

# EE5381 Foundations in Semiconductors

Fall 2016

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Office Hours: MWF2:00PM-3:00PM or by appointment

Section Information: EE5381-001 (Live) ,-002 (Web) -003 (Web) Foundations in Semiconductors

Time and Place of Class Meetings: MWF1:00-1:50 NH203

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 2<sup>nd</sup> 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 2<sup>nd</sup> 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. 12, 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. 30, 2016.

**Attendance:** At The University of Texas at Arlington, taking attendance is not required but attendance is a critical indicator in student success. Each faculty member is free to develop his or her own methods of evaluating students' academic performance, which includes establishing course-specific policies on attendance. As the instructor of this section, **attendance is required**. However, while UT Arlington does not require instructors to take attendance in their courses, the U.S. Department of Education requires that the University have a mechanism in place to mark when Federal Student Aid recipients "begin attendance in a course." UT Arlington instructors will report when students begin attendance in a course as part of the final grading process. Specifically, when assigning a student a grade of F, faculty report the last date a student attended their class based on evidence such as a test, participation in a class project or presentation, or an engagement online via Blackboard. This date is reported to the Department of Education for federal financial aid recipients.

**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](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:** UT 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)*, *The Americans with Disabilities Amendments Act (ADAAA)*, and *Section 504 of the Rehabilitation Act*. 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 disability. Students are responsible for providing the instructor with official notification in the form of a **letter certified** by the Office for Students with Disabilities (OSD). Only those students who have officially documented a need for an accommodation will have their request honored. Students experiencing a range of conditions (Physical, Learning, Chronic Health, Mental Health, and Sensory) that may cause diminished academic performance or other barriers to learning may seek services and/or accommodations by contacting:

**The Office for Students with Disabilities, (OSD)** [www.uta.edu/disability](http://www.uta.edu/disability) or calling 817-272-3364. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at [www.uta.edu/disability](http://www.uta.edu/disability).

**Counseling and Psychological Services, (CAPS)** [www.uta.edu/caps/](http://www.uta.edu/caps/) or calling 817-272-3671 is also available to all students to help increase their understanding of personal issues, address mental and behavioral health problems and make positive changes in their lives.

**Non-Discrimination Policy:** *The University of Texas at Arlington does not discriminate on the basis of race, color, national origin, religion, age, gender, sexual orientation, disabilities, genetic information, and/or veteran status in its educational programs or activities it operates. For more information, visit [uta.edu/eos](http://uta.edu/eos).*

**Title IX Policy:** The University of Texas at Arlington (“University”) is committed to maintaining a learning and working environment that is free from discrimination based on sex in accordance with Title IX of the Higher Education Amendments of 1972 (Title IX), which prohibits discrimination on the basis of sex in educational programs or activities; Title VII of the Civil Rights Act of 1964 (Title VII), which prohibits sex discrimination in employment; and the Campus Sexual Violence Elimination Act (SaVE Act). Sexual misconduct is a form of sex discrimination and will not be tolerated. *For information regarding Title IX, visit [www.uta.edu/titleIX](http://www.uta.edu/titleIX) or contact Ms. Jean Hood, Vice President and Title IX Coordinator at (817) 272-7091 or [jmhood@uta.edu](mailto:jmhood@uta.edu).*

**Academic Integrity:** Students enrolled all UT Arlington courses 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 in their courses by 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. Additional information is available at <https://www.uta.edu/conduct/>.

**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](mailto:resources@uta.edu), or view the information at <http://www.uta.edu/universitycollege/resources/index.php>.

**The IDEAS Center** (2<sup>nd</sup> Floor of Central Library) offers **free** tutoring to all students with a focus on transfer students, sophomores, veterans and others undergoing a transition to UT Arlington. To schedule an appointment with a peer tutor or mentor email [IDEAS@uta.edu](mailto:IDEAS@uta.edu) or call (817) 272-6593.

**The English Writing Center (411LIBR):** The Writing Center Offers free tutoring in 20-, 40-, or 60-minute face-to-face and online sessions to all UTA students on any phase of their UTA coursework. Our hours are 9 am to 8 pm Mon.-Thurs., 9 am-3 pm Fri. and Noon-6 pm Sat. and Sun. Register and make appointments online at <http://uta.mywconline.com>. Classroom Visits, workshops, and specialized services for graduate students are also available. Please see [www.uta.edu/owl](http://www.uta.edu/owl) for detailed information on all our programs and services.

The Library's 2<sup>nd</sup> floor Academic Plaza offers students a central hub of support services, including IDEAS Center, University Advising Services, Transfer UTA and various college/school advising hours. Services are available during the library's hours of operation. <http://library.uta.edu/academic-plaza>

**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.

**Campus Carry:** Effective August 1, 2016, the Campus Carry law (Senate Bill 11) allows those licensed individuals to carry a concealed handgun in buildings on public university campuses, except in locations the University establishes as prohibited. Under the new law, openly carrying handguns is not allowed on college campuses. For more information, visit <http://www.uta.edu/news/info/campus-carry/>

**Student Feedback Survey:** At the end of each term, students enrolled in face-to-face and online classes categorized as "lecture," "seminar," or "laboratory" are 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 via the SFS database is aggregated with that of other students enrolled in the course. Students' anonymity will be protected to the extent that the law allows. UT Arlington's effort to solicit, gather, tabulate, and publish student feedback is required by state law and aggregate results are posted online. Data from SFS is also used for faculty and program evaluations. For more information, visit <http://www.uta.edu/sfs>.

**Final Review Week:** for semester-long courses, 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 **safe** exit, [which is located at the end of the hall to the left](#). When exiting the building during an emergency, one should never take an elevator but should use the stairwells. Faculty members and instructional staff will assist students in selecting the safest route for evacuation and will make arrangements to assist individuals with disabilities.



Evacuation plans may be found at [http://www.uta.edu/campus-ops/ehs/fire/Evac\\_Maps\\_Buildings.php](http://www.uta.edu/campus-ops/ehs/fire/Evac_Maps_Buildings.php).  
UT Arlington Procedure 7-6: Emergency/Fire Evacuation Procedures  
([http://www.uta.edu/police/Evacuation\\_Procedures.pdf](http://www.uta.edu/police/Evacuation_Procedures.pdf))

Students are also encouraged to subscribe to the MavAlert system that will send information in case of an emergency to their cell phones or email accounts. Anyone can subscribe at <https://mavalert.uta.edu/> or <https://mavalert.uta.edu/register.php>

**Emergency Phone Numbers:** In case of an on-campus emergency, call the UT Arlington Police Department at **817-272-3003** (non-campus phone), **2-3003** (campus phone). You may also dial 911. Non-emergency number 817-272-3381

## Course Schedule. (Tentative)

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

39	30-Nov-15	Longitudinal and Transverse Transport Theory
40	30-Nov-16	Carrier Statistics Applied to Transport Processes, Term Paper Due
41	2-Dec-16	Review #1
42	7-Dec-15	Review #2
42	7-Dec-16	Review #3: Last Day of Classes
43	12-Dec-16	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*

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

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](mailto:sbeckett@uta.edu) or at 817.272.0923.