Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NPHD522	THIN FILM AND VACUUM TECHNOLOGY	3	0	0	3

Prerequisite: Condensed Matter Physics

Course Objective

- To guide the students to the doorsteps of materials processing and device fabrication at micro and nanoscale, primarily using vacuum techniques – indispensable for miniaturization, reproducibility and reliability of the fabricated device;
- To prepare students with a specialized direction of materials science and engineering ready to land up in education, research, development and production useful for both in academia and industry.

Learning Outcomes

Students will learn:

- Theories of thin film growth from nano to micro scale, processes of growing thin films,
- Properties of materials at two dimensional structures and their possible applications,
- Theories and techniques of vacuum generation and measurements,
- Applications of vacuum from high pressure to ultra-low pressure.

Unit No.	Topics to Be Covered	Lecture Hours	Learning Outcome
1	Nucleation and Growth: Film formation and structure; Thermodynamics of nucleation, Nucleation theories: Capillarity model – homogeneous and heterogeneous nucleations, Atomistic model – Walton-Rhodin theory; Post-nucleation growth; Deposition parameters; Epitaxy; Thin film structure; Structural defects and their incorporation.	7	The theory and models of thin film growth, involved energetic, dependence of nucleation and growth on deposition parameters, microstructural models of thin films; formation of structural defects.
2	Preparation methods: Electrochemical Deposition (ECD); Spin coating; Physical Vapour Deposition (PVD)- thermal evaporation, electron beam evaporation, RF-sputtering; Pulsed Laser deposition (PLD); Chemical Vapour Deposition (CVD), Plasma-Enhanced CVD (PECVD), Atomic Layer Deposition (ALD), Molecular Beam Epitaxy (MBE).	7	Deposition or fabrication of thin films using various chemical and physical processes based on solution, vacuum, laser, plasma techniques yielding thin films with structural features ranging from course microstructure to atomically controlled layers.
3	Thickness measurement and monitoring: Electrical, mechanical, optical interference, microbalance, quartz crystal methods.	3	Various techniques of thin film thickness measurement and control.
4	Properties of thin films: Electrical, mechanical, optical and magnetic.	3	Important physical properties of thin films.
5	Thin film devices: Fabrication and applications.	2	Application oriented fabrication of thin film devices.
6	Vacuum principles: Basic terms and concepts; Continuum and Kinetic gas theory; Pressure ranges; Types of flow; Conductance.	5	Definitions of fundamental terminologies relevant to the subject; theories involved with gas flow in various levels of vacuum.
7	Vacuum generation: Vacuum pumps – a survey; Diaphragm pump, Rotary vane pump, Diffusion Pump, Turbomolecular Pump (TMP), Sorption pumps: Adsorption pumps, Sublimation pumps, Sputter-ion pumps; Cryo Pump.	7	Various techniques used to produce vacuum based on the principles of compression, condensation and gettering.
8	Vacuum measurement: Thermal conductivity vacuum gauges, Ionization vacuum gauges.	3	Techniques of vacuum measurement at various levels of pressure range.
9	Analysis of gas at low pressures: Residual gas analyzers, Quadrupole mass spectrometer.	2	Analysis of gases present in a closed chamber at high vacuum using different techniques.
10	Leaks and their detection: Types of leaks, Leak rate, leak size, mass flow; Leak detection methods: Pressure rise and drop tests, Tests using vacuum gauges, Bubble immersion test, Foam-spray test, Halogen and Helium leak detectors.	3	Various types of leaks observed in a vacuum chamber with varying levels of seriousness and their different detection procedures.
	Total	**42**	

Text Books:

1. Thin Film Phenomena; K. L. Chopra; McGraw-Hill; 1969.
2. Materials Science of Thin Films; Milton Ohring; Academic Press; 2001.
3. Fundamentals of Vacuum Technology; Walter Umrath; Leybold, 1998.

Reference Books:

1. Thin Films; Heavens; Dover Publications Inc.; 1991.
2. Thin-Film Deposition: Principles and Practice; Smith; McGraw-Hill; 1995.
3. Handbook of Vacuum Science and Technology; Hoffman, Singh and Thomas; Academic Press; 1998.
4. Vacuum Technology; Roth; North Holland, 1990.
5. Handbook of Thin Film Technology; Leon I. Maissel and Reinhard Glang; McGraw-Hill; 1970.
6. Thin Film Fundamentals; A. Goswami; New Age International Pvt. Ltd; 2007.
7. Vacuum Science and Technology; V. V. Rao, T. B. Ghosh and K. L. Chopra; Allied Publishers, 1998.