BOSTON UNIVERSITY
Department of Electrical & Computer Engineering
ENG EC/MS774 / Spring 2025

Semiconductor Quantum Structures and Photonic Devices

Objectives

The objective of this course is to develop a fundamental understanding of the basic physics and practical operation of semiconductor optoelectronic devices, with emphasis on devices based on quantum structures. Design principles based on band-structure engineering will be highlighted.

Catalog Description

Optical properties of semiconductors: interband optical transitions; excitons. Low-dimensional structures: quantum wells, superlattices, quantum wires, quantum dots, and their optical properties; intersubband transitions. Lasers: double-heterojunction, quantum-well, quantum-dot, and quantum-cascade lasers; high-speed laser dynamics. Electro-optical properties of bulk and low-dimensional semiconductors; electroabsorption modulators. Detectors: photoconductors and photodiodes; quantum-well infrared photodetectors.

Lectures

Tuesdays & Thursdays 1:30 – 3:15 PM, in 111 Cummington St MCS B37

Instructor

Roberto Paiella: office: PHO 529 phone: 3-8883
e-mail: rpaiella@bu.edu office hours: T 9-11am or by appointment

Grader

TBD e-mail: TBD

Web Page: available on Blackboard Learn (https://learn.bu.edu)

Prerequisites

Introductory quantum mechanics and semiconductor device physics

Requirements

Homework 30%; Midterm exam 35%; Final exam 35%

Textbook

Physics of Photonic Devices, S. L. Chuang (2nd edition, Wiley, 2009)

Course Topics

Electronic band structures: *review of relevant concepts of quantum mechanics and semiconductor physics;* ***k·p*** *method; key results of Luttinger-Kohn's theory; effective mass approximation; band structures of compound semiconductors; strain effects.*

Optical properties of bulk semiconductors: *interband optical transitions; absorption and gain; spontaneous and stimulated emission; carrier-induced refractive index; exciton absorption.*

Semiconductor quantum structures and their optical properties: *electronic structures of quantum wells, superlattices, quantum wires and quantum dots; interband optical transitions and exciton effects in low-dimensional systems; intersubband optical transitions; polarization selection rules.*

Semiconductor lasers: *double-heterojunction lasers; quantum-well and strained-layer quantum-well lasers; quantum-dot lasers; intersubband (quantum-cascade) lasers: light-current characteristics; laser dynamics and direct modulation characteristics; linewidth enhancement factor.*

Modulators: *Franz-Keldysh effect; quantum-confined Stark effect; electroabsorption modulators; interferometric modulators; all-optical switches.*

Photodetectors: *photoconductors; p-i-n and avalanche photodiodes; quantum-well infrared photodetectors (QWIPs).*

Course Calendar (tentative)

Week 1	T 1/21	Quantum mechanics review	
	R 1/23	Electronic band structures	
Week 2	T 1/28		
	R 1/30		
Week 3	T 2/4		HW 1 due
	R 2/6	Bulk optical properties	
Week 4	T 2/11		
	R 2/13		HW 2 due
Week 5	T 2/18	**----- No class -----**	
	R 2/20	Bulk optical properties	
Week 6	T 2/25		
	R 2/27	Low-dimensional structures	HW 3 due
Week 7	T 3/4		
	R 3/6		
Week 8	T 3/11	**----- No class -----**	
	R 3/13		
Week 9	T 3/18	Low-dimensional structures	
	R 3/20		HW 4 due
Week 10	T 3/25	**----- Midterm -----**	
	R 3/27	Semiconductor lasers	
Week 11	T 4/1		
	R 4/3		
Week 12	T 4/8		HW 5 due
	R 4/10		
Week 13	T 4/15		
	R 4/17	Modulators	
Week 14	T 4/22		HW 6 due
	R 4/24	Photodetectors	
Week 15	T 4/29		
	R 5/1		HW 7 due