THE UNIVERSITY OF UTAH

ECE 6255-001: Advanced Electron Microscopy for Semiconductor Materials and Devices

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Sections: meet with ECE 5255-001
Lecture: Tuesday / Thursday 12:25 pm ~ 1:45 pm (MEB 3235)
Lab: To be announced (TBA)

Office Hours: Tuesday / Thursday 1:45 pm ~ 2:45 pm
Other times scheduled by appointment via email

Textbook: (1) Scanning Electron Microscopy and X-ray Microanalysis (3rd Edition)
J. Goldstein et al., Springer 2003 ← recommended
(2) Scanning Electron Microscopy and X-Ray Microanalysis (4th Edition)

References: (1) Principles of Semiconductor Devices (Second Edition)
Sima Dimitrijev, Oxford University Press 2012
(2) Scanning Electron Microscopy: Physics of Image Formation and Microanalysis, L. Reimer, Springer 1998
(3) 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.

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University Policies

1. ***The Americans with Disabilities Act***. The University of Utah seeks to provide equal access to its programs, services, and activities for people with disabilities. If you will need accommodations in this class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building, (801) 581-5020. CDS will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in an alternative format with prior notification to the Center for Disability Services.

2. ***University Safety Statement.*** The University of Utah values the safety of all campus community members. To report suspicious activity or to request a courtesy escort, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit safeu.utah.edu.

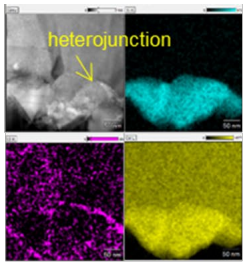
3. ***Addressing Sexual Misconduct***. Title IX makes it clear that violence and harassment based on sex and gender (which Includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran's status or genetic information. If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or the Office of the Dean of Students, 270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to the police, contact the Department of Public Safety, 801-585-2677(COPS).

4. ***Undocumented Student Support Statement.*** Immigration is a complex phenomenon with broad impact—those who are directly affected by it, as well as those who are indirectly affected by their relationships with family members, friends, and loved ones. If your immigration status presents obstacles to engaging in specific activities or fulfilling specific course criteria, confidential arrangements may be requested from the Dream Center. Arrangements with the Dream Center will not jeopardize your student status, your financial aid, or any other part of your residence. The Dream Center offers a wide range of resources to support undocumented students (with and without DACA) as well as students from mixed-status families. To learn more, please contact the Dream Center at 801.213.3697 or visit dream.utah.edu.

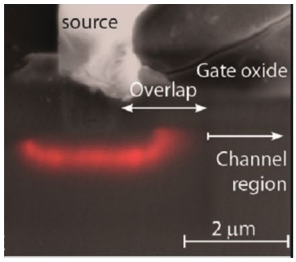
Course Objectives / Outcomes:

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.

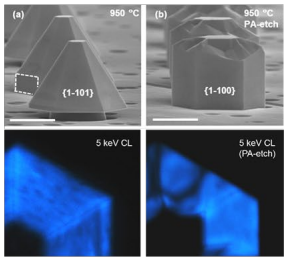
The lab sessions will be held in the state-of-the-art laboratories of the Utah's Nanofab. We will also use software to perform simulations and data analysis. Students will understand what studies can be addressed with each technique and what is the level of details that can be expected. This course is 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: 30 %
Midterm exam: 30 %
Final Presentation: 40 %

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Course Outline

Week 1: SEM: capabilities and limitations

Week 2: SEM: modes, sources, brightness equation

Week 3: Electron beam interaction with materials (Monte Carlo simulation)

Week 4: Nanoscale imaging

Week 5: Charging, Low vacuum (how to make it and why it works)

Week 6: Qualitative / quantitative compositional analysis (EDS)

Week 7: Review, Midterm exam

Week 8: Fall Break

Week 9: Carrier generation and transport in semiconductor devices

Week 10: Focused ion beam (interconnection of devices)

Week 11: Focused ion beam (cross-section of devices)

Week 12: Local luminescence of semiconductor materials (CL)

Week 13: Local electrical characterizations (EBIC)

Week 14: EBIC analysis, Thanksgiving break

Week 15: Review, Student project presentation

Week 16: Student project presentation, Invited seminar