

MLL 738 Electronic Devices and Characterization

2022 – 2023 Odd Semester

First Interaction session 4th August, 2021 11 AM.

Material science and engineering has been fundamental in the development of several technological advances in the last century. Particularly in the field of semiconductors, the majority of ‘today – commonplace’ devices have been made possible by important breakthroughs in material science and engineering such as single crystal growth, heterojunction epitaxy, elemental doping, lithography and nanoscale fabrication. We bring this course from the department of material science and engineering to underline the principles that made possible the unimaginable technological boom we have experienced in the last few decades.

MLL738 is a post graduate level course on solid state electronic devices and characterization. In the course of the semester, we will cover the physical aspects of basic electronic devices such as PN junction diodes, Schottky diodes, metal oxide semiconductor capacitors and field effect transistors. We will deviate from the traditional electrical engineering treatment of this subject by addressing various material science and engineering principles behind the device operation allowing us to expand the scope of lectures to ‘non-Silicon’ novel materials. We will discuss in detail different measurement schemes and characterization techniques that a device engineer, research scientist or a semiconductor enthusiast would require to understand the various device operations.

The subject is truly inter-disciplinary and we welcome attendees from all departments and centers. Besides the basic undergraduate level mathematical techniques, the only requisite for attending the course is the curiosity to learn.

Course Content:

- General introduction to electronic devices and materials
- Conduction in solids, origin of resistance
- Semiconductors, metals and Insulators
- Band structure, carrier statistics and doping
- Transport
- PN Junction principles
- Metal-Semiconductor junctions
- Metal-Oxide-Semiconductor Capacitor
- MOSFETs

People:

Instructor: Krishna Balasubramanian

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Teaching Assistant: Tajamul Wani (Tajamul.Ahmad.Wani.msm21@mse.iitd.ac.in)

Course Timing:

- Tuesday, Thursday and Friday 11 AM – Noon

Prerequisites:

- Bachelor level Mathematics (Differential equations, calculus)
- Basic Electromagnetics, electrical devices and terminal characteristics

Books and Reference:

- Physics of semiconductor devices, (SM SZE)
- Solid State Electronic devices (Ben G. Streetman and Sanjay Banerjee)
- Introduction to Solid state Physics (Charles Kittel)
- Semiconductor Material and Device Characterization (Dieter K. Schroder)

Evaluation:

Two quizzes, 1 mid-term and 1 final exam with the following split

- Homework 15%
- Quiz 15%
- Mid-term 25%
- Final 35%
- Overall participation – 10%

Course Information:

- Course delivery:
 - In-person (room will be announced later)
 - <https://web.iitd.ac.in/~bkrishna/MLL738.html>
- Homework every week to be submitted before the interaction session. Could involve simple coding exercising. Deadlines are razor sharp (its automated).
- Other things, we will make up as we go. :)

Academic Honesty:

All students registering to this course voluntarily commit to the academic integrity, research and Ethics policy, IIT Delhi (https://academics.iitd.ac.in/sites/default/files/registration/forms/10_FORM%20H.pdf). This is a post-graduate level course and I expect the students to know their responsibility. If, any document submitted to us is plagiarized (copied verbatim either from textbook/ online resources/ fellow students...), the student will be deregistered and promptly handed to institute authorities. Discussion are okay for homework, but the submission needs to reflect the student's work. No discussion/references are allowed in quizzes/ mid-semester/final exams.

Detailed Course Schedule:

Lecture	Topic	Reference
1	General Introduction	General
2	Conduction in metals general properties, Drude model	AM/SB
3	Resistance measurement and techniques	AM/SB
4	Understanding Solids, Lattices and structures	DS
5	Reciprocal lattice, symmetry directions	AM/SB
6	Band structures and band gaps, semiconductors	AM/SB
7	bandstructure measurement techniques	AM/SB
8	Electron statistics, Intrinsic and Extrinsic	DG
9	Carrier dynamics (Drift, diffusion and recombination)	AM/SB
10	Transport equations, Continuity, steady state injection	AM/SB
11	PN junction , Field and charge at the junction	SB
12	Ideal Schottky diode	SB
Minor Test		
13	Characterization: Doping Density, Resistivity, Mobility	SB
14	Diode measurement techniques	DS
15	Schottky diode (Metal Semiconductor)	SB
16	Current conduction in metal-semiconductor	SB
17	Characterization of MS , contact resistance	DS
18	MIS capacitor introduction	DS
19	Surface charge characteristics, charges and traps	SB
Semester Break		
20	Capacitance measurement techniques	SB
21	BJT Introduction and basics	DS
22	MOSFET introduction	SB/SM
23	Basic IV and sub-threshold	SB/SM
24	Short channel effects	SB/SM
25	MOSFET characterization	SB/SM
26	Summary and conclusions	