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

ENMA 311: Experimental Methods in Materials Science (Materials Laboratory II)
Transport Properties

Course Description: Introduction to experimental methods in materials transport properties measurements: electrical, thermal, magnetic. Emphasis on structure - processing - properties relationship.

Pre-requisite: ENMA 310; ENMA 460

Texbook: Notes supplied by faculty.

A good reference: Understanding the Properties of Matter, M. De Podesta, Taylor and Francis, 2002, available in the bookstore. The chapter numbers refer to this book.

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

1. Describe a variety of experimental methods to measure electrical, magnetic and thermal properties of materials.
2. Identify what specific property(ies) a particular method describes.
3. Identify the most appropriate method or methods to probe specific materials' properties.
4. Identify the limitations of a specific measurement method.
5. Describe how different methods can be used to describe the behavior of a particular material.
6. Understand the relationship between a material's properties, the method used to prepare (process) it, and its structure.
7. Understand how the relationship above can be used to improve products.

Course Goals to meet ABET 2005 Criteria:

1. Be able to distinguish between the different transport properties in materials and how the atomic structure is responsible for them: conductivity, resistivity, capacitance, thermal expansion, thermal conductivity, specific heat.
2. Design an experiment to determine the above properties.
3. Be able to write reports on the laboratories.
4. Be able to present orally their results and discuss the experiments or equipment they have designed.

Laboratory Exercises (Topics covered):

Book Chapters are referred to by a letter plus the chapter number (dP = De Podesta). The approximate length of the laboratory appears after the name of the faculty in charge.

IMPORTANT! The order of the exercises depends on laboratory availability. Names in parenthesis indicate the faculty member overseeing the particular exercise.

1. Introduction (Prof. Martínez-Miranda): 1.5 - 2 weeks
    a. Lecture:
    Electrical conductivity and resistivity of materials: relation to electronic structure (dP 7.7.1 - 7.7.5)
    b. Safety issues – How to position all electrical and optical experiments
    c. Review of electrical measurements: resistors, capacitances.
    c. Simple resistance experiment: electrical resistivity (conductivity).

Number of reports: 1

2. I-V characteristics (Prof. Martínez-Miranda): 1 - 1.5 weeks
    a. Lecture: overview of linear and non-linear components, semiconductor devices (Prof. Martínez-Miranda) (dP 7.7.8- 7.7.9; notes given in class)
    b. A simple "manual" experiment:
        i. intro to I-V characteristics: diodes
        ii. If available: C-V characteristics of diodes – Diode in reverse voltage.
        iii. Dependence on materials processing parameters
        iv. Schottky barriers

Number of reports: 1 or may be combined with No. 1 or No. 3

3. The curve tracer: analysis of electronic components (instructions in laboratory): 0.5 – 1 week
        i. linear – a resistance
        ii. two-terminal – two diodes
        iii. three terminal – a transistor

Number of reports: 1

4. Optical properties of materials (Prof. Martínez-Miranda): 1 - 1.5 weeks (dP 7.9.6)
    a. Optical Properties of Electronic Materials – LED's
    b. Optical properties of Display Materials - Response to an electric field – an LC

Number of reports: 1-2 (a and b are different laboratories)

5. Density of materials (Prof. Wilson, Prof. Martínez-Miranda): 1 - 2 weeks (dP 7.2.1-7.2.2)
    a. Lecture - structure and density of materials
    b. Simple density measurement of liquids
    c. Densitometer measurements

Number of reports: 1

6. Thermal properties (Prof. Lloyd, Prof. Martínez-Miranda, Prof. Lloyd) - 1.5 - 3 weeks

a. Heat capacitance (dP 7.6ff)
b. Thermal conductivity of materials (dP7.8.1 – 7.8.2)
c. Thermal expansion of materials (dP7.4.1 – 7.4.2)*
-Differential thermal expansion - relation to stress (TBA)

Number of reports: 2 - 3, depending on order and time of exercises
*- if available

7. Effects of deposition parameters on materials' properties (Prof. Rubloff, Prof. Martínez-Miranda)
Number of reports: 1*

* if available, Prof. Rubloff will be in charge

8. Dielectric properties of materials - the four point probe (Prof. Martínez-Miranda, Prof. Lloyd or Electrical analysis laboratory), if available: 0.5 - 1 week (dP 7.7.4-7.7.5)
Number of reports: 0 - 1

9. Magnetic properties of materials (Prof. Gomez): 0.5 week (handout) - if available
a. Domain observation/demonstration

Number of reports: 0 - 1

The order of the laboratories depends on the availability of the equipment and whether or not it is working.

Class Schedule:

Lecture: W 12 – 12:50 PM Rm. 2304 CHE
Laboratory: M 12 – 2:45 PM; W 1 – 2:45 PM, locations arranged according to week's exercise.
Note: *Depending on the laboratory schedule,* ***the lecture may be on Mondays, and the laboratory will be completed on Wednesday****. There will be weeks when there will be no lecture and there will be laboratory on Monday and Wednesday.*

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. In addition to the reports, selected exercises may include "thought questions", and oral presentations which will be graded independently. The purpose of the thought questions is to help students design experiments and measurements to characterize a particular material. The purpose of the oral presentations is, in addition to helping in the design of experiments, to help the students with their oral skills as required by ABET.

Reports homework, and participation: 80%
Laboratory notebook: 20%
Deadline to submit last report: May 11, 2004

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 1 point out 10 points per day until two weeks afterwards, when the total points will be taken from them. In other words, reports, homework or laboratory notebooks turned in after two weeks* ***will not be graded, and will be given a zero.***

Instructor-Coordinator:
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Prepared by L. J. Martínez-Miranda, Jan, 2004