Fall 2017
University of Illinois at Urbana-Champaign
ECE 488: Compound Semiconductors

Course Director:
Professor John M. Dallesasse

The course information listed below is included on the following pages:

Course Goals

Provide insight into advanced semiconductor materials and devices; elementary semiconductor band theory; heterostructures and band alignment in compound semiconductors; transport issues; three-terminal devices; and two-terminal devices including LEDs, lasers, and light modulators.

Key Goals:

- Develop a working knowledge of compound semiconductor materials and devices
- Provide a foundation for future advanced physical electronics courses
- Provide basic device knowledge to support a career in wireless communications or photonics
- Provide sufficient background such that you can begin to read and understand the literature on compound semiconductor materials and devices

ECE 488 Instructor and TA Office Hours

Course Director: Professor John Dallesasse
2114 Micro and Nanotechnology Laboratory
333-8416
jdallesa@illinois.edu

Fall 2016 ECE 488 Instructor & TA Office Hours:

Name	Office Hours Location	Tel. #	Office Location	e-mail
Prof. J. Dallesasse	2114 MNTL	333-8416	2114 MNTL	jdallesa@
TA: Kanuo Chen	4036 ECEB		3034 MNTL	kchen15@

ECE 488 - INSTRUCTOR AND TA OFFICE HOUR SCHEDULE

TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
9 - 10				K. Chen	
10 - 11					
11 - 12					
12 - 1					
1 – 2					
2 – 3					
3 – 4		J. Dallesasse			
4 – 5					

Office hours will be held as listed, in the offices given in the table. You can make individual appointments to see the instructor or TA at times other than the scheduled office hours if needed.

Required:

- Class notes (required) can be purchased from the ECE Supply Center
- Additional reading materials will be distributed in class or through the course web-site

Reference Textbooks Available in Grainger Engineering Library:

Call No: 621.38152W832p
Physical Properties of Semiconductors, Prentice Hall, 1989
Author: C.M. Wolfe, N. Holonyak, Jr., and G.E. Stillman

Other Reference for Further Reading and Background (Not Required):

Solid State Physics:

- C. Kittel, *Introduction to solid state physics* (any edition), John Wiley

Semiconductor physics and devices:

- S. Wang, *Fundamentals of semiconductor theory and device physics*, Prentice Hall, 1989

Quantum Wells and Heterostructures:

- J. H. Davies, *Physics of low-dimensional semiconductors*, Cambridge, 1998
- C. Weisbuch and B. Vinter, *Quantum semiconductor structures*, Academic Press, 1991

Compound Semiconductor Materials:

- V. Swaminathan and A.T. Macrander, *Materials Aspects of GaAs and InP based structures*, Prentice Hall, 1991

Basic Semiconductors:

- Free online textbook, see: http://ecee.colorado.edu/~bart/book/contents.htm, Prof. Bart Van Zeghbroeck, University of Colorado

Requirements of the Course

Prerequisites: ECE 340. Credit or concurrent registration in ECE 350 is optional.

Class Etiquette: Read the assigned sections from the notes prior to coming to class so you can participate in discussions. Come to class and do the homework. Cell phones, electronic recording of the lectures, and the taking of photos are not permitted in class. All class materials (homework, exams, quizzes, notes, etc.) are copyright protected. Sale or distribution by any means to any 3rd party without permission is prohibited.

Homework: Homework problems are designed to build skills in performing hand calculations needed to validate computer models, to reinforce understanding of key concepts, to build skills in extending conceptual knowledge in novel ways, or to advance a capacity to design or develop new devices. In some cases, completion of a homework problem will require independent study of topics related to but not necessarily covered in class. These are designed to advance the skills needed as a practicing engineer or researcher, where encountering new problems is both normal and common.

Homework is due in class on or before the assigned date. Late homework is not accepted.

Homework guidelines:
Homework must be done on 8-1/2 x 11 paper. The pages for each homework assignment must be stapled together. We are not responsible for lost pages on homework assignments that have not been stapled together. The following information must be on the first page: (1) your name, (2) Net ID #, (3) assignment number, and (4) date.

The homework must be neat and easily readable, in pen, dark pencil, or computer output, and all work leading to your answer must be shown. Don't give us HW ripped from a spiral-bound notebook with ragged edges as it makes grading difficult. A penalty may be incurred for its use. Also, if we can't read or follow your solution you will likely lose points. You are responsible for points missed due to illegible writing or lack of a logical flow in your solution.

The units commonly used in semiconductor device work are those in the SI system of units, with the exception that it is common to use cm (10^{-2} m) or sometimes μm (10^{-6} m), instead of meters for length measurements, and cm^3 rather than m^3 for volume measurements.

You are encouraged to discuss the homework assignments in small groups, but you must solve the problems on your own. Please see the professor and/or the TAs during their office hours for assistance with concepts or homework problems that you do not understand. If you are having difficulty with a particular topic, try reading about the same topics in the books that are available for ECE 488 in the Grainger Engineering Library (See the list on page 3).

You will need a scientific calculator for the homework.

Quizzes, Exams, and Grading

Quizzes: There will be two short in-class quizzes that will be announced in advance. Each quiz will consist of a few conceptual questions and will take 20 minutes.

Midterm & Final Exams: There will be one midterm exam and a comprehensive final exam. The exams will be closed book. One hand-written 8.5" X 11" double-sided formula sheet may be brought in for the midterm, and two 8.5" X 11" double-sided formula sheets may be brought in for the final exam. A simple scientific calculator is allowed, but additional formulae must not be stored in the calculator and it must not have networking capability. You will not be allowed to use your cell phone's calculator function during quizzes or exams. The format of your exam solutions should be the same as that used for the homework assignments: units must be shown explicitly, your answer must be circled and your work must be readable. Numerical answers should contain an appropriate number of significant figures. The final exam is three hours, which will be given at a time to be announced.

Midterm:	Wednesday, October 18th (Tentative)
Final Exam:	To Be Announced (Per Registrar's Office)

Grading Criteria: Your grade in ECE 488 is based primarily on your scores on the reading checks, homework assignments, quizzes, one hour-exam, final exam, and your class participation as follows:

Final Score = Homework + Quizzes + Midterm + Final Exam score as follows:

Homework & Participation:	30%
Quizzes:	10%
Midterm Exam:	20%
Final Exam:	40%
Total :	100%

Course Policy on Absences

If you miss a quiz, exam, or homework assignment the following procedures apply:

1) Absences for job interviews or for specific university-sponsored events must be pre-arranged with the course director, Prof. Dallesasse. Pre-arranged excused absences will not be given for homework assignments - you must turn in your homework or arrange to have it turned in for you prior to your absence. Pre-arranged excused absences will not be given for exams except in the case of specific university-related events.

2) In the event of a severe illness or other emergency absence, you must obtain an Excused Absence Form from the Undergraduate College Office, Room 207 Engineering Hall. The office may be reached at 333-0050. Note that Excused Absence Forms in the case of illness are now only given out by the office for the case of a serious illness lasting more than 3 days.

Scores on quizzes and hour exams missed due to excused absences may either be made up or prorated, at the discretion of the course director. If prorated, your grade will be determined based on the average of the grades that you have completed. Specifically, the average of your completed scores will be used to determine the total, homework or hour exam score and the final total score. Work missed due to an unexcused absence will be counted as a 0.

You must take the final exam to receive a grade for the course. If you miss the final exam for a legitimate reason, you will automatically receive a final course grade of INCOMPLETE. In this case to complete the course, you must make arrangements through your Dean's office and with the instructor to take a makeup final exam that will be given at the scheduled time at the end of the following semester. An unexcused absence from the final will result in a grade of “0” on the final.

Students with Disabilities

Students with disabilities who may qualify for extra time while taking tests must provide a current DRES letter to Prof. Dallesasse immediately. Specific arrangements will be made on a case-by-case basis.

Fall 2017 ECE 488 COURSE SCHEDULE AND OUTLINE			
Lecture Number	**Date**	**Topic**	**Assigned §'s**
1	M 08/28	**Introduction to the course and overview of compound semiconductor applications**	**Review Syllabus**
2	W 08/30	**Compound semiconductor applications, introduction to quantum mechanics**	§'s 1.1, 1.1.1, 1.1.2, 1.1.3
3	F 09/1	**Free and bound particles, infinite square well, triangle well**	§'s 1.2, 1.2.1, 1.2.2, 1.2.3
	M 09/04	**Labor day: No Class**	
4	W 09/06	**Scattering from potential steps, finite square well, Coulomb well (hydrogen atom)**	§'s 1.3, 1.4, 1.5
5	F 09/08	**Crystal structures, ionic bonding**	§'s 2.1, 2.1.1, 2.1.3, 2.2
6	M 09/11	**Covalent bonding, mixed ionic-covalent bonding, Major semiconductor crystal structures, crystal diffraction, reciprocal lattice, properties of the reciprocal lattice vector**	§'s 2.3, 2.3.1, 2.3.2, 2.3.3, 2.3.4, 2.4, 2.4.1, 2.4.2, 2.4.3, 2.5, 2.5.1, 2.5.2, 2.5.3
7	W 09/13	**Diffraction condition, The Brillouin Zone, free electron theory and the density of states**	§'s 2.5.4, 2.5.5, 3.1, 3.1.1, 3.1.2, 3.1.3
8	F 09/15	**Periodic crystal structures and the Bloch Theorem**	§'s 3.2, 3.2.1, 3.2.2, 3.2.3
9	M 09/18	**Energy gaps in periodic structures**	§'s 3.3, 3.3.1, 3.3.2
10	W 09/20	**Kronig-Penney model**	§'s 3.4, 3.4.1, 3.4.2
11	F 09/22	**Effective mass, band structure of common semiconductors**	§'s 3.5, 3.6, 3.6.1, 3.6.2, 3.6.3, 3.6.4
12	M 09/25	**Compound semiconductor crystal properties, structural properties**	§'s 4.1, 4.2, 4.2.1, 4.2.2
13	W 09/27	**Phonons**	§ 4.2.3
14	F 09/29	**Electrical properties: gap, effective mass, mobility**	§'s 4.3, 4.3.1, 4.3.2, 4.3.3
15	M 10/02	**Doping, deep levels**	§'s 4.3.4, 4.3.5
16	W 10/04	**The Fermi Integral, free carrier concentrations, surface states**	§'s 4.4, 4.4.1, 4.4.2, 4.4.3, 4.5
17	F 10/06	**III-V semiconductor lattice constant & bandgap**	§'s 4.6, 4.6.1, 4.6.2,
18	M 10/09	**III-N semiconductors, group IV compounds**	§'s 4.7, 4.7.1, 4.7.2, 4.8
19	W 10/11	**Growth of bulk crystals, crystal imperfections, epitaxy, phase diagrams**	Chapter 5
20	F 10/13	**Energy band alignment**	§'s 6.1, 6.1.1, 6.1.2, 6.1.3, 6.1.4
21	M 10/16	**Strained layer structures**	§'s 6.2, 6.2.1, 6.2.2,
22	W 10/18	**Midterm Exam (Tentative)**	
23	F 10/20	**Strain effects on band edge energies**	§'s 6.3, 6.3.1, 6.3.2, 6.3.3, 6.3.4
24	M 10/23	**Band edges in strained alloys, constructing band diagrams**	§'s 6.4, 6.5, 6.5.1, 6.5.2, 6.5.3, 6.5.4

25	W 10/25	**Heterojunctions in equilibrium**	§'s 7.1, 7.1.1, 7.1.2
26	F 10/27	**Heterojunctions under bias**	§'s 7.2, 7.2.1, 7.2.2
27	M 10/30	**Realistic finite quantum wells**	§'s 7.3, 7.3.1, 7.3.2, 7.3.3, 7.3.4
28	W 11/01	**Superlattices and minibands**	§'s 7.4, 7.4.1, 7.4.2, 7.4.3, 7.4.4
29	F 11/03	**Heterostructures in electric fields and the Franz-Keldysh Effect**	§'s 7.5, 7.5.1, 7.5.2
30	M 11/06	**Basic optical properties of dielectric media**	§'s 8.1, 8.1.1, 8.1.2, 8.1.3, 8.1.4, 8.1.5
31	W 11/08	**Absorption in semiconductors**	§'s 8.2, 8.2.1, 8.2.2, 8.2.3, 8.2.4
32	F 11/10	**Transitions between discrete states**	§'s 8.3, 8.3.1, 8.3.2, 8.3.3
33	M 11/13	**Optical transitions between bands, non-radiative re-combination processes**	§'s 8.4, 8.4.1, 8.4.2, 8.4.3, 8.5
34	W 11/15	**Introduction to Heterostructure Electronic Devices, MESFETs**	§'s 9.1, 9.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.2.5
35	F 11/17	**Modulation Doping**	§'s 9.3, 9.3.1, 9.3.2
	11/20-24	**Thanksgiving: No Class**	
36	M 11/27	**High Electron Mobility Transistors (HEMTs)** Basics	§'s 9.4, 9.5, 9.5.1, 9.5.2, 9.5.3
37	W 11/29	**High Electron Mobility Transistors (HEMTs)** Microwave noise performance, optimal design	§'s 9.5.4, 9.6, 9.6.1, 9.6.2
38	F 12/01	**High Electron Mobility Transistors (HEMTs)** GaN HEMTs	§'s 9.7, 9.7.1, 9.7.2, 9.7.3
39	M 12/04	**Heterojunction Bipolar Transistors (HBTs)** HBT basics	§'s 9.8, 9.8.1, 9.8.2, 9.8.3
40	W 12/06	**Heterojunction Bipolar Transistors (HBTs)** High speed operation	§'s 9.8.4, 9.8.5
41	F 12/08	**Heterostructure Lasers** Basic structure, waveguiding, threshold condition, thresh-old current density, laser output power	§'s 10.1, 10.1.1, 10.1.2, 10.1.3, 10.1.4, 10.1.5, 10.1.6
42	M 12/11	**Heterostructure Lasers** Stripe-geometry lasers, DFBs, VCSELs	§'s 10.2, 10.2.1, 10.2.2, 10.3, 10.4, 10.4.1, 10.4.2, 10.4.3, 10.4.4, 10.4.5
43	W 12/13	**Photodiodes and Solar Cells**	
		FINAL EXAM (Inclusive)	**Date TBD (Per Regis-trar's Office)**