GUJARAT TECHNOLOGICAL UNIVERSITY

M.E. - Electronics & Communication Engineering
(VLSI &Embedded Systems Design)
Semester: I

Subject Name: **Semiconductor Device Modeling**
Subject Code: **715201**

Objective:

The main objectives of this course are to study the basics of semiconductor devices and their modeling. Understand technology and process flows for bipolar and MOS integrated circuits, operation principles, characteristics and computer models of the different types of semiconductor devices used in VLSI. In the process of the laboratory work, technological methods and process flows of devices and IC will be studied using appropriate software.

Lectures :

Unit I – Review of Semiconductor Fundamentals

Semiconductor materials. Energy bands of semiconductors, electrons and holes, doping, carrier densities and transport (mobility, diffusion, drift, and currents). Recombination and generation. Continuity equation.

Unit II – Devices based on PN Junctions

P-N junction structure and principle of operation. Energy band diagram. Thermal equilibrium. The built-in potential. Forward and reverse bias. Voltage-current characteristics. Diffusion and barrier capacitances. The parameters and I-V characteristics of real P-N diode. General breakdown characteristics. Tunnel, avalanche, and thermal breakdown. Schottky diode. Review of BJT operation.

Unit III - Metal-oxide-semiconductor field effect transistors

Structure and principles of operation. MOSFET analysis. Accumulation, depletion and inversion modes. Parameters and characteristics. Threshold voltage calculation, the substrate bias effect. Performance limitations. Advanced MOSFET issues - channel length modulation. Short channel effects, sub-threshold current, field dependent mobility, punch-through, velocity saturation, bipolar action, oxide injection etc. SPICE models of MOS transistors .

Unit IV – Device Modeling

Introduction to Device modeling, numerical methods and meshing (fixed and adaptive). Numerical solutions, common methods – Newton, Gummel. IV characteristics and parametric extraction. Gate currents.

Unit V - Integrated Circuits Technology Overview

A historical review of integrated circuits (IC). Moore's Law. Performance metrics for ICs (density, speed, power consumption, cost, reliability, and yield). Basic structures of MOS IC (P-MOS, N-MOS). CMOS technology and device structure. Silicon on insulator structures (SOI). Basic Processes of IC Fabrication – Diffusion, Ion Implantation, Oxidation, Photolithography, Etching, Chemical Vapor Deposition. Introduction to

process simulation.

Lab:

Tool used during laboratory works: HSPICE.

- Study of one-dimensional ion implantation profiles
- Study of thermally grown and deposited oxide layers

Course Project:

A project of suitable complexity, comprising of IC fabrication processes must be completed by the student.

Course Material:

The field of VLSI and Embedded Systems is getting updated constantly and to keep up to date with the latest research, technology and industry trends, Instructor for this course will decide and provide the course material. This could be a combination of slides or research material or text book references or any other relevant documentation depending on a) the nature of the curriculum and b) relevant skills to be imparted as outcome of the course.

Reference Books:

1. S.M.Eze, Semiconductor Devices: Physics and Technology, John Wiley & Sons, Inc.
2. Solid State Electronics Devices, Ben G. Streetman, ISBN 0-13-025538-6, Prentice Hall, New Jersey (2000).
3. Silicon VLSI Technology - Fundamentals, Practice and Modeling" by James D Plummer et al. Pearson Education 2001.
4. VLSI Fabrication Principles, Sorab K. Ghandhi, ISBN 0471-58005-8, John Wiley and Sons, New York (1994).
5. Silicon Processing for the VLSI Era, S. Wolf, and R.N. Tauber, ISBN0-9616721-6-1, Lattice Press, Sunset Beach (2000).
6. Introduction to Microelectronic Fabrication, R. C. Jaeger, ISBN 0-201-44494-1