ECE 5018	Physics of VLSI Devices	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**None**	**Syllabus version**				
		v.1.1				

Course Objectives:

The course is aimed to

1. Expound the fundamentals of intrinsic, extrinsic semiconductors with carrier concentration, modeling and physics of various carrier current transport mechanisms
2. Introduce detailed physics and modeling of PN Junction, MOS capacitors, and MOSFETs
3. Review and discuss in detail the short channel effects and the issues of UDSM transistors

Expected Course Outcome :

At the end of the course the student will be able to

1. Design extrinsic semiconductors with specific carrier concentrations and, understand the band structure and diagrams of semiconductors.
2. Calculateand model the carrier transport mechanism in semiconductors.
3. Model PN- junctions of given specifications
4. Model MOS capacitors
5. Model MOSFETs and model the MOSFETs
6. Mitigate the short channel effects and design UDSM transistors

Student Learning Outcomes (SLO): 1,5,17

Module:1	**Semiconductor Physics**	**5 hours**

Energy bands in solids - Intrinsic and Extrinsic semiconductors - Direct and Indirect bandgap - Density of states - Fermi distribution -Free carrier densities - Boltzmann statistics - Thermal equilibrium.

Module:2	**Carrier Transport in Semiconductors**	**4 hours**

Current flow mechanisms: Drift current, Diffusion current - Mobility of carriers - Current density equations - Continuity equation.

Module:3	**P-N Junctions**	**5 hours**

Thermal equilibrium physics - Energy band diagrams - Space charge layers - Poisson equation - Electric fields and Potentials - p-n junction under applied bias - Static current-voltage characteristics of p-n junctions - Breakdown mechanisms.

Module:4	**MOS Capacitor**	**8 hours**

Accumulation - Depletion - Strong inversion - Threshold voltage - Contact potential - Gate work function - Oxide and Interface charges - Body effect - C-V characteristics of MOS

Module:5	**MOSFETs and Compact Models**	**8 hours**

Drain current - Saturation voltage - Sub-threshold conduction - Effect of gate and drain voltage on carrier mobility - Compact models for MOSFET and their implementation in SPICE: Level 1, 2 and 3 - MOS model parameters in SPICE.

Module:6	**Scaling and Short Channel Effects**	**6 hours**
Effect of scaling - Channel length modulation - Punch-through - Hot carrier degradation - MOSFET breakdown - Drain-induced barrier lowering.		
Module:7	**UDSM Transistor Design Issues**	**7 hours**
Effect oftox - Effect of high-k and low-k dielectrics on the gate leakage and Source and drain leakage - tunneling effects - Different gate structures in UDSM - Impact and reliability challenges in UDSM.		
Module:8	**Contemporary issues:**	**2 hours**
Total Lecture hours:		**45 hours**

Text Book(s)	
1.	Ben G. Streetman and S. Banerjee, Solid State Electronic Devices, Pearson Education, U.S, Seventh Edition, 2014.
2.	J.P. Colinge and C. A. Colinge, Physics of Semiconductor Devices, Kluwer Academic Publishers, US, 2017.
Reference Books	
1.	Y.P. Tsividis and Colin McAndrew, Operation and Modelling of the MOS Transistor, Oxford University Press, US, Third Edition, 2011.
2.	M K Achutan and K N Bhatt, Fundamental of Semiconductor Devices, McGraw Hill Education, US, 2017.

Mode of Evaluation: CAT / Assignment / Quiz / FAT

Recommended by Board of Studies	05-10-2017		
Approved by Academic Council	No. 47		05-10-2017