ECE 572 - Optoelectronics

Department of Electrical and Computer Engineering
University of Massachusetts Amherst

Syllabus

Spring 2020

Instructor

Prof. Amir Arbabi
Office: Knowles 113D
Phone: (413)-545-6193
email: arbabi@umass.edu

Time and Location

Lecture: 11:30AM-12:45PM Tu-Th, ELab 305
Office hours: 2:00PM-2:50PM Tuesdays and Thursdays or by appointment, Knowles 113D

Prerequisite:

ECE 333 (Fields and Waves I), ECE 344 (Semiconductor Devices & Materials).

Course Objectives

This objective of this course is to introduce students to the fundamental operating principles of optoelectronic devices. Students should be able to understand optical waveguides, semiconductor lasers and detectors, and learn how to use their knowledge in practice.

Resources

Main text:
Kasap, S. O. *Optoelectronics & photonics: principles & practices*. 2nd edn, (Pearson, 2012).

Other References:
Saleh, B. E. A. & Teich, M. C. *Fundamentals of photonics*. 2nd edn, (Wiley, 2007).
Yariv, A. *Optical electronics in modern communications*. 5th edn, (Oxford University Press, 1997).
Chuang, S. L. *Physics of photonic devices*. 2nd edn, (Wiley, 2009).
Pollock, C. R. *Fundamentals of optoelectronics*. (R. D. Irwin, 1994).
Coldren, L. A., Corzine, S. W. & Mashanovitch, M. L. *Diode lasers and photonic integrated circuits*. 2nd edn, (Wiley, 2012).

Grading

Homework: 20%
Midterms I: 25% 7pm-9pm, Friday, Feb. 21, 2020, ELAB 306
Midterm II: 25% 7pm-9pm, Thursday, March 26, 2020, ELAB 306
Final Exam: 30%

Homework Policies

Weekly problem sets (approximately 9 sets) will be assigned and are due in class before the start of the lecture. Students get one late homework pass and may turn them in without a penalty at the beginning of the lecture following the due date.

Collaboration on problem sets is allowed and encouraged. However, you must write your own solutions to the problems and **must cite all people with whom you have collaborated**.

Exam Policies

The class will have two midterms and a final exam. The exams are closed-book, but students are allowed to bring one double-sided page of notes. Use of calculators is also allowed.

Course Topics

1. **Review of the electromagnetic theory of light**

Maxwell's equations, boundary conditions, power and energy, plane waves, complex refractive index, absorption and gain, refractive index, phase and group velocities, Snell's law, total internal reflection, anti-reflection coating, dielectric mirrors, photon.

2. **Optical waveguides and resonators**

Guided waves, waveguide modes, slab waveguide modes, optical fibers, dispersion and loss, commonly used photonic waveguides, optical resonators.

3. **Review of semiconductor physics**

Schrodinger equation, Bloch wavefunction, energy bands, bandgap, direct and indirect semiconductors, compound semiconductors and alloys, electrons and holes, effective mass, density of states, Fermi-Dirac distribution, Fermi and quasi Fermi levels, semiconductor doping, conductivity, generation and recombination, band diagram in the presence of electric fields, phonons, pn junctions, forward and reverse biased junctions, pin diode, heterojunctions.

4. **Interaction of light with atoms**

Spontaneous and stimulated emission, population inversion and optical gain, EDFA.

5. **Light emitting diodes**

Spontaneous emission in semiconductors, homojunction and heterojunction LEDs, LED spectrum, quantum-well LED, efficiency and brightness, LED characteristics, modulation bandwidth, LED lighting, coherence length, coupling LEDs to waveguides.

6. **Semiconductor amplifiers and lasers**

Gain in semiconductors, semiconductor optical amplifier, lasing condition, quantum-well lasers, laser characteristics, Fabry-Perot, DBR, DFB, VCSELs

7. **Photodetectors, solar cells, and image sensors**

pin photodiode, quantum efficiency, responsivity, noise, avalanche photodiode, heterojunction photodiode, Schottky photodetector, photoconductive detectors, solar cells, CMOS image sensors, CCDs.

Note on Inclusivity

The diversity of the participants of this course is a valuable source of ideas, problem solving strategies, and engineering creativity. If you feel that your contribution is not being valued or respected for any reason, please speak with me privately. If you wish to communicate with someone else in the College, speak with Assistant Dean Dr. Paula Rees (rees@umass.edu, 413.545.6324, 128b Marcus Hall). You may also submit anonymously through the College of Engineering Climate Concerns and Suggestions on-line form (https://tinyurl.com/UMassEngineerClimate) and/or the Positive and Negative Classroom Experience online form (https://tinyurl.com/UMassEngineerClassroom). We are all members of an academic community with a shared responsibility to cultivate a climate where all students/individuals are valued and where both they and their ideas are treated with respect.