

**Department of Materials Science and Engineering**  
University of Maryland, College Park, Maryland

**ENMA 310: Experimental Methods in Materials Science (Materials Laboratory I)**

**Course Description:** Introduction to experimental methods in materials characterization; diffraction (X-ray, TEM, optical); scanning techniques (SEM, AFM); optical microscopy; vibrational spectroscopy.

**Pre-requisite:** ENMA 230; **Co-requisite:** ENMA 460

**Textbook:** Faculty notes and written instructions on how to do the experiments

**Course Objectives:** At the end of this course, the student should be able to:

1. Describe a variety of experimental methods and tell in general what they are good for (see 3).
2. Identify what materials' properties a particular method probes.
3. Identify the most appropriate method or methods to probe specific materials characteristics. Be able to design experiments, based on this knowledge.
4. Identify the limitations of a specific characterization method.
5. Understand how different characterization methods complement each other.
6. Be able to communicate effectively their results and findings through reports.
7. Become familiar with modern methods of materials characterization, similar to those they will encounter in industrial and government laboratory and testing facilities.

**Course Goals to meet ABET 2005 Criteria**

1. Distinguish between different techniques to characterize materials and which one is more appropriate to study a particular characteristic
2. Design an experiment given a set of conditions to find the properties of a certain material
3. Be able to write reports on the laboratories
4. Be able to present their results and discuss the experiments they have designed

**Laboratory Exercises (Topics covered):**

- I. Introduction: 1 lecture
  1. Class organization
  2. Overview: Structure characterization methods - methods studied in this course
  3. Group division
  4. Introductory lecture: diffraction
- II. Safety issues: radiation training - required (1/2 week) – Sept. 3, 2003 - Steve Hand, Radiation Office.
- III. DIFFRACTION - approx. 3 weeks
  1. Diffraction - General (Prof. Martínez-Miranda; Prof. Salamanca-Riba)

- a. Lecture: characterization methods
    - b. Lecture/library search: use of structure tables
    - c. Exercise: Lattice determination
  - 2. X- ray diffraction (Prof. Martínez-Miranda)
    - a. Lecture: average (global structure)
    - b. Structure Form Factor (Prof. Martínez-Miranda)
      - i. Lecture: relationship to diffraction measurements
      - ii. Exercise: Calculation for different structures
      - iii. Exercise: Comparison to data
    - b. Exercise:
      - i. Polycrystalline (powder) Si
      - ii. Single crystal
      - iii. Nanocrystalline material
      - iv. Thin film measurement
  - 3. TEM (Prof. Salamanca-Riba)
    - a. Lecture: local structure
    - b. Demonstration: thin film measurement
    - c. Exercise: local lattice determination using visible diffraction and optical diffraction method (if available)
  - 4. Optical (Visible) Diffraction (Prof. Martínez-Miranda, Prof. Salamanca-Riba)
    - a. Exercise/Demonstration: optical-size diffraction pattern
    - b. Structure Determination - micrometer-size structures
  - 5. Oral presentation
- IV. SURFACE PROBE TECHNIQUES
- 1. Scanning Electron Microscopy (SEM) - approx. 1.5 - 2 weeks (Prof. I. Lloyd)
    - a. Lecture:
      - capabilities
      - sample topography, grain size
    - b. Exercise: grain size, deformation
    - c. Quantitative metallography
  - 2. Surface microscope probes: AFM (TBA) - approx. 0.5 - 1 week
    - a. Lecture: AFM principles - comparison and similarities to other surface probes
    - b. Exercise/demonstration: surface imaging
  - 3. Oral presentation
- V. VIBRATIONAL SPECTROSCOPY - approx. 2 weeks
- 1. Fourier Transform Infra-Red Spectroscopy (FTIR) (Prof. M. Al-Sheikly)
    - a. Lecture and Exercise: Radiation Effects in Polymers
  - 2. Oral presentation (if there is time)
- VI. OPTICAL MICROSCOPY:
- 1. Optical microscopy observation: (Prof. Martínez-Miranda; Prof. R. Briber) - approx. 1 - 1.5 weeks
    - a. Lecture: optical characteristics and relation to structure; anisotropy
    - b. Exercise: observation of micron-size domains and structures; grain size; birefringence

- c. Exercise: observation of phase transformations
2. Oral presentation
3. Ellipsometry (Prof. R. Briber, Prof. L. J. Martínez-Miranda) - approx. 1 - 1.5 weeks
4. Oral presentaion

**Class Schedule:**

Lecture: ENG. 1102, Tues., 2- 3:15PM. Room will change to 2304CHE after the first week of classes.

Laboratory: Undergrad Materials Laboratory, RM. 2304CHE, MW 9AM - 12 noon. Other Locations scheduled according to the exercises to be performed.

**Grading:** Grading will be based on written reports submitted at the end of each exercise, a laboratory notebook grade, and student participation in class and the discussion (oral presentation). In addition to the reports, selected exercises may include "thought questions", which will be graded independently. The thought questions may be included in the oral presentations. The purpose of the thought questions is to help students design experiments and measurements to characterize a particular material. There is **no final**.

**Reports, homework, and participation (including the oral presentations and attendance): 80%**

**Laboratory notebook: 20%**

**Deadline to submit last report: December 12, 2003, last day of classes this semester.**

***ATTENTION:*** Reports, homeworks (when given) and Laboratory notebook, will be due **a week** after the completion of the experiment. After the week, the report, homework and laboratory notebook will loose 0.71 out of 10 points per day(double when we have an assignment good for 20 points) until two weeks afterwards, when the total points will be taken from them. In other words, homework turned in after two weeks **will not be graded, and will be given a zero. Attendance to classes is required.**

**Contribution of course to meeting the professional component:** This course is a laboratory course aimed at introducing the students to the methods used to characterize materials in order to explain and improve the material's behavior as specified by certain design criteria or needs.

**Relationship of course to program objectives:** This course is a required junior level course in Materials Science and Engineering. Its purpose is to allow the students to become familiar with characterization methods and data analysis techniques, through a combination of hands-on experience, measurement demonstration and data analysis.

**Instructor-Coordinator:**

**Teaching Assistant:**

Prof. Luz J. Martínez-Miranda

TBA

Bldg. 090, RM. 1110D

email: [ljmm@umd.edu](mailto:ljmm@umd.edu)

Web: <http://www.AJOnline.umd.edu>, select ENMA 310

**Office Hours:** TBA the week of Sept. 8

Prepared by L. J. Martínez-Miranda, Aug, 2003