Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NECC 514	MOS Device Physics and Modeling	3	1	0	4

Course Objective

- Builds the knowledge-base on the physics of MOS devices which is essential to understand the device characteristics which is undoubtedly helpful to have a place in the semiconductor industry.
- Provides the foundation for the use of device models in circuit analysis and design tools and motivation for life-long learning

Learning Outcomes

Upon successful completion of this course, students will:

- Learn to apply suitable approximations and techniques to derive the model starting from drift-diffusion transport equations.
- The subject will also offer clues to qualitative understanding of the physics of a new device and conversion of this understanding into equations

Module No.	Topics to be Covered	Contact Hours	Learning Outcome
1	Semiconductor theory: Evolution of semiconductors, energy band model, Fermi level, Fermi potential, generation and recombination, concept of quasi-Fermi level, carrier mobility, resistivity and sheet resistance, Poisson's equation, Transport and Continuity equations	6L+3T	This introduces the subject andemphasis on its need insemiconductor industry. Few fundamental concepts will also be developed which will be useful for understanding the other modules
2	MOS transistor structure and operation: Evolution of MOSFET, Lilienfield Model, theory and operation, punch through, MOS intrinsic extrinsic capacitances, large and small signal models, device Speed, MOSFET scaling, hot carrier effects, SPICE model, device gate material, nonuniform channel doping, source-drain structures, source/drain resistance evaluation, MOSFET effective channel length and width definition.	8L+2T	The anatomy of a MOS structurewill be discussed in this section, with emphasis on the physics and engineering issues
3	MOS capacitor: Source/drain junction capacitance, gate overlap capacitances, C-V characteristics, effect of metal workfunction, oxide and interface trapped charges, flat band voltage, temperature dependent flat band voltage, concept of accumulation, depletion and inversion with the help ofenergy band diagrams; Threshold voltage: Uniformly doped and non-uniformly doped MOSFET, threshold voltage variations with device length and width, temperature effects on threshold voltage	8L+2T	Students here will gain a detailed understanding of a MOS capacitor which is the heart of the MOS device
4	MOSFET DC models: Pao-Sah model, charge sheetmodel, piece-wise linear model, models for depletion devices, carrier mobility models in deep-submicron andnanoscale dimensions, short geometry models, effect of temperature on drain current	8L+2T	Various MOS DC models will be discussed in this module
5	Dynamic models: Intrinsic charges and capacitance,Meyer's model, long channel and short channel charge model, quasi-static and non-quasi-static model, low frequency modeling of MOS transistors, highfrequency modeling of MOS transistors. Hot-carrier modeling: Substrate current model, gate current model, correlation of gate and substrate current, measure of device lifetime degradation, MOSFET degradation due to temperature	7L+3T	This section deals with the ACmodels of a MOS device
6	SPICE MOSFET models: Level 1, 2, 3 and 4 models and their comparison. Statistical modeling: Model sensitivity, principal factor method, principal component analysis, regression models	5L+2T	Students here will come to knowabout few SPICE models which will help them to simulate MOS circuits in circuit simulators.
	Total	**42L+14T**	

Textbook:

1. N. D. Arora, MOSFET Models for VLSI Circuit Simulation, Springer-Verlag
2. S. M. Sze & Kwok K. Ng, Physics ofSemiconductor Devices, Wiley

Reference Books:

1. Y. Taur and T.H. Ning, "Fundamentals of Modern VLSI Devices", Wiley
2. M.S.Tyagi, "Introduction to Semiconductor Materials and Devices", Wiley India Pvt.Ltd.

3. Y. P. Tsividis, "Operation and Modelling of the MOS Transistor", McGraw-Hill. 3rd Edition.