

ECE 451 - Fall 2011

Physics of Semiconductor Devices (3)

✓ Electronics and Optoelectronics Properties of Semiconductors

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Required Reading Textbook:

1. Nelson Tansu, *Lecture Notes on Semiconductor Physics and Device Physics*, Draft Version (2010).

Other Additional References or Readings:

1. J. Singh, *Electronics and Optoelectronics Properties of Semiconductor Structures*, Cambridge (2003).
2. M. Cardona, and P. Yu, *Physics of Semiconductors* (4th Edition), Springer (2010).

Course Abstract:

This course covers the fundamental physics of semiconductors, in particular covering the electronic and optoelectronic properties of semiconductors as well as the device physics for novel semiconductor structures. The course will start with the discussion on the crystal structure and fabrication method, in particular focusing on the state of the art fabrication approach. The course will then move to the development of the electronic band structure properties in semiconductors, as well as strain and nanostructure effects on band structures. The transport properties will be clarified in the context of Boltzmann Transport Equation approximation, as well as the various carrier-carrier and defect scattering processes. The phonon scattering process will be clarified, and application in thermoelectric devices will be discussed. The topic on velocity-field transport will be discussed, and followed by discussion on coherence, disorder, and mesoscopic effects in semiconductors. The optical and optoelectronics characteristics of semiconductor will be discussed, and various device applications will be provided. The excitonic effects in semiconductors will be discussed, as well as the effect of magnetic fields on semiconductors. The polarization fields, self-consistent 6-band k.p method, gain calculation, and various analyses on lasers and light-emitting diodes will be discussed.

Intended Levels:

The course is intended for graduate students in engineering (Electrical and Computer Engineering, Material Science Engineering, and other related engineering) and applied physics areas, who are physics of semiconductors, semiconductor device physics, semiconductor nanoelectronics, and semiconductor optoelectronics. Strong background in *undergraduate-level* semiconductor device physics, quantum mechanics, and solid state physics are required.

Prerequisites:

1. ECE 203, ECE 126
2. Physics of Solids (PHY 361) or equivalent
3. Applied Quantum Mechanics (ECE 450) or equivalent
4. Computing: knowledge of programming or numerical programs (ie. MatLab, MathCad, Mathematica, C language, Fortran, or other numerical programs).

The course will cover all the chapters in the textbook with the following topics:

1. Crystal Structure and Fabrication Technologies
2. Semiconductor Band Structures
3. Band Structure Modifications
4. Transport in Semiconductors : General Formalism
5. Defect and Carrier-Carrier Scattering Processes
6. Lattice Vibration : Phonon Scattering
7. Thermoelectric Materials and Physics
8. Velocity-Field Relation in Semiconductors (Optional)
9. Coherence, Disorder, and Mesoscopic Physics in Semiconductors (Optional)
10. Optical and Optoelectronics Properties of Semiconductors
11. Excitonic Effects and Modulation of Optical Properties
12. Semiconductors in Magnetic Fields (Optional)
13. Polarization Fields in Semiconductors
14. Electronic Structure Calculations in Nanostructures
15. Optical Gain and Spontaneous Emission Calculation in Nanostructures
16. Density Functional Theory Analysis (Optional)
17. Intersubband Carrier-Phonon and Carrier-Photon Scattering Processes (Optional)
18. Novel Optoelectronics and Electronics Devices (Optional)

Structure of the Course Grading:

The structure of the course will consist of weekly homework assignments, a midterm exam, and a final exam with the following proportion toward the final grade:

1. Problems – 50 % (approximately 8 homework sets)
2. Midterm Exam – 20 % (scheduled in the evening)
3. Final Take Home Exam – 30 %

Homework and Exam Policy:

1. Homework is given on every Tuesday, and due on the following Tuesday before class. (a week later)
2. No late homework is accepted, unless there is a medical emergency or permissions given in advance.
3. Working together in homework is encouraged, but not copying!
4. Academic Dishonesty will be subject to disciplinary action by Lehigh University.

Accommodations for Students with Disabilities:

If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, University Center 212 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.