Synthesis and Characterization of Semiconductor Materials

EMA 6412 (sections 13910, 13911, 13912,13913/ 4615 (sections 13841 and 13842)

Class Periods: MWF, 8.30-9.25 AM

Location: EDGE Studios, NEB 0100

Academic Term: Spring 2020

Instructor: S.J. Pearton
343 Nuclear Science Building
Phone:352/846-1086
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http://pearton.mse.ufl.edu

Office Hours: 9.30-10.30 pm Monday & Wednesday

Teaching Assistants:

There are usually none for this course

Course Description

This is a 3 credit graduate class. Materials characteristics of common semiconductors, crystallography, principles of materials growth and characterization of semiconductors and related materials for electronic and photonic applications. Thermal oxidation of Si and bulk and epitaxial growth technologies with a special emphasis on CVD approaches for semiconductors, metals and dielectrics. Corresponding electrical, optical, structural and chemical characterization methods for evaluation and quality control are covered.

Brief List of Topics to Be Covered

a. Introduction to course (1 hour)
b. Crystallographic properties of semiconductors (4 hours)
c. Epitaxial growth of semiconductors (6 hours)
d. Thermal oxidation kinetics of Si (4 hours)
e. Chemical vapor deposition (9 hours)
f. Physical vapor deposition (4 hours)
g. Chemical cleaning of semiconductors (1 hour)
h. Electrical properties of semiconductors (3 hours)
i. Common characterization techniques for semiconductors and semiconductor devices (4 hours)

Course Pre-Requisites / Co-Requisites

None, but some knowledge of semiconductor physics is assumed.

Course Objectives

Specific Outcomes of Instruction: To provide the student with a comparison of materials properties of semiconductor materials synthesized in both bulk and thin film form; growth/deposition methods such as molecular beam epitaxy, CVD and sputtering; kinetics and characterization of Si oxidation and an overview of characterization techniques used in the semiconductor industry. This knowledge is needed for pursuit of a professional career in the semiconductor industry.

Materials and Supply Fees
None

Professional Component (ABET):
This course addresses the following MSE Program outcomes:
(a)To apply mathematics, science, engineering basics and the fundamentals of materials science to envision solutions to and to solve engineering problems. (High coverage)
This course builds on fundamental concepts learned in previous courses and applies them to materials processing. Students are assigned homework and exam problems in which they must describe appropriate applications of the various processing techniques.
There is also some discussion of economic impact of the semiconductor industry (Low coverage) and trends in this technology (contemporary issues, low coverage)

Relation to Program Outcomes (ABET):

Outcome	***Coverage****
1. An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.	Medium
2. An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs.	
3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	
4. An ability to communicate effectively with a range of audiences	
5. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	
6. An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately.	
7. An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty	

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

Required Textbooks and Software

None

Recommended Materials

- Title Text: Fabrication Engineering at the Micro- and Nanoscale, Stephen A. Campbell, fourth edition, Oxford University Press, 2012, ISBN-13: 978-0199861224, ISBN-10: 0199861226 (available in the University Bookstore in paperback edition).
- There is a E-Learning System page for the course containing additional relevant material, including lecture notes, solution sets from the text book and semiconductor videos http://elearning.ufl.edu/

Course Schedule

Day/Date	Topic	Assigned Problems
Monday, 1/6	General Introduction	
Wednesday, 1/8	Properties of Semiconductors	
Friday, 1/10	Semiconductors/Doping	
Monday, 1/13	Video (Semiconductors)	
Wednesday, 1/15	Semiconductors/Doping	Problems from Chapter 2
Friday, 1/17	Semiconductor Crystallography	
Monday, 1/20	MLK Holiday	
Wednesday, 1/22	Videos (Intel China Day)	
Friday, 1/24	Bulk Growth	
Monday, 1/27	Bulk Growth +Si Run Lite video	
Wednesday, 1/29	Epitaxial Growth	
Friday, 1/31	MOCVD	
Monday, 2/3	MOMBE/MBE	Problems from Chapter 14
Wednesday, 2/5	Si oxidation	
Friday, 2/7	Quiz #1	*******
Monday, 2/10	Si oxidation	Problems from Chapter 4
Wednesday, 2/12	Si Oxidation	
Friday, 2/14	Video (Deposition)	
Monday, 2/17	CVD	
Wednesday, 2/19	Quiz #2	*******
Friday, 2/21	ALD/RTCVD	Problems from Chapter 13
Monday, 2/24	Evaporation	
Wednesday, 2/26	Evaporation	
Friday, 2/28	Video (Intel Panel)	
Monday, 3/2	Spring Break	
Wednesday, 3/4	Spring Break	
Friday, 3/6	Spring Break	
Monday, 3/9	Sputtering	
Wednesday, 3/11	Sputtering	

Friday, 3/13	PVD	Problems from Chapter 12
Monday, 3/16	PECVD	
Wednesday, 3/18	Video (MEMS)	
Friday, 3/20	Thermal oxidation vs. CVD	
Monday, 3/23	Dielectric deposition	
Wednesday, 3/25	Video (Nano)	
Friday, 3/27	First exam	******
Monday, 3/30	Dielectric deposition	
Wednesday, 4/1	Comparison of CVD approaches	
Friday, 4/3	Electrical properties	
Monday, 4/6	Lab Tour NIMET	
Wednesday, 4/8	Electrical properties	
Friday, 4/10	Electrical properties	
Monday, 4/13	Characterization	
Wednesday, 4/15	Characterization	
Friday, 4/17	Characterization	
Monday, 4/20	Course review	
Wednesday, 4/22	Second Exam	******

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.aa.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://gatorevals.aa.ufl.edu/ Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

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 Honor Code (https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. 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
• Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.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: http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html

Campus Resources:

Health and Wellness

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: http://www.counseling.ufl.edu/cwc, 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 suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.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://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

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