MANGALORE UNIVERSITY

Department of Materials Science

MSc Materials Science

MSS 507: **CRYSTAL GROWTH (**3 Credits**)**

Objectives: Objective of the course is to provide a fairly detailed knowledge on the various crystal growth processes. In particular, single crystal growths in bulk form and in epitaxial thin film forms which are essential for various research and development/technological applications.

Expected course outcomes: The student should be familiar with the crystal growth techniques with the necessary nucleation-growth theory. Good foundation on these topics would be helpful during their career in research or industry.

Unit I

Crystal growth phenomena: Significance of single crystals – crystal growth techniques. Ideal growth laws – crystal-ambient phase equilibrium – criteria for equillibria in crystal growth – phase diagrams. Classification of growth processes.

Theories of nucleation- energy of formation - homogeneous nucleation – Gibb's Thompson equation for vapour, melt and solution, equilibrium shape of crystals. Heterogeneous nucleation – cap and disc shaped nuclei –constitutional supercooling - velocity of growth. Atomistic, thermodynamical models of crystal growth - Kossel and BCF theory.

14 hours

Unit II

Crystal growth techniques : Bulk crystal growth – solution growth methods - supersaturation - aqueous solution, flux, hydrothermal methods. Melt growth – Kryopoulos, Bridgman – Stockbarger, Czochkralski, float zone and zone refining techniques. Impurity levelling factor – segregation coefficient. Verneuil method.

Low and high temperature solution growth – methods of crystallization – temperature gradient methods - growth of KDP and KTP crystals. 14 hours

Unit III

Epitaxial growth methods – advantages - PVD – chemical vapour deposition – liquid and chemical vapour phase epitaxy – hot wall epitaxy- molecular beam epitaxy – MOCVD. Surface impurity contamination, defects and dislocations, determination of dislocation density.

Application: Si and Ge in semiconductor industry- IC technology: monolithic IC- masking and etching - elements of lithography- resist systems and patterning.

14 hours

References

1. M.A. Wahab, Essentials of Crystallography, 2nd Edition (Narosa Publishing House Pvt. Ltd, 2011)
2. Saito Yukio, Statistical Physics of Crystal Growth (World Scientific, Singapore, 1996)
3. Ivan V. Markov, Crystal Growth for Beginners: Fundamentals of Crystal Growth, Nucleation and Epitaxy (World Scientific, Singapore, 1996)
4. R.C. Ropp, Solid state Chemistry,(Elsevier, 2003)
5. H.V.Keer, Principles of the Solid State (Wiley Eastern,1993)
6. Crystal Growth 1974, Proc. Of 4th Int. Conf. on Crystal Growth, Tokyo, Japan 24-29 March 1974, Eds. K.A.Jackson, N.Kato and J.B.Mullin.
7. Current Trends in Crystal Growth and Characterization, Byrappa.K (MIT,1991)
8. Physics of Crystal Growth, Pimpinelli Alberto (Cambridge University 1998)
9. The Growth of Crystals from Liquids, Brice J.C (North Holland Press, Amsterdam,1973)