

EE5381 Foundations in Semiconductors

Fall 2013

Instructor(s): Donald Butler; <http://www-ee.uta.edu/eedept/Faculty/Dbutler.htm>

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Office Hours: M11:00AM-12:00noon, W2:30-3:30PM, F1:00-2:00PM

Section Information: EE5381-001 (Live) , -002 (Web) Foundations in Semiconductors

Time and Place of Class Meetings: MWF1:00-1:50 WH404

Course Announcements and Material will be posted on the course webpage in Blackboard
<http://www.uta.edu/blackboard>.

Description of Course Content: A study of basic principles of semiconductors that have direct applications on device operation and fabrication. The course covers basic semiconductor properties, elements of quantum mechanics, energy band theory, equilibrium carrier statistics, carrier transport and generation-recombination processes, semiconductor characterization techniques using resistivity measurement, mobility measurement through Hall effect, defect characterization, carrier lifetime measurement and optical characterization.

Student Learning Outcomes:

1. Introduce graduate students to properties of semiconductors and selected semiconductor characterization techniques relevant to professionals working on semiconductor materials, devices, and integrated circuits.
2. Students will learn how to solve the one-dimensional Schrodinger equation for electron transport properties.
3. Students will learn energy band theory.
4. Students will learn the fundamentals of carrier statistics and carrier transport in semiconductors.
5. Students will learn generation recombination statistics and carrier lifetimes.
6. Students will learn electrical and optical properties of semiconductors.
7. Students will learn the continuity equation and its solution in typical device situations.
8. Students will learn beyond the drift diffusion model for nanodevices.

Required Textbooks and Other Course Materials:

Required:

Advanced Semiconductor Fundamentals, Modular Series on Solid State Devices Vol. VI 2nd Edition, by R.F. Pierret, Prentice-Hall 2003.

References (not required):

Semiconductor Material and Device Characterization, D.K. Schroder, Wiley-Interscience 1998, ISBN 0-471-24139-3

Physics of Semiconductor Devices 2nd Ed. by S.M. Sze, Wiley-Interscience 1981.

Semiconductor Fundamentals, Modular Series on Solid State Devices Volume I, by R. F. Pierret, Addison-Wesley 1983.

Physics of Semiconductors and their Heterostructures by Jasprit Singh, McGraw-Hill 1993.

Semiconductors for Micro- and Nanotechnology: An Introduction for Engineers by Jan G. Korvink and Andreas Greiner, Wiley-VCH 2002.

Descriptions of major assignments and examinations:

Midterm Examinations: 1 midterm exam (~mid-October)

Final Examination: Final Exam Monday Dec. 9, 11:00AM-1:30PM

Other Graded Assignments (Homework / Projects / Labs / Research Papers):

Homework roughly every other week, Term Paper due at end of semester, Wed. Nov. 27, 2013.

Attendance: Attendance is required.

Other Requirements: no graduate level prerequisites, no special meetings.

Grading: (tentative)

Homework 10%; Check **Blackboard** for assignments and due dates.

Midterm Exam 25%;

Term Paper 25%

Final Exam 40%

A	>80%
B	70-79.9%
C	60-69.9%
D	50-59.9%
F	<50%

Students are expected to keep track of their performance throughout the semester and seek guidance from available sources (including the instructor) if their performance drops below satisfactory levels. Your grades will be posted on Blackboard to help you monitor your performance in the class.

Expectations for Out-of-Class Study: Beyond the time required to attend each class meeting, students enrolled in this course should expect to spend at least an additional **9** hours per week of their own time in course-related activities, including reading required materials, completing assignments, preparing for exams, etc.

Make-up Exams: Late homework will be penalized at 50% per day late. Homework is due at the beginning of class. Missed exams and quizzes will be given a makeup only for serious illness or emergency and require a doctors certificate or similar written documentation. Students requiring a makeup exam must make an appointment as soon as possible after the scheduled exam date. Any special consideration for travel to conferences or other business/academic travel must be made at the beginning of the semester or as soon as you become aware of the trip.

Grade Grievances: Any appeal of a grade in this course must follow the procedures and deadlines for grade-related grievances as published in the current graduate catalog.

http://grad.pci.uta.edu/about/catalog/current/general/regulations/#grade_grievances

Drop Policy: Students may drop or swap (adding and dropping a class concurrently) classes through self-service in MyMav from the beginning of the registration period through the late registration period. After the late registration period, students must see their academic advisor to drop a class or withdraw. Undeclared students must see an advisor in the University Advising Center. Drops can continue through a point two-thirds of the way through the term or session. It is the student's responsibility to officially withdraw if they do not plan to attend after registering. **Students will not be automatically dropped for non-attendance.** Repayment of certain types of financial aid administered through the University may be

required as the result of dropping classes or withdrawing. For more information, contact the Office of Financial Aid and Scholarships (<http://www.uta.edu/aao/fao/>).

Americans with Disabilities Act: The University of Texas at Arlington is on record as being committed to both the spirit and letter of all federal equal opportunity legislation, including the *Americans with Disabilities Act (ADA)*. All instructors at UT Arlington are required by law to provide "reasonable accommodations" to students with disabilities, so as not to discriminate on the basis of that disability. Any student requiring an accommodation for this course must provide the instructor with official documentation in the form of a letter certified by the staff in the Office for Students with Disabilities, University Hall 102. Only those students who have officially documented a need for an accommodation will have their request honored. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at www.uta.edu/disability or by calling the Office for Students with Disabilities at (817) 272-3364.

As a faculty member, I am required by law to provide "**reasonable accommodation**" to students with disabilities, so as not to discriminate on the basis of that disability. Student responsibility primarily rests with **informing faculty at the beginning of the semester and in providing authorized documentation through designated administrative channels.**

If you require an accommodation based upon disability, please meet with me in my office during the first week of classes.

Academic Integrity: Students enrolled in this course are expected to adhere to the UT Arlington Honor Code:

I pledge, on my honor, to uphold UT Arlington's tradition of academic integrity, a tradition that values hard work and honest effort in the pursuit of academic excellence.

I promise that I will submit only work that I personally create or contribute to group collaborations, and I will appropriately reference any work from other sources. I will follow the highest standards of integrity and uphold the spirit of the Honor Code.

UT Arlington faculty members may employ the Honor Code as they see fit in their courses, including (but not limited to) having students acknowledge the honor code as part of an examination or requiring students to incorporate the honor code into any work submitted. Per UT System *Regents' Rule* 50101, §2.2, suspected violations of university's standards for academic integrity (including the Honor Code) will be referred to the Office of Student Conduct. Violators will be disciplined in accordance with University policy, which may result in the student's suspension or expulsion from the University.

Student Support Services: UT Arlington provides a variety of resources and programs designed to help students develop academic skills, deal with personal situations, and better understand concepts and information related to their courses. Resources include tutoring, major-based learning centers, developmental education, advising and mentoring, personal counseling, and federally funded programs. For individualized referrals, students may visit the reception desk at University College (Ransom Hall), call the Maverick Resource Hotline at 817-272-6107, send a message to resources@uta.edu, or view the information at www.uta.edu/resources.

Electronic Communication: UT Arlington has adopted MavMail as its official means to communicate with students about important deadlines and events, as well as to transact university-related business regarding financial aid, tuition, grades, graduation, etc. All students are assigned a MavMail account and are responsible for checking the inbox regularly. There is no additional charge to students for using this account, which remains active even after graduation. Information about activating and using MavMail is available at <http://www.uta.edu/oit/cs/email/mavmail.php>.

When sending an email to me, please put the course number as part of the email subject so that I can give it prompt attention.

Student Feedback Survey: At the end of each term, students enrolled in classes categorized as “lecture,” “seminar,” or “laboratory” shall be directed to complete an online Student Feedback Survey (SFS). Instructions on how to access the SFS for this course will be sent directly to each student through MavMail approximately 10 days before the end of the term. Each student’s feedback enters the SFS database anonymously and is aggregated with that of other students enrolled in the course. UT Arlington’s effort to solicit, gather, tabulate, and publish student feedback is required by state law; students are strongly urged to participate. For more information, visit <http://www.uta.edu/sfs>.

Final Review Week: A period of five class days prior to the first day of final examinations in the long sessions shall be designated as Final Review Week. The purpose of this week is to allow students sufficient time to prepare for final examinations. During this week, there shall be no scheduled activities such as required field trips or performances; and no instructor shall assign any themes, research problems or exercises of similar scope that have a completion date during or following this week *unless specified in the class syllabus*. During Final Review Week, an instructor shall not give any examinations constituting 10% or more of the final grade, except makeup tests and laboratory examinations. In addition, no instructor shall give any portion of the final examination during Final Review Week. During this week, classes are held as scheduled. In addition, instructors are not required to limit content to topics that have been previously covered; they may introduce new concepts as appropriate.

Emergency Exit Procedures: Should we experience an emergency event that requires us to vacate the building, students should exit the room and move toward the nearest exit, [which is located across the hall, on your right as you leave the classroom. Note, the classroom has exits at the front and rear. If the stairway at the immediate right of the classroom is unsafe, there is another stairway at the end of the hall on the left as you leave the classroom.](#) When exiting the building during an emergency, one should never take an elevator but should use the stairwells. Use the nearest safe stairway to leave the building. Faculty members and instructional staff will assist students in selecting the safest route for evacuation and will make arrangements to assist handicapped individuals.



Nearest stairway, immediately to the right of the classroom door of WH404.

Alternate stairway on left of WH404 at end of hall.

Inclusion of this verbiage as well as a brief discussion on the matter with your students at the beginning of the term is mandated by UT Arlington Procedure 7-6: Emergency/Fire Evacuation Procedures (<https://www.uta.edu/policy/procedure/7-6>).

Course Schedule. (Tentative)

Lecture #	Date	Subject
1	23-Aug-13	Review Syllabus, Basics, and Crystal Structure
2	26-Aug-13	QM foundations
3	28-Aug-13	SE Equation + QM Principles
4	30-Aug-13	Free Electron, Probability Current
5	4-Sep-13	Infinite Potential Well
6	6-Sep-13	Electron Scattering + Potential Step
7	9-Sep-13	Finite Potential Barrier: Scattering and Tunneling
8	11-Sep-13	Finite Potential Well 1
9	13-Sep-13	Finite Potential Well 2
10	16-Sep-13	Energy Band Theory 1
11	18-Sep-13	Energy Band Theory 2
12	20-Sep-13	Properties of Energy Bands, Carrier Velocity, and Effective Mass
13	23-Sep-13	Carriers and Currents
14	25-Sep-13	3-D Energy Bands
15	27-Sep-13	Constant Energy Surfaces and Effective Mass
16	30-Sep-13	Density of States
17	2-Oct-13	Density of States in 1-D and 2-D Systems
18	4-Oct-13	Density of States for Electrons and Holes
19	7-Oct-13	Density of States Effective Mass
20	9-Oct-13	Fermi Function
21	11-Oct-13	More on reduced dimension systems
22	14-Oct-13	Midterm Review
23	16-Oct-13	Midterm Exam
24	18-Oct-13	Donors, Acceptors, and Carrier Concentrations #1
25	21-Oct-13	Donors, Acceptors, and Carrier Concentrations #2
26	23-Oct-13	Donor and Acceptor Impurity Ionization
27	25-Oct-13	Degenerate Semiconductors 1
28	28-Oct-13	Degenerate Semiconductors 2
29	30-Oct-13	Carrier Statistics
30	1-Nov-13	Energy Bands and Electric Fields
31	4-Nov-13	Thermoelectric Effects, Generation-Recombination Processes
32	6-Nov-13	Generation-Recombination Statistics 1
33	8-Nov-13	Generation-Recombination Statistics 2
34	11-Nov-13	Surface Generation-Recombination Statistics
35	13-Nov-13	Carrier Transport: Drift 1
36	15-Nov-13	Carrier Transport: Drift 2
37	18-Nov-13	Carrier Transport: Diffusion
38	20-Nov-13	Applications of Drift-Diffusion Theory 1
39	22-Nov-13	Applications of Drift-Diffusion Theory 2

40	25-Nov-13	Longitudinal and Transverse Transport Theory
41	27-Nov-13	Carrier Statistics Applied to Transport Processes, Term Paper Due
42	2-Dec-13	Review #1
43	4-Dec-13	Review #2: Last Day of Classes
44	9-Sep-13	Final Exam 11:00 AM - 1:30PM

As the instructor for this course, I reserve the right to adjust this schedule in any way that serves the educational needs of the students enrolled in this course. –Donald P. Butler

Library Home Page.....	http://www.uta.edu/library
Subject Guides	http://libguides.uta.edu
Subject Librarians.....	http://www.uta.edu/library/help/subject-librarians.php
Database List.....	http://www.uta.edu/library/databases/index.php
Course Reserves.....	http://pulse.uta.edu/vwebv/enterCourseReserve.do
Library Catalog	http://discover.uta.edu/
E-Journals.....	http://liblink.uta.edu/UTALink/az
Library Tutorials	http://www.uta.edu/library/help/tutorials.php
Connecting from Off- Campus.....	http://libguides.uta.edu/offcampus
Ask A Librarian	http://ask.uta.edu

The following URL houses a page where we have gathered many commonly used resources needed by students in online courses: <http://www.uta.edu/library/services/distance.php>

Finally, the subject librarian for your area can work with you to build a customized course page to support your class if you wish. For examples, visit <http://libguides.uta.edu/os> and <http://libguides.uta.edu/pols2311fm> . If you have any questions, please feel free to contact the Coordinator for Information Services, Suzanne Beckett, at sbeckett@uta.edu or at 817.272.0923.