MatSE 405, Spring 2008 **Microstructure Determination**

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office hours: MW 10:00-11:30, and by appointment.

TEACHING ASSISTANTS: The lab TAs will be Wenjun Cai cai3@uiuc.edu and Abhishek Chatterjee achatte2@uiuc.edu. The grader for problem sets and quizzes will be Teresa Lazarz slazarz2@uiuc.edu. Wenjun and Abishek will hold office hours after the labs on Tuesdays and Thursdays in 113 Ceramics Bldg. Teresa's office hours will be announced soon.

SCHEDULE AND LOCATION: Lectures meet Monday and Wednesday, 1–1:50 in 305 Materials Science and Engineering Bldg. The lab sections will meet in 113 Ceramics Bldg. beginning the week of January 28. The lab sections will not meet the week of April 28.

OBJECTIVES: Your goal as a student in this course should be to understand the fundamentals of crystallography, diffraction, microscopy, and spectroscopy (core-level, Raman, and NMR); and the application of these methods and concepts in characterization of the microstructure of materials. More specifically, you should understand

1. the science of microscopy and diffraction based on the physical optics of scalar waves and elastic scattering of waves from atoms;
2. how the design and performance of simple microscopes and diffractometers is based in the fundamentals of geometrical and physical optics;
3. diffraction from simple objects and crystals in one-, two-, and three-dimensions;
4. the operation of powder diffractometers for studying the microstructure of materials;
5. the use of optical bench components for optical metrology; and
6. the fundamentals of the use of spectroscopies (core-level, Raman, and NMR) for microanalysis and the determination of structure and composition.

Some examples of specific outcomes you should work toward:

1. Given a powder specimen of a material with a simple crystal structure, be able to collect, analyze and understand powder diffraction data.
2. Be able to describe the construction of transmission and reflection optical microscopes; and the factors that control resolution, and contrast mechanisms.
3. Be able to calculate intensities of a microscope image of a one-dimensional diffraction grating using bright-field, dark field, and phase contrast apertures.

4. Be able to use Ewald sphere constructions and calculations of structure factors to predict diffraction conditions and intensities from a three-dimensional crystal.

5. Be able to calculate estimates of x-ray mass absorption coefficients at x-ray energies.

6. Be able to calculate estimates of electron extinction lengths in transmission electron microscopy.

7. Be able to collect, analyze and understand Raman spectroscopy data.

EXAMS: I will give a quiz every Thursday beginning Jan 24. The final exam (1:30-4:30, Tuesday, May 6 in 305 Materials Science and Engineering Bldg) will be comprehensive. You can bring two sheets of notes (both sides of a 8.5×11 sheet of paper) to the final.

HOMEWORK: Homework problems will be assigned approximately once a week. You should work on the problems independently and then compare answers with your classmates if you wish. If you have difficulty completing the problems I encourage you to collaborate with your classmates or come see me, or the teaching assistants, for assistance. A penalty of 10% per day (linear decay, not exponential, and not counting weekend days) will be taken off for late homework. After the solutions have been distributed, an additional 20% will be subtracted. Many of the problem sets will include the use of MatLab.

LABORATORY: The laboratory experiments will give you hands-on experience in x-ray diffraction, optics, NMR, and Raman spectroscopy. You will work in groups of two; each group will keep a laboratory notebook and each group will turn in a joint report report and analysis of the experiments. Each experiment will extend over 2 weeks. A partial draft of the laboratory report must be shown to the lab TAs at the beginning of the second lab period. The final laboratory report will be due in the laboratory one week after the completion of each lab. The laboratory grade will be determined by the quality of the presentation and analysis of the results. You will use MatLab to analyze and plot data acquired in the laboratory. A penalty of 10% per day will be taken off for late lab reports.

GRADING: The following weighting factors will be used to determine your final grade:

final exam: 30 %
laboratory: 30 %
quizzes: 25 %
homework: 15 %

Grades will be assigned using the following scale:
A^+=98-100%, A=93-97%, A^-=90-92%
B^+=88-90%, B=83-87%, B^-=80-82%
C^+=78-80%, C=73-77%, C^-=70-72%
D^+=68-70%, D=63-67%, D^-=60-62%
E<60%
At my discretion, the minimum score to earn a certain letter grade may be lowered but it will not be raised.

TEXT: "The Basics of Crystallography and Diffraction," by C. Hammond (2nd edition, Oxford University Press, 2001). The assigned reading should be completed *before* the week indicated on the classroom schedule so that you will be prepared to discuss the readings in class. Several other texts are on reserve at the Engineering Library.