ECE 572 - Optoelectronics

Department of Electrical and Computer Engineering
University of Massachusetts Amherst

Syllabus

Fall 2017

Instructor

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Time and Location

Lecture: 9:05AM-9:55AM Mon-Wed-Fri, Marston 220
Office hours: 10:10AM-11:00AM Mondays and Fridays or by appointment, Knowles 211C

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: 25%
Midterms I: 20% (8:00AM-10:00AM, Tuesday Oct. 10)
Midterm II: 20% (8:00AM-10:00AM, Monday Nov 13)
Final Exam: 35% (8:00AM-10:00AM, Thursday Dec 14)

Homework Policies

Weekly problem sets (approximately 11 sets) will be assigned on Mondays, and are due the following Monday 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 in-class midterm and the final exams. 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

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, non-monochromatic light, coherence.

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

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.

Interaction of light with atoms
Photon, spontaneous and stimulated emission, population inversion and optical gain, EDFA.

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

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

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.