UNIVERSITY DEPARTMENTS

REGULATIONS - 2013

CURRICULUM I TO II SEMESTERS (FULL TIME)

M.Phil. Crystal Science

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	CG8101	Experimental Aspects of Crystal Growth	4	0	0	4
2.	CG8102	Research Methodology	4	0	0	4
3.	CG8103	Theoretical Aspects of Crystal Growth	4	0	0	4
4.		Elective	4	0	0	4
		TOTAL	**16**	**0**	**0**	**16**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
Project						
1.	CG8211	Seminar	0	0	2	1
2.	CG8212	Project	0	0	32	16
		TOTAL	**0**	**0**	**34**	**17**

TOTAL CREDITS: 33

SL. NO	COURSE CODE	Electives	L	T	P	C
1.	CG8001	Bio-Material and Bio-Crystallization	4	0	0	4
2.	CG8002	Crystals Characterization Techniques for Devices	4	0	0	4
3.	CG8003	Ferroelectrics and Relaxor Materials	4	0	0	4
4	CG8004	Nanomaterials and Nanotechnology	4	0	0	4
5.	CG8005	Non-Linear Optics and Lasers	4	0	0	4
6.	CG8006	Semiconductor Physics and Devices	4	0	0	4

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CG8101 EXPERIMENTAL ASPECTS OF CRYSTAL GROWTH L T P C
4 0 0 4

OBJECTIVE:

- To provide information and to introduce the development and experimental aspects of crystal growth. To train the students in specific areas of growing techniques in making bulk single crystals and crystalline thin films related to Lasers, Electronics and Photonics.

UNIT I SOLUTION GROWTH TECHNIQUES 12

Growth of crystals from solutions - solvents and solutions - solubility - preparation of a solution - saturation and supersaturation - Measurement of supersaturation - Expression for supersaturation - Low temperature solution growth - Slow cooling method - Mason-jar method - Evaporation method - Temperature gradient method - Crystal growth in gels - Experimental methods - Chemical reaction method - Reduction method - Complex decomposition method Solubility reduction method.

UNIT II MELT GROWTH TECHNIQUES 12

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

UNIT III VAPOUR GROWTH TECHNIQUES 12

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

UNIT IV EPITAXIAL GROWTH TECHNIQUES 12

Epitaxy - Homo and Heteroepitaxy – Growth rate - Vapour Phase Epitaxy (VPE)- Liquid Phase Epitaxy (LPE) -Molecular Beam Epitaxy (MBE) - - Metalorganic Vapour Phase Epitaxy - (MOVPE) - Chemical Beam Epitaxy (CBE), Epitaxial lateral overgrowth (ELOG) - Atomic Layer Epitaxy (ALE) - Electroepitaxy.

UNIT V THIN FILM GROWTH TECHNIQUES 12

Thin film Deposition - Thermal Evaporation – Electron Beam Evaporation – Electrodeposition - Photo-chemical Deposition – Chemical Bath Deposition – Pulsed Laser Deposition - Spray Pyrolysis Process - Spin Coating process – Screen Printing process – Sputtering techniques.

TOTAL : 60 PERIODS

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. J.C.Brice, Crystal Growth Process, John Wiley publications, New York, 1986.
6. A.A.Chernov, Modern crystallography:III,- Crystal Growth, Springer Series in Solid State, New York, 1984.
7. J.W. Mullin, Crystallization, (4th Edition), Butterworth-Heinemann, New Delhi, 2001.
8. E. Kaldis, Crystal Growth of Electronic Materials: Summer School Proceedings, Elsevier Science Ltd. (1985).
9. Subash Mahajan, Principles of Growth and Processing of Semiconductors, McGraw-Hill. (1998).

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10. D.Elwell and H.J. Scheel , Crystal Growth from High Temperature Solution Growth, Academic Press, New York, 1975.
11. Hans J. Scheel, Crystal Growth Technology, John Wiley & Sons Ltd., 2003.
12. Peter Capper, Bulk Crystal Growth, John Wiley & Sons Ltd., 2005.
13. Heiny-K.Henisch, Crystals in gels and Liesegang Rings, Cambridge University Press, 1988.
14. Brain Pamplin, Crystal Growth, (2nd Edition), International Series on the Science of the Solid State, Vol.16, 1980.

CG8102 RESEARCH METHODOLOGY L T P C
4 0 0 4

OBJECTIVE:

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

UNIT I RESEARCH DESIGN AND METHODOLOGY 12

Defining research problem- research design – Important concepts - different research design – basic principles of experimental design- sampling design – steps in sampling design – criteria – characteristic – types of sample designs. Purpose and problem statements – Literature review – frameworks – Research questions and hypotheses – quantitative and qualitative designs – multimethod research – study validity and elements of good design. Train the students on the Regulations - important statistics.

UNIT II NUMERICAL INTERPOLATION, DIFFERENTIATION AND INTEGRATION 12

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

UNIT III NUMERICAL SOLUTION OF ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS 12

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

UNIT IV EMPRICAL LAWS AND CURVE FITTING 12

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

UNIT V C-PROGRAMMING 12

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

TOTAL: 60 PERIODS

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REFERENCES

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

CG 8103 THEORETICAL ASPECTS OF CRYSTAL GROWTH L T P C
4 0 0 4

OBJECTIVE:

- To introduce the development of crystal growth through basic concepts and evolution of crystals by theoretical aspects.

UNIT I GENERAL CONCEPTS OF NUCLEATION 12

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 for different shapes.

UNIT II HOMOGENEOUS & HETEROGENEOUS NUCLEATION 12

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 THEORIES OF CRYSTAL GROWTH 12

Origion of 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 MODELS OF CRYSTAL GROWTH 12

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 techniques.

UNIT V EFFECT OF IMPURITIES ON CRYSTAL GROWTH 12

Effect of impurities on growth processes - thermodynamics and structure of solutions - adsorption – Habit modification - 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 : 60 PERIODS

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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.
4. K.Sangwal, Elementary Crystal Growth, Saaan Publiser, UK, 1994
5. J.C. Brice, Crystal growth processes John wiley and sons, New York, 1986.
6. J.W. Mullin, Crystallization, (4th Edition), Butterworth-Heinemann, New Delhi, 2001.
7. Zettlemoyer, A.C., Nucleation, M. Dekker Inc., New York, 1969.
8. Brain Pamplin, Crystal Growth, (2nd Edition), International Series on the Science of the Solid State, Vol.16, 1980.
9. Piet Hartman, Crystal growth, North-Holland Publication Co., 1973.

CG8001 BIO-MATERIALS AND BIO-CRYSTALLISATION L T P C
4 0 0 4

OBJECTIVES:

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

UNIT I BIOLOGICAL CRYSTALS 12

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

UNIT II CRYSTAL AND JOINT DISEASES 12

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

UNIT III HYDROXYAPATITE 12

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

UNIT IV STEROIDS 12

Steroids - The chemistry of sterols - Analysis of steroids and related steroids - steroids in biological membranes cholesterol and atherosclerosis - sterol storage diseases - cholesterol gallstones: Plasma cholesterol in liver disease - solubilization of cholesterol - conditions required for the formation of stones - Bile supersaturated with cholesterol - Origin of biliary lipids - The pathogenesis of

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supersaturated bile - Secretion rates of biliary lipids - Effect of removing the gallbladder - Medical treatment of gallstones - Dissolution of cholesterol stones by chenodeoxycholic acid - Experimental gallstones in animals - Plasma lipids - lipoproteins - the cause of hypercholesterolaemia - Lipid composition of blood cells - Xanthomas in biliary obstruction - parenchymatous liver disease.

UNIT V CRYSTALLISATION OF PROTEINS 12

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

TOTAL : 60 PERIODS

REFERENCES:

1. N.B.Myant The biology of cholesterol and related steroids, William Heinemann Medical Books Ltd, London, 1981.
2. Paul Dieppe & Paul Calvert, Crystals & Joint disease, Chapman and Hall Ltd, London, 1983.
3. Sujata V. Bhat, Biomaterials, Narosa Publising House, New Delhi,2002
4. Albert L.Lehninger, Principles of Biochemistry, CBS, Publishers, India, 1984.
5. Brain R. Pamlin, Inorganic Biological Crystal Growth, Pergamon Press Ltd., UK, 1988
6. A.Ducruix and R.Giege, Crystallization of Nucleic Acids and Proteins A Practical Approach, Oxford University Press, England, 1992
7. Terese M. Bergfor's, Protein Crystallization Techniques, Strategies and Tips, International University Line, 1999.

CG8002 CRYSTALS CHARACTERIZATION TECHNIQUES FOR DEVICES

L	T	P	C
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OBJECTIVES:

- To make the students to understand the salient features of characterization techniques to analyse the crystalline quality, composition and homogeneities for making devices from bulk crystals and crystalline thin films.

UNIT I FUNDAMENTALS OF SPECTROSCOPY 12

Atomic energy levels - Molecular electronic energy levels - Absorption and Emission spectroscopy – Fluorescence and Phosphorescence - vibrational and rotational spectra – Stokes and Anti-Stokes – Raman Scattering - Nature of electromagnetic radiation - X-ray energy levels.

UNIT II STRUCTURAL ANALYSIS 12

Infrared spectroscopy - Near IR - Mid IR - Far IR Region - FT-IR instrumentation and analysis FT-IR imaging Correlation of infrared spectra with molecular structure - structural Analysis - Radiation sources - Spectrophotometers - Fourier Transforms Interferometer . X-ray methods - Production of X-rays and X-ray Spectroscopy - Instrumental units - Detectors for the measurements of radiation - Semiconductor detectors Laue. Weisenberg methods, determination of cell parameters – Composition rocking curves – reciprocal space maps, x-ray imaging methods.

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UNIT III SPECTROSCOPY STUDIES 12

Raman spectroscopy - Theory - Resonance Raman Spectroscopy - Comparison of Raman with Infrared Spectroscopy - Diagnostic - Structural Analysis - Polarization measurements - Instrumentation - Quantitative analysis - - Secondary ion mass spectroscopy (SIMS)-Nuclear magnetic Resonance Spectroscopy - Basic principles - Quantitative analyses Photoluminescence spectroscopy.

UNIT IV MICROSCOPY AND ELECTRICAL ANALYSIS TYPES 12

Microscopy Techniques and optical microscopy - Scanning Electron Microscopy - Transmission electron microscopy (TEM) Atomic Force Microscopy, Scanning tunneling microscopy – EDAX - Electron Spectroscopy for Chemical Analysis - Auger electron spectroscopy (AES) – Hall measurements Electrical Conductivity and Sheet Resistance Measurements - Measurement of dielectric constant - I-V and C-V analysis - DLTS Technique.

UNIT V THERMAL AND MECHANICAL ANALYSIS 12

Methodology of Thermo Gravimetric Analysis, DTA, Differential Scanning Calorimetry - Instrumentation - Specific heat capacity and thermal conductivity measurements -. Thermo-mechanical analysis - Microhardness – Chemical Etching for Defect analysis.

TOTAL: 60 PERIODS

REFERENCES:

1. X.F. Zong, Y.Y.Wang, J. Chen, Material and Process characterization for VLSI, World Scientific, New Jersey, 1988.
2. H.H.Willard, D.L.Merrti, Dean and Settle, Instrumental methods of analysis, CBS publishers.1992.
3. Dieter.K. Schroder, Semiconductor Material and Device characterization, John
4. Wiley & Sons Inc., New York, 1990
5. Cahn Materials Science and Technology, VCH Series
6. D.Velmurugan, Elementary Crystallography, MJP Publishers, 2008.
7. Richard Telley, Crystals and Crystal Structures, John Wiley & Sons Ltd., 2006.

CG8003 FERROELECTRICS AND RELAXOR MATERIALS L T P C
4 0 0 4

OBJECTIVE:

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

UNIT I FERROELECTRICS 12

Theory of Ferroelectricity - Dipole moment – Polarization - Ferroelectric domains - Hysteresis - First and second order transitions - polar materials - piezoelectric materials - pyroelectric materials - Ferroelectric materials and their characteristic properties and polarizability – Frequency and Temperature dependence.

UNIT II OPTICAL PROPERTIES 12

Snell's Law - Refractive index and Birefringence - Optical dispersion – Relation between k and alpha - Thermo-optic – Elasto-optic – Electro-optic characteristics - Non-Linear optical effects – photo-refractive effect – Negative refractive index.

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UNIT III MODULATORS **12**

The modulation of optical radiation – Electro-optic effect – Electro-optic Retardation – Electro-optic Amplitude modulation - Phase modulation of light - Transverse Electro-optic modulators – Electro-optic beam deflection - The photo-elastic effect - Bragg diffraction of light by Acoustic Waves – SAW devices.

UNIT IV NONLINEAR OPTICS **12**

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

UNIT V APPLICATION OF FERROELECTRICS **12**

Order-Disorder Ferroelectrics – Displacive Ferroelectrics - Applications of Ferroelectrics –Memories and display. Relaxor Ferroelectrics - Materials for Relaxor applications – PZT – PMN-PT – Lead free piezoelectrics etc. for SONAR Transducers.

TOTAL: 60 PERIODS

REFERENCES:

1. C. Kittel, Introduction to Solid state Physics, John Wiley Publications, 7th Ed, New York,1996
2. A.J.Dekkar, Electrical Engineering Materials, Prentice Hall, New Delhi, 1996
3. E. Lines and A.M.Glass, Principles and applications of ferroelectrics materials,Clarendon press, Oxford ,1979.
4. Amnon Yariv , Quantum Electronics , John Wiley and sons Inc, New York, 1975
5. C. Burfoot, D. Van, Ferroelectrics, Nostrand Co Ltd, London, 1967.
6. Uchino, K., Ferroelectric Devices, Marcel Dekker, NY (2000)
7. David Jiles "Electronic properties of Materials",

CG8004 NANOMATERIALS AND NANOTECHNOLOGY **L T P C**
4 0 0 4

OBJECTIVES

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

UNIT I INTRODUCTION TO NANOMATERIALS **12**

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

UNIT II SEMICONDUCTOR NANOSTRUCTURES **12**

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

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UNIT III NANOMAGNETIC MATERIALS 12

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

UNIT IV PROPERITIES OF NANOMATERIALS 12

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

UNIT V CHARACTERISATION OF NANOMATERIALS 12

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

TOTAL : 60 PERIODS

REFERENCES:

1. M C Petty, M R Bryce, D Bloor (eds.), 'Introduction to molecular electronics', Edward Arnold, London, 1995.
2. G.Hadziioannou, P F van Hutten, 'Semiconducting polymers: Chemistry, Physics, and Engineering', Wiley-VCH, 2000.
3. Nanomaterials: Synthesis, Properties and Applications, Ed. A. S.Edelstein and R.C. Cammarata, IOP (UK), 1996.
4. Nanotechnology, ed. By Gregory Timp, Springer-Verlag, NewYork 1999.
5. "Fundamental properties of Nanostructured materials", Ed. D. Fiorani, G.Sberveglieri,World Scientific, 1994.
6. Handbook of Nanoscience, Engineering , and Technology ("HNET"), Ed. W.A. Goddard, D.W.Brenner, S.E. Lyshevski, G.J. Lafrate, CRC Press, New York, 2003.
7. Instrument Methods of Analysis H. W. Willard, L.L.Merritt., J.A Dean and F.A Settle (VI Edition), East West Publishers (1992).
8. Microelectronic materials, C.R.M. Grovernor, IOP Publishing Ltd, 1989.

PROGRESS THROUGH KNOWLEDGE

CG8005 NON-LINEAR OPTICS AND LASERS L T P C
4 0 0 4

OBJECTIVES:

- To teach the students the principles of nonlinear optics, origin of optical nonlinearities and Lasers. To analyze various types of nonlinearities in optics.

UNIT I ORIGIN OF OPTICAL NONLINEARITIES &SHG 12

Landau's Theory - Effects due to quadratic and cubic polarization – Response functions – Susceptibility tensors – Linear, second order and n^{th} order susceptibilities – Wave propagation in isotropic and crystalline media – The index ellipsoid. Optical SHG – Phase Matching – Experimental verification – Parametric oscillation – Frequency tuning – Power output and pump saturation – Frequency up conversion – Materials.

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UNIT II THIRD ORDER NONLINEARITIES & PHOTOREFRACTIVE EFFECTS 12

Intensity dependent refractive index – Nonlinearities due to molecular orientation – Self-focusing of light and other self-action effects - Optical phase conjugation – Optical bistability and switching - Electro-optic effects – Electro-optic modulators - Photorefractive effect. Stimulated scattering processes – Stimulated Brillouin scattering – Phase conjugation – Spontaneous Raman effect – Stimulated Raman Scattering – Stokes – Anti-Stokes Coupling in SRS

UNIT III INTERACTION OF LIGHT WITH MATTER 12

Population inversion - Threshold condition - Gain profile – super-radiance Laser - Rate equation for 3 level and 4 level systems - conditions for CW and pulsed laser action. Theory of Q-switching and experimental methods - Theory of Mode locking and experimental methods - cavity dumping - Spatial and Temporal coherence –whispering Gallery modes.

UNIT IV SOLID STATE LASERS 12

Pumping mechanism - Arc lamp - Diode pumping - Cavity configuration - Ruby laser - Nd:YAG, Ho:YLF laser, Alexandrite laser - Ti - Sapphire laser – Double Tungstate and Borate laser, Vanadate laser, Colour center laser - Fiber Raman laser.

UNIT V NLO & LASER APPLICATIONS 12

CW and Pulsed laser beam measurements- Beam focusing effects-spot size-Power and Energy density Measurements - Interferometric techniques – Displacement, Shock and Vibration – Calibration Methods -LIDARS – Holography – Materials Processing Applications – Bio-medical Applications – Spectroscopic Applications.

TOTAL: 60 PERIODS

REFERENCES:

1. Robert W. Boyd, “Non-linear Optics”, Academic Press, London, 1992. (Units II and IV)
2. P.N.Butcher and D.Cotter, “The Elements of Nonlinear Optics”, Cambridge Univ. Press, New York, 1990. (Unit I & V)
3. Ammon Yariv, Quantum Electronics, John Wiley & Sons, Inc., New York, 1989.
4. A.Ghatak & K.Thiagarajan, Optical Electronics, Cambridge University, 1994.
5. R.B. Laud - Lasers and Non linear optics. New Age International (P) Ltd. Publishers, New Delhi. (1996).
6. Walter Koechner - Solid State Lasers Engineering, Springer Verlag, New York. (1992).
7. F.J. Durate and L.W. Hilman - Dye Lasers Principles With Applications, Inc Academic Press, New York. (1990).
8. Arecchi, F.T., Laser Handbook, Vol.2, North Holland Publication, 1974.

PROGRESS THROUGH KNOWLEDGE

CG8006 SEMICONDUCTOR PHYSICS AND DEVICES L T P C

4 0 0 4

OBJECTIVES:

- To motivate the students to design and fabricate technologically important electrical and optical devices.

UNIT I SEMICONDUCTOR PROPERTIES 12

Semiconductor Basics: 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 - Schrodinge wave equation – eigen values – eigen function – Particle in a box – Carrier confinement in low dimentional structures - processes for optoelectronic devices - Heterojunctions and Heterostructures and device configuration.

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UNIT II PHYSICS OF SEMICONDUCTOR DEVICES 12

Unipolar devices: Metal-Semiconductor contacts - Ohmic Contact - Energy - Band Relation – Barrier Height - Device Structure - JFET and MESFET - basic device characteristic - general characteristic - Microwave performance - MIS diode - Si-SiO_2 MOS diode - Charge-Coupled Device -MOSFET - basic device characteristic - Nonuniform doping and buried-channel devices- short-channel effect.

UNIT III ELECTRON DEVICES 12

Ion implantation : Ion implantor - general description - ion sources - range distribution -Theoretical approaches - sample holder - profiles - MeV implants ion damage -Annealing - Rapid thermal annealing - Laser annealing. Bipolar devices: p-n junction diode - basic device technology - depletion region and depletion capacitance - I-V and C-V Characteristics - junction breakdown - terminal functions - Heterojunction -Bipolar transistor - Static characteristics - microwave transistor - power transistor -switching transistor - device structures - Thyristors - basic characteristics -Schottky diode - Three terminal thyristor - power thyristor – Unijunction transistor and trigger thyristor - Field-controlled thyristor.

UNIT IV LIGHT EMITTING DEVICES AND PHOTOVOLTAICS 12

Photonic Devices: Light Emitting diodes - LED for fiber optics – LED performance - reliability - Semiconductor Laser - Lasers for optical communication system - Photodetectors - Photoconductor- Photodiode - Avalanche Photodiode - Phototransistor - Solar cells - Thin film Solar cells. Some common and emerging solar cells - Fabrication process and photovoltaic performance of some standard solar cells like Silicon, Gallium arsenide (GaAs) and electrochemical (Grade cell) Solar cells - I-V characteristics - Spectral response and calculation of solar cell efficiency -The ideal cell under illumination - effects of series and parallel resistance - effect of temperature and illumination on solar cell efficiency - Loss analysis.

UNIT V INTEGRATED CIRCUITS AND DEVICES 12

Types of lithography – Wet and dry etching – Metallizaiton - 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 – Monolithic integration of compound semiconductor and silicon devices.

TOTAL: 60 PERIODS

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.
8. Martin A. Green, Solar Cells : Operating Principles, Technology and System Applications, Prentice-Hall, New Jersey, 1982.

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