Syllabus

Diffraction Physics of Materials

MATSE 580

Meeting Time /Location TH 2:30-3:50 pm, MSEB 4101

***Instructors*:** Prof. Jian-Min (Jim) Zuo, MRL1006, 244-6504, jianzuo@uiuc.edu

***Course Format and Philosophy*:** This course is designed to give an introduction of theory and techniques of diffraction, especially the principle of modern diffraction techniques and their applications to materials science and engineering. Field trips will be arranged to obtain hands-on experience of the experimental methods. Topics include elastic and inelastic scattering of periodic and nonperiodic structures, X-ray, neutron and electron instrumentation, powder method, thin film and surface scattering, and electron diffraction.

There will be *I*) a mid-term examination, *II*) a term paper, and *III*) problem assignments to solve. The grade will given based on the grade of all three above, each contributes to 1/3 of the total score. The midterm will be given in class that will last for 80 minutes. The midterm will be arranged in the second half of the semester. The term paper includes an oral presentation. You are expected to present your term paper in class, which will counts toward your term paper grade.

Course Goals and Objectives When you have successfully completed this course, you will 1) be able to apply diffraction theory to interpret experimental diffraction patterns and 2) develop quantitative and qualitative understanding of advanced diffraction techniques for material characterization, specifically, the principle of these techniques, their applications and limitations.

Lecture Outline:

I. Introduction
- Properties of X-Rays
- X-ray scattering

II.Kinematic approximation
- Atomic scattering of X-rays, Neutrons and Electrons
- Scattering from a molecule
- Scattering from a crystal lattice
- Crystals; symmetry, lattice, real and reciprocal spaces
- Diffraction from a small crystal and crystal structure factors
- The measured integrated intensity

III.Instrumentation
- X-ray sources and detection
- Neutrons
- Electrons

IV.Diffraction techniques
- Powder method
- Surface scattering, X-ray
- Transmission Electron diffraction
- Resonant X-ray scattering

V.Structural analysis
- Effect of temperature vibration on the intensity from a small crystal
- Patterson map and direct method
- Rietveld analysis for powder diffraction
- X-ray studies of order and disorder

Text Recommended: Jens Als-Nielsen and Des McMorrow, Elements of Modern X-ray Physics, Wiley, 2001, Jon Wiley and Sons, Ltd ($79 paperback version, www.amazon.com or wiley's website), Warren, B.E., X-ray diffraction, Dover (Amazon offers it for $14). N. Kasai and M. Kakudo, Kondasha, "X-ray Diffraction by Macromolecules", Springer 2005 (Available as PDF files on UIUC Library web site);

Reading Materials:

"Diffraction Physics", J.M. Cowley, 3rd Edition, 1995, North-Holland
"Optical Principles of the Diffraction of X-rays" R.W. James, 1950, Bell
"Thermal Vibrations in Crystallography" BTW Willis and A.W. Pryor, 1975, Cambridge
"The Determination of Crystal Structures", H. Lipson and W. Cochran, 1966, Cornell
"Dynamical Theory of X-ray Diffraction" A. Authier, 2001, Oxford
"Structure Determination by X-ray Crystallography", M.F.C. Ladd and R.A. Palmer, Plenum, 1994