THE UNIVERSITY OF UTAH

ECE 5255 / 6255: Advanced Electron Microscopy for Semiconductor Materials and Devices

Instructor: Prof. Heayoung Yoon
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Meeting: Tuesday / Thursday 12:25 pm ~ 1:45 pm
(**In-person; *attendance is required*.**)

Lab: Tuesdays; details to be announced after the first class
Lab fee: $135.00

Office Hours: TBA
Other times scheduled by appointment by email

Textbook: Scanning Electron Microscopy and X-ray Microanalysis (3rd Edition)
J. Goldstein et al., Springer 2003

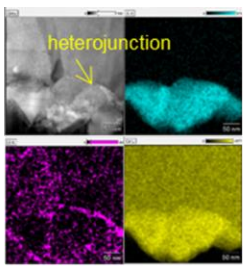
References: (1) Scanning Electron Microscopy and X-Ray Microanalysis (4th Edition)
(2) Principles of Semiconductor Devices (Second Edition)
Sima Dimitrijev, Oxford University Press 2012
(3) Scanning Electron Microscopy: Physics of Image Formation and Microanalysis, L. Reimer, Springer 1998
(4) Cathodoluminescence Microscopy of Inorganic Solids
B. G. Yacobi and D. B. Holt, Plenum 1990

Pre-requisites: No prior knowledge of microscopy techniques is required for this course. One semester of undergraduate level semiconductor devices/physics (e.g., ECE 3200) is recommended.

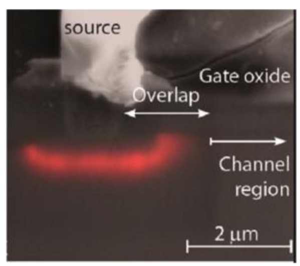
Course Objectives / Outcomes:

The goal of this course is to introduce the students to both the theory and practical use of modern scanning electron microscopy (SEM) for micro/nano materials and devices. We will start from the principle of electron microscopy, proceed to the description of conventional and advanced modern technique, and evaluate advantages and disadvantages of each method. In particular, we will focus on metrologies for semiconductors devices, such as energy dispersive X-ray spectroscopy (EDX), electron beam induced current (EBIC), and cathodoluminescence (CL), to study active defects, junction interfaces, and excess carrier dynamics of the devices.

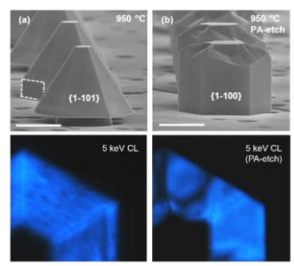
The lab sessions will be held in the state-of-the-art laboratories of the Utah's Nanofab. We will also use software to perform simulations and data analysis. Students will understand what studies can be addressed with each technique and what is the level of details that can be expected. This course is also designed to provide students from various field a practical introduction to nanoscale electrical and optical measurements of emerging semiconductor materials and devices.



EDS (compositional)



EBIC(electrical)



CL (optical properties)

Grading Policy:

The course grade will be distributed as follows:

- Lab Reports / HWs: 35 %
- Midterm exams: 30 %
- Final Project / Presentation / Report: 35 %

Students have ultimate responsibility for their learning and must decide what actions to take to maximize progress and efficiency. Participation in class discussion, reading the text in advance of class lectures, homework effort, independent and group study may be viewed by the instructor as an indication of a student's interest and effort in learning the class materials (bonus grade: 3 %).

Grading

A: ≥ 93 %,   A-: ≥ 90 %
B+: ≥ 87 %, B: ≥ 83 %,   B-: ≥ 80 %
C+: ≥ 77 %,   C: ≥ 73 %,   C-: ≥ 70 %
D+: ≥ 67 %,   D: ≥ 63 %,   D-: ≥ 60 %
E: ≤ 67 %

* The grading will NOT be curved. We apply this grading scheme to all students (no exceptions for senior students). Students earn their grades based on their efforts.

Late Homework

Late homework will be accepted ONLY in extraordinary circumstances and by specific arrangement with the instructor. A written email that describes the particular situation and ***supporting documents*** are required.

Otherwise, -1 % by hour (if you submit your work after 100 hours from the deadline, you will receive no credit)

Exams

There will be in-class exams and a mini-conference. The exams will cover the material during the lecture as well as in reading and homework assignments.

Registering for this class (in-person; not online) means that students have committed to participate during class time. If you have a conflict with a scheduled exam, you should notify the instructor in advance (at least **48 hours**, excluding medical emergencies - required Doctor's note). A written email that describes the specific situation and ***supporting documents are required***.

Additional SEM Usage

The SEM (Quanta) will be available if you need extra hours outside the assigned class time. This course is ***not*** responsible for this additional fee.

Here is the current rate. https://emsal.nanofab.utah.edu/u-of-u-academic-rate/

Email Response Policy:

Your email inquiries will be answered within 24 hours during business days (Monday ~ Friday; 9 am ~ 5 pm). If you send an email for a question between Friday 5 pm and Sunday, it will be answered by Tuesday 9 am.

Course Outline (Tentative)

Week 1: SEM: capabilities and limitations

Week 2: SEM: modes, sources, brightness equation

Week 3: Electron beam interaction with materials

Week 4: Monte Carlo simulations

Week 5: SEM Operation (Lab 1)

Week 6: Nanoscale Imaging (Lab 2)

Week 7: Chemical Analysis (Lab 3)

Fall Break

Week 8: Surface Charging (Lab 4), Practice session for Exam 1

Week 9: ***Exam 1*** (SEM; Lab 5), ***Proposal for individual project***

Week 10: Carrier generation in SMD, Local characterizations (EBIC, CL; Demo 1)

Week 11: Review, ***Exam 2*** (Theory)

Week 12: Focused Ion Beam (FIB I; Demo 2), Individual Project (Lab 6)

Week 13: Individual Project (Lab 7), Thanksgiving

Week 14: Focused Ion Beam (FIB II; Demo 3), Individual Project (Lab 8)

Week 15: Special topic, ***Mini-Conference***