Transmission Electron Microscopy Practical Lab Syllabus

MATSCEN 6741 - SP23

Course Information

Course times and location: A lecture/demonstration and a 3-hour laboratory per week. Location: CEMAS Digital Theatre (room 144).

- Lecture/demonstration on Monday, 3 p. m. – 5 p. m.
- Lab day/time TBD

Credit hours: 2
Mode of delivery: In-person

Instructors

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Teaching Assistant

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Course Prerequisites

You should have some knowledge of elementary crystallography and reciprocal lattice construction. You should understand Bragg's Law and the Ewald sphere construction.

Course Description

Objective: students will develop a basic understanding of practical aspects of transmission electron microscopy (TEM) operation

Content: Topics will include:

- Operation, alignment, and calibration of the TEM
- Electron Diffraction, Bright Field, Dark Field, and STEM imaging.
- X-ray analysis in the S/TEM.
- Crystal orientation and diffraction indexing.
- Biological sample imaging and preparatory imaging for cryo-TEM.

How This Course Works

Mode of delivery: Each week have a lecture/demonstration session on Monday from 3 to 5 p. m. and a 3-hour lab session. Both will take place in within Digital Theatre (room 144) and Tecnai 30 (room 140) at CEMAS. Lab sessions start the second week of the course, and day/time will be decided during the first week of the semester.

Credit hours and work expectations: This is a 2 credit-hour course. Students should expect around 5 hours of work per week, divided in 1-2 hours per week of lecture/demo, 3 hours per week of practical lab, and 1-2 hour of homework (assignments/lab reports).

Grading: This course is graded A-E. Grading is based on lab reports and on a practical exam at the end of the term. The practical exam counts the same as one lab report.

Attendance and participation requirements:

- You are expected to attend all lecture/demonstration and lab sessions. If you have a situation that might cause you to miss a class, discuss it with instructor as soon as possible. Unexcused class absences will factor into the grade.
- You are expected to present a lab report after each lab session. Lab reports are due one week after the lab. In any event, lab reports will not be accepted any later than 5:00 pm on the final day of class. See assignment section below for more information about lab reports.
- You may practice for the practical exam any time after the last lab has finished. You should contact the instructor to schedule time for practice.
- It is your responsibility to contact instructor to schedule your practical exam. It may be scheduled any time before the end of finals.

Descriptions of Major Course Assignments

Lab Assignments/Reports

- Each laboratory session will have an assignment/lab repot. The laboratory notebook should be a record of **all your observations** during the lab sessions as well as **discussion of your results**.
- Photomicrographs and diffraction patterns should be printed and included in your notebooks/reports and sized to be legible.
- You must include all your data so that we can follow your analysis.
- You may share the micrographs of your lab session with your partners, but you are expected to write the lab report individually.

Course Schedule

		Common		
Week	**Day**	**Lecture**		**Labs**
1	9-Jan	Course Intro & Specimen Interactions		
	16-Jan	Martin Luther King Jr. Day		
2	23-Jan	Operation 1		Lab 1
3	30-Jan	Operation 2		Lab 2
4	6-Feb	Imaging & Sample Loading		Lab 3
5	13-Feb	Electron Diffraction		Lab 4
6	20-Feb	Objective Aperture & TEM Imaging Modes (BF and DF)		Lab 5
7	27-Feb	STEM		Lab 6
8	6-Mar	Operations & Alignment review		
	13-Mar	Spring Break		
		Crystalline Materials	**Biologic Materials**	
9	20-Mar	EDX	Negative Staining & Single Particles Imaging	Lab 7C // Lab 7B
10	27-Mar	Kikuchi Lines Sample Orientation	Cryo-EM vs RT Imaging	Lab 8C // Lab 8B
11	3-Apr	Crystallographic Imaging	Sample Preparation and Imaging of Tissues Part 1	Lab 9C// Lab 9B
12	10-Apr	Sample Preparation	Sample Preparation and Imaging of Tissues Part 2	Practice
13	17-Apr			Practice / Exam
14	24-Apr			Practice / Exam

This is a tentative schedule. It may be revised due to instrument availability, holidays, conferences, etc.

Lab outline

Lab 1: Basic Operation
Goal: Learn knobs, initial alignment, and operation of illumination system
Sample: Au islands
Task: Scope alignment, gun operation

Lab 2: Basic Operation
Goal: Learn knobs, initial alignments, and operation of imaging system
Sample: Au islands
Task: Scope alignment, gun operation

Lab 3: Imaging
Goal: Learn digital camera and software operation
Sample: Grating replica
Task: Flat field, magnification calibration

Lab 4: Diffraction
Goal: Learn optimization and collection of electron diffraction patterns
Sample: Polycrystalline Al or Au sample
Task: Electron diffraction collection and calibration

Lab 5: Objective aperture
Goal: Understand function of Objective aperture, formation BF/DF images
Sample: MoO_3
Task: Image with different apertures & defocus

Lab 6: STEM
Goal: Familiarize with microprobe/nanoprobe, HAADF
Sample: Al-Cu Alloy, Pt nanoparticles
Task: Image nanoparticles, image diffraction sample with different CL

Crystalline Materials

Lab 7C: EDX
Goal: Familiarize with EDX detector and analysis, CL method, and statistics
Sample: NiAl sample
Task: Determine k-factor, Uncertainty calculation

Lab 8C: Crystal orientation/Kikuchi lines
Goal: Identify Kikuchi lines, learn to set up crystal orientation using Kikuchi lines
Sample: [001] Si
Task: Tilt to several zones, predict 3rd zone from stereo projection; index patterns

Lab 9C: Review
Goal: Put in practice acquired knowledge by working on a case sample

Sample: -
Task: It will be specified at the starting of the lab

Biologic Materials

Lab 7B: Negative Staining & Single Particles Imaging
Goal: Learn negative staining of protein samples. Identify and image individual stained protein molecules
Sample: Apoferritin
Task: Determine the radius of apoferritin

Lab 8B: Cryo-EM vs RT imaging
Goal: Familiarize with FFTs and defocus
Sample: -
Task: Identify "good" vs. "bad" images based on FFTs

Lab 9B: Sample preparation and imaging of tissue
Goal: Learn basics of tissue sample preparation.
Sample: -
Task: Fix a tissue sample for sectioning and staining. Tissue samples imaging and identify sample prep. artifacts

Recommended/Optional Materials and/or Technologies

- D.B. Williams and C.B. Carter, *Transmission Electron Microscopy: A Textbook for Materials Science,* Plenum, 2nd edition (2009)
- J.W. Edington, *Practical Electron Microscopy in Materials Science*, Tech Books, Inc. (out of print)
- P. Hirsch, A. Howie, R.B. Nicholson, D.W. Pashley, M.J. Whelan, *Electron Microscopy of Thin Crystals*, R.E. Krieger, 1977 (out of print)
- MyScope - http://myscope.training/
- Grant Jensen videos (series of 48 videos) - https://www.youtube.com/playlist?list=PLhiuGaXlZZenm7lu5qv_A59zEWkRKkBn5

Other Course Policies

Accessibility Accommodation for Students with Disabilities

Requesting Accommodations

The university strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability including mental health, chronic or temporary medical conditions, please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services (SLDS). Students that have been certified by the Office for Disability Services will be appropriately accommodated and should inform the instructor as soon as possible of their needs.

Disability Services Contact Information

- Phone: 614-292-3307
- Website: slds.osu.edu
- Email: slds@osu.edu
- In person: Baker Hall 098, 113 W. 12th Avenue

Ohio State's Academic Integrity Policy

Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, The Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand the university's Code of Student Conduct (studentconduct.osu.edu), and that all students will complete all academic and scholarly assignments with fairness and honesty.

Students must recognize that failure to follow the rules and guidelines established in the university's *Code of Student Conduct* and this syllabus may constitute "Academic Misconduct." Academic misconduct is defined as "Any activity that tends to compromise the academic integrity of the university or subvert the educational process" by Ohio State University's *Code of Student Conduct* (Section 3335-23-04). Examples of academic misconduct include, but are not limited to, plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487).

Other sources of information on academic misconduct (integrity) to which you can refer include:

- Committee on Academic Misconduct (go.osu.edu/coam)
- Ten Suggestions for Preserving Academic Integrity (go.osu.edu/ten-suggestions)
- Eight Cardinal Rules of Academic Integrity (go.osu.edu/cardinal-rules)

Creating an Environment Free from Harassment, Discrimination, and Sexual Misconduct

The Ohio State University is committed to building and maintaining a community to reflect diversity and to improve opportunities for all. Members of the university community have the right to be free from harassment, discrimination, and sexual misconduct. Ohio State does not discriminate on the basis of age, ancestry, color, disability, ethnicity, gender, gender identity or expression, genetic information, HIV/AIDS status, military status, national origin, pregnancy (childbirth, false pregnancy, termination of pregnancy, or recovery therefrom), race, religion, sex, sexual orientation, or protected veteran status, or any other bases under the law, in its activities, academic programs, admission, and employment.

To report harassment, discrimination, sexual misconduct, or retaliation and/or seek confidential and non-confidential resources and supportive measures, contact the Office of Institutional Equity:

1. Online reporting form at equity.osu.edu,
2. Call 614-247-5838 or TTY 614-688-8605,
3. Or email equity@osu.edu

Your Mental Health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University's Student Life Counseling and Consultation Service (CCS) is here to support you. If you find yourself feeling isolated, anxious or overwhelmed, on-demand mental health resources (go.osu.edu/ccsondemand) are available. You can reach an on-call counselor when CCS is closed at 614- 292-5766**. 24-hour emergency help** is available through the National Suicide Prevention Lifeline website (suicidepreventionlifeline.org) or by calling 1-800-273-8255(TALK). The Ohio State Wellness app (go.osu.edu/wellnessapp) is also a great resource.