SEMESTER II

PEPHC20 - ELECTIVE II A: CRYSTAL GROWTH, NANO SCIENCE AND RESEARCH METHODOLOGY

Year: I **Sem:** II	**Course Code:** PEPHC20	**Title of the Course:** Crystal Growth, Nano Science and Research Methodology	**Course Type:** Theory	**Course Category:** Major Elective	**H/W** 4	**Credits** 4	**Marks** 100

Course Objectives

1. To provide the students, knowledge on crystal growth techniques and nanoscience
2. To learn the basic concepts in research methodology for pursuing future research work.

Course Outcomes (CO)

The learners will be able to

1. Explain the fundamental concepts behind in the formation of crystal.
2. Demonstrate the various methods in crystal growth techniques and their advantages.
3. Understand the advanced methods of characterization instruments for crystal and nanomaterials.
4. To familiarize about the physical concepts and principles of nanoscience and nanotechnology.
5. Provide a broad view of various approaches for the synthesis and fabrication of nanostructures and their outstanding properties useful to carry out their project and research work.

CO	**PSO**					
	1	**2**	**3**	**4**	**5**	**6**
CO1	H	H	H	M	M	M
CO2	H	H	L	H	H	M
CO3	H	H	M	H	H	M
CO4	H	M	M	H	L	H
CO5	H	M	M	H	H	H

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
CO1	H	H	H	H	M	H
CO2	H	H	H	H	M	H
CO3	H	H	H	H	M	H
CO4	H	M	H	H	H	H
CO5	M	M	M	M	M	H

(Low - L, Medium – M, High - H)

Course Syllabus

Unit I: Nucleation and Growth (10 Hours)

1.1 Nucleation - Different kinds of nucleation - Theories of nucleation (K1, K2)
1.2 Classical theory of nucleation - Gibbs Thomson equation for vapour (K1, K2)
1.3 Modified Thomson's equation for melt - Gibbs Thomson equation for solution (K1, K2)
1.4 Concept of formation of critical nucleus - Spherical and cylindrical nucleus (K1, K2, K3)
1.5 Crystal growth techniques - Solution Growth Technique: Low temperature solution growth:Solution - Solubility and super solubility - Expression of super saturation - Miers T-Cdiagram(K1, K2, K3)
1.6 Gel Growth Technique: Principle - Various types - Structure of gel - Importance of gel - Experimental procedure (K1, K2, K3)

Unit II: Growth and Characterization Techniques (10 Hours)

2.1 Melt technique: Bridgman technique - Basic process –Vertical Bridgman technique – Crystal Pulling technique (K1, K2, K3, K4)
2.2 Czochralski technique - Experimental arrangement - Growth process (K4, K5, K6)
2.3 X - Ray Diffraction (XRD) - Powder and single crystal (K1, K2)
2.4 Fourier transforms Infrared analysis (FT-IR) - FT –Raman Elemental analysis (K1, K2)
2.5 Elemental dispersive X-ray analysis (EDAX) - Scanning Electron Microscopy (SEM) - Transmission electron microscopy (TEM) (K2, K4, K5, K6)
2.6 UV-Vis-NIR Spectrometer - Etching (Chemical) - Vickers Micro hardness - TGA - DTA - PL studies (K4, K5, K6)

Unit III: Basics of Nano Technology (9 Hours)

3.1 History of Nano technology - concept of Nano technology and Nano machines (K1, K2)
3.2 Atomic structure molecules and phases - Molecular and atomic sizes - Surfaces and dimensional space (K1, K2, K3)
3.3 Top down and bottom up approach in synthesis - Nano scale formation (K3, K4, K5)
3.4 Strong intermolecular forces - Covalent and coulomb interactions (K2, K4)
3.5 Weak inter molecular forces - Vander Waal forces - Repulsive forces (K2, K4, K5)
3.6 Hydrogen bonding, Hydrophobic and hydrophilic interactions (K2, K5, K6)

Unit IV: Fabrication Techniques and Properties of Nano-Structure (9 Hours)

4.1 Vacuum Techniques: Thermal evaporation - Physical Vapour deposition - Ionized Cluster beam deposition - Laser vaporization (ablation) - laser pyrolysis (K1, K2, K3)
4.2 Sputter deposition - DC sputtering - RF sputtering - Magnetron sputtering - ECR plasma deposition (K1, K2)
4.3 Chemical vapour deposition - Electric arc deposition - Ion beam techniques –molecular beam epitaxy (K2, K3, K4)
4.4 Nanolithography techniques: Lithography using Photons (UV-VIS, Lasers and X-rays) (K2, K3, K5)
4.5 Lithography using particle beams - Electron and Ion beam Lithography (K1, K2, K3, K4)
4.6 Quantum dots and Quantum wires - Size dependent variation in magnetic properties - Thermal and electronic transport properties (K3, K4, K5, K6)

Unit V: Research Methodology (10 Hours)

5.1 Meaning of research - Objectives of research - Motivation of research - Types, approaches and significance - Methods versus methodology (K1, K2, K3)

5.2 Identification of the problem - Literature survey - Reference collection - Necessity and techniques involved in defining the problem (K2, K3, K4)

5.3 Research design - Needs and features ofgood design - Different research design - Basic principles of experimentaldesigns - Meaning of research report (K2, K3, K4)

5.4 Logical format for writing thesis and paper - Essential of scientific report: abstract, introduction, review of literature, materials and methods and discussion (K3, K4, K5)

5.5 The use of quotation, footnotes, tables and figures - Referencing - Appendixes - Revising the paper or thesis (K4, K5, K6)

5.6 Oral power point presentation - Poster preparation - Editing and evaluating the final product - Proof reading - The final typescopy(K4, K5, K6)

Books for Study:

1. Charles P.Poole, Frank J.Owens - Introduction to Nanotechnology - Wiley-Interscience,2003.
2. P. Santhana Ragavan and P. Ramasamy - Crystal Growth Processes and Methods - KRU Publications, Kumbakonam,2001.
3. C.R. Kothari and Gaurav Garg - Research Methodology, Methods and Techniques - New age International Publishers, III Edition.2014
4. Santosh Gupta - Research Methodology Methods and StatisticalTechniques
5. Rajammal et al., -A hand Book of Methodology of Research - Sri Ramakrishna Mission Vidyalaya Press,Coimbatore.

Books for Reference:

1. J.C. Brice - Crystal Growth Processes - John Wiley and Sons, New York,1986.
2. C.Hawkins & M Sorgi - Research Ed Norosa Publishing House, New Delhi - 2000
3. Robert Ross - Research: An introduction - - Harper and RowPublications.
4. P. Saravanavel - Research methodology - - KitlabMahal, SixthEdition.
5. R.A. Day - How to write and publish a scientific paper – CambridgeUniversity press
6. Anderson - Thesis and Assignment writing - - Wiley EasternLtd.