Course Type	Course Code	Name of Course	L	T	P	Credit
DE	ECD418	Semiconductor Device Modeling and Simulation	3	0	0	9

Course Objective

The objective of the course is to motivate the students in the field of semiconductor device by creating the ability among the students for developing model of semiconductor devices and also by making them capable to propose new device structure for any desired performance. Modeling of semiconductor device is always useful to get insight into the device physics for satisfactory explanation of device characteristics and also to predict the characteristics of any new device. It is helpful to optimize the structure and hence cuts down the fabrication cost and time. Understanding the device model is pre-requisite for IC design, usually done by VLSI experts.

Learning Outcomes

Upon completion of this course students shall be able to

- Explain the equation, approximations and techniques available for modeling semiconductor devices
- Apply suitable approximations and techniques to derive the model for new device structures
- To simulate the characteristics of semiconductor device using ATLAS, SENTAURUS, SYNOPSIS, SPICE, MATLAB etc.
- Propose new structure for semiconductor device as per the requirement
- To develop compact device model, which will be useful for designing of IC through circuit simulation.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: What is device modeling – different forms of device model, brief discussion with example of ideal p-n junction diode	6	Students will have idea about different ways of representing the device characteristics
2	EM-field and transport equations - Maxwell's equation under quasi static approximation, Lorentz force equation, current continuity equation; Fully Classical Model-Drift Diffusion Model, Importance of approximations, e.g., abrupt junction, low level injection etc. in developing p-n junction device model, Developing p-n junction diode model with and without assumptions	10	Students will know, how to develop semiconductor p-n junction device model. Also they will learn the importance of approximations in simplification of device model.
3	Semi-classical Model: Carrier transport - Scattering as semi-classical phenomena, concept of ballistic transport. Effective mass approximation for developing semi-classical model for devices. Boltzman Transport Equation (BTE) - carrier, momentum and energy balance equation.	10	They will be able to develop more accurate model for semiconductor devices considering the quantum mechanical phenomenon.
4	Model for MOSFET considering the MOS capacitance, equations, boundary conditions and approximations. Qualitative model for some advanced structure of MOSFET and effect of short channel. Numerical calculation based on developed models for MOSFET	8	MOSFET modeling is very important in view of IC design. From this unit, students will be able to develop accurate model for MOSFET including low-dimensional physics
5	Numerical Simulation: FDM, FEM, FDTD Techniques. Meshing and discretization of device equations for different simulation techniques, formation of proper boundary conditions. Self consistent solution of 2D Poisson equation and Schrodinger equation	8	Merits and demerits of different simulation techniques can be understood. Students would be able to choose proper simulator and technique e.g., meshing, boundary condition etc., for accurate and efficient simulation of a specific device.

Textbook:

1. Introduction to Semiconductor Device Modeling by Christopher M Snowden - World Scientific

Reference Books:

1)Fundamentals of Carrier Transport - M. Lundstrom, Cambridge Univ. Press
2) Operation and Modeling of MOS Transistor - Y. Tsividis and C. McAndrew, Oxford Univ. Press
3) BSIM_4v4_MOSFET_MODEL_Manual
4) Fundamentals of Modern VLSI Devices – Y.Taur, T. H. Ning - Cambridge Univ. Press
5) Solid State Electronic Devices - Ben. G. Streetman, S. Banerjee, Pearson.