### UNIVERSITY DEPARTMENTS
REGULATIONS - 2013
CURRICULUM I TO II SEMESTERS (FULL TIME)
M.Phil. Crystal Science

#### SEMESTER I

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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

UNIT II MELT GROWTH TECHNIQUES

UNIT III VAPOUR GROWTH TECHNIQUES
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 Polytypism.

UNIT IV EPITAXIAL GROWTH TECHNIQUES
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

TOTAL : 60 PERIODS

REFERENCES:
3. K. Sangwal, Elementary Crystal Growth - Saan Publisher, UK, 1994
4. M.M. Faktor, I. Garret, Growth of Crystals from Vapor, Chapmann and Hall, 1988

CG8102 RESEARCH METHODOLOGY

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

UNIT I RESEARCH DESIGN AND METHODOLOGY
- Defining research problem - research design - 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
- 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

UNIT IV EMPIRICAL LAWS AND CURVE FITTING
- 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
- 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
REFERENCES

CG 8103 THEORETICAL ASPECTS OF CRYSTAL GROWTH

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

UNIT I GENERAL CONCEPTS OF NUCLEATION

UNIT II HOMOGENEOUS & HETEROGENEOUS NUCLEATION
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
Origin 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
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
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
REFERENCES:
1. T.Nishinaga, Advances in the understanding of crystal growth mechanisms Elsevier, 1997

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
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 - Hydroxyapatite - Calcium oxalate - Calcium hydrogen phosphate dihydrate - Lithium heparin crystals.

UNIT II CRYSTAL AND JOINT DISEASES
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 acute inflammation - Chronic inflammation and fibrosis - Destruction of articular cartilage and bone - Gout - Introduction - History - Metabolism of uric acid - hyperuricaemia - Crystallization of urate - Gout crystal - monosodium urate monohydrate - Pathology of gout - Unanswered question regarding gout - Other purine disorders associated with crystals.

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

CG8002 CRYSTALS CHARACTERIZATION TECHNIQUES FOR DEVICES

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
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

UNIT V  THERMAL AND MECHANICAL ANALYSIS  12
Methodology of Thermo Gravimetric Analysis, DTA, Differential Scanning Calorimetry - Instrumentation - Specific heat capacity and thermal conductivity measurements - Thermomechanical analysis - Microhardness – Chemical Etching for Defect analysis.

TOTAL: 60 PERIODS

REFERENCES:
4. Cahn Materials Science and Technology, VCH Series

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

UNIT II  OPTICAL PROPERTIES  12
UNIT III  MODULATORS  12

UNIT IV  NONLINEAR OPTICS  12

UNIT V  APPLICATION OF FERROELECTRICS  12

TOTAL: 60 PERIODS

REFERENCES:
7. David Jiles “Electronic properties of Materials”

CG8004  NANOMATERIALS AND NANOTECHNOLOGY

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

UNIT II  SEMICONDUCTOR NANOSTRUCTURES  12
UNIT III   NANOMAGNETIC MATERIALS  

UNIT IV   PROPERITIES OF NANOMATERIALS  
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  
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-Augener, UV*PS.

TOTAL : 60 PERIODS

REFERENCES:

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  
UNIT II  THIRD ORDER NONLINEARITIES & PHOTOREFRACTIVE EFFECTS


UNIT III  INTERACTION OF LIGHT WITH MATTER


UNIT IV  SOLID STATE LASERS


UNIT V  NLO & LASER APPLICATIONS


TOTAL: 60 PERIODS

REFERENCES:

CG8006  SEMICONDUCTOR PHYSICS AND DEVICES

OBJECTIVES:
• To motivate the students to design and fabricate technologically important electrical and optical devices.

UNIT I  SEMICONDUCTOR PROPERTIES

UNIT II PHYSICS OF SEMICONDUCTOR DEVICES
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\textsubscript{2} MOS diode - Charge-Coupled Device -MOSFET - basic device characteristic - Nonuniform doping and buried-channel devices- short-channel effect.

UNIT III ELECTRON DEVICES

UNIT IV LIGHT EMITTING DEVICES AND PHOTOVOLTAICS

UNIT V INTEGRATED CIRCUITS AND DEVICES

REFERENCES:

TOTAL: 60 PERIODS