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| **ECX512** | **Semiconductor Device Modelling** | **L-T-P: 3-0-0; Total 42 Lectures** |

**Prerequisites:**1. Solid State Devices and Circuits

**Course Objectives:**

The course will provide adequate understanding of semiconductor devices and their modelling aspects, useful for designing devices in electronic, and optoelectronic applications.

**Course Outcomes:**

Upon Completion of the course, the students will be able to:

Analyse MOSFET functionalities and physics

Understand Short Channel Effects (SCEs)

Design Scaled MOSFETs.

Design flow for MOSFET Virtual Fabrication flow.

Analyse performance of special optoelectronics devices.

Topics Covered:

**Unit I: MOS Capacitor: (8 Lectures)**

Energy band diagram of Metal-Oxide-Semiconductor contacts, Mode of Operations: Accumulation, Depletion, and Inversion, 1D Electrostatics of MOS, Depletion Approximation, CV characteristics of MOS, LFCV and HFCV. Non-idealities in MOS, oxide fixed charges, interfacial charges, Midgap gate Electrode, Poly-Silicon contact, inversion layer quantization, quantum capacitance.

**Unit II: Physics of MOSFET: (12 Lectures)**

Physics of MOSFET: Energy Band Diagram(E-K) of Silicon, Concept of effective mass, fermi and quasi-fermi levels, Drift-Diffusion Approach for IV, Gradual Channel Approximation, Sub-threshold current and slope, Body effect, Detail 2D effects in MOSFET, High field and doping dependent mobility models, High field effects and MOSFET reliability issues (SILC, TDDB, & NBTI).

**Unit III: Metal-semiconductor junctions: (8 Lectures)**

Rectifying and ohmic contacts, role of surface states, application in energy level characterization; Comparison of p-n junction and Schottky diodes.

**Unit IV: Leakage mechanisms: (6 Lectures)**

Leakage mechanisms in thin gate oxide, High-K-Metal Gate MOSFET devices and technology issues, MOSFET capacitances and resistances, properties of junction and ohmic & schottky contact, tunneling, fowler-nordheim tunneling, direct tunneling

**Unit V MOS Scaling: (8 Lectures)**

Basic physics of MOS transistors scaling, charge sharing effect (CSE), narrow and reverse narrow width effect, SCE, DIBL, GIDL, mobility degradation due to gate field, hot electron effect and velocity saturation, channel in-homogeneity, velocity overshoot, tunneling through oxide.

**Unit V SOI MOSFET: (8 Lectures)**

FDSOI and PDSOI, 1D Electrostatics of FDSOI MOS, VT definitions, Back gate coupling and body effect parameter, IV characteristics of FDSOI-FET, FDSOI-sub-threshold slope, Floating body effect.

**Text Books:**

1. Solid State Electronic Devices, 6th Edition, Ben Streetman, University of Texas, Austin Sanjay Banerjee, University of Texas at Austin, 2006.

2. S.M. Sze & Kwok K. Ng, Physics of Semiconductor Devices, Wiley, 2007.

3. Semiconductor Physics and Devices, Basic Principles, Third Edition, Donald A. Neamen, 2004.

**Reference Books:**

1. Yuan Taur & Tak H. Ning, Fundamentals of Modern VLSI Devices, Cambridge 2013

2. Mark Lundstrom & Jing Guo, Nanoscale Transistors: Device Physics, Modeling & Simulation, Springer 2006

3. Yannis Tsividis, Operation and Modeling of the MOS Transistor, Oxford University Press, 2010