Chemistry 8201/4201        Materials Chemistry        Fall 2016
11:15–12:30 h Tuesdays/Thursdays
Smith 231

Instructor:     Andreas Stein; 219 Smith;  612-624-1802    a-stein@umn.edu
Office hours: Tue 12:30–13:30 h, Thu 16:45–17:45 h; or by appointment
http://www.chem.umn.edu/groups/stein

TA:            Zhao Wang; 366 Kolthoff; 612-626-8036    wang6235@umn.edu
Office hours: Wed 16:45–17:45 h

The Course: This is a survey course of materials and solid-state chemistry. Lectures will be based on the themes in West’s text, Solid State Chemistry And Its Applications (structure and bonding, selected characterization techniques, solid state synthesis, structure-property relationships), supplemented by materials from other texts (especially Rao & Gopalakrishnan) 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. Our textbook is supported by a website which gives you access to a CrystalMaker viewer program to view and manipulate many representative crystal structures. I encourage you to use this program together with the physical models of the structures. The Department of Chemistry also has a site license of the full version of CrystalMaker. The program is available in the Microlab in Smith 101C/D/E. http://www.wiley.com/go/west/solidstatechemistrystudent
### Grading:

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<thead>
<tr>
<th></th>
<th>Chem 8201</th>
<th>Chem 4201</th>
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<tbody>
<tr>
<td>Quizzes:</td>
<td>4%</td>
<td>4%</td>
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<tr>
<td>Assignments:</td>
<td>25 %</td>
<td>25 %</td>
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<tr>
<td>Short synthesis presentation:</td>
<td>n/a</td>
<td>18 %</td>
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<tr>
<td>End-of-term applications presentation:</td>
<td>18 %</td>
<td>n/a</td>
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<tr>
<td>Midterm exam (Th., Oct. 27):</td>
<td>25 %</td>
<td>25 %</td>
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<tr>
<td>Final exam:</td>
<td>28 %</td>
<td>28 %</td>
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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 Moodle site can be accessed by going to your “my page” at [https://www.myu.umn.edu/](https://www.myu.umn.edu/). After you login, click on the “My Courses” tab and then on the appropriate link for the course Moodle site (CHEM 4201/8201). This site will be used for posting the syllabus, lecture notes, grades, and other course-related material.

**Scholastic Dishonesty Policy:** Scholastic dishonesty is conduct as described as follows (from "CLA Classroom Grading and Examination Procedures"): "Scholastic dishonesty is any act that violates the rights of another student with respect to academic work or that involves misrepresentation of a student's own work. Scholastic dishonesty includes (but is not limited to) cheating on assignments or examinations; plagiarizing (misrepresenting as one's own anything done by another); submitting the same or substantially similar papers for more than one course without consent of all instructors concerned; depriving another of necessary course materials; sabotaging another's work." A student found guilty of scholastic dishonesty will receive a grade of zero for the work involved; the student may also be reported to the appropriate Scholastic Conduct Committee.
**Tentative Course Outline**

Introduction to course and to solid-state chemistry

Structure (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. 4.12, 4.13, 4.14, 6.11, 6.12, 8.7, 8.9 Rao & Gop., Chpt. 7 in Cheetham & Day Cpds.)

Characterization (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

- Band diagrams
- Effects of nanostructure and quantum size effects
- Conductive polymers

Synthetic methods in solid-state chemistry (Chpt. 4, West, 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)
Possible topics for 9-minute synthesis presentations (Chem 4201):
Methathesis synthesis of ceramics
Microwave synthesis
Sonochemical synthesis
High pressure synthesis
Hydrothermal synthesis
Solvothermal synthesis
Ionothermal synthesis
Sol-gel processing
Non-hydrolytic sol-gel processing
Soft templating of mesoporous materials
Vapor phase transport method
Coating methods (spin coating, dip coating, doctor blade)
Cathode sputtering
Vacuum evaporator
Liquid phase epitaxy
Molecular beam epitaxy
Pulsed laser ablation/deposition
Chemical vapor deposition (CVD, MOCVD)
Atomic layer deposition
Self-assembled monolayers
Combinatorial synthesis
Nanoparticle synthesis

Possible topics for student group presentations (Chem 8201):
Materials for gas storage
Materials for tissue engineering
Bioactive glasses
Molecular electronics
Fiber optic materials
Luminescent and laser materials
Piezo-electric devices
Ferroelectric materials
Thermoelectric materials
Ceramers/Ormocers
Superhard materials
Electrical energy storage: batteries
Electrical energy storage: supercapacitors
Fuel Cells
Chemical sensors
High temperature superconductors
Catalyst and catalyst support materials
Biomimetic materials
Self-healing materials
Nonlinear optical materials
Optical properties of hybrid organic-inorganic materials (luminescence, photochromism, nonlinear optics, plasmonics)
Photonic crystals
Magnetically responsive nanostructures
Another suitable topic, upon mutual agreement with the instructor.
Bibliography on materials chemistry and solid-state chemistry


**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**

Chemistry 4201 – Materials Chemistry – Fall 2016

9-Minute Undergraduate Student Presentations

Every undergraduate student registered for Chem 4201 will have to give one 8–9-minute presentation on synthetic methods between now and November 22. These presentations will probably take place in the mid October to mid November time-frame, depending on where I'll be in lecture. The material presented by the students is fair game for the final exam. Please choose one of the following topics by September 20, so that I can plan my lecture schedule accordingly. First come-first serve. You should prepare your presentation well in advance because I'll let you know only about a week in advance when the presentation will be given. You must discuss the outline of your presentation with me in advance of the presentation.

Please send me your presentation (up to 6 slides) as a pdf file at least 2 days before the lecture so that I can forward it to the rest of the class. You will lose points if your presentation exceeds 9 minutes.

Methathesis synthesis of ceramics
Microwave synthesis
Sonochemical synthesis
High pressure synthesis
Hydrothermal synthesis
Solvothermal synthesis
Ionothermal synthesis
Sol-gel processing
Soft templating of mesoporous materials
Vapor phase transport method
Coating methods (spin coating, dip coating, doctor blade)
Cathode sputtering
Vacuum evaporator
Liquid phase epitaxy
Molecular beam epitaxy
Pulsed laser ablation/deposition
Chemical vapor deposition (CVD, MOCVD)
Atomic layer deposition
Self-assembled monolayers
Combinatorial synthesis
Nanoparticle synthesis

In 8–9 minutes (NOT more), give a general overview of the method. Include diagrams/images/schematics of associated equipment, and state the type of materials suitable for the technique. Then, using one recent reference (2010-2016) from the literature, provide some details for this method (conditions, precursors, etc.). You should also discuss the product structure/morphology/composition/homogeneity. Name advantages of the technique (compared to some other related techniques), as well as disadvantages or challenges. You may use a powerpoint presentation (not more than 6 slides), the white board, or both. You must list the recent reference you used, as well as any other reference material. Also, provide 1 homework question related to your topic to the class. You will grade everybody’s answer to this homework question.
**Points:**
Overview of technique (2)
To what materials is this technique applicable (1)
Equipment (1)
Reaction conditions (1)
Starting materials/intermediates/products (as applicable) (1)
Example from recent reference (2)
Product structure/morphology/composition/homogeneity (2)
Advantages/disadvantages/challenges (1)
Clarity of presentation (volume, speaking clearly, clear explanations) (3)
Clarity/usefulness of slides/board material (2)
References listed in proper ACS format (1)
Presentation exceeds 9 minutes (-1 per excess minute)
Homework question (1)
Discussed outline with professor (1)

**Reference format:**
Journal:
Author 1; Author 2; Author 3; etc. Title of Article. *Journal Abbreviation Year, Volume*, Inclusive Pagination.

Book chapter:
Author 1; Author 2; Author 3; etc. Chapter Title. *Book Title*, Edition Number; Series Information (if any); Publisher: Place of Publication, Year; Volume Number, Pagination.

Chapter in edited book:
Author 1; Author 2; Author 3; etc. Chapter Title. In *Book Title*, Edition Number; Editor 1, Editor 2, etc., Eds.; Series Information (if any); Publisher: Place of Publication, Year; Volume Number, Pagination.

Websites:
Author (if any). Title of Site. URL (accessed Month Day, Year), other identifying information (if any).
Student Group Presentations will be given during class on Dec. 6, Dec. 8 and Dec. 13 — two groups of 3 students per class. As a group, give a ca. 35-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**

- Materials for gas storage
- Materials for tissue engineering
- Bioactive glasses
- Molecular electronics
- Fiber optic materials
- Luminescent and laser materials
- Piezo-electric devices
- Ferroelectric materials
- Thermoelectric materials
- Ceramers/Ormocers
- Superhard materials
- Electrical energy storage: batteries
- Electrical energy storage: supercapacitors
- Fuel Cells
- Chemical sensors
- High temperature superconductors
- Catalyst and catalyst support materials
- Biomimetic materials
- Self-healing materials
- Nonlinear optical materials
- Optical properties of hybrid organic-inorganic materials (luminescence, photochromism, nonlinear optics, plasmonics)
- Photonic crystals
- Magnetically responsive nanostructures
- Another suitable topic, upon mutual agreement with the instructor.

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 hand-outs 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 two questions based on one of the references cited in your sections to the rest of the class. 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.

The information presented by the students is fair game for the final exam. Please check your topic selection with me by November 8. Meet with me by Nov. 17 to discuss the outline of your presentation.

**Evaluation of Oral Presentations**

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

<table>
<thead>
<tr>
<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>
<td>Background information:</td>
<td>15 pts. G</td>
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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>
<td>15 pts. G</td>
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<td>Understanding of material:</td>
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<td>Organization:</td>
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<tr>
<td>Clarity of presentation (delivery):</td>
<td>15 pts. I</td>
<td>( )</td>
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<tr>
<td>Graphics:</td>
<td>15 pts. G</td>
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<td>Response to oral questions:</td>
<td>15 pts. I</td>
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<tr>
<td>Handouts:</td>
<td>15 pts. G</td>
<td>( )</td>
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<td>Questions:</td>
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<td>Answers to questions:</td>
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<td>Consulted with professor?:</td>
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Total: 200 pts. equivalent to 18% of the course grade

Note: G = group grade, I = individual grade

Comments: