BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI- HYDERABAD CAMPUS

SECOND SEMESTER 2020-2021

COURSE HANDOUT PART II

Date: 16/01/2021

In addition to Part-I (General Handout for all courses appended to the timetable) this portion gives further specific details regarding the course.

Course No.	**:**	**EEE F477**
Course Title	**:**	**Modeling of Field-Effect NanoDevices**
Instructor-in-charge	**:**	**Dr. Sayan Kanungo**

1. Course description:

Basics of MOSFET operation (1D electrostatics, 2D electrostatics, MOSFET I-V Characteristics, CMOS technology, Performance limits), MOSFET scaling, Small-dimensional effects (Hot electron effect, Velocity saturation, Drain-induced barrier lowering, Gate-induced drain leakage, Poly-silicon depletion, Gate-tunneling currents, Quantum effects, Variability issues), Scaled-down MOSFET technology (Strain engineering, High-k/metal-gate, PDSOI-MOSFET, FDSOI-MOSFET, Multigate MOSFET/FinFET, Nanowire-MOSFET), Quantum mechanical origin (Distribution function, Density of States, Carrier Density, Ballistic transport, Scattering), Nano-scale MOSFET (Physics of nano-MOSFET, Ballistic nano-MOSFET, Scattering in nano-MOSFET), Emerging Nano-scale FET devices (Tunnel FET, CNT FET, 2D FET).

2. Course Objective:

This course deals with the physics and operation of Metal Oxide Semiconductor Field Effect Transistor (MOSFET) structure under downscaling. In this course, the different limiting factor for performance of MOSFET at nano-scale device dimensions will be analyzed and the subsequent device engineering strategies for performance improvement will be emphasized. Finally, the state-of the art MOSFET architectures will be investigated in details and their modelling approach will be detailed in context of quantum mechanical carrier transport description. The course is expected to develop advance-level knowledge on MOSFETs, typically its electrostatics and carrier transport phenomenon at scaled down technology nodes and thereby skills for analyzing and modelling nano-scale devices in general. The course material will also incorporate certain research perspectives of the subject. Therefore, in addition to relying on the subject oriented text books and reference books, the students are advised to follow technical articles and study materials that are shared by the instructor from time to time.

3. Text Books

[T1] Yannis Tsividis, Operation and Modelling of MOS Transistor. Oxford, 2nd ed., 1999.

[T2] S.M. Sze, Kwok K. Ng, Physics of Semiconductor Devices, Wiley, 3rd ed., 2010.

[T3] Donald A Neaman, Semiconductor Physics and Devices, McGraw Hill, 3rd ed., 2003.

4. Reference Books

[R1] Mark Laundstrom, Jing Guo, Nanoscale Transistors, Springer, 1st ed., 2008.

[R2] Supriyo Datta, Quantum Transport- Atom to Transistor, Cambridge, 1st ed., 2005.

4. Course Plan

Sl.No	Topics to be covered	Learning Objectives	Chapter in the Text Book	No. of Lectures
1	Introduction to the course and its components	Course Handout Discussion		1
2	Basics of MOSFET operation (1D electrostatics, 2D electrostatics, MOSFET I-V Characteristics, CMOS technology, Performance limits)	Basics of MOSFET Physics and Operation	R1: Ch. 2	5
3	MOSFET scaling	Motivation, Objective and Present Status of MOSFET Downscaling	T2: Ch. 6.4	2
4	Small-dimensional effects (Hot electron effect, Velocity saturation, Drain-induced barrier lowering, Gate-induced drain leakage, Poly-silicon depletion, Gate-tunneling currents, Quantum effects, Variability issues)	Analysis and Modelling of Small Dimensional Effects	T1: Ch. 6 T2: Ch. 6.4 T3: Ch. 12	9
5	Scaled-down MOSFET technology (Strain engineering, High-k/metal-gate, PDSOI-MOSFET, FDSOI-MOSFET, Multigate MOSFET/ FinFET, Nanowire-MOSFET)	Device Design in Scaled-down Technology Nodes	T2: Ch. 6.5 R1: Ch. 5.2	10
6	Quantum mechanical origin (Distribution function, Density of States, Carrier Density, Ballistic transport, Scattering)	Quantum Mechanical Description of Carrier Transport	R1: Ch.1 R1: Ch.1 R2: Ch.1	6
7	Nano-scale MOSFET (Physics of nano-MOSFET, Ballistic nano-MOSFET, Scattering in nano-MOSFET)	Operation and Modelling of Nano-scale MOSFET	R1: Ch.3 R1: Ch.4	6
8	Emerging Nano-scale FET devices (Tunnel FET, CNT FET, 2D FET)	Introduction to Post-MOSFET Devices	T2: Ch. 8.2 R1: Ch. 5.3	3
		Total Number of Lectures		42

6. Evaluation Scheme

Component	Duration	Weightage	Date & Time	Remarks
Midsem Test	90 minutes	30%	03/03 3.30 - 5.00PM	Open Book
Quiz		20%	To be announced	Open Book
Assignment		10%	To be announced	Open Book
Comprehensive Exam	120 minutes	40%	08/05 FN	Open Book

7. **Chamber Consultation Hour**: To be announced

8. **Notices**: Notices concerning this course will be on CMS.

9. Academic Honesty and Integrity Policy:

Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Dr. Sayan Kanungo
Instructor-in-Charge