MSE 111: Properties of Electronic Materials

Instructor: Prof. Junqiao Wu, MSE Department, UC Berkeley
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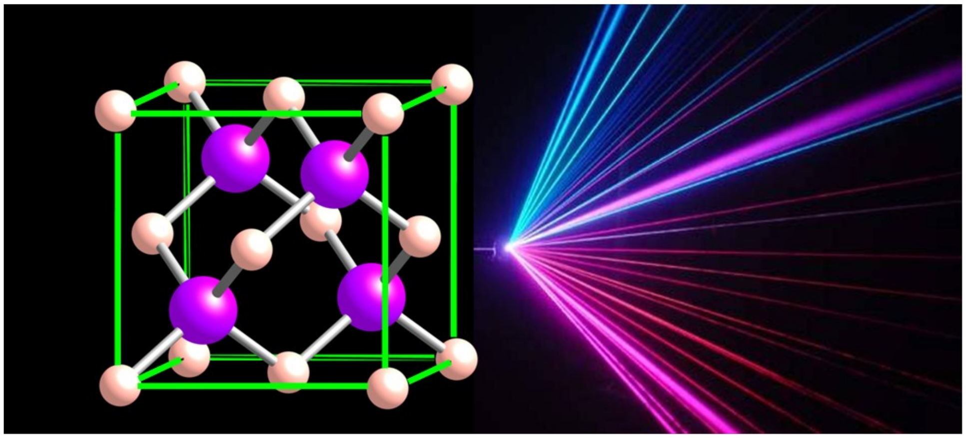

- the zincblende structure of common semiconductors, and emission of semiconductor lasers.

ONLINE RESOURCES

Course website: http://bcourses.berkeley.edu
Only enrolled students may access this site. Login with your CalNet ID, then select the MSE111. If you don't have access to bcourses, please see the instructor for electronic copy of course materials.

CATALOG DESCRIPTION

Introduction to the physical principles underlying the electronic properties of solids from macroscopic to nano dimensions. General solid state physics will be taught in the context of technological applications, including the structure of solids, behavior of electrons and atomic vibration in periodic lattice, and interaction of light with solids. Emphasis will be on semiconductors and the materials physics of electronic and optoelectronic devices.

COURSE PREREQUISITES

E45, Physics 7A-7B-7C or consent of instructor. It is usually OK if you have not yet taken Physics 7C.

PREREQUISITE KNOWLEDGE AND/OR SKILLS TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

Knowledge of introductory physics (e.g., atoms, electromagnetism, wave mechanics) and mathematics (e.g., calculus, differential equations, vectors, Fourier transform, complex numbers) is essential for this course.
Required text: S. O. Kasap, *Principles of Electronic Materials and Devices* (McGraw Hill, 2002, or any other version)

COURSE OBJECTIVES

Students will gain a fundamental understanding of the following topics: i) electrical conduction (transport) in solids based on quantum mechanics and modern band theory, ii) lattice vibration and thermal conduction (transport) in solids, iii) major properties of bulk and nanostructured semiconductors, iv) effects of dopant impurities and defects in semiconductors, and v) the principles of light-solid interactions.

DESIRED COURSE OUTCOMES

Students who have successfully completed this course will have gained an understanding of:

- the structure of ideal crystalline solids and their defects
- the basics of electrical and thermal conduction in solids
- the major kinds of chemical bonds
- the behavior of electron as a particle and as a wave
- the basic free electron theory of metals
- the basic energy band theory of solids
- basic semiconductor materials properties
- free charge carrier distribution in intrinsic and extrinsic semiconductors
- physics of the p-n junction and related solar cells and light emitting diodes
- principles of light-solid interactions including light absorption and emission

The students will be able to use mathematical and conceptual approaches to applying this knowledge in solving a wide range of problems originating in semiconductor research and development and industrial technologies.

TOPICS COVERED

Introduction to Solid State Physics, Crystal Bonding, Basic Quantum Mechanics, Electrical and Thermal Conduction, Energy Band Structure of Solids, Intrinsic and Extrinsic Semiconductors, Carrier Transport and Recombination in Semiconductors, Properties of Semiconductor Nanostructures, Semiconductor Junctions, Solar Cells, LEDs, Defects in Semiconductors, Light Propagation, Absorption, and Emission in Solids.

CLASS/LABORATORY SCHEDULE

Lectures: Mon, Wed, 3:30-5:00pm, https://berkeley.zoom.us/s/3490161661
Discussion: Tue 5-6:00PM, (by TA: Maria Folgueras, mcf26@berkeley.edu, https://berkeley.zoom.us/j/6217299516)
Office hours: Wed 2-3:00PM, https://berkeley.zoom.us/s/3490161661, or by email appointment

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

The course provides a thorough fundamental understanding of properties of the solid state with emphasis on semiconductors. Many students from different departments who took the course in the past went on to positions in the semiconductor industry, and reported back that the course had provided them with a good background for their work. This course teaches the scientific and technological knowledge of solid materials (semiconductors, insulators, metals, etc.) that are important for the high-tech industry.

RELATIONSHIP OF THE COURSE TO UNDERGRADUATE DEGREE PROGRAM OBJECTIVES

This course is a core course in our electronic materials emphasis of the MSE undergraduate education. The science, technology, processing and making of devices of electronic materials are an integral part of any modern MSE undergraduate curriculum.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

Students prepare 11 sets of homework, which will be due normally in a week. Solution to each homework will be thoroughly discussed in the discussion hour. There are one midterm exam and one final exam, both open-book and open-Internet, but discussion/sharing with other people is not allowed.

PERSON(S) WHO PREPARED THIS DESCRIPTION

Prof. Junqiao Wu

COURSE PROGRAM (see syllabus for details):

1. Elementary materials science
2. Electrical and thermal conduction
3. Elementary quantum mechanics
4. Modern theory of solids
5. Semiconductors
6. Semiconductor devices (if time allows)
7. Optical properties (if time allows)

GRADING:

Approximately 11 Homeworks: 20%
1 Midterm: 30%
Final Exam: 50%

	MSE 111	Properties of Electronic Materials	Spring 2021	
		Lecturew by Prof. J. Wu: Mon&Wed, 3:30PM-5PM, https://berkeley.zoom.us/s/3490161661		
		Discussion by Maria Folgueras: 5-6PM Tuesdays, https://berkeley.zoom.us/j/6217299516		
lecture Date	**Chapter**	**Lecture Topics**	**reminds**	
1/20	1 Elementary materials science	1.1 atomic structure (Kasap 1.1, 1.2)		
1/25	1	1.2 Bonding and types of solids (Kasap 1.3)	HW1 given	
1/27	1	1.3 Kinetic molecular theory (Kasap 1.4, 1.5)		
2/1	1	1.4 Crystalline state (Kasap 1.8)	HW1 due, HW2 given	
2/3	1	1.5 Defects in solids (Kasap 1.9)		2/2, HW1 discussion
2/8	2 Electrical and thermal conduction	2.1 The Drude model (Kasap 2.1, 2.2)	HW2 due, HW3 given	
2/10	2	2.2 Electrical conduction of metals and nonmetals (Kasap 2.3-2.4)		2/9, HW2 discussion
2/15			no class, Holiday	
2/17	2	2.3 Hall effect and mobility (Kasap 2.5)	HW3 due, HW4 given	2/16, no discussion
2/22	2	2.4 Thermal conduction and heat capacity (Kasap 2.6)		
2/24	3 Elementary quantum physics	3.1 The wave-particle duality (Kasap 3.1)	HW4 due, HW5 given	2/23, HW3 discussion
3/1	3	3.2 The Schordinger equation in 1D (Kasap 3.2, 3.3)		
3/3	3	3.3 The Heisenberg's uncertainty principle (Kasap 3.4)	HW5 due, HW6 given	3/2, HW4 discussion
3/8	3	3.4 Quantum tunneling (Kasap 3.5)		
3/10	3	3.5 The Hydrogen atom and particle in a box (Kasap 3.6, 3.7)	HW6 due, HW7 given	3/9, HW5 discussion
3/15	midterm	midterm exam	**midterm exam 1.5 hrs**	
3/17	4 Modern theory of solids	4.1 The hydrogen molecule (Kasap 4.1)		3/16, HW6 and midterm discussion
3/22			No class, Spring break	
3/24			No class, Spring break	3/23, no discussion
3/29	4	4.2 The band theory of solids (Kasap 4.2)	HW7 due, HW8 given	
3/31	4	4.3 Semiconductors and their band structure (Kasap 4.3, 4.4)		3/30, HW7 discussion
4/5	4	4.4 Density of states and Fermi distribution (Kasap 4.5, 4.6)	HW8 due, HW9 given	
4/7	4	4.5 Metals and Fermi energy (Kasap 4.5, 4.6)		4/6, HW8 discussion
4/12	4	4.6 Phonons and lattice dynamics (Kasap 4.10)	HW9 due, HW10 given	
4/14	5 Semiconductors	5.1 Intrinsic semiconductors (Kasap 5.1)		4/13, HW9 discussion
4/19	5	5.2 Extrinsic semiconductors (Kasap 5.2)	HW10 due, HW11 given	
4/21	5	5.3 Semiconductor conductivity (Kasap 5.3)		4/20, HW10 discussion
4/26	5	5.4 Excitation and recombination (Kasap 5.4)	HW11 due	
4/28	5	5.5 Diffusion, drift and random motion (Kasap 5.5, 5.6)		4/27, HW11 discussion
5/5			Instructor's office hour 2-3PM	
5/3-6			RRR week	can make appointment if needed
5/12			Instructor's last office hour 2-3 PM(or longer)	
5/13			**final exam Wed 5/12/2020, 7-10PM**	