



Virginia Commonwealth University

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Department of Physics

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## **PHYS 550**

### **Techniques in Materials Research - Spring 2005**

#### **Instructor: Dr. Martin Muñoz**

General Information about the course: This course is intended to provide an introduction to modern characterization techniques in materials research. Structural (AFM, XRD and RHEED), electrical (Hall Effect and DLTS) and optical techniques (Modulation spectroscopy and Photoluminescence) will be analyzed in the classroom, and their corresponding experiments will be performed in the Electrical Engineering and Physics department's laboratories.

#### Class schedule

Wednesday: 9:00-10:50a.m. (Room OLVPH2121)

Friday: 9:00-11:50a.m. (Laboratory or room OLVPH2121)

Office hours: Wednesday: 11:00a. m. -1:00 p. m. or by appointment.

Class: Class sessions will focus on discussing the fundamental principles of the experimental techniques and discussion of specific applications. There are no attendance requirements, however you are responsible for all the announcements, and material covered in class whether you are present in class or not. Participation in class sessions will be considered.

Grades: The students will be graded based on the following components:

- Three Formal Laboratory Reports 45% (15% each)
- Two Technical Paper Presentations 30% (15% each)
- One Formal Lab Report Presentation 20%
- Participation in class 5%
- Tentative letter grades will be assigned on the following scale: A: 90-100%, B: 80-89%, C: 70-79%, D: 60-69%, and F: <60%

Reports: Each student will write three Formal Laboratory Reports in the style of a technical paper, one based on structural, one on electrical and one on optical techniques. The specific topics will be distributed on class in order to cover all the techniques. **No late reports** will be accepted; however, your **lowest** report grade will be **dropped**. Reports should include the following information: abstract, introduction, experimental procedure, data results, discussion, conclusions, and references. For some techniques, students may have the option of replacing one of the formal reports with the submission of an updated user manual with a short technique write-up included. This choice must be approved within the first few weeks of the semester.

Presentations: Each student will give three Powerpoint presentations in the style used for

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conference talks. The topic will be defined by the instructor. For the two presentations based on technical papers, students will choose journal articles that incorporate techniques relevant to the course. Each talk should be a summary of the paper and be no more than 12 minutes in length. For the Lab Report presentation, each student will discuss results from one of their formal reports or from their thesis work.

## COURSE SCHEDULE

Date	Wednesday lecture	Friday Laboratory
January 19 <sup>th</sup> , 21 <sup>st</sup>	Introduction	No class
January 26 <sup>th</sup> , 28 <sup>th</sup>	XRD	XRD (group 1)
February 2 <sup>nd</sup> , 4 <sup>th</sup>	AFM	XRD (group 2)
February 9 <sup>th</sup> , 11 <sup>th</sup>	Student Talks (group 1)	AFM (group 1)
February 16 <sup>th</sup> , 18 <sup>th</sup>	Student Talks (group 2)	AFM (group 2)
February 23 <sup>rd</sup> , 25 <sup>th</sup>	DLTS ( <b>Report #1 due 2/23</b> )	DLTS (group 1)
March 2 <sup>nd</sup> , 4 <sup>th</sup>	Hall Effect and RHEED	DLTS (group 2)
March 8 <sup>th</sup> , 11 <sup>th</sup>	Student Talks (group 1)	Hall Effect (group 1), RHEED (group 2)
March 23 <sup>rd</sup> , 25 <sup>th</sup>	Student Talks (group 2)	Hall Effect (group 2), RHEED (group 1)
March 30 <sup>th</sup> , April 1 <sup>st</sup>	Modulation Spectroscopy ( <b>Report #2 due 4/1</b> )	Modulation Spectroscopy (group 1)
April 6 <sup>th</sup> , 8 <sup>th</sup>	PL	Modulation Spectroscopy (group 2)
April 13 <sup>th</sup> , 15 <sup>th</sup>	Student Talks (group 1)	PL (group 1)
April 20 <sup>th</sup> , 22 <sup>nd</sup>	Student Talks (group 2)	PL (group 2)
April 27 <sup>th</sup> , 29 <sup>th</sup>	Formal Lab Report Presentation (group 1) ( <b>Report #3 due 4/27</b> )	Formal Lab Report Presentation (group 2)

### References:

- *Semiconductor material and device characterization*, D. K. Schroder, John Wiley & Sons Inc., 1990.
- *Optical Characterization of Semiconductors: Infrared, Raman and Photoluminescence*, S. Perkowitz, Academic Press, 1993.
- *Elements of X-Ray diffraction*, B. D. Cullity, Addison-Wesley 1977.
- *Optical Characterization of Epitaxial Semiconductor Layers*, G. Bauer and W. Richter (Eds.), Springer, 1996.

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- *Photoluminescence of Al<sub>x</sub>Ga<sub>1-x</sub>As alloys*, L. Pavesi and M. Guzzi, *J. of Appl. Phys.* **75**, 4779 (1994).
- *Modulation Spectroscopy*, M. Cardona, Academic Press, 1969.
- *Modulation spectroscopy of semiconductors: bulk/thin film, microstructures, surfaces/interfaces and devices*, F. H. Pollak and H. Shen, *Mater. Sci. Eng.*, **R10**, 275 (1993).
- *Modulation Spectroscopy of the group III nitrides*, F. H. Pollak, in *Group III Nitride Semiconductor Compounds*, edited by By B. Gil (Clarendon, Oxford, 1998) p. 158.
- *Modulation Spectroscopy/Electric field effects on the dielectric function of semiconductors*, D.E. Aspnes, in: *Handbook on Semiconductors*, Vol. 2, edited by M. Balkanski (North-Holland, NewYork, 1980), p. 109.
- *Surface photovoltage phenomena: theory, experiment, and applications*, L. Kronik, Y. Shapira, *Surface Science Reports* **37** 1 (1999).
- *Modern Semiconductor Quantum Physics*, M. Li, World Scientific, 1994.
- *Fundamentals of Semiconductors*, P. Yu and M. Cardona; Springer, New York, 1999.
- *Semiconductor Devices*, J. Singh, McGraw Hill, 1994.
- *Applied RHEED: reflection high-energy electron diffraction during crystal growth*, W. Braun. Springer, 1999.
- *Encyclopedia of materials characterization*, R. Brundle, C. A. Evans, Jr., S. Wilson (Eds.). Boston, Butterworth-Heinemann, 1992.

**Students with Disabilities:** The Americans with Disabilities Act of 1990 requires Virginia Commonwealth University to provide a "reasonable accommodation" to any individual who advises us of a physical or mental disability. If you have a physical or mental limitation that requires an accommodation or an academic adjustment, please arrange a meeting with me at your earliest convenience.

**Honor Code:** Please read the [VCU Honor System Statement](#). Clear and convincing evidence of honor system violations in this class will result in the submission of formal written charges to the Honor System Coordinator. Under these circumstances I do not give warnings or ask students for explanations.