

SYLLABUS

MTSE-3020: Microstructure and Characterization of Materials

Department of Materials Science and Engineering

Fall 2025

Introduce the principal methods for characterizing materials at all scales (from nano to micro) in terms of atomic composition, atomic structure and chemical bonding. During this course, Students are presented with the basic operation and capabilities of the principal characterization methods used in materials science. This course applies basic science concepts to develop a fundamental understanding of materials characterization methods that are fundamental for graduate research and employment in the area of materials design.

Professor: El Bouanani

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Office Hours: Wednesday 10:00 AM – 12:00 PM and via Appointment

Class Hours: T/Th 2:30-3:50 PM Class Location: D-202

Textbook: The Instructor will supply handouts and references.

Course notes for each class (PPT files) will be posted on Canvas

Suggested text book: Materials Characterization, Y. Leng, Wiley (2010) ISBN 978-0-470-82298-2

Others:

- Materials Characterization, Y. Leng, Wiley (2010) ISBN 978-0-470-82298-2
- Microstructural Characterization of Materials, David Brandon and Wayne Kaplan, Wiley
- J.B. Wachtman, Characterization of Materials, Butterworth-Heinemann, ISBN 0-7506-9215-4 (1992).
- C.R. Brundle, C. A. Evans, Jr., and S. Wilson, Encyclopedia of Materials Characterization, Butterworth-Heinemann, ISBN 0-7506-9168-9 (1992).

Homework: Five homework sets will be assigned and graded. The purpose of the homework is to aid in learning the material. Although some collaboration among students in preparing the homework is acceptable, the main work should be primarily yours.

Late homework will not be accepted.

Exams: There will be three examinations and one student project:

Midterm-I: October 16th

Midterm-II: November 13th

Comprehensive final Exam: Tuesday December 9th, 1:30 PM - 3:30 PM

Student's projects are assigned on November 20th and are due on December 4th.

Grading:

(1) Homework (~ 5 total)	20%
(2) Quizzes	10%
(3) Student project	10%
(4) Midterm Exam-I + Midterm Exam-II	30%
(5) Comprehensive Final Exam	30%

If your grade in the comprehensive Final Exam is higher than the above grading plan, it will be used as your final course grade on the condition that you attend all classes, turn in all your Homeworks and take all mid-term Exams.

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1. Quizzes are closed-book. Pop-up quizzes will not be announced.
2. [Final exam will cover all chapters](#)
3. Attendance of the class is required. Any student missing 5 classes without acceptable justification will be dropped from class.
4. Unethical conduct in quizzes or exams will automatically lead to failure of the course.

Course Topics (Subject to Change)

- Syllabus overview/General Introduction to Characterization
- Brief overview of Materials depositions and vacuum Technology
- Overview of X-ray, electron and ion sources
- **Spectroscopies Using Photon and Ion Probes**
 - Photon interactions with matter
 - X-Ray Fluorescence
 - X-ray absorption in materials
 - Instrumentation
 - Elemental identification and quantification
 - Basic principles
 - Instrumentations
 - Chemical identification and quantification
 - Examples and applications
 - X-ray Photoelectron Spectroscopy/UV Photoelectron Spectroscopy
 - Basic principles
 - Instrumentations
 - Chemical identification and quantification
 - Examples and applications
 - Fourier Transform Infra-Red and Raman
 - Basic principles
 - Examples and applications
 - Ion interactions with matter
 - Rutherford Backscattering Spectroscopy
 - Basic principles
 - Instrumentations
 - Atomic Collisions and Backscattering
 - Energy Loss and Backscattering Profiles
 - Examples and applications

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- Secondary Ion Mass Spectroscopy
 - Basic principles
 - Instrumentations
 - Sputtering processes
 - Examples and applications
- *Examples and comparison of various spectroscopies in applications*
- **Topics on Optical microscopy**
 - Metallographic Preparation Techniques
 - Resolution (Rayleigh criterion, pixel counts)
 - Contrast Formation
 - Digital Imaging
 - Image Quantification – Stereology
 - Examples of optical microscopy in applications*
- **Topics on Electron microscopy**
 - Basics of electron sources and vacuum
 - Signal types (SE, BSE)
 - Energy Dispersive Spectroscopy (EDS)
 - How TEM fundamentally differs
 - Examples of electron microscopy in applications*
- **Topics on X-ray diffraction**
 - Bragg's Law
 - Structure Factor
 - Powder diffraction
 - Textured diffraction
 - Examples of X-Ray diffraction in applications*

Course Goal:

The emphasis of this course will be on techniques utilizing X-ray, electron and ion probes.

Relationship to program Objectives:

- (a) An ability to apply knowledge of mathematics, science, and engineering.
- (e) An ability to identify, formulate, and solve engineering problems.
- (k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Prepared by: El Bouanani

Date: August 19, 2025