

### 3. CRYSTALLOGRAPHY AND CRYSTAL GROWTH

#### Module I (10 hrs)

Crystal Morphology: Internal Order in Crystals, Crystallographic Axes, Form, Zones, Crystal Habit, Crystal projections (Spherical Projection, Stereographic Projection), Crystal Symmetry operations and Symmetry Elements (Translation, Rotation, inversion, reflection), Rotation Angle Restrictions, Symmetry Content of Planar Motifs, Hermann-Mauguin notation, Point Groups, Space Groups, Illustration of Crystal Structures, Isostructuralism, Polymorphism, Polytypism,

#### Module II (7hrs)

Introduction : Crystallization, Crystal growth, velocity of growth, theories and mechanism of growth, twinning, growth twins, deformation twins, transformation twins, growth in the solid state recrystallization and grain growth.

#### Module III (14 hrs)

Crystal Growth Techniques: Growth from melt, thermodynamic principles and crystal growth equilibria, nucleation from solution, melt, vapour and solid phase. Preparation of Single Crystals; Czochralski method, Bridgman method growth from epitaxy. Purification: Zone refining and floating zone methods. Epitaxial Growth: Lattice matching in epitaxial growth, liquid-phase epitaxy, vapour phase epitaxy, molecular beam epitaxy, growth for polycrystalline materials. photochemical deposition. Growth and characterization of large crystals for devices.

#### Module IV (5 hrs)

Quality assessment by X-ray diffraction and optical techniques. Current trends in crystal growth, quantum wells and superlattices, heterostructures, Quasicrystals, Liquid Crystals,

#### Text and Reference Books:

1. Introduction to Crystallography, Donald E. Sands, Dover Publications, 1975.
2. Elements of X-ray Diffraction, Cullity B. D., Addison-Wesley Publishing Co., 1979.
3. Crystallography and Crystal Defects, A. Kelly and K.M. Knowles, Wiley, 2<sup>nd</sup> edition, 2012.
4. The basics of Crystallography and Diffraction, C. Hammond, Oxford Univ. Press, 4<sup>th</sup> edition, 2015
5. Elementary Crystallography, M.J. Buerger, John Wiley & Sons, 1956.
6. The Manual of Mineral Science, Cornelis Klein, John Wiley & Sons, 22<sup>nd</sup> edition, 2002
7. Structure of Materials: An Introduction to Crystallography, Diffraction and Symmetry, M. De Graef, M.E. McHenry, Cambridge Univ. Press, 2007.
8. Springer Hand book of Electronic and Photonic Materials, S.O. Kasap, 2<sup>nd</sup> edition
9. Springer Hand book of Crystal Growth, Govindhan Dhanaraj, Kullaiah Byrappa
10. Crystal Growth Technology\_ From Fundamentals and Simulation to Large-scale Production- Hans J. Scheel, Peter Capper, - Wiley-VCH (2008)
11. A.W.Vere, Crystal Growth, Principles and Progress, Plenum, New Delhi.
12. B.G.Streetman, Solid State Electronic Devices, Prentice Hall of India, New Delhi.
13. M.C.Fleming, Solidification Processing, Wiley, New York.