

Semiconductor Device Fabrication Laboratory

EEE 5354L Section 262E

Class Periods: Lectures on Mondays, Period 7-8 (1:55 PM – 3:50 PM); Labs on other days

Lecture Location: NANO 115 (Spring 2022); **Lab Location:** NRF Teaching Lab

Academic Term: Spring 2022

Instructor:

Md Abdul Halim Miah

md.miah@ufl.edu

(352) 328-2974

Office: 122 Larsen Hall

Office Hours: Tuesdays and Wednesdays 11:00 am - 12:00 pm Zoom meeting: <https://ufl.zoom.us/my/mahalim>

Instructor:

Yong-Kyu Yoon

ykyoon@ece.ufl.edu

(352) 392-985

Office: 225 Larsen Hall

Office Hours: Tuesdays and Wednesdays 1:00 pm - 2:00 pm Zoom meeting: ufl.zoom.us/j/3523925985

Teaching Assistant/Peer Mentor/Supervised Teaching Student:

Please contact through the Canvas website

- Paritosh Rustogi, paritoshrustogi@ufl.edu, NRF 200, office hours: TBA
- Sai Amiriseti, s.amiriseti@ufl.edu, Benton 200, office hours: TBA
- Another TA: TBA

Course Description

The overall goal is to provide students with hands-on experience in semiconductor material characterization and device-fabrication techniques. (3 credits)

Course Pre-Requisites / Co-Requisites: None

Course Objectives

This course enables students to gain hands-on experience with semiconductor-based processes, units, and corresponding equipment, such as photolithography, oxidation, thin film deposition, etching, and packaging; and also let students gain experience on the design, fabrication, and characterization of electronic devices, micro sensors and actuators.

Materials and Supply Fees

N/A

Required Textbooks and Software

- No required textbooks; lecture notes will be distributed
- Required software: Klayout
 - Download link: <http://www.klayout.de/build.html>

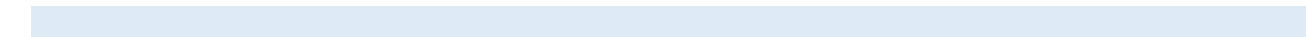
Recommended Materials

- R.C. Jaeger, Introduction to Microelectronic Fabrication, 2nd ed., Prentice Hall, 2002. ISBN-13: 978-0201444940.
- Stephen A. Campbell, The Science and Engineering of Microelectronic Fabrication, 2nd ed., Oxford University Press, 2001. ISBN-13: 978-0195136050.

- Dieter K. Schroder, Semiconductor material and device characterization, Third Edition ed.: John Wiley & Sons, Inc., 2006.
- G.S. May and S.M. Sze, Fundamentals of semiconductor fabrication, Wiley, 2004

Course Schedule

| Week | Monday | Lecture | Lab | Note |
|------|---------|----------------------------------------------------|----------------------------------------------------------------------|-----------------------------------------------|
| 1 | Jan. 10 | Syllabus/Lab Safety/Photolithography | No lab | Grouping/Lab tour |
| 2 | Jan. 17 | No Lecture | Lab#1: Photolithography (Diode mask#1) | PR coating, exposure, develop |
| 3 | Jan. 24 | Wet Etching | Lab#2: SiO ₂ (BOE) | Thermal treatment, strip off SOG |
| 4 | Jan. 31 | Doping, diffusion | Lab#3: Spin-on-glass (SOG)/Diffusion | Thermal treatment, strip off SOG |
| 5 | Feb. 7 | Oxidation; PN diodes | Lab#4: Photolithography (Diode mask#2) + BOE | Modified process is applied |
| 6 | Feb. 14 | Dry etching; CMOS Intro (optional) | Lab#5: Drive-in + Photolithography (Diode mask #3) | TAs continue Photolithography of Diode mask#3 |
| 7 | Feb. 21 | Deposition -PVD, CVD; Metallization; Klayout Intro | Lab#6: Descum + Remove Natural Oxide + Sputtering aluminum, Lift-off | Rapid Thermal Annealing (TRA) is applied |
| 8 | Feb. 28 | MEMS Intro; MEMS micro actuator design | Mask layout design | |
| 9 | Mar. 7 | Spring Break (No class, No Lab) | | |
| 10 | Mar. 14 | PN diodes characterization | Lab#7: Diodes Characterization | |
| 11 | Mar. 21 | MEMS surface micromachining | Lab#8: Photo (MEMS mask#1); sputter Ti/Ni; Liftoff | MEMS layout design due |
| 12 | Mar. 28 | MEMS bulk micromachining; DRIE | Lab#9: Photo (MEMS mask#2); BOE | Si wafers w/oxide |
| 13 | Apr. 4 | Actuator characterization | Lab#10: DRIE | |
| 14 | Apr. 11 | Makeup | Lab#11: MEMS testing | |
| 15 | Apr. 18 | Project Presentation | No Lab | |



Attendance Policy, Class Expectations, and Make-Up Policy

Excused absences must be consistent with university policies in the Graduate Catalog (<https://catalog.ufl.edu/graduate/regulations>) and require appropriate documentation. Additional information can be found here: <https://catalog.ufl.edu/graduate/regulations/>

Evaluation of Grades

| Assignment | Total Points | Percentage of Final Grade |
|------------------------|--------------|---------------------------|
| Attendance | 100 | 10% |
| Pre-lab | 100 each | 10% |
| In-lab performance | 100 each | 20% |
| Lab report | 100 each | 30% |
| Lab final presentation | 100 | 10% |
| Project | 100 | 20% |
| Total | | 100% |

- Pre-Lab Assignment and Lab Report Submission: The deadline for the individual pre-lab assignment submission is the beginning of each experiment, and the deadline for the group lab report submission is to be announced by your TA. Please work ahead to ensure that your pre-labs and all lab reports are finished on time.
- Pre-Lab Late Policy: Pre-Labs must be turned in on time. You can participate in the lab that week, but you will not get any credit for the pre-lab for that week.
- Lab Report Late Policy: -20% within 24 hours of deadline; No credit after 24 hours past due date

Grading Policy

| Percent | Grade | Grade Points |
|--------------|-------|--------------|
| 90.0 - 100.0 | A | 4.00 |
| 87.0 - 89.9 | A- | 3.67 |
| 84.0 - 86.9 | B+ | 3.33 |
| 81.0 - 83.9 | B | 3.00 |
| 78.0 - 80.9 | B- | 2.67 |
| 75.0 - 79.9 | C+ | 2.33 |
| 72.0 - 74.9 | C | 2.00 |
| 69.0 - 71.9 | C- | 1.67 |
| 66.0 - 68.9 | D+ | 1.33 |
| 63.0 - 65.9 | D | 1.00 |
| 60.0 - 62.9 | D- | 0.67 |
| 0 - 59.9 | E | 0.00 |

More information on UF grading policy may be found at:

<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.ua.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.ua.ufl.edu/public-results/>.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in

connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Conduct Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources:
Health and Wellness

Covid-19 Protocols:

- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the UF Health Screen, Test & Protect website for more information.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](#), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. <https://lss.at.ufl.edu/help.shtml>.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. <https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.

<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>;<https://care.dso.ufl.edu>.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.