

## **EMA6518L: transmission electron microscopy laboratory**

Spring 2015

1 Credit

Prerequisite: EMA6518

Classroom location: TBD

Meeting times: TBD

### **I. Instructor information**

Dr. Nicholas G. Rudawski

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Office hours: TBD and by appointment

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

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

This course provides a 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. 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

These topics will all build around the course goals of being able to independently operate the JEOL 200CX TEM at the Major Analytical Instrumentation Center and understand/analyze TEM-related data (images, diffraction patterns, etc).

### **III. Recommended 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)	Recommended reading
01/05	DROP/ADD WEEK: NO LAB	N/A
01/12	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
01/19	Alignment; beam convergence; spot size; C2 aperture illumination area; current reaching specimen	WC: 5.5.B
01/26	Alignment; mass-thickness contrast (latex spheres); depth of field; objective lens focus, imaging with a digital camera	WC: 6.7, 7.1, 7.3.C, 22.3.A, 22.3.B
02/02	Alignment; diffraction contrast (nano-particles); imaging with a digital camera	WC: 22.5
02/09	Alignment; working in diffraction mode; selected area diffraction of large crystals; acquiring diffraction patterns	WC: 9.3.A
02/16	Alignment; magnification, camera length, and rotation calibration	WC: 9.6
02/23	Bright- and dark-field (centered and “dirty”) TEM (polycrystalline Al specimen)	WC: 9.3.B, 9.3.C
03/02	SPRING BREAK: NO LAB	N/A
03/09	Bright- and dark-field (centered and weak beam dark-field) TEM (defective single-crystal Si specimen)	WC: 22.5
03/16	Bright- and dark-field (centered and weak beam dark-field) TEM (defective single-crystal Si specimen); fault analysis	WC: 27.1 – 27.5
03/23	High-resolution TEM imaging of single crystals	WC: 8.12, 23.1, 23.2, 23.4; FH: 2.3.4, 10.3, 10.5
03/30	Scanning TEM and analytical TEM (energy dispersive spectroscopy)	WC: 22.3.C, 22.4, 32.4, 32.9; FH: 11.1 – 11.5
04/06	TBD	TBD
04/13	TBD	TBD

## B. Recommended reading

Recommended reading from both textbooks (where applicable) for each week is specified in the above tentative schedule (subject to change); in addition to the textbooks, I may also provide additional recommended reading from other sources (e.g., from publications) as needed. Should you choose to do the reading, you should do it for the specified week *prior* to your lab session. It is not necessary to complete this reading to be successful in this course, but it will be very helpful to do so.

## C. List of assessments

### 1. Weekly quizzes (50% of final score)

*All quizzes will be composed of true/false questions; each quiz take 10 min, will contain 5 questions, and will be graded as follows: 100% for 4 or 5 questions correct; 75% for 3 questions correct; 50% for 2 questions correct; 25% for 1 question correct; 0% for 0 questions correct. Quizzes will be graded immediately after being taken to give you immediate feedback.*

### 2. Driver's test (50% of final score)

Towards the end of the term, each student will take a time-constrained "Driver's test" on the JEOL 200CX TEM, which covers basic instrument operating and data collection. A detailed list of what is contained on the Driver's test will be disseminated a few weeks into the course. Unlike the weekly quizzes, grading of the driver's tests will be more subjective in nature and driver's test grades will not be determined until completion of the driver's test by all students. In addition to comprising 50% of the student's final score, passing of the driver's test will complete the student's training on the instrument and allow him or her to start unsupervised usage. Lastly, to encourage a little healthy competition, the top 3 performers on the driver's test will have their lowest quiz grades changed to full credit.

## D. Make-up lab/quiz policy

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, 01/09/15 (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

Attendance is not optional; If any lab is missed without being made up, the student will fail the course and 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 and read newspapers during lab; you may bring in your laptop computers to take digital notes, but please do not use your computers for leisure 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 being 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, of the 9 students enrolled in the course, no student received a grade lower than B- and 7 students received 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, leaking of quiz questions, etc.) is a very serious matter and will not be tolerated in any capacity; all students are required to abide by the Student Honor Code as described in detail at:

<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>

*It is the responsibility of you, the students, to understand what does and does not constitute a violation of the student honor code.* If I believe any student violated the student honor code, he/she will be reported immediately to academic services in the MSE department, fully investigated, and (if necessary) properly sanctioned.

## **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.