

## **EMA6518L: Transmission Electron Microscopy Laboratory**

Spring 2013

1 Credit

Prerequisite: EMA6518

Classroom location: TBD

Meeting times: TBD

### **I. Instructor information**

Dr. Nicholas G. Rudawski

Office location: MAE (building #719) 109

Office phone: (352) 392-3077

E-mail: ngr@ufl.edu (preferred contact method)

Office hours: TBD and by appointment

Class website: run through e-learning at <https://lss.at.ufl.edu/>

### **II. Course description and objectives**

This course provides hands-on introduction to the basic operation of transmission electron microscopes (TEMs) and related instrumentation and analysis of TEM-related data as emphasized for materials scientists and those studying the physical sciences. Emphasis will be placed mainly on the study and analysis of crystalline and polycrystalline materials. A few weeks into this course, students will be able to independently operate the JEOL 200CX TEM at the Major Analytical Instrumentation Center; by the end of the course students will be able to collect and understand/analyze TEM-related data (images, diffraction patterns, etc). Specifically, the following topics will be covered:

- TEM-related instrumentation (specimen holders, digital cameras, etc.)
- Operation and alignment of a TEM
- Relationship between TEM parameters and resulting TEM data
- Instrument calibration (magnification, camera length, rotation calibration, etc.)
- Demonstration of mass-thickness, diffraction, and phase contrast in TEM data
- Bright-field and dark-field imaging in both single- and poly-crystalline specimens
- Defect analysis (stacking faults, dislocations, etc.)
- High-resolution TEM imaging
- Scanning and analytical TEM

### **III. Required textbooks**

1. "Transmission electron microscopy: a textbook for materials science" by Williams and Carter; second edition (ISBN: 978-0-387-76500-6)
2. "Transmission electron microscopy and diffractometry of materials" by Fultz and Howe; third edition (ISBN: 978-3-540-73885-5)

Both of these textbooks are available online, fully downloadable, and completely free of charge at [www.springerlink.com](http://www.springerlink.com) when accessed through the UF network. Additionally, print black and white hard copies may be ordered for \$25 through [www.springerlink.com](http://www.springerlink.com) when the website is accessed through the UF network; if you are planning on doing a lot of TEM work, I strongly recommend you invest in hardcopies of these books as both are excellent TEM reference texts, particularly for materials scientists.

#### IV. Course outline

##### A. Tentative course schedule and assigned reading (subject to change)

Week	Topic(s)	Assigned reading
01/06	DROP/ADD WEEK: NO LAB	N/A
01/13	TEM construction; working with holders; holder insertion + removal; alignment	WC: 6.3, 6.4, 8.1, 8.7 – 8.11, 9.1, 9.2, 9.5
01/20	Alignment; beam convergence; spot size; C2 aperture illumination area; current reaching specimen	WC: 5.5.B
01/27	Alignment; mass-thickness contrast (latex spheres); depth of field; imaging with a digital camera	WC: 6.7, 7.1, 7.3.C, 22.3.A, 22.3.B
02/03	Alignment; diffraction contrast (nano-particles); imaging with a digital camera	WC: 22.5
02/10	Alignment; working in diffraction mode; selected area diffraction of large crystals; acquiring diffraction patterns	WC: 9.3.A
02/17	Alignment; magnification, camera length, and rotation calibration	WC: 9.6
02/24	<b>JEOL 200CX DRIVER'S TESTS</b>	N/A
03/03	SPRING BREAK: NO LAB	N/A
03/10	Bright- and dark-field (centered and "dirty") TEM (polycrystalline Al specimen)	WC: 9.3.B, 9.3.C
03/17	Bright- and dark-field (centered and weak beam dark-field) TEM (defective single-crystal Si specimen)	WC: 22.5
03/24	Bright- and dark-field (centered and weak beam dark-field) TEM (defective single-crystal Si specimen); fault analysis	WC: 27.1 – 27.5
03/31	High-resolution TEM imaging of single-crystal ITO nanowires	WC: 23.1, 23.2, 23.4; FH: 2.3.4, 10.3, 10.5
04/07	High-angle annular dark-field scanning (Z-contrast) TEM and analytical TEM (energy dispersive spectroscopy)	WC: 22.3.C, 22.4, 32.4, 32.9; FH: 11.1 – 11.5
04/14	Final quiz + TBD	TBD

##### B. Assigned reading

Assigned reading from both textbooks for each week is specified in the above tentative schedule (subject to change). All information that is part of the assigned reading may be considered as potential material for inclusion on any quiz, so you need to be sure to keep up with the reading assignments.

### **C. List of assessments**

1. Weekly (approximately) written quizzes (100% of final score)

Quizzes will be true/false, multiple choice, and/or short answer; there will be no extended answer questions on the quizzes. Last year, I used oral quizzes, but these took up an excessive amount of lab time and several students understandably claimed I wasn't always fair with how these were graded.

### **D. Make-up lab/quiz policy**

In general, make-ups for missed labs and/or quizzes will not be given except in cases of extenuating circumstances. If you are planning on traveling to a scientific conference at some point during this term, you have until 5:00 PM Friday, 01/10/14 (end of drop/add period) to notify me of this so I can adjust the schedule accordingly. If you feel you will be unable to be present for a lab or quiz due to extenuating circumstances, you should contact me BEFOREHAND for me to evaluate the situation and determine if something can be worked out.

### **V. Attendance and classroom conduct**

If more than 2 labs are missed without being made up, the student will fail the course; only absences for legitimate reasons may be made up; if you were not present for a lab, you are still responsible for the material that you missed that will likely be included on the following week's quiz. During the labs, please be respectful and pay attention; silence your cell phones and put them away; please do not bring in newspapers and read them during lab; you may bring in your laptop computers to take digital notes, but please do not use your computers for leisurely activities (aimlessly surfing the internet, accessing social networking sites, etc.).

### **VI. Grading procedure**

At the end of the term, students will be ranked in terms of final scores. Different letter grades will be assigned to distinct groupings of scores (i.e., the top group will receive A and A- grades, the next group will receive B+ through B- grades, etc.); thus, you are effectively been graded relative to the performance of the rest of the students in the case. There is no predetermined or preset scale for grading, but I will give projected final grades at certain points throughout the term. Last year, no student received a grade lower than B+ with the vast majority receiving A or A- grades. Greater information on current UF policies for assigning grade points may be found at: <http://gradcatalog.ufl.edu/>.

## **VII. Academic misconduct**

Academic misconduct (cheating, plagiarism, etc.) is a very serious matter and will not be tolerated in any capacity; I expect you all to abide by the Student Honor Code and Student Code of Conduct as specified at

<http://www.dso.ufl.edu/sccr/honorcodes/conductcode.php>. If I feel that any academic misconduct is occurring, it will be referred to the Division of Student Affairs for further action and consideration and will be reported to academic services in the MSE department.

## **VIII. Accommodations for students with disabilities**

Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the instructor when requesting accommodation.