DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 3: SEMICONDUCTOR DEVICES FABRICATION

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Semiconductor Devices Fabrication PHYSICS DSE 3	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

This course provides a review of basics of semiconductors such as energy bands, doping, defects etc. and introduces students to various semiconductor and memory devices, thin film growth techniques and processes including various vacuum pumps, sputtering, evaporation, oxidation and VLSI processing are described in detail. By the end of the syllabus, students will have an understanding of MEMS based transducers.

LEARNING OUTCOMES

At the end of this course, students will be able to achieve the following learning outcomes.

- Learn to distinguish between single crystal, polycrystalline and amorphous materials based on their structural morphology and learn about the growth of single crystals of silicon, using Czochralski technique, on which a present day electronics and IT revolution is based.
- Students will understand about the various techniques of thin film growth and processes.
- Appreciate the various VLSI fabrication technologies and learn to design the basic fabrication process of R, C, P- N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology.
- Gain basic knowledge on overview of MEMS (Micro-Electro-Mechanical System) and MEMS based transducers.

SYLLABUS OF PHYSICS DSE – 3

THEORY COMPONENT

Unit – I **(9 Hours)**

Introduction: Review of energy bands in materials, metal, semiconductor and insulator, doping in semiconductors, defects (point, line, Schottky and Frenkel), single crystal, polycrystalline and amorphous materials, Czochralski technique for silicon single crystal growth, silicon wafer slicing and polishing.

Vacuum Pumps: Primary pump (mechanical) and secondary pumps (diffusion, turbomolecular, cryopump, sputter-ion) – basic working principle, throughput and characteristics in reference to pump selection, vacuum gauges (Pirani and Penning)

Unit – II **(10 Hours)**

Thin film growth techniques and processes: Sputtering, evaporation (thermal, electron beam),

pulse laser deposition (PLD), chemical vapour deposition (CVD), epitaxial growth
Thermal oxidation process (dry and wet) passivation, metallization, diffusion

Unit – III **(7 Hours)**

VLSI Processing: Clean room classification, line width, photolithography: resolution and process, positive and negative shadow masks, photoresist, step coverage, developer, electron beam lithography, etching: wet etching, dry etching (RIE and DRIE), basic fabrication process of R, C, P-N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology, wafer bonding, wafer cutting, wire bonding and packaging issues (qualitative idea)

Unit – IV **(4 Hours)**

Micro Electro-Mechanical System (MEMS): Introduction to MEMS, materials selection for MEMS devices, selection of etchants, surface and bulk micromachining, sacrificial subtractive processes, additive processes, cantilever, membranes, general idea of MEMS based pressure, force, and capacitance transducers

References:

Essential Readings:

1) Physics of Semiconductor Devices, S. M. Sze. Wiley-Interscience.
2) Fundamentals of Semiconductor Fabrication, S.M. Sze and G. S. May, John-Wiley and Sons, Inc.
3) Introduction to Semiconductor materials and Devices, M. S. Tyagi, John Wiley & Sons
4) VLSI Fabrication Principles (Si and GaAs), S. K. Gandhi, John Wiley & Sons, Inc.

Additional Readings:

1) Handbook of Thin Film Technology, L. I. Maissel and R. Glang

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Deposition of thin films using dip coating and deposition of metal contacts using thermal Evaporation and study its IV characteristics
2) Deposition of thin films using spin coating and deposition of metal contacts using thermal evaporation and study its I-V characteristics
3) Fabrication of p-n Junction diode and study its I-V characteristics
4) Create vacuum in a small tube (preferably of different volumes) using a mechanical rotary pump and measure pressure using vacuum gauges.
5) Selective etching of different metallic thin films using suitable etchants of different concentrations.
6) Wet chemical etching of Si for MEMS applications using different concentration of etchant.
7) Calibrate semiconductor type temperature sensor (AD590, LM 35, LM 75)
8) To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150C) by four-probe method.
9) To fabricate a ceramic and study its capacitance using LCR meter.
10) To fabricate a thin film capacitor using dielectric thin films and metal contacts and study its capacitance using LCR meter

References for laboratory work:

1) The science and Engineering of Microelectronics Fabrication, S. A. Champbell, 2010, Oxford University Press
2) Introduction to Semiconductor Devices, F. Kelvin Brennan, Cambridge University Press, 2010