.,) behaviour of different types of biosensors.

UNIT III TYPES OF BIOSENSOR
Enzyme based biosensor; (glucose biosensor, cholesterol biosensor), microbial immunobiosensor and their characteristics.

UNIT IV APPLICATIONS OF BIOSENSORS
Validation (Specificity, Speed, Simplicity, Capability), application of biosensor in environment, Microbiology: bacterial and viral analysis, Food and beverage production and analysis, Clinical Diagnosis.

UNIT V INSTRUMENTATION OF BIOSENSOR
Transducers:OpticalTransducers, Fluroescensce transducers, Acoustic transducer.Polarizable and non-polarizable electrodes acoustic, plasmon resonance, holographic and microengineered sensors for monitoring low molecular weight anlaytes, proteins, DNA and whole cells.

REFERENCES:
1. Biomolecular sensors, Eds.: Electra Gizeli and Christopher R.Lowe, Taylor and Francis, London (2002).
2. Cass,A.E.G, Biosensors: A Practical Approach, ORL Press (1990).
3. Jon Cooper and Tony Cass, Biosensors: A Practical Approach, Oxford Press (2004).

FS1914 DOMINATION IN GRAPHS L T P M
3 0 0 100

UNIT I DOMINATING SETS 9

Dominating sets in graphs – Minimal dominating sets – Hereditary and superhereditary properties – Minimal and Maximal P-sets – Independent sets – Every maximal independent set is a minimal dominating set – Irredundant sets– Domination chain – Bounds involving domination, independence and irredundance numbers.

UNIT II CHANGING AND UNCHANGING DOMINATION 9

Changing and unchanging domination – Basic terminology – Changing – Vertex removal - CVR graphs – Edge removal – CER graphs – Edge addition – CEA graphs – Unchanging – Vertex removal – UVR graphs – Edge removal – UER graphs – Edge addition – UEA graphs.

UNIT III CONDITION ON DOMINATING SET 9

Condition on the dominating set – Independent dominating sets – Total dominating sets – Connected dominating sets – Bounds for connected domination number – External graphs attaining the bounds.

UNIT IV DOMINATING CLIQUES 9

Dominating cliques – Sufficient condition for existence of a dominating clique – Bounds for the clique domination number – Paired dominating sets – Paired domination number – Bounds for paired domination number – Inequalities connecting paired domination number and other domination parameters

UNIT V VARIETIES OF DOMINATION 9

Varieties of domination – Multiple domination – Bounds for the multiple domination number – *k* – dependence number – Inequality connected *k*–domination number and *k*–dependence number – Locating domination – Locating domination number – Bounds – Strong and weak domination – Strong and weak domination number – Bounds.

TOTAL : 45 PERIODS

TEXT BOOK:

1. T.W. Haynes, S.T.Hedetniemi and P.J. Slater, Fundamentals of Domination in Graphs, Marcel Dekker, Inc., 1997.
(Sections 1.2, 3.1, 3.2, 3.3, 3.4, 5.1, 5.2, 5.3, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 7.1, 7.3, 7.5)

FS1915 DOMINATION RELATED FUNCTIONS IN GRAPHS L T P M
3 0 0 100

UNIT I FRACTIONAL DOMINATION 9

Fractional domination – Fractional and Upper fractional domination numbers – Fractional packings – Fractional packing number and Upper fractional packing number – Fractional total domination – Fractional total domination number – Fractional irredundance – *k*–domination– *k*–packings and *k*–irredundance

UNIT II MINIMAL DOMINATING FUNCTIONS 9

Properties of Minimal dominating functions – Positive sets and boundary sets Existence of positive minimal dominating functions – Convex combination of dominating functions – Universal Minimal Dominating functions – Graphs having Universal Minimal Dominating functions

UNIT III VERTICES OF TREES 9

Convexity of Minimal Dominating functions of trees – Cool vertices of trees – Characterization of cool vertices – Loose vertices – Characterization of loose vertices– Universal Minimal Dominating Functions in Trees – Algorithm for 0–1 Universal Minimal Dominating functions in trees

UNIT IV TOTAL DOMINATING FUNCTIONS 9

Universal Minimal Total dominating functions in Graphs – Basic results – Graphs having a unique Minimal Total Dominating Function – Short vertices and Hot vertices – Existence and Non existence of Universal Minimal Total Dominating Functions in trees

UNIT V SIGNED DOMINATION 9

Minus domination – Signed domination – Signed domination number – Upper signed domination number – Trees with minus domination number 1 – Bounds for signed domination number of trees

TOTAL: 45 PERIODS

REFERENCES:

1. T. W. Haynes, S. T. Hedetniemi and P. J. Slater, Domination in Graphs – Advanced Topics, Marcel Dekker, Inc., New York, 1998. (Sections 3.1, 3.2.1, 3.2.2, 3.3.1)
2. T.W. Haynes, S.T.Hedetniemi and P.J. Slater, Fundamentals of Domination in Graphs, Marcel Dekker, Inc., 1997. (Section 10.2)
3. E.J. Cockayne et.al., Properties of Minimal Dominating functions of Graphs, Ars Combinatoria, 41(1995), 107 – 115.
4. E.J. Cockayne et.al., Convexity of Minimal Dominating functions of trees, Utilitas Mathematica, 48(1995), 124 – 144.
5. E.J. Cockayne et.al., Universal Minimal Total Dominating Functions in Graphs, Networks, (1994), 83–90.

FS1916 CRYSTAL GROWTH AND SPECTROSCOPY L T P M
3 0 0 100

UNIT I

Nucleation concept- Kings of nucleation – Homogenerous and Heterogeneous nucleation – Gibbs – Thomson equation – Kinetic theory of nucleation – Energy of formation of a nucleus- Statistical theory of nucleation – Equilibrium concentration of embryos for different sizes- Secondary nucleation.

UNIT II

Growth of crystals from solutions – Solubility – Preparation of a solution – saturation and supersaturation – Measurement of super saturation – Low temperature solution growth – Evaporation method – Temperature gradient method – Electro crystallization-Crystal growth from gel – Growth of biological crystals.

UNIT III

Nonlinear Optics – Harmonic generation – Second Harmonic generation (SHG) – Phase matching – Phase conjugation – Optical parametric oscillator (OPO) – Optical mixing – rNLO crystals-Nanoscalematerials – thin films –Nanoporous Materials-Solgel techniques.

UNIT IV

Infrared Spectroscopy – Near IR-Mid IR –Far IR Region – Correlation of infrared Spectra with molecular structure- Fourier transform interferometer – Sample handling- Raman Spectroscopy- Resonance Raman Spactroscopy – Comparison of Raman with Infrared Spectroscopy – Nuclear magnetic resonance Spectroscopy.

UNIT V

X-ray methods – Production of X-rays and X-ray spectroscopy – Scanning electron microscopy- Thermal analysis – differential thermal analysis – Structure analysis- Luminescence- Photoluminescence – Thermo luminescence – Measurement of electrical conductivity – Measurement of dielectric constant – Microhardness – Etching studies.

REFERENCES:

1. K.Sangwal, Elementary Crystal Growth, Saan Publisher, UK,1994.
2. B.R.Pamplin, Progress in Crystal Growth Characterisation, Pergamon press Ltd., Y.K.1982
3. Banwell, Collin N. Fundamentals of Molecular Spectroscopy, McGraw Hill 1995.
4. P.Ramasamy, P.Santhana Raghavan, Crystal Growth and Processess, KRU 2000.

FS 1917 RESERVOIR SEDIMENTATION L T P C
3 0 0 3

UNIT I CATCHMENT PROCESSES 8

Catchment processes – Soil erosion – nutrient transport – basin morphometry – USLE/MUSLE – Types of erosion – Sedimentation of reservoirs – spatial data models – concepts of GIS and application in erosion and NPS pollution studies – Sediment yield.

UNIT II RESERVOIR EUTROPHICATION 10

Hydrological processes and water quality – Water pollution – Eutrophication of water – causes and problems – methods of investigation and control of Eutrophication – Limnochemistry of Reservoirs – Nutrient profiles and vertical Zonation.

UNIT III SEDIMENTS 12

Sediment composition – nutrient profiles – mechanism of accumulation, transformation and release – aerobic and anaerobic decomposition – sorption / desorption mechanisms – resuspension and redeposition of sediments – degradation of particulate / dissolved organic matter in sediments of running water – spatial and seasonal changes – pollutants – sediment / water interphase – pesticides – metabolites – reservoir sedimentation problems.

UNIT IV SEDIMENT SAMPLING AND ANALYSIS 8

Sampling of reservoir sediments – sediment traps – sampling equipment and gear – sample preparation – sediment quality – nutrients – Sediment yield estimation methods.

UNIT V SEDIMENT CONTROL AND MANAGEMENT 7

Control of reservoir sedimentation– sediment removal and disposal – environmental, social and economical impacts.

TOTAL : 45 PERIODS

REFERENCES:

1. Odum, E.P., Fundamentals of Ecology, 3rd Edition, Natraj Publishers, 1996.
2. O'Sullivan, P.E., Reynolds, C.S., The lakes Hand book, Limnology and Limnetic Ecology, Vol 1, a Blackwell publishing company, 2004.
3. Robert G. Wetzel, Limnology – Lake and River Ecosystems, 3rd Edition, Academic Press, An Imprint of Elsevier, 2006.
4. Standard methods for the examination of water and wastewater, 20th Edition, American public health association, Washington, 1998.

FS 1918 GENETIC ENGINEERING L T P C
3 0 0 3

UNIT I SALIENT FEATURES OF CLONING VECTORS 9

Types of cloning vectors viz. Plasmids, Cosmids, ssDNA Phages, Yeast cloning vectors, Animal viruses, Ti Plasmids and cauliflower Mosaic Virus.

UNIT II PLASMID BIOLOGY 8

Structural and Functional Organization of Plasmids, Plasmid Replication, Stringent and Relaxed Plasmids, Incompatibility of Plasmid Maintenance.

UNIT III ENZYMES IN GENETIC ENGINEERING 8

DNA polymerase, Polynucleotide kinase, T4 DNA ligase, Nick translation System, Terminal deoxynucleotide transferase, Reverse transcriptase Restriction Endonucleases Type I & II.

UNIT IV ISOLATION OF GENOMIC AND NUCLEAR DNA 9

DNA digestion and restriction fragment analysis and sequencing by chemical, Enzymatic and big-bye terminator methods.

UNIT V GENE MODIFICATION & APPLICATION OF RECOMBINANT DNA TECHNOLOGY 11

Mutagenesis-Deletion mutagenesis, Oligonucleotide derived mutagenesis,Site directed mutagenesis- Its applications; Applications of rDNA technology in Diagnistics; Pathogenesis; Genetic diversity; Therapeutic proteins-Vaccines. Molecular probes (production, labeling and uses), P.C.R.

TEXT BOOKS:

1. “Principles of Gene manipulation” by R.W. Old and S.B.Primrose Third Edition Blackwell Scientific Publication 1985.
2. “Genes VI” by B.Lewin
3. “From Genes to Clones” by E.L. Winnecker.
4. “Gene Cloning” by T.A. Brown.

FS 1919 ANALTICAL TECHNIQUE IN BIOTECHNOLOGY L T P C
3 0 0 3

UNIT I CHROMATOGRAPHY - TECHNIQUES 8

Chromatography – adsorption, affinity, partition (GLC, GC, HPLC, TLC, RPC etc.) Immobilized cells.

UNIT II MICROSCOPY - TECHNIQUES 8

Microscopic identification of various microorganisms: phase contrast and confocal microscopy: SEM-TEM microscopy.

UNIT III SPECTROSCOPIC TECHNIQUES 9

Introduction to principles and applications of Spectroscopic methods UV, Vis, IR,Fluorescence, ORD, CD, PAS, NMR, ESR and mass spectrometry.

UNIT IV NUCLEOTIDE AND DNA ANALYSIS 8

DNA purification, PCR – based analysis; DNA fingerprinting; DNA sequencing.

UNIT V IMMUNO-TECHNIQUES 12

Antiserum production, immunofluroscence, immuno histocompatibility ELISA; Isolation of cells in tissues immunoblotting; monoclonal antibodies. Theory of Lyophilization and its applications to biological systems. Cell sorter and their applications. Theory of centrifugation and application to biological systems. Rotors angle / vertical, zonal / continuous flow buoyant density centrifugation. Ultracentrifuge – principle and application.

TEXT BOOK:

1. Readings in Scientific American, W.H. Freeman. 1985-1993.

FS 1920 KEY COMPONENTS FOR ALL-OPTICAL NETWORKS L T P C
3 0 0 3

UNIT I DWDM & All OPTICAL NETWORKS 9

ITU grid frequencies – Basic network elements of a point to point DWDM system – Issues in DWDM networks- wavelength stabilization, chirping, non-linearities –self phase modulation, FWM, dispersion management, DWDM link design (case study) , Evolution of all – optical networks (optical internet)

UNIT II NETWORK ELEMENTS 9

Key Components for DWDM networks – media – Advanced fibers, tunable sources – ECL's – Detectors – Metal semiconductor photodiodes, Optical Fiber Amplifiers and lasers for C,L,S and S+ bands, fiber based dispersion compensators.

UNIT III WAVELENGTH ROUTING ELEMENTS 9

ROADM architectures, OXC's, Wavelength converters, Adaptation of these components to optical MEMs based systems for dynamic configurability.

UNIT IV PHOTONIC COMPONENTS & MATERIALS 9

SEED based devices for optical programming logic, photonic bandgap structures, metamaterials, photonic crystal fibers, programmable optical delays

UNIT V OPTICAL PACKET SWITCHING 9

GMPLS, Key elements of All- optical packet switching nodes, KEOPS test-bed

REFERENCES:

1. G.P. Agarwal, "Fiber optic communication systems" , 2nd Edition, John Wiley & Sons, New York, 1997.
2. Govind P.Agarwal, Nonlinear Fiber Optics, AT & T – Academic Press, 1989
3. G.Keiser, "Optical fiber communication" , Systems, McGraw-Hill, New York, 2000.
4. Rajiv Ramaswamy and Kumar Sivarajan, "Optical Networks-A Practical perspective", Morgan-Kauffman
5. Photonic Crystals. Molding the flow of light, 2nd Edition, J D Joannopolous, Steven G Johnson, Joshua N Winn, R D Meade, Princeton University Press, 2007

FS 1921 BIOMIMETIC OXIDATION CHEMISTRY L T P C
3 0 0 3

UNIT I BIOCATALYST OXIDATIONS 9

Introduction – Oxygen activation and oxidation mechanism – Biocatalyst oxidators – classification of oxido reductases.

UNIT II BIOMIMETIC OXIDATIONS OF CYTOCHROME P450MIMIES 9

Biocatalytic conversion – oxygenases – oxidases – peroxidases – Biomimetic oxidations – cytochrome P450mimies – MMO mimies

UNIT III BIOMIMETIC CHEMISTRY OF MOLYBDENUM 9

Biomimetic chemistry of Molybdenum – Overview of Biomimetic systems – Oxygen atom transfer reaction – Coupled electron - Proton transfer reaction

UNIT IV DISTINGUISHING BIOMIMETIC OXIDATIONS FROM OXIDATIONS MEDIATED BY FREELY DIFFUSING RADICALS-FREE RADICALS 9

Distinguishing Biomimetic oxidations from oxidations mediated by freely diffusing radicals-free radicals – Clock-choice of activation source – Effect of additives – competitive Kinetics – Oxygenated Penton chemistry.

UNIT V METAL – OXO AND METAL – PEROXO INTERMEDIATES 9

Biometic oxygenation related to Cytochrome P450 Metal- Oxo and Metal – Peroxo intermediates – Mechanism of hydroxylation by Cytochrome P450-Decomposition catalysis for Peroxy nitrite by impartan biological oxidants.

REFERENCES:

1. Ortiz de Montellano, P.R.(ed) Cytochrome P450 Structure, Mechanism and Biochemistry, Plerum press, New York, 1995.
2. Peroxidases in Chemistry and Biology, (ed) Everse, J., Evers, K.E and Grisham, M.B.CRC press, Boca Raton, 1991.
3. Pilato,R.S. and Stiefel, E.I, in Bio inorganic catalysis (ed) Reedijk,J.Dekker, New York, 2nd Ed., 1999, Pp.81-152.
4. Que,L. in Bio inorganic catalysis (ed) Reedijk,J.Mareel Dekker, New York,1993.
5. Biomimetic Oxidations Catalyzed by Transition Metal Complex by Bernard Meunier, Imperial College Press.

FS1922 BOSE EINSTEIN CONDENSATION L T P C
3 0 0 3

UNIT I INTRODUCTION & THE NON-INTERACTING BOSE GAS 9

Bose-Einstein condensation in atomic clouds - Superfluid helium - Other Condensates - The Bose Distribution - Transition temperature and condensate fraction – Density profile and Velocity distribution - Thermodynamic quantities (Condensed phase, Normal phase and specific heat close to TC) – Effect of finite particle number – Lower dimensional systems.

UNIT II TRAPPING AND COOLING OF ATOMS 9

Magnetic traps – Influence of laser light on an atom – Laser cooling (the Doppler Process) – the magneto-optical trap – Sisyphus cooling – Evaporative cooling – Spin polarized hydrogen.

UNIT III THEORY OF CONDENSED STATE & ITS DYNAMICS 9

The Gross – Pitaevskii equation – The ground state for trapped bosons – Surface structure of clouds – Healing of the condensate wave function – General formulation (The Hydrodynamic equations) – Elementary excitations – Collective modes in traps – Surface modes – Free expansion of the condensate – Solitons

UNIT IV SUPER FLUIDITY 9

The Landau criterion – The two component picture (Momentum carried by excitations and Normal fluid density) – Dynamical processes – First and second sound – Interactions between excitations (Landau damping)

UNIT V MIXTURES AND SPINOR CONDENSATES 9

Mixtures – Equilibrium properties and collective modes, Spinor Condensates – Mean field description and Beyond the mean field approximation.

REFERENCES:

1. Pethick C.J and Smith H., “Bose – Einstein Condensation in Dilute Gases”, Cambridge University Press, Cambridge, 2002.
2. Pitaevskii Lev and Stringari Sandro, ”Bose – Einstein Condensation”, Oxford Science Publications, Oxford, 2003 .

FS1923 ICT FOR DEVELOPMENT L T P C
3 0 0 3

AIM

To introduce the students to principles and tools of information and communication technology (ICT), and its applications for development.

OBJECTIVES

- To understand the information and communication technology developments in India and their role in creating social change.
- To know the different tools of ICT.
- To know the benefits of the tools of ICT for development.

UNIT I INTRODUCTION 9

Information and Communication Technology: Principles – limitations – understanding the adoption and implementation of ICT interventions – Development in ICT – Digital Divide: Definition and Causes – Bridging Digital Divide through ICT – ICT Indicators.

UNIT II ICT IN HEALTH 9

Telemedicine: ICT techniques adopted, Advanced Computer methods for patients safety, (Patient Care information systems) – Health awareness through ICT: Nutrition, Diseases, Preventive methods, Health Management Information System – Community based Health Access to Health Information.

UNIT III ICT IN AGRICULTURE 9

Kisan call centres – Gyandoot, Bhoomi Project – Village Knowledge Centres, AGMARKNET – Feasibility of ICT in Rural Areas, ICTs, Critical information Flow – Agricultural Knowledge System – FAO – Knowledge Management and Agriculture, Agricultural Development Strategies and the Value of ICT – ICT in market facilitation and trade.

UNIT IV ICT IN HOLISTIC DEVELOPMENT 9

Knowledge sharing in Innovative Business Transformation – Creation of Internet Business Solutions – Strategies for Emerging Markets Economic Development – Analysis of Sustainable Community Development – Planning Non-Profit Organization – Non-government Organization – Management and Funding Strategy – International Digital Community Network Development – Information & Communication Technology and Community – based Economy Social Network Tools – Internet Activism – Global Culture Convergence Facilitation.

UNIT V ICT IN SUSTAINABLE DEVELOPMENT 9

Sustainable Development Definition – economic, environmental, social and human sustainability – Brundtland report – Improving public awareness – Monitoring – Response systems – Facilitating environmental activism – Enabling more efficient resource use through ICT.

TEXT BOOKS:

1. Rohan Samarajiva and Ayesha Zainudeen. ICT *Infrastructure in Emerging Asia*, Sage Publications, New Delhi, 2008.

2. Akhtar Badshah, Sarbuland Khan and Maria Garrido, Connected for Development, UN ICT Task Forces.
3. Sharmila Majumdar and Asis Kumar Pain, ICT for Development: Prospects and Problems, ICFAI University Press, Delhi, 2009.

REFERENCES:

1. Ashwani Saith, M.Vijaya Baskar and V.Gayathri, ICTs and Indian Social Change, Sage Publications, New Delhi, 2008.
2. Ashwani Saith, M.Vijaya Baskar, ICTs and Indian Economic Development, Sage Publications, New Delhi, 2005.
3. Subhash Bhatnagar and Robert Schware, *Information and Communication Technology in Development Cases from India,* Sage Publication, New Delhi,2000

FS9001 FINITE VOLUME METHOD L T P C
3 0 0 3

UNIT I CONSERVATION LAWS AND BOUNDARY CONDITIONS 9

Governing equation of fluid flow: Mass, Momentum and Energy equations, Equation of state; Navier-Stokes equations for a Newtonian fluid, Conservative form of equations of fluid flow, Differential and integral forms of the transport equation, classification of PDE's and fluid flow equations, viscous fluid flow equations, transonic and supersonic compressible flows.

UNIT II FINITE VOLUME METHOD FOR DIFFUSION & CONVECTION-DIFFUSION PROBLEMS 12

FVM for Diffusion Problems: one-dimensional steady state diffusion, two-dimensional diffusion and three-dimensional diffusion problems; FVM for Convection-Diffusion problems one-dimensional steady state convection-diffusion, central differencing schemes for one-dimensional convection-diffusion, upwind differencing scheme, hybrid differencing scheme, Higher-order differencing scheme for convection-diffusion problems, TVD schemes

UNIT III SOLUTION ALGORITHMS FOR PRESSURE-VELOCITY LINKED EQUATUIONS 9

Staggered grid, momentum equations, SIMPLE, SIMPLER, SIMPLEC algorithms, PISO algorithms, solution of discretised equation: Multigrid techniques.

UNIT IV FINITE VOLUME METHOD FOR UNSTEADY FLOWS 9

One-dimensional unsteady heat conduction: Explicit, Crank-Nicolson, fully implicit schemes, implicit method for two- and three- dimensional problems, transient convection – diffusion equation and QUICK differencing scheme, solution procedures for unsteady flow calculations and implementation of boundary conditions.

UNIT V METHOD WITH COMPLEX GEOMETRIES 9

Body-fitted co-ordinate grids for complex geometries, Cartesian Vs. Curvilinear grids, difficulties in Curvilinear grids, Block-structured grids, Unstructured grids and discretisation in unstructured grids, Discretisation of the diffusion term, Discretisation of convective term, treatment of source terms, Assembly of discretised equations, Pressure-velocity coupling in unstructured meshes, staggered Vs. co-located grid arrangements, face velocity interpolation method to unstructured meshes.

TOTAL : 45 PERIODS

TEST BOOK:

1. Versteeg H.K. and Malalasekera W."An Introduction to Computational Fluid Dynamics: The Finite Volume Method",(Second Edition), Pearson Education, New Delhi, 2008

REFERENCES:

1. Ferziger J.H and Peric. M" Computational methods for Fluid Dynamics", (Third Edition), Springer (India), New Delhi 2005.
2. Chung T.J."Computational Fluid Dynamics", Cambridge University Press, 2002
3. Suhas V. Patankar" Numerical Heat Transfer and Fluid Flow", Taylor & Francis, 2007.

FS9002 NEUTRAL NETWORKS, FUZZY LOGIC SYSTEMS AND GENETIC ALGORITHMS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION ON TO NEURAL NETWORKS 9

Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Characteristics of ANN, Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN – Connectivity, Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules.

UNIT II FEED FORWARD NEURAL NETWORKS 9

Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Limitations of the Perceptron Model, Credit Assignment Problem, Generalized Delta Rule, Derivation of Back propagation (BP) Training, Summary of Back propagation Algorithm, Kolmogorov Theorem, Learning Difficulties and Improvements.

UNIT III ASSOCIATIVE MEMORIES 9

Paradigms of Associative Memory, Pattern Mathematics, Hebbian Learning, General Concepts of Associative Memory, Bidirectional Associative Memory(BAM) Architecture, BAM Training Algorithms: Storage and Recall Algorithm, BAM Energy Function. Architecture of Hopfield Network: Discrete and Continuous versions, Storage and Recall Algorithm, Stability Analysis.

UNIT IV FUZZY LOGIC SYSTEM COMPONENTS 9

Introduction to classical sets – properties, Operations and relations: Fuzzy sets, Membership, Uncertainty, Operations, Properties, Fuzzy relations, cardinalities, membership functions. Fuzzification, Membership value assignment, development of rule base and decision making system, Defuzzification to crisp sets, Defuzzification methods. Neural network applications: Process identification, control, fault diagnosis. Fuzzy logic applications: Fuzzy logic control and Fuzzy classification.

UNIT V GENETIC ALGORITHMS 9

Basics of Genetic Algorithms – Goals of Optimization, Simple Genetic Algorithm, Data Structures, Reproduction, Crossover, Mutation, codlings, Constraints, Applications of Genetic Algorithms: Multi Objective Optimizations, Knowledge based techniques.

TOTAL: 45 PERIODS

TEXTBOOKS:

1. S.Rajasekharan and G.A.Vijayalakshmipai, “Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications”, PHI Publication, 2004.
2. John Yen and Reza Langan, “Fuzzy Logic: Intelligence, Control and Information”, Pearson Education, 2004.
3. S.N.Sivanandam, S.Sumathi, S.N.Deepa, ”Introduction to Neural Networks using Matlab 6.0”, TMH, 2006.

REFERENCES:

1. Simon Haykin, “Neural Networks – A comprehensive foundation”, Pearson Education, 2001
2. James A Freeman and Davis Skapura, Neural Networks Pearson Education, 2002.
3. Timothy J.Ross, “Fuzzy Logic With Engineering Application”, McGraw-Hill Inc.1997

FS9003 VIBRATIONAL SPECTROSCOPY L T P C
4 0 0 4

UNIT I MOLECULAR VIBRATIONS & INFRARED SPECTROSCOPY 12

Vibration of diatomic and polyatomic molecules - Origin of infrared spectra - Spectral transitions - Internal Vibrations - Spectral of simple molecules - Vibrational assignments – Infrared instrumentation – Sources – monochromator – Detectors – Single beam and Double Spectrophotometers – Sampling Techniques – F.T.I.R. Spectroscopy.

UNIT II RAMAN SPECTROSCOPY 12

Nature of Raman effect – Quantum Mechanical description – Selection rules – Depolarization ratio – Rotation – Vibration spectra – Resonance Raman effect – Instrumentation – Sample handling techniques – Nonlinear Raman effects – F.T.Raman Spectroscopy.

UNIT III GROUP THEORETICAL APPLICATIONS 12

Groups and their properties – Molecular symmetry – Symmetry elements – Molecular point group – Reducible and Irreducible representations – Great orthogonality Theorem – Character tables – Normal vibrations – Classification – Selection rules for vibrational transitions – Infrared and Raman spectral activity.

UNIT IV NORMAL COORDINATE ANALYSIS 12

Internal and symmetry coordinates – Kinetic and potential energy matrices – Force constants – Wilson's Secular equation – Factorization and solution – Spectral of isotopic molecules – Approximation methods – Force fields – Normal coordinate analysis of some simple symmetric molecules.

UNIT V LATTICE DYNAMICS AND CRYSTAL SPECTRAL 12

Monoatomic chain – Diatomic chain – Vibration of three dimensional lattice – Brillouin zones – Dynamic matrix – Crystal spectral – Factor group analysis – Inter atomic forces in solids – Force constants of perovskite fluorides – Separation of internal and external vibrations.

TOTAL : 60 PERIODS

REFERENCES:

1. Sathyanarayana.D.N, Vibrational Spectroscopy – Theory and applications, New Age international, New Delhi, 1996.
2. Turrell G, "Infrared and Raman Spectra of crystals"; Academic Press, New york, 1972.
3. Barrow.G.M., "Introduction to Molecular Spectroscopy", Tata Mc Graw-Hill Co., New Delhi, 1982.
4. Wilson E.B., Decius J.C. and Cross D.C., Molecular Vibrations, Mc Graw Hill, New York, 1980.
5. Banwell C.N. and MCcash E.M., Fundamentals of Molecular Spectroscopy, 4th edition, Tata Mc Graw-Hill Co., New Delhi, 1995.

FS9004 QUANTUM MECHANICAL COMPUTATION OF MOLECULAR MODELS L T P C 4 0 0 4

UNIT I COMPUTATIONAL THEORY, MODELING AND MOLECULAR MECHANICS 12

Definition of terms – Quantum mechanics – Cost and efficiency – Note on units – Introduction of molecular mechanics and fundamental assumptions – potential energy functional forms – Force field energies and thermodynamics – Geometry optimization – Menagerie of modern force field and Docking – Case study.

UNIT II SIMULATIONS OF MOLECULAR ENSEMBLES 12

Relationship between MM optima and Real systems – phase space and Trajectories – Molecular dynamics – Monte Carlo – Ensemble and dynamic property examples – Key details in formalism – Force field performance in simulations – case study : Silica Sodalite.

UNIT III MOLECULAR ORBITAL THEORY 12

Quantum mechanics and wave function – The Hamiltonian operator – Construction of Trial wave function – Huckel theory – Many electron wave function – Extended Huckel Theory.

UNIT IV SEMIEMPIRICAL IMPLEMENTATIONS OF MOLECULAR ORBITAL THEORY 12

CNDO, INDO, NDDO Formalism – Overview of basic NDDO models – Ab initio – Implementation of Hartee Fock theory – Electron correlation – Dynamic and non dynamic electron correlation – Perturbation theory – Coupled cluster theory.

UNIT V DENSITY FUNCTIONAL THEORY 12

Theoretical Motivation – Rigorous Foundation – Kohn sham self consistent field methodology – Exchange – Correlation functions – Advantages and disadvantages of DFT compared to MO Theory – General performance overview of DFT – Case study: Transition metal catalyzed carbonylation of methanol.

TOTAL : 60 PERIODS

REFERENCES:

1. Christopher J.Cramer, Essentials of Computational Chemistry – Wiley edition, 2005.
2. Jurg Hatter, Lecture notes in Computational Chemistry Electronic Structure Theory, 2005.
3. Alan Hinchliffe, Molecular Modelling for Engineers – Wiley edition, 2005.

FS9005 DIFFERENTIAL SUBORDINATION L T P C
3 0 0 3

UNIT I PRELIMINARIES AND THEORY OF SECOND ORDER DIFFERENTIAL SUBORDINATIONS 9

Basic definitions and results – Subordinations – Hyper geometric functions – Classes of functions – Integral operators.
Introduction – Fundamental lemmas – admissible functions and examples – Open door lemma and integral existence theorem

UNIT II APPLICATIONS OF FIRST ORDER DIFFERENTIAL SUBORDINATION 9

First order linear differential subordinations – Briot – Bouquet differential subordination - Analytic integral operators – Subordination preserving integral operators.

UNIT III APPLICATIONS OF SECOND ORDER DIFFERENTIAL SUBORDINATION 9

Second order linear differential subordination – integral operators preserving functions with positive real parts – Integral operators preserving bounded functions – Averaging integral operators – Hyper geometric functions – Schwarzian and Starlikeness

UNIT IV SPECIAL DIFFERENTIAL SUBORDINATION 9

Conditions for special sub classes of star like functions – Simple Conditions for star likeness and convexity – On a theorem of Robertson – subordination by convex functions – Function with bounded turning and star like functions – star like with respect to symmetric points.

UNIT V DIFFERENTIAL SUBORDINATION OF SEVERAL COMPLEX VARIABLES AND APPLICATIONS 9

Preliminary lemmas – extensions of the fundamental lemma – Dominant and admissible functions in C^n - Differential subordination in C^n.
Applications of differential subordination in other fields – Harmonic functions – Meromorphic functions – Differential subordination in the upper half plane – extension to Banach spaces.

TOTAL : 45 PERIODS

TEXT BOOK:

1. S.S. Miller and P.T. Mocanu**,** Differential Subordination : Theory and Applications, Series on Monographs and Textbooks in Pure and Applied Mathematics(No. 225), Marcel Dekker, New York and Basel,2000

REFERENCES:

1. P.L.Duren, Univalent functions, Springer – Verlag, New York, Berlin, Heidelberg, and Tokyo ,1983.
2. A.W. Goodman, Univalent functions, Vol.I, and II Polygonal Publishing House Washington, New Jersey,1983.

FS9006 POLYMERS IN DRUG DELIVERY AND TISSUE ENGINEERING APPLICATIONS **L T P C 3 1 0 4**

UNIT I Polymers **8**

Basics of Polymers – types of polymers – biodegradable polymers – role in drug delivery and tissue engineering application.

UNIT II Drug Delivery **12**

Introduction and Overview of Drug Delivery System. Factors that Impact Drug Delivery – Various Strategies for Drug Delivery Polymer, Peptide, Protein, Ultrasound, Antibody, Nanotechnology.

UNIT III Controlled, Sustained and Advances in drug delivery system **14**

Fundamentals of Controlled Release Drug Delivery, Influence of drug properties, and routes of drug administration on the design of sustained & controlled release systems. Targeted Drug Delivery – Definition, concept, target-drug interactions, and delivery systems – Advances in Controlled and Sustained Drug Delivery – Microencapsulation.

UNIT IV Introduction to tissue engineering and regenerative medicine **14**

Basic definition – current scope of development – regenerative medicine, stem cell concepts and its role in tissue and organ developments – use in therapeutics and in vitro testing.

UNIT V Scaffolds **12**

Scaffolds – importance of scaffolds – fabrication of scaffolds – tissue culture methods, types of cells – cytotoxicity – bioreactors and its types – Advantages of Composites and Composite scaffolds.

TOTAL : 60 PERIODS

TEXT BOOK:

1. Drug Delivery: Principles and Applications B. Wang, S. Siahaan, R. Soltero Wiley-VCH, 2005.
2. Fundamentals of Tissue Engineering and Regenerative Medicine Meyer, U.; Meyer, Th.;Handschel, J.;Wiesmann, H.P. (Eds.) 2009.

REFERENCES:

1. Drug Delivery S: Engineering principles for drug therapy W.Mark Saltzman (edt.), Oxford Univ. Press 2004.
2. Biodegradable polymers as drug delivery systems Mark Chasin, Robert Langer, Marcel Dekker INC,1990.
3. Polymers for tissue engineering M.S. Shoichet, J.A. Hubbel, VSP BV, 1998.
4. Synthetic biodegradable polymers scaffolds Anthony Atala, David Mooney, Joseph P.Vacanti, Robert Langer, Hamilton Printing Co,1997.

FS9007 EPITAXIAL GROWTH L T P C
3 0 0 3

AIM: To introduce the fundamentals of various types of epitaxy.
To enhance the understanding of the phase diagrams, epitaxial growth processes and instrumentation of epitaxial techniques.

OBJECTIVES: On completion of the course the student would be in position

- To understand the concepts of homoepitaxy and heteroepitaxy
- To derive the expressions for the kinetically controlled and thermodynamically controlled growth regimes in epiatxy
- To design the various reactor models in LPE, VPE, MOCVD, MBE, CBE and ALE

UNIT I (10)

Phase diagrams of III-V semiconducting compounds - experimental - apparatus & procedure - tipping - dipping - sliding - homoepitaxy - principle of LPE for growth from two component solution - Heteroepitaxy - uses & limitations of LPE.

UNIT II (10)

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.

UNIT III (9)

Principle of method and apparatus - reactor design - growth of III-V compound Semiconductors - InP - GaAs - GaInAs - GaInAsP and other III-V compounds.

UNIT IV (6)

Mechanism of MOCVD growth - Thermodynamic concepts - growth rate calculations - applications of III-V materials grown from MOCVD - Low pressure MOCVD (LPMOCVD)

UNIT V (10)

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

TOTAL PERIODS : 45

REFERENCES:

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
4. A.B.Balderschi and C.Paorici, Epitaxial electronic Materials, World Scientific Publishers, London, 1986
4. P.R.Vaya, Lecture notes on Technology and characterisation of epitaxial Semiconductor films and devices, IIT, Madras, 1987
5. David L.Pulfery & N.Garry Tarr, Introduction of Microelectronic Devices, Prentice Hall, New York, 1989
6. T.Santola and M.Simpson, Atomic Layer Epitaxy, Prentice Hall, New York, 1990.

FS9008 SEMICONDUCTOR DEVICES L T P C
3 0 0 3

AIM: To impart sound knowledge of working principles of various types of electron and optical semiconductor devices.

OBJECTIVES:

- To understand different types of heterostructures in devices.
- To develop the skills in electron devices using ion implantation
- To know the concepts of unipolar and bipolar electron devices
- To develop the knowledge in microwave and optical devices
- To gain the knowledge of integrated circuits and sensors

UNIT I (8)

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

UNIT II (3)

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 (6)

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

UNIT IV (7)

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 - future trends in Fiber optic communications - Photodetectors - Photoconductor - Photodiode - Avalanche Photodiode - Phototransistor - Solar cells - Thin film Solar cells.

UNIT V **(9)**

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 PERIODS = 45

REFERENCES:

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

FS9009 **FLUID DYNAMICS** **L T P C**
3 0 0 3

UNIT I KINEMATICS OF FLUIDS IN MOTION **9**

Real and ideal fluids – Velocity of a fluid at a point – Acceleration of a fluid – Streamlines – Pathlines – Steady & Unsteady Flows – Velocity Potential – Vorticity vector – Local and particles rates of change – Equation of continuity – Conditions at rigid boundary.

UNIT II EQUATIONS OF MOTION **9**

Pressure at a point in a fluid at rest and in a moving fluid – Boundary conditions of two inviscid immiscible fluids - Euler's equations of motion – Bernoulli's equation – Some potential flows - Flows involving axial symmetry.

UNIT III TWO DIMENSIONAL FLOWS **9**

Two-dimensional flows – Use of cylindrical polar co-ordinates – Stream function – Complex potential for two-dimensional flows – Two dimensional image systems – Milne-Thomson circle theorem – Theorem of Blasius.

UNIT IV EXACT SOLUTIONS OF THE NAVIER-STOKES EQUATIONS 9

Parallel flows – Couette flow – Hagen-Poiseuille flow – Flow between two concentric rotating cylinders – Stokes' first and second problems – Stagnation in plane flow – Flow in convergent and divergent channels.

UNIT V VERY SLOW MOTION AND LAMINAR BOUNDARY LAYER 9

Very slow motion - Parallel flow past a sphere – Hydrodynamic theory of lubrication – Boundary layer equations for two-dimensional flow – Boundary layer on a plate – Similar solutions – Momentum and energy integral equations for the boundary layer – Flow past a cylinder - symmetrical case – the Blasius series.

TOTAL PERIODS = 45

BOOKS FOR STUDY:

1. Frank Chorlton, "Textbook of Fluid Dynamics", CBS publishers, New Delhi, 1985. (Sections 2.1 – 2.10, 3.1 – 3.9, 5.1 – 5.9)
2. H. Schlichting, "Boundary Layer Theory", 6th Edition, McGraw-Hill Book Company, New York 1968. (Chapters V, VI a,b,c, VII, VIII a,b,c,e, IX c)

REFERENCE BOOKS:

1. F.M.White, "Fluid Mechanics", McGraw-Hill, 2000.
2. G. K. Batchelor, "An Introduction to Fluid Dynamics", Cambridge University Press, 1993.
3. F.M.White, "Viscous Fluid Flow", McGraw-Hill, 1991.

FS9010 FUEL CELLS FOR ENERGY SOURCES L T P C

3 0 0 3

UNIT I INTRODUCTION TO FUEL CELLS 9

Relevance and Importance of fuel cells; Fuel cell basics - Fuel cell definition - Difference between batteries and fuel cells – Principle and working of fuel cells - Types of fuel cells – Electrolyte membranes.

UNIT II CLASSIFICATION OF FUEL CELLS 9

Proton exchange membrane fuel cell (PEMFC) - Direct methanol fuel cell (DMFC) - Alkaline fuel cell (AFC) - Phosphoric acid fuel cell (PAFC) - Solid oxide fuel cells (SOFC) - Molten carbonate fuel cell (MCFC) – Borohydride fuel cell (BHFC) – Bio fuel cell (BFC).

UNIT III ELECTROCHEMISTRY IN FUEL CELLS 9

Basics of electrochemistry – Cyclic Voltammetry – Chronoamperometry – Chronocoulometry - Fuel cell thermodynamics - second law - Analysis of fuel cells - efficiency of fuel cells -fuel cell electrochemistry - Nernst equation, Electrochemical Kinetics - Butler-Volmer equation – Conductive measurement by impedance spectroscopy.

UNIT IV CONSTRUCTION AND WORKING OF FUEL CELLS 9

Fuel cell design and components - Cell components, stack components, system components – Membrane electrode assembly (MEA) preparation - - Fuel Cell Performance - Activation, Ohmic and Concentration over potential

UNIT V NANOTECHNOLOGY IN FUEL CELLS 9

Hydrogen energy – Hydrogen: Its merit as a fuel; Applications – Hydrogen production methods – Hydrogen storage – carbon nano tubes (CNTs) – Nano catalysts and Nano composite membranes – preparation methods – methods of fabricating CNT and CNF (Carbon nano fibers) – Electrospinning, Chemical vapor deposition, Pyrolysis – Hydrogen sensors.

TOTAL: 45 PERIODS

TEXTBOOKS/REFERENCE BOOKS

1. J. Larminie and A. Dicks, Fuel Cell Systems Explained, 2nd Edition, Wiley (2003)
2. Xianguo Li, Principles of Fuel Cells, Taylor and Francis (2005)
3. S. Srinivasan, Fuel Cells: FroSm Fundamentals to Applications, Springer (2006)
4. O'Hayre, S. W. Cha, W. Colella and F. B. Prinz, Fuel Cell Fundamentals, Wiley (2005)
5. A. J. Bard and L. R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd Edition, Wiley (2000)
6. B. Viswanathan and M. Aulice Scibioh, Fuel cells principles and applications, Universities Press (India) Pvt Ltd (2006)
7. Frano Barbir, PEM Fuel cells – Theory and Practice, Elsevier Academic Press (2005)
8. Suddhasatwa Basu, Recent trends in Fuel Cell Science and Technology, Anamaya Publishers (2007)