

# Electronic properties of materials: Band structure of solids

## MSE 580B7

Spring 2020  
Class Location: Engineering B3  
Class Meeting Time: Mondays/Thursdays 12:00 – 1:20 PM  
from Feb 24 to Apr 05

Instructor: Diego Krapf      Scott 318, [diego.krapf@colostate.edu](mailto:diego.krapf@colostate.edu), 970-4914255  
Office Hours: By appointment

### **I. Rationale:**

This course is a core course for students in the MSE program. The overall objective of the MSE program is to develop students to be science and engineering professionals who use their multidisciplinary problem-solving skills to address global challenges in the field of materials science and engineering. Electronic properties of materials constitute the fundamental basis for new materials design and discovery with application in electronic and optical devices. Band structures is the second module within the electronic properties of materials series. The first and third modules within the series are (1) quantum mechanics and (3) electronic and optical properties.

### **II. Course Aims and Outcomes:**

#### ***Description and Aims***

Introductory band structure of materials regarding their electronic properties. The course describes qualitatively the concept of band structure, it introduces methods that are used to calculate band structure of solids, and it introduces basic concepts that show how transport is explained by the electronic structure of solids.

#### ***Specific Learning Outcomes:***

By the end of this course, students will:

1. Describe the features of a band structure presented in reciprocal space (gap/no gap, high symmetry points, localization, etc.)
2. Diagram the band structure of a given crystal structure.
3. Identify the relations between transport phenomena and band structures.
4. Evaluate the trends and methods for band structure engineering.
5. Describe strategies for achieving engineered band structures.
6. Explain how band structures can be studied experimentally and computationally

### **III. Format and Procedures:**

- (a) **Use of mobile devices, laptops, etc. during class:** I expect students to refrain from using laptops, cell phones and other electronic devices during class. The use of mobile phones (including sending and/or reading text messages) is not accepted during class.
- (b) **Recording of Classes:** Classroom activities may be recorded by a student for the personal, educational use of that student or for all students presently enrolled in the class only, and may not be further copied, distributed, published or otherwise used for any other purpose without the express written consent of the instructor.
- (c) **Policy on contacting the instructor:** You can contact me at any time via email using the Inbox Canvas tool to communicate. Note that there are no make-up credits and that questions about the topics to be included in the exam are only answered in class.

**IV. Course Requirements:** Whatever tasks and assignments you include in your course should be aligned with the specified learning outcomes (final learning state, skills, knowledge, attitudes and values the students leave the course with) you have defined and specified earlier.

#### **1. Class attendance** and participation policy:

Regular attendance in class is mandatory. Notifications regarding material covered in the exam, assignments, etc. will be provided only in class.

#### **2. Course readings:**

Reading materials will be provided by the instructor directly in Canvas

#### **3. Assignments:**

Homework assignments and solutions will be posted on canvas once a week. Each assignment will be due at the start of the class meeting a week from the assignment date. I plan for there to be a total of three assignments.

Assignments are turned in as a hard copy in class. Electronic copies are not accepted. Your first and last name, homework number, and course number must be written in the first page. Your homework must be stapled, and your solutions to the problems must be in the correct order. Your solutions must be clear, and you must include how you reach your results. Writing only the final solution is not acceptable.

Homework turned in after the due date without prior approval from the instructor or not complying with these guidelines will not receive credit.

#### **4. Final exam**

Final exam is closed book, but you are allowed to bring one hand-written sheet of notes (front and back). You should bring to the exams enough blank paper to solve the problems, a calculator, and your handwritten note sheet. The use of cell phone, smart phone, or computer is not allowed.

## **5. Team Quizzes**

Quizzes will be given at the start of class once or twice a week. All quizzes will be solved in pre-established teams of 3 or 4 students. The quizzes may cover any portion of the material covered in class. You are not allowed to use any electronic device during quizzes (including calculators, smart phones, etc.) and all quizzes are closed book. The use of a phone during a quiz will automatically result in a grade of zero in all the quizzes in the semester. No make-up quizzes are offered. An unexcused absence from a quiz is graded as zero. One excused absence from one quiz will result on your grade being set according to the remaining quizzes. It is your responsibility to arrive to the classes on time for the quizzes, the quiz will be graded as a team and only students that arrive on time for the quiz receive a grade.

**V. Grading** will be based on:

**Quizzes** 10%

**Assignments** 50%

**Final exam** 40%

## **VI. Academic Integrity**

The course will adhere to the Academic Integrity Policy of the CSU General Catalog (page 7, <http://www.catalog.colostate.edu/FrontPDF/1.6POLICIES1112f.pdf>) and the Student Conduct Code (<http://www.conflictresolution.colostate.edu/conduct-code>).

## **VII. Accommodations for students with disabilities**

In compliance with the University policy, I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first two weeks of the semester, except for unusual circumstances, so arrangements can be made. Students with disabilities are encouraged to find appropriate resources at <https://disabilitycenter.colostate.edu/>.

### VIII. Tentative Course Schedule (*May change during the course*)

Topics	Readings to be discussed / Assignment
<b>Week 1</b> Introduction to bands in solids. Schrodinger equation in a periodic potential. Reciprocal ( $k$ ) space.	
<b>Week 2</b> Band structure models: metals, semiconductors and insulators. Engineered band structures	Assignment 1 due
<b>Week 3</b> Population statistics for electrons and holes. Density of states. Measurements of band structure.	Assignment 2 due
<b>Week 4</b> Transport of heat and electricity in solids.	Assignment 3 due
<b>Week 5</b> Review	Final exam