

17VL007 SEMICONDUCTOR DEVICE MODELING

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P	WA/RA	SSH/HSB	CS	SA	S	BS
45	15	-	15	30	-	5	5	-

Course Objectives:

- This course provides a solid foundation in the physics of semiconductors so that students will be able to not only understand current devices and exploit them in novel applications.
- It also appreciate the workings of new semiconductor devices as they materialize and evolve in future years.

Course Outcomes:

Upon successful completion of this course student should be able to:

- At the end of this course you should be able to Explain the equations, approximations and techniques available for deriving a model with specified properties, for a general device characteristic with known qualitative theory.
- Apply suitable approximations and techniques to derive the model referred to above starting from drift-diffusion transport equations (assuming these equations hold).
- Offer clues to qualitative understanding of the physics of a new device and conversion of this understanding into equations.
- Simulate characteristics of a simple device using MATLAB, SPICE and ATLAS / SYNOPSIS.
- Explain how the equations get lengthy and parameters increase in number while developing a compact model
- List mathematical functions representing various non-linear shapes

SKILLS:

- Ability to apply knowledge on different device models and design of devices and circuits.
- Ability to undertake problem identification through simulation which in turn cuts the fabrication costs significantly.

UNIT – I

SEMICONDUCTOR PHYSICS : Metals, insulator, semiconductors, intrinsic and extrinsic semiconductors, direct and indirect band gap, free carrier densities, Fermi distribution, density of states, Boltzmann statistics, thermal equilibrium, current flow mechanisms, drift current, diffusion current, mobility, band gap narrowing, resistance, generation and recombination, lifetime, internal electro-static fields and potentials, Poisson's equation, continuity equations, drift-diffusion equations.

UNIT – II

PN-JUNCTION DIODES : Thermal equilibrium physics, energy band diagrams, space charge layers, internal electro-static fields and potentials, reverse biased diode physics, junction capacitance, wide and narrow diodes, transient behavior, transit time, diffusion capacitance, small signal model.

UNIT – III

BIPOLAR TRANSISTORS : Basic theory and operation, heavy doping effects, double diffused transistors, Ebers-Moll model, low forward bias, junction and diffusion capacitance, transit times, parasitic, small-signal models, Early effect, saturation and inverse operation, breakdown mechanisms, punch-through.

UNIT – IV

MOS TRANSISTORS : MOS capacitor, accumulation, depletion, strong inversion, threshold voltage, contact potential, oxide and interface charges, body effect, drain current, saturation voltage, gate work function, channel mobility, sub-threshold conduction, short channel effects, effective channel length, effects of channel length and width on threshold voltage, Compact models for MOSFET and their implementation in SPICE. Level 1, 2 and 3, MOS model parameters in SPICE.

UNIT – V

UDSM TRANSISTOR DESIGN ISSUES : Short channel and ultra short channel effects, effect of high k and low k dielectrics on the gate leakage and Source –drain leakage; tunneling effects; different gate structures in UDSM - impact and reliability challenges in UDSM.

TEXT BOOKS:

1. Y.P. Tsividis, The MOS Transistor, McGraw-Hill, international edition ed.,1988.
2. Nandita DasGupta, Amitava DasGupta, Semiconductor Devices: Modeling and Technology, PHI
3. S.M.Sze, Semiconductor Devices Physics and Technology, John Wiley & Sons Inc, (2/e).
4. Angsuman Sarkar, Short Channel Effects(SCE's) in sub-100nm MOSFETs: A Review.

REFERENCE BOOKS:

1. Getreu, Modeling the bipolar transistor, New York, NY: Elsevier, 1978.
2. D. Roulston, Bipolar Semiconductor Devices, McGraw Hill, 1990.
3. N.Arora, MOSFETModels for VLSICircuit Simulation, Springer-Verlag, 1993.
4. P.Antognetti and G. Massobrio, Semiconductor DeviceModeling with SPICE,McGraw-Hill, 1988.
5. D.W. Greve, Field Effect Devices and Applications, Prentice Hall Series in Electronics and VLSI, 1998.

ACTIVITIES:

- *Modelling and simulation of III-IV and Ge transistors for logic and power applications.*
- *A simple sub threshold CMOS voltage reference circuit with channel- length modulation compensation.*
- *Extremely-wide-range supply-independent CMOS voltage references for telemetry-powering applications.*