Fundamentals of Semiconductors: Physics and Materials Properties

Course Number: ECE 634
Credits: 3 hours
Times: 2:20 - 3:25 pm Tue, 2:20 - 3:45 pm Thu
Location: Min Kao Engineering Bldg., Rm 434
Instructor: Gong Gu

An interdisciplinary course that welcomes graduate students from departments of EECS, Physics, MSE, Chemistry, etc. Although not considered a prerequisite, it helps to prepare students for ECE 635 Advanced Semiconductor Devices. It serves multiple purposes:

- To prepare graduate students in research areas related to electronic materials and devices with adequate background knowledge in semiconductor physics and processing;
- To bridge the gap between frontier research in condensed matter physics and real-world applications in the semiconductor industry; and
- To relate advanced materials research, including materials preparation and characterization techniques, to micro- and nanoelectronics.

List of topics

1. Introduction/survey: review and survey widely used concepts, raising questions that lead you to advanced inquiries
2. Semiconductor crystal structures and electronic band structures: a quick quantum mechanics primer/review, periodic crystal structures and energy bands, unified band (physics) and bond (chemistry) pictures
3. Defects, doping, carrier statistics
4. Lattice vibrations (phonons), thermal & mechanical properties
5. Electrical transport: semiclassical model, mobility, scattering mechanisms; ballistic/quantum transport
6. Optical properties
7. Surfaces and interfaces: The interface is the device!
8. Semiconductor material characterizations
9. Semiconductor material growth and processing
10. Selected advance topics (TBD by student research areas and interests: e.g. wide-band gap semiconductors for power electronics, defect engineering for memristors, first-principles methods for computational materials science or condensed matter physics, etc.)

Reference books (*not* textbooks)

On semiconductor physics

Marius Grundmann, *The Physics of Semiconductors An Introduction: Including Nanophysics and Applications*, Third Edition. Available as e-book and paper book at UT Library. (Comprehensive)

Peter Y. Yu & Manuel Cardona, *Fundamentals of Semiconductors: Physics and Materials Properties*, 4th Edition. Available as e-book and paper book at UT Library. (Many contents too advanced for our purpose)

On broader solid-state physics

Marvin L. Cohen & Steven G. Louie, *Fundamentals of Condensed Matter Physics*.

On quantum mechanics

The Feynman Lectures on Physics Vol. III. Available online: https://www.feynmanlectures.caltech.edu/III_toc.html

Townsend, J. S. (2000). *A Modern Approach to Quantum Mechanics*. The 1992 version available at UT Lib and checked out by me. (I largely follow the same, also Feynman's, approach.)

On semiconductor processing

Plummer, Deal, and Griffin, *Silicon VLSI Technology: Fundamentals, Practice and Modeling*, Dorling Kindersley, 2009.

Grading

TBD.

Course Website

Available soon: https://web.eecs.utk.edu/~ggu1/files/GradHome.html