Photo by Steven Koumholz

materials science & solid state chemistry
semester overview

This course is divided into three projects that are briefly described below. As we progress through the semester, the project constraints will be loosened, and the level of student autonomy in the projects will increase.

1 ATOMIC STRUCTURE, COMPOSITION, AND PROPERTIES OF MATERIALS

In Part 1, we'll use common consumer products as a basis for learning new laboratory skills and using scientific theory to explain real-world behaviors of materials. You and your teammates will select a cheap consumer product that you find interesting from the perspective of both technology and societal impacts, and you'll rip it apart to discover its material secrets. During Part 1, we will explore the many reasons why different materials are chosen for different product components, examine material chemistry and structure, and test the properties and performance of these materials in different contexts. We will also gauge how materials used in cheap consumer products impact the environment. By the end of Part 1, you will have measured a variety of material properties such as strength, hardness, and melting point, and you will be able to explain and predict observed material properties based on your understanding of the chemical composition and arrangements of atoms or molecules in the materials. You will also gain a sense of how different raw materials are produced, and what impacts the materials in consumer products have on the larger societal and environmental systems.

The assignments in Part 1 will include the following:

- Personal learning goals statement
- Assigned readings and problems on atomic structure and bonding, crystallography, mechanical and thermal properties, environmental degradation and ecosystem impact, and defects in materials
- Project proposal
- Project poster
- Self- and peer-evaluations of teaming
- Weekly open-book exams

Additional details on the Part 1 project will be provided in supplementary documents.

2 MICROSTRUCTURE-PROCESSING-PROPERTIES RELATIONSHIPS

Imagine listening to Bon Jovi's *Livin' on a Prayer* while eating ice cream and listening to a massive crowd chant your name as you cliff dive into an ocean of butterscotch pudding – this may *begin* to capture the thrill of our second course project. In Part 2, we will focus on the interrelationships among material structure, processing, properties, and performance of materials. You will learn about diffusion, binary phase diagrams, phase transformations, strengthening mechanisms, thermal processing, mechanical processing, and applications of materials. For the Part 2 project, your team will explore microstructure-processing-property connections in modern alloy systems. Your team will select an alloy system (e.g., 6061 aluminum, 4140 steel) and a fabrication or processing technique (e.g., welding, heat treating, casting), and you will design experiments and use modern laboratory equipment to answer a question of technical significance. You'll also explore where metals come from, how they are processed into a usable form, and what impacts metal extraction and processing have on people and the environment. By the end of Part 2, you will understand how to control, modify, and predict material properties and microstructure; you will be able to increase the strength, decrease the brittleness, refine the grain size, and change the microstructural features of alloy systems while humming the theme song from *The Magnificent Seven*. As a result of your Part 2 experiences, your hands will smell like oxidized metal, and you will long for the warmth of the heat treating furnaces.

The assignments in Part 2 will include the following:

- Assigned readings and problems on diffusion, phase diagrams, phase transformations, strengthening mechanisms, nucleation and growth, and metal mining and processing
- Project proposal, status report, and final written report
- Self- and peer-evaluations of teaming
- Open-book exam questions
- Lifelong learning reflection

Additional details on the Part 2 project will be provided in supplementary documents.

3 MODERN MATERIALS AND METHODS

What's the current state of materials development? What's the future of materials? In Part 3, you will study modern materials science topics such as biodegradable plastics, advanced ceramics and glasses, composites, synthetic polymers, modern alloys, biomaterials, electronics materials, contemporary processing techniques, or sustainable materials. You will explain how modern materials or materials-related technologies are having positive or negative ecosystem or societal impacts, and predict how modern materials will help solve or exacerbate the problems we face. For the Part III project, your team will select a materials science topic of technological and societal significance in today's world, and you will explore this issue through a self-designed program of research and laboratory experimentation. The final report and presentation will include a discussion of your technical results and consideration of relevant context surrounding your modern materials science topic.

The assignments in Part 3 will include the following:

- Self-assigned readings
- Project proposal
- Team-designated final deliverable
- Project presentation
- Self- and peer-evaluations of teaming
- Lifelong learning reflection

Additional details on the Part 3 project will be provided in supplementary documents.