Solid-State Optics (3 units). Basic concepts in crystals and in optical response; optical properties of metals, insulators and semiconductors; quantum wells; glass and polymers; optical nonlinearities; solid-state devices and laser diodes. P, PHYS 371 or OPTI 511R. Knowledge of quantum mechanics is necessary.

Meeting Times:
Lectures: Tu/Th 11:00 a.m. to 12:15 p.m. | Room 307

Description:
This is an introductory-level course in the field of solid-state optoelectronics. It includes an introduction to the microscopic properties of solids such as bulk metals, insulators, semiconductors, polymers, glass and semiconductor heterostructures, as well as their linear and nonlinear optical response. It also contains a discussion of basic operation of principles of opto-electronic devices such as lasers, light modulators and detectors.

A necessary prerequisite is a good understanding of electromagnetic theory (including Maxwell’s equations and the mathematics of Fourier transformations) and a solid understanding of quantum mechanics (including the mathematical framework of quantum mechanics, the physics of the hydrogen atom and perturbation theory).

Some of the topics of this course will be covered in detail (for example, the linear optical response of solids, simple optical properties of phonons and the physics of quantum wells), whereas other topics will only be covered in the form of general overviews (for example electro-optical properties of semiconductors and nonlinear optical effects).

No advanced mathematical techniques, such as second quantization, will be used.

There are two major goals of this course. First, the course should present basic facts about optical properties of solids based on their microscopic structure. Second, the student should be enabled to understand various optical and opto-electronic phenomena used in devices on the basis of the few microscopic aspects presented in this course.

Homework:

- Weekly homework assignments with a few problems will be handed out each week. Homework assignments are due one week after distribution.

Exams:

- Closed book in-class midterm exam.
- Closed book in-class final exam.

Grades:

- The grades will be based 30% on the homework, 25% on the midterm and 45% on the final exam.

Professor:
Dr. Rolf Binder
binder@optics.arizona.edu
621-2892
Meinel Building, Room 632
Office Hours: Mondays 3:00-3:45 p.m., Thursdays 12:30-1:15 p.m.

Teaching Assistant:
See Class Website

Class Website: http://wp.optics.arizona.edu/binder/opti-507/

Course Outline:

- Basic concepts of crystals (direct lattice, reciprocal lattice, Brillouin zone, electronic wave functions in single atoms and in solids, Bloch wave functions, energy bands, effective mass, Fermi and Bose distribution functions, classification of solids, electrons and holes, density-of-states).
- Basic concepts of optical response (Dielectric optical response, refractive index and absorption, dispersion relations, Kramers-Kronig relations, optical properties of metals, plasmons, surface plasmons.
• Optical properties of phonons (optical and acoustic phonons, dispersion relations, diatomic lattice, 3-dimensional crystals, effective charges, Bose functions, optical excitation of phonons, infrared absorption, phonon polaritons, light scattering, Raman and Brillouin scattering, coherent Raman spectroscopy).

• Linear optical properties of semiconductors (direct and indirect gap semiconductors, energy and momentum conservation in band-to-band transitions, optical absorption and quantum mechanical time-dependent perturbation theory, dipole allowed transitions in the parabolic band approximation, indirect optical transitions, excitons, two-particle Schrödinger equation, selection rules, excitonic absorption in semiconductors, emission in semiconductors, examples of important semiconductors.

• Quasi-two-dimensionalsemiconductors (quantum confinement, quantum wells, subbands, superlattices, optical transitions and selection rules in 2D, excitons in quantum wells).

• Overview of electro-optical properties of semiconductors and quantum wells (Franz-Keldysh effect, DC Stark effect, exciton ionization, quantum-confined dc-Stark effect).

• Electrical transport (doping, p-n heterojunctions).

• Concepts of semiconductor lasers and detectors (lasing conditions, biased p-n junctions, edge-emitting lasers, VCSELs, DFBs, photovoltaic cells).

• Overview of organics and polymer optics (basic concepts in chemistry, molecules, polymers, bonds, σ and π orbitals, light absorption and emission in organics, transport in polymers, organic light-emitting diodes).

• Overview of glass optics (glass formation, doping of glass, glass waveguides and fibers, fiber amplifiers and lasers).

Textbook (Required):


Available in the Class Notes section of the UofA Bookstore.

Most of the material presented in this course will be taken from this text. However, not all chapters of the book will be covered in this course. Some topics are not covered in the text.

Other Textbooks for Reference:

• C. Klingshirn, Semiconductor Optics (Springer, Berlin, 1995)
• J.D. Jackson, Classical Electrodynamics Wiley, New York, 1975)
• C.R. Dillard and D.E. Goldberg, Chemistry; Reactions, Structures and Properties (Macmillan, New York, 1971)
• J.B. Pierce, The Chemistry of Matter (Houghton Mifflin, Boston, 1970)
• C. Kittel, Introduction to Solid State Physics (Wiley and Sons, New York, 1986)
Academic Integrity
According to the Arizona Code of Academic Integrity, "Integrity is expected of every student in all academic work. The guiding principle of academic integrity is that a student’s submitted work must be the student’s own." Unless otherwise noted by the instructor, work for all assignments in this course must be conducted independently by each student. Co-authored work of any kind is unacceptable. Misappropriation of exams before or after they are given will be considered academics misconduct.

Misconduct of any kind will be prosecuted and may result in any or all of the following:

- Reduction of grade
- Failing grade
- Referral to the Dean of Students for consideration of additional penalty, i.e., notation on a student’s transcript re: academic integrity violation, etc.

Students with Learning Disabilities
If a student is registered with the Disability Resource Center, he/she must submit appropriate documentation to the instructor if he/she is requesting reasonable accommodations.

The information contained in this syllabus may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.