CH 580X - Electron Microscopy-I (3 credits)

Spring Term 2011

Instructor: Dr. Yi Liu, Director of OSU Electron Microscopy Facility, 1071 Cordley Hall
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Classroom: to be determined
Meeting time: Twice a week with each 80 minutes, data of meeting to be determined

Introduction: This course constructs the basics of the electron microscopy and its applications for students from both materials science and biological sciences.

Prerequisites: General Physics (PH 211, or equivalent) and General Chemistry (CH 221, 222, 223, or equivalent)
Co-prerequisites: none
Enforced Prerequisites: none

Office Hours: to be determined

Textbook: Lecture hand-out

Reference books:

1. Joseph I. Goldstein and Harvey Yakowitz, *Practical Scanning Electron Microscopy*, Plenum Press, New York and London.
2. David B. Williams and C. Barry Carter, *Transmission Electron Microscopy*, Plenum Press, New York and London.
3. J. J. Bozzola, and L. D. Russell, *Electron Microscopy-Principles and Techniques for Biologists*. Jones and Bartlett Publishers: Boston.

Course Content (2 credits)

1. **Instrumentation:**
   - Duality of electron beam;
   - Basic set-up of TEM and SEM;
   - Electron sources;
   - Lenses and apertures;
   - Astigmatism;
   - Resolution;
   - Sample holders;
   - Attachments;
2. **Interaction between electron beam and atoms:**
   - Elastic scattering and structure factor
   - Inelastic scattering and X-Ray
3. **Electron diffraction and analysis:**
   - Reciprocal space and lattice;
   - Bragg Law;

- The Ewald sphere and deflection;
- Structure factor and Extinction of diffraction;
- Diffraction from crystal and indexing the diffraction patterns;
- Thin film effect;
- Kikuchi patterns;
- Convergent-beam diffraction

4. **Contrast of image in TEM:**
   - Mass thickness contrast;
   - Diffraction contrast: Bright field, dark field, two-beam, weak-beam, multi-beam and applications
   - Phase contrast: atomic level lattice images, Scherzer defocus and experimental considerations;
   - Contrast in biological samples;
5. **Sample Preparations:**
   - Powder samples;
   - Nanoparticles;
   - Metals & Alloys, ceramics, Electrical devices and thin films;
   - Biological sample Preparations: Fixation, Critical point drying, staining;
6. **Contrast of image in SEM:**
   - Secondary electron image;
   - Backscattering electron images (Z contrast and channeling contrast);
7. **Energy Dispersive Spectrometry**
   - The detector and basic set-up;
   - Qualitative analysis;
   - Artifacts in the spectrum;
   - Spatial resolution;
   - Quantitative analyses: ZAF and Cliff-Lorimer method and practical considerations;
8. **Introduction to Electron Energy Loss Spectrometry (EELS)**
   - Experimental set-up;
   - The spectrum and applications;

Laboratories (1 Credit):

Lab 1 Diffraction experiments on single crystals, polycrystalline and amorphous alloy
Lab 2 Mass thickness contrast and diffraction contrast
Lab 3 Sample preparations
Lab 4 Energy dispersive spectrometry

Tentative Course Schedule

Date	Lectures	Content
3-29-2011	1	Instrumentation-1
3-31-2011	2	Interaction - Elastic and inelastic scattering
4-5-2011	3	Diffraction-1 Reciprocal space
4-7-2011	4	Diffraction-2 Diffraction analysis, thin film effect
4-12-2011	5	Diffraction-3 Kikuchi patterns, introduction to convergent-beam diffraction (CBED)
4-14-2011		Lab-1 Diffraction
4-19-2011	6	Contrast in TEM-1 Mass thickness contrast, diffraction contrast
4-21-2011	7	Contrast in TEM-2 Diffraction contrast
4-26-2011		Midterm Exam
4-28-2011	8	Contrast in TEM-3 Diffraction contrast and Phase contrast
5-3-2011	9	Contrast in TEM-4 Phase contrast
5-5-2011		Lab 2 Contrast in TEM
5-10-2011	10	Sample preparation
5-12-2011		Lab-3 sample preparation
5-17-2011	11	Contrast in SEM: SE, BSE (Z-contrast, channeling contrast)
5-19-2011	12	EDS
5-24-2011	13	Introduction to EELS
5-26-2011		Lab-4 SEM Energy Dispersive Spectrum and quantitative analysis
5-31-2011		Final Exam

Grading:

Midterm	30%
Final Exam	30%
Homework	10%
Lab Report	30%
TOTAL	100%

Grading Scale

P= Total points accumulated (maximum is 100)

A+	$P \geq 95$
A	$90 \leq P < 95$
A-	$86 \leq P < 90$
B+	$80 \leq P < 85$
B	$75 \leq P < 80$
B-	$70 \leq P < 75$
C+	$65 \leq P < 70$
C	$60 \leq P < 65$
C-	$55 \leq P < 60$
D+	$50 \leq P < 55$
D	$45 \leq P < 50$

D- $40 \leq P < 45$
F $P < 40$

Policy on Deferred Grades: An "I" grade will only be given if the student is unable to complete the course because of an emergency or health problems, and the student is not failing the course.

Statement Regarding Students with Disabilities
Accommodations are collaborative efforts between students, faculty and Disability Access Services (DAS). Students with accommodations approved through DAS are responsible for contacting the faculty member in charge of the course prior to or during the first week of the term to discuss accommodations. Students who believe they are eligible for accommodations but who have not yet obtained approval through DAS should contact DAS immediately at 737-4098.

Student Conduct
Every student attending this course is required to abide by the principles of academic integrity. Academic integrity means that a student is honest with him/herself, fellow students, instructors, and the University academic code. Therefore no student should falsely claim the work of others as his/her own, or misrepresent him/herself to obtain a higher academic performance which does not reflect his/her own work or personal knowledge. Cheating will not be tolerated. All homework and projects must be an individual effort unless specifically noted. **Should copying occur, both the students related will automatically be given a zero grade for the assignment. Penalty for violation of this Code will be possibly extended to the failure of this course and University disciplinary action.** Therefore avoid all appearance of improper behavior! Students who witness cheating should report the incident to the instructor as soon as possible.