Compound Semiconductor Materials

EMA 4615 Section CAMP/OVER
Class Periods: MWF 2 (8:30-9:20am)
Location: Online
Academic Term: Spring 2021

Instructor:
Jiangeng Xue
jxue@mse.ufl.edu
(352) 846-3775
Office Hours: Mondays 1-2pm, RHN 237A or by appointments

Teaching Assistant/Peer Mentor/Supervised Teaching Student:
Please contact through the Canvas website

- N/A

Course Description
Physical properties of technologically important compound semiconductor materials. Epitaxial growth and practical application of compound semiconductor heterostructures

Course Pre-Requisites / Co-Requisites
EMA 3413

Course Objectives
The course emphasizes the fundamental physical properties and fabrication of compound semiconductor heterojunctions and multi-layered structures with a view to satisfying application requirements in the electronic and opto-electronic device areas. The influence of material and interface properties on device performance will also be stressed.

Materials and Supply Fees
N/A

Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	Medium
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3. An ability to communicate effectively with a range of audiences	
4. 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	
5. An ability to function effectively on a team whose members together provide leadership, create a	

collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	

*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

- Fabrication Engineering at the Micro- and Nanoscale, Stephen A. Campbell, fourth edition, Oxford University Press, 2012, ISBN-13: 978-0199861224, ISBN-10: 0199861226 (e-book available at UF)

Recommended reading:

- VLSI Fabrication Principles: Silicon and Gallium Arsenide, 2nd edition; S.K. Ghandhi (0-471-58005-8)
- Principles of Growth and Processing of Semiconductors, by S. Mahajan and K. S. Sree Harsha (ISBN 0-07-039605-1)
- Physics of Semiconductor Devices, by S. M. Sze and K. K. Ng, 3rd edition (ISBN 978-0-471-14323-9)

Course Schedule

Section I. Introduction to compound semiconductors (5 lectures)
- i. classes of compound semiconductors
- ii. crystal structures
- iii. electronic band structures
- iv. binary, ternary, and quaternary compound semiconductors

Section II. Physics and device applications of semiconductor heterojunctions (8 lectures)
- i. energy band diagrams of ideal single heterojunctions
- ii. non-ideal heterojunctions and double heterojunctions
- iii. electronic devices – HBTs and MODFETs
- iv. opto-electronic devices – LEDs and double heterostructure lasers

Section III. Bulk crystal growth of semiconductors (6 lectures)
- i. overall bulk crystal growth considerations: phase diagram, crystal structure, defects
- ii. Czochralski growth
- iii. Bridgman growth
- iv. flat zone growth

Section IV. Epitaxial growth of compound semiconductors (7 lectures)
- i. overview of epitaxy: advantages, materials issues, constraints/limitations
- ii. molecular beam epitaxy (MBE)
- iii. vapor phase epitaxy (VPE)
- iv. liquid phase epitaxy (LPE)

Section V. Semiconductor characterization techniques (6 lectures)
- i. electrical characterization
- ii. optical characterization
- iii. electron and ion spectroscopy

Section VI. Organic electronic materials (6 lectures)
- i. fundamental properties of organic semiconductors
- ii. organic thin film growth: vacuum deposition, vapor deposition, solution processes
- iii. organic electronic and opto-electronic devices – OLEDs, OPV cells, OTFTs

Online Course Recording
Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

Attendance Policy, Class Expectations, and Make-Up Policy

- Attendance is strongly recommended for this online course. Students are encouraged to actively participate in various in-class interactive activities. Questions from students are also encouraged.
- Excused absences must be consistent with university policies in the undergraduate catalog (https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx) and require appropriate documentation. Other than in emergency situations, you must notify the instructor of your scheduled absence for exams and discuss make-up options **at least one week prior to your absence**; failure to do so may not allow you to make up for the missed exam.
- It is preferred that e-mail communications with the instructor should originate from Canvas.

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Homework Sets (6-7)*	0	0%
Exams (3)	100 each	25% each
Design Projects (2)	100 each	12.5% each
		100%

*Optional homeworks will be assigned on a biweekly basis, which will not count towards the final grade.

Grading Policy
The following is given as an example only.

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:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

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.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://ufl.bluera.com/ufl/. 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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-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: https://registrar.ufl.edu/ferpa.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://care.dso.ufl.edu.

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