

SYNTHESIS AND CHARACTERIZATION OF SEMICONDUCTOR MATERIALS EMA 6412/4615

1. Description: This is a 3 credit graduate/undergraduate class. The course will cover materials characteristics of common semiconductors, crystallography, principles of materials growth and characterization of semiconductors and related materials for electronic and photonic applications. Bulk and epitaxial growth technologies and corresponding electrical, optical, structural and chemical characterization methods for evaluation and quality control are emphasized.

2. Pre-requisites and Co-requisites: None, but some knowledge of semiconductor physics is assumed.

3. Course Objectives: 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 MBE, CVD and sputtering; kinetics and characterization of Si oxidation and an overview of characterization techniques used in the semiconductor industry.

4. Contribution of course to meeting the professional component for EMA 4615 (ABET). This is a 3 credit course elective offered to students in the electronic materials specialty of the MSE program. It provides 3 credits towards Engineering Sciences.

5. Relationship of course to program outcomes for EMA 4615 (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.

6. Instructor: S.J. Pearton
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<http://pearton.mse.ufl.edu>

Office Hours: 1.00-2.00 pm Monday & Wednesday

7. Teaching assistants-there are generally none assigned to the class.

8. Lecture times: MWF, 10.40-11.30 am

9. Lecture location: MAE 126

10. There are no material or supply fees

11. Text: Fabrication Engineering at the Micro- and Nanoscale, Stephen A. Campbell, fourth edition, Oxford University Press, 2013, ISBN 978-0-19-986122-1 (available in the University Bookstore in paperback edition).

There is an E-Learning page containing additional relevant material, including notes, slides from the text, solution sets and semiconductor videos <https://lss.at.ufl.edu/>.

No other recommended reading is suggested.

12. Course Outline

| Lecture | Day/Date | Topic | Assigned Problems |
|---------|-----------------|-------------------------------|--------------------------|
| 1 | Monday, 1/6 | General Introduction | |
| 2 | Wednesday, 1/8 | Semiconductors/Bonding | |
| 3 | Friday, 1/10 | Semiconductors/Doping | |
| 4 | Monday, 1/13 | Video (Microchip) | |
| 5 | Wednesday, 1/15 | Semiconductor Crystallography | Problems from Chapter 2 |
| 6 | Friday, 1/17 | Semiconductor Crystallography | |
| --- | Monday, 1/20 | MLK Holiday | |
| 7 | Wednesday, 1/22 | Bulk Growth | |
| 8 | Friday, 1/24 | Bulk Growth | |
| 9 | Monday, 1/27 | Epitaxial Growth | |
| 10 | Wednesday, 1/29 | MOCVD | |
| 11 | Friday, 1/31 | MOMBE/MBE | Problems from Chapter 14 |
| 12 | Monday, 2/3 | Video (MBE) | |
| 13 | Wednesday, 2/5 | Quiz #1 | ***** |
| 14 | Friday, 2/7 | Si oxidation | |
| 15 | Monday, 2/10 | Si oxidation | Problems from Chapter 4 |
| 16 | Wednesday, 2/12 | Si Oxidation | |
| 17 | Friday, 2/14 | Video (Deposition) | |
| 18 | Monday, 2/17 | CVD | |
| 19 | Wednesday, 2/19 | Quiz #2 | ***** |
| 20 | Friday, 2/21 | CVD | Problems from Chapter 13 |
| 21 | Monday, 2/24 | Evaporation | |
| 22 | Wednesday, 2/26 | Evaporation | |
| 23 | Friday, 2/28 | Video (Si Run 1) | |
| -- | Monday, 3/3 | Spring Break | |
| -- | Wednesday, 3/5 | Spring Break | |
| -- | Friday, 3/7 | Spring Break | |
| 24 | Monday, 3/10 | Sputtering | |
| 25 | Wednesday, 3/12 | Sputtering | Problems from Chapter 12 |
| 26 | Friday, 3/14 | PECVD | |
| 27 | Monday, 3/17 | Thermal oxidation vs. CVD | |

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|----|-----------------|------------------------------|-------|
| 28 | Wednesday, 3/19 | Surface cleaning/defects | |
| 29 | Friday, 3/21 | Si/poly Si deposition | |
| 30 | Monday, 3/24 | First exam | ***** |
| 31 | Wednesday, 3/26 | Video (Si Run 2) | |
| 32 | Friday, 3/28 | No class | |
| 33 | Monday, 3/31 | Dielectric deposition | |
| 34 | Wednesday, 4/2 | Comparison of CVD approaches | |
| 35 | Friday, 4/4 | Electrical properties | |
| 36 | Monday, 4/7 | Electrical properties | |
| 37 | Wednesday, 4/0 | Electrical properties | |
| 38 | Friday, 4/11 | Characterization | |
| 39 | Monday, 4/14 | Lab Tour NIMET | |
| 40 | Wednesday, 4/16 | Characterization | |
| 41 | Friday, 4/18 | Characterization | |
| 42 | Monday, 4/21 | Course review | |
| 43 | Wednesday, 4/23 | Second Exam | ***** |

13. Attendance/Expectations: Attendance is not required, but experience has shown it is beneficial to the student's understanding. If you attend the lectures, be prompt in your arrival as a courtesy to the other students. Cell phones must be turned off during lectures and cannot be visible during an exam or quiz.

14. Grading: Quiz (2) 30%
 First Exam 30%
 Second Exam 40%

15. Homework: Optional, but any serious student will do it.

16. Grade Scale: 90-100% A 85-89% B⁺
 80-84% B 75-79% C⁺
 65-74% C 61-64% D⁺
 56-60% D 0-55% E

Grades are absolute and are not curved.

For EMA 4615 students-A "C-" will not be a qualifying grade for critical tracking courses. In order to graduate, students must have an overall GPA and an upper-division GPA of 2.0 or better (C or better). Note: a C- average is equivalent to a GPA of 1.67, and therefore, it does not satisfy this graduation requirement. For more information on grades and grading policies, please visit: <https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

For EMA 6412 students-In order to graduate, graduate students must have an overall GPA and an upper-division GPA of 3.0 or better (B or better). Note: a B- average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement. For more information on grades and grading policies, please visit: <http://gradschool.ufl.edu/catalog/current-catalog/catalog-general-regulations.html#grades>

17. Requirements for class attendance and make-up exams, assignments, and other work are consistent with university policies that can be found at:
<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>

18. Make-up Exam Policy .Reasonable excuses will be entertained for absences from exams or quizzes and the student will be expected to take the exam as soon as possible after it was originally scheduled.

19. Honesty Policy – All students admitted to the University of Florida have signed a statement of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a UF student and to be honest in all work submitted and exams taken in this course and all others.

Note that failure to comply with this commitment will result in disciplinary action compliant with the UF Student Honor Code Procedures.
See <http://www.dso.ufl.edu/sccr/procedures/honorcode.php>

20. Accommodation for Students with Disabilities – Students Requesting classroom accommodation must first register with the Dean of Students Office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation.

21. UF Counseling Services –Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:

- UF Counseling & Wellness Center, 3190 Radio Rd, 392-1575, psychological and psychiatric services.

- Career Resource Center, Reitz Union, 392-1601, career and job search services.

22. Software Use – All faculty, staff and student 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.