EC575A1 Physics of Semiconductors Devices

Spring Semester 2025

Instructor: Enrico Bellotti

Assistant: TBD

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General Information

- Time: Monday and Wednesday from 10:10. - 11:55.
- Place: 888 Commonwealth Ave IEC B11
- Prerequisites: SC574A1 Physics of Semiconductor Materials
- Things you need to know:
  - Quantum Mechanics And Undergraduate Semiconductor Device Physics
  - Mathematics: vector calculus, solution of first and second order linear ODEs, separation of variables for PDEs.
  - Electromagnetism: solution of poisson equation
  - Circuit theory: basic knowledge of device operation.
- Grading and Exams
  - Problem set solutions returned by email must be in pdf format only or in paper format. You are responsible for making sure they are received.
  - Two midterm exams, 35% each
  - Final exam, 30%
  - NOTE - No make up exams
- Suggested Textbooks
  - Class notes will be provided.
  - R.S. Muller and T.I. Kamins, *Device Electronics for Integrated Circuits*, Third Edition, Wiley.
  - H.C. Casey, *Devices for Integrated Circuits: Silicon and III-V Compound Semiconductors*, Wiley.

- Other Useful Books
  - K. Hess, *Advanced Theory of Semiconductor Devices*, Prentice Hall, ISBN 0130115118, make sure you try to get the paperback edition, either first or second.
  - B.H. Brandsen, and C.J. Joachain, *Introduction to Quantum Mechanics*, Longman Scientific and Technical, ISBN 0582444985, *This is a great text on quantum mechanics*
  - Additional notes and papers will be provided for all topics not present in the textbook.
- Student hours
  - Student hours with the teaching assistant will be announced after the final schedule is available.
  - To convince you to get the homework done on time, I will not have student appointments starting a week before exams.
- Classroom Behavior
  - It is assumed you come to class to learn.
  - Audio/video recording is not allowed due to Privacy Laws.
  - You can use your PCs to take notes.
  - Phones: playing/texting/calling/"whatever-else-you-do-with-them" is not allowed. Please turn them off and put them away or leave them at home.
- Academic Misconduct
  - BU takes academic integrity very seriously (unlike Harvard). Academic misconduct is conduct by which a student misrepresents his or her academic accomplishments, or impedes other students' opportunities of being judged fairly for their academic work. Knowingly allowing others to represent your work as their own is as serious an offense as submitting another's work as your own. More information on BU's Academic Conduct Code, with examples, may be found at http://www.bu.edu/academics/policies/academic-conduct-code.
- Collaboration Policy - In this class you may use any textbooks or web sources when completing your homework, and/or one human collaborator (from class) per homework, subject to the following strictly enforced conditions:
  - Use of chatGPT is not allowed.
  - You must clearly acknowledge all your sources (including your collaborators) on the top of your homework.
  - You must write all answers in your own words.
  - You must be able to fully explain your answers upon demand.
  - You may not use any human resource outside of class (including web-based help services, outside tutors, etc.) in doing your homework.

- You may not collaborate with anyone on exams.
- Failure to meet any of the above conditions could constitute plagiarism and will be considered cheating in this class. If you are not sure whether something is permitted by the course policy, as the the instructor or TA.

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Class Syllabus

⇒ **Part I – Introduction and Review of Quantum Mechanics and Semiconductor Physics**

- Review of Quantum Mechanics. Periodic Potential, Tight-Binding, Pseudopotential
- Semiconductor Properties
- Survey of Semiconductor Material Properties.
- Numerical Example: Band Structure Calculation with Pseudopotential.

⇒ **Part II – Carrier Transport Models**

- Carrier Transport Models: BTE
- Numerical Example: Monte Carlo Simulation of Carrier Transport
- Drift Diffusion Model

⇒ **Part III – Junction**

- Metal-Semiconductors Junctions.
- Oxide-Semiconductor Junctions
- p-n Junctions.
- p-N and P-n heterostructures.

⇒ **Part IV – BJT and HBTs**

- The Bipolar Junction Transistor: Basic Theory and Limitations.
- The Heterojunction Bipolar Junction Transistor

⇒ **Part V – Mesfet, Modulation Doping and HEMTs**

- Modulation Doping Fundamentals

- High Electron Mobility Transistor

⇒ **Part VI – MOS Transitors**

- MOS Structures
- Field-Effect Three-Terminal Devices
- Fundamental MOS Transistor Properties

⇒ **Part VII – Photodetectors**

- Detection Fundamentals
- Photodiodes and p-i-n detectors
- Avalanche Phototdetectors

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Class Calendar

January

January 22
January 27
January 29

February

February 3
February 5
February 10
February 12
February 17 – No class
February 18 – Substitute for 2/19
February 19
February 24
February 26

March

March 3
March 5
March 10 – No class
March 12 – No class
March 17
March 19
March 24
March 26
March 31

April

April 2
April 7
April 9
April 14
April 16
April 21 – No class
April 23
April 28
April 30