## B. Sc. Physical Sciences with Electronics as one of the Core Disciplines

# DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-4 : SEMICONDUCTOR DEVICES - FABRICATION AND APPLICATIONS

| Course Title and Code | Credits | Credit distribution of the course | | | Pre-requisite of the course |
|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical | |
| Semiconductor Devices - Fabrication and Applications DSE 8-4 | 4 | 2 | 0 | 2 | |

### COURSE 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 (MicroElectro-Mechanical System) and MEMS based transducers.

## SYLLABUS OF DSE 8-4

## THEORY COMPONENT

**(Hours: 30)**

**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, electronBeam), Pulse Laser Deposition (PLD), Chemical Vapor 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 MEMS based Pressure, Force, and Capacitance Transducers.

## PRACTICAL COMPONENT: SEMICONDUCTOR DEVICES - FABRICATION AND APPLICATIONS

**(Hours: 60)**

*At least 6 experiments from the following:*

1. Fabrication of thin films via dip-coating technique, deposition of metal contacts through thermal evaporation and investigation of their current–voltage (I–V) characteristics.
2. Fabrication of thin films via spin-coating technique, deposition of metal contacts through thermal evaporation and investigation of their current–voltage (I–V) characteristics
3. Fabrication of p-n junction using either p or n type substrate along with

appropriate semiconducting layer and study its current-voltage (I-V) Characteristics.

4. Generation of vacuum in small tubes (varying volumes) using a mechanical rotary pump and measurement of 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 Micro-Electro-Mechanical Systems (MEMS) applications using different concentrations of etchant.
7. Calibrate semiconductor type temperature sensor (AD590, LM 35, LM 75).
8. To measure the resistivity of a germanium (Ge) semiconductor crystal with temperature (up to 150 $^{o}$C) by four-probe method.
9. Capacitance measurements of ceramics using LCR meter.
10. Capacitance measurements of dielectric thin film capacitor using LCR meter

## REFERENCES

**Essential Readings for the theory component**


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 VLSI Fabrication Principles (Si and GaAs), S. K. Gandhi, John Wiley & Sons, Inc.


**Additional Readings for the theory component**


Handbook of Thin Film Technology, Leon I. Maissel and Reinhard Glang.


**Essential Readings for the practical theory component**


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