The Course: This is a survey course of materials chemistry/solid-state chemistry. Lectures will be based on the themes in Smart & Moore’s text, *Solid State Chemistry* (structure and bonding, selected characterization techniques, solid state synthesis, structure-property relationships), supplemented by materials from other texts (especially Rao & Gopalakrishnan and West) and from the more recent literature. Some specific course topics include: crystal systems/unit cells, structure types, porous materials, nanostructured materials, ceramics, liquid/molecular crystals, X-ray diffraction, bonding in solids, electronic structure, solid state synthesis, and thin film preparation. Other topics will be introduced through student presentations, including selected topics from the following list: defects/interfaces, optical/dielectric properties, electrical/thermal conductivity, magnetic/optical materials, piezoelectric materials, biomedical materials, catalysts. Chemistry graduate students should enroll in Chem 8201, undergraduate students in Chem 4201. Graduate students from other departments should discuss their enrollment choice with the instructor.


Supplementary Texts:

Reading Assignments: These should be read in advance so that they can be discussed during the lectures.

Structural Models: Models of important structure types will be kept in Kolthoff 193. You may use them there to learn and understand these structures, but please do not remove them from that room. I encourage you to use the physical models of the structures together with the computer program called CrystalMaker to help you learn and visualize structures. The Department of Chemistry has a site license of CrystalMaker. The program is available in the Microlab in Smith 101D, across from the 101J conference room.
Grading:  

<table>
<thead>
<tr>
<th></th>
<th>Chem 8201</th>
<th>Chem 4201</th>
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<tbody>
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<td>Assignments:</td>
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<tr>
<td>Group presentation:</td>
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</tr>
<tr>
<td>Midterm exam 1</td>
<td>18%</td>
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<td>Midterm exam 2</td>
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</tr>
<tr>
<td>Final exam</td>
<td>24%</td>
<td>25%</td>
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</table>

During the course, all grades will be scored on a percentage basis. The final percentage grade will be converted to a letter grade, with the class average corresponding approximately to a B+ grade. At various points during the semester, I will inform you of class averages. Separate averages will be used for Chem 8201 and Chem 4201, and letter grades may be assigned on different scales for the two courses. Typical letter grades in previous years were A (>85%), B (>75%), C (> 65%), but some variations are possible from year to year.

The A-F and S-N grading systems will be used in this course. If you are taking the course on an S-N basis, you will receive an S only if your grade on the A-F scale would have been C- or better. An I grade will be assigned only to students who have received passing grades on all work up to the final exam. If this occurs, you are responsible for contacting me before the end of finals week. Otherwise, a grade of F will be entered on the grade report.

Course Web Page: The course Canvas site will be used for posting the syllabus, lecture notes, grades, and other course-related material. Please ignore any letter grades listed on the Canvas site. These are automatically generated by Canvas but will not be used during the course.

University-wide policies on the following topics:

- Student Conduct Code
- Use of Personal Electronic Devices in the Classroom
- Scholastic Dishonesty
- Makeup Work for Legitimate Absences
- Appropriate Student Use of Class Notes and Course Materials
- Grading and Transcripts
- Sexual Harassment
- Equity, Diversity, Equal Opportunity, and Affirmative Action
- Disability Accommodations
- Mental Health and Stress Management
- Academic Freedom and Responsibility

can be found at this webpage: https://policy.umn.edu/education/syllabusrequirements-appa
Tentative Course Outline

Introduction to course and to solid-state chemistry

Structure (Chpt. 1 Smart & Moore, Chpt. 1 West, Chpt. 1 Rao & Gop.)
- Crystal systems and unit cells
- Close packing and space filling polyhedra approaches
- Structure types
- Factors that influence crystal structure
- Special topics (silicates, carbon, amorphous materials, liquid crystals)
  (Chpts. 6, 10 Smart & Moore, Chpts. 4.12, 4.13, 4.14, 6.11, 6.12, 8.7, 8.9, Rao & Gop.,
  Chpt. 7 in Cheetham & Day Cpd.s.)

Characterization (Chpt. 2 Smart & Moore, Chpt. 5 West, Chpt. 2 Rao & Gop., Chpts. 1 & 2,
Weller)
- X-Ray diffraction (powder methods, PDF files, indexing, point groups, space groups,
  identification of unknowns)
- Neutron diffraction
- Small-angle X-ray scattering (from H. Schnablegger, Y. Singh, A Practical Guide To
  SAXS, Anton Paar: 2006) (Order a newer version of The SAXS Guide at this website
  (free): https://www.anton-paar.com/corp-en/saxs-guide (Do this right at the beginning of
  the semester to receive it on time.)

Electronic structure of solids (Chpts. 4, 10.4 Smart & Moore, Chpt. 8, West, Chpt 6 Rao & Gop.,
- Band diagrams
- Effects of nanostructure and quantum size effects
- Conductive polymers

Synthetic methods in solid-state chemistry (Chpt. 3 Smart & Moore, Chpt. 4 West, Chpt. 3 Smart
& Moore, Chpt. 3 Rao & Gop., student presentations)
- Bulk methods for powders: high temperature and low temperature syntheses
- Single crystal growth
- Thin films and surfaces
- Nanomaterials

Phase diagrams (if time permits)
Defects and nonstoichiometry (if time permits)

Structure-property relations and materials design (most of these topics may be covered as
student group presentations)
Bibliography on materials chemistry and solid-state chemistry


• Wold, A.; Dwight, K. *Solid State Chemistry*, Chapman & Hall, 1993. Good introductory chapters on crystal structure, characterization, and phase diagrams; the rest of the book is an anecdotal view of the author’s research on metal oxides and sulfides.


**Books on crystallography**
• Bragg, W. L. *The Development of X-ray Analysis*, Hafner, 1975. Interesting from both a historical and scientific perspective.

**Books on solid state physics**

**Selected journals covering research in materials and solid-state chemistry**
Student group presentations will be given in December during class (Dec. 5, Dec. 10). As a group of 3 graduate students, give a 20-minute presentation on one of the following topics and prepare one assignment question to be completed by everybody. The material presented by the students is fair game for the final exam.

**Student Presentation Topics**

- Molecular electronics
- Luminescent and laser materials
- Piezo-electric devices
- Ferroelectric materials
- Thermoelectric materials
- Superhard materials
- Electrical energy storage
- Chemical sensors (solid state sensors)
- High temperature superconductors
- Optical properties of hybrid organic-inorganic materials (luminescence, photochromism, nonlinear optics, plasmonics)
- Photonic crystals
- Magnetically responsive nanostructures

The topics will be assigned on a first-come–first-served basis.

You can start your presentations with some basic background from general textbooks and review articles, but you should also include at least one or two examples from the recent primary literature in your discussions.

For the topic you select, provide the necessary background information, explain typical methods of synthesis, structural and compositional aspects, any special characterization techniques (if applicable), and how the structure-property relationships associated with the material(s) lead to their applications. You should also discuss the relevance of the work and possible future directions (you can be creative here).

You should use a lecture/teaching style, incorporating class interaction, rather than a straight seminar style. Make good use of the board, PowerPoint or overhead projector, and/or other media that you might find suitable. You should also provide the class with handouts in the form of a pdf file, which must include a list of relevant references or recent reviews. (Send me that file at least two days before your presentation, so that I can distribute it to the other class members.) Divide your work equally among the group members. Please allow time for questions in class.

**One week before your presentation, hand out the assignment question,** based on one of the references cited in your presentation, to the rest of the class (including both Chem 4201 and Chem 8201 students). The questions are meant to give your classmates the opportunity to read the article before class and to introduce them to the topic. Hopefully this will prepare everyone for better participation during your presentation. The questions are due at the beginning of your presentation and will be graded by your group. At least two days before your presentation, send me the...
PowerPoint file of your presentation so that I can post it on Canvas. Please do not use a dark background, in case students want to print out the slides to take notes.

The information presented by the students is fair game for the final exam. Please check your topic selection with me by November 7. Meet with me by Nov. 21 to discuss the outline of your presentation. You should have an outline prepared for this meeting. All group members are expected to be present for the meeting.

**Evaluation of Oral Presentations**

The oral presentations will be graded according to the following criteria:

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<thead>
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<th>Category</th>
<th>Outstanding</th>
<th>Very Good</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
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<tbody>
<tr>
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<td>Structural features:</td>
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<td>Synthetic methods:</td>
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<td>Structure-property relationships:</td>
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<tr>
<td>Future outlook:</td>
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<tr>
<td>Understanding of material:</td>
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<td>Organization:</td>
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<td>Submitted files to professor on time:</td>
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<td><strong>Total:</strong></td>
<td><strong>190 pts.</strong></td>
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Note: G = group grade, I = individual grade

Comments: