

ECE 447 Syllabus¹ Spring 2014

Instructor: Dr. S. S. Ahmed

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Here is Professor Ahmed's [Linkedin Profile](#)

Office: ENGR E-222

Office Phone: 453-7630

Office Hours: TR 11 a.m.–1:45 p.m. (or by appointment)

Lecture: TR 9:35 – 10:50 a.m., ENGR A-310

Lab: T 4:00 – 5:50, p.m. ENGR E-132 (or available as determined by the TA)

R 11:00 – 12:50 a.m., ENGR E-132 (or available as determined by the TA)

(Using online simulations on NSF's nanoHUB.org and *Sentaurus* commercial simulator)

Prerequisite: ECE 345, 375 (or instructor consent)

Textbook:

Semiconductor Physics and Devices, 3rd edition (or newer if available), by Donald A. Naemen, McGraw Hill, ISBN# 0-07-232107-5

Other Useful Books:

(1) Solid State Electronic Devices, 6th edition, by Ben Streetman and Sanjay Banerjee, ISBN# 9780131497269.

(2) Online book: <http://ecee.colorado.edu/~bart/book/>

Course Topics (Tentative):

Introduction: Semiconductor devices and IC Industry {2 classes}

Atoms and electrons, quantum mechanics {4 classes}

From atoms to crystals: Energy bands {2 classes}

Semiconductor statistics {2 classes}

Carrier transport phenomena {4 classes}

PN diodes: dc, small-signal, high-frequency {4 classes}

Bipolar junction transistors (BJTs and HBTs) {6 classes}

Metal-Oxide-Semiconductor Field-effect transistors (MOSFETs) {10 classes}

Optoelectronic devices: LEDs and solar cells {4 classes}

Integrated circuits {2 classes}

Grading/Evaluation (Tentative):

Homework (7-8)	20%
Short Tests (4)	40%
Final Exam	25%
Lab	15%

A: 90-100; **B:** 80-89; **C:** 70-79; **D:** 50-69; **F:** <50

¹ Pages 3, 4, 5 are for ABET

Classroom Policies:

- A. Syllabus is subject to change at the instructor's discretion. Students are responsible for all announcements made in class and/or posted to D2L.
- B. **Attendance Policy:** Attendance will be taken at random throughout the semester, and it may be counted toward the final grade.
- C. **Late Homework/Missed Exams:** Late homework is not accepted. If an exam is missed for a *legitimate* reason, a grade will be assigned based on the remaining homework/exams.
- D. **Mobile Technology Policy:** N/A.

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1. **Course number and name:** ECE 447 Semiconductor Devices
2. **Credits and contact hours:** 4 credits, One 50-minute session per week, Five 2-hour design experiments, Five 2-hour sessions in simulations
3. **Course Committee:** S. Ahmed, M. Sayeh, C. Hatziaioniu
4. **Text book(s), title, author, and year:**

[1] *Semiconductor Physics and Devices*, 3rd edition, by Donald A. Naemen, McGraw Hill, ISBN# 0-07-232107-

References or other supplemental materials:

[1] *Solid State Electronic Devices*, 6th edition, by Ben Streetman and Sanjay Banerjee, ISBN# 9780131497269

[2] Online book: <http://ecee.colorado.edu/~bart/book/>

5. Specific course information

- a. (catalog description): Fundamental principles of semiconductor carrier statistics, band diagrams, pn-junction diodes, Schottky diodes, BJTs, MOS capacitors and MOSFETs for advanced VLSI technology.
 - b. prerequisites or co-requisites: ECE 345, ECE 375
 - c. indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program: elective
 - d. Professional Component {Credit Hours}
- | | | | | | |
|--------------|---|-------------|---|-------------|---|
| Mathematics | 0 | Sciences | 0 | General Ed. | 0 |
| Eng. Science | 3 | Eng. Design | 1 | | |

6. Instructional Objectives (with SO's), ex. The student will be able to explain the significance of current research about a particular topic. (a, b, h)

Upon completion of the course, the students should be able to:

1. Understand the various figures-of-merit widely used for efficient semiconductor device design and performance studies. (i, j)
2. Understand the Moore's Law and the trend in semiconductor device industry (j)
3. Understand the basic quantum mechanical principles and approached as applied in semiconductor devices. (a, b)
4. Explain and visualize the crystal structure and energy band diagram and extract effective mass and bandgap for common semiconductor materials. (a, b)
5. Understand the density-of-states that charge carriers can occupy and the basic statistical mechanics as needed to obtain the carrier density. (a, b)
6. Understand the basic carrier transport processes. (a, b)
7. Design PN and Schottky junctions to specifications. (a, b, c, k)
8. Design BJTs to specifications. (a, b, c, k)
9. Understand the *CV* and *IV* characteristics of MOSFETs and how to extract useful circuit parameters from these characteristics. (a, b, c)
10. Understand various higher order effects (e.g. short channel effects, quantum effects, discrete dopants and process variation) that influence today's nanoscale devices. (a, b, e)
11. Learn how computer programming (Matlab/Fortran/C/others) can facilitate learning of physical phenomena and device design. (c, k)
12. Undertake a design project in a related topic. (c, e, k)

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7. Brief list of topics (class, lab and project) to be covered (with hours)²

a. Classroom Topic (Hours)

- Introduction {2 classes}
- Atoms and electrons, quantum mechanics {4 classes}
- Crystal properties and energy bands {2 classes}
- Carrier statistics, generation and recombination {3 classes}
- Carrier transport mechanisms {3 classes}
- PN diodes {4 classes}
- Field-effect transistors {10 classes}
- Bipolar junction transistors {6 classes}
- Optoelectronic devices {4 classes}
- Integrated circuits {2 classes}

b. Laboratory Topics (Hours)

- Bandstructure modeling of semiconductors 2
- Mobility modeling of common semiconductors 2
- *pn*-diode simulation and design 2
- BJT modeling and simulation 2
- HBT modeling and simulation 2
- MOSFET modeling and simulation 2

c. Projects (Hours)

- Design/optimization of a MOSFET/SOI device 6

8. CAD and Computer Tools Used: online simulations on NSF's nanoHUB.org and Sentaurus TCAD commercial simulator

9. Assessment of the Contribution to Student Outcomes

Outcome →	a	b	c	d	e	f	g	h	i	j	k
Assessed →	x	x	x		x				x	x	x

Student Outcomes (ABET criteria a-k) are quoted here:

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (d) an ability to function on multidisciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility

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- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

University Policies

- A. **Incomplete Grades:** An *INC* is assigned when, for reasons beyond their control, students *engaged in passing work* are unable to complete all class assignments. An *INC* must be changed to a completed grade within a time period designated by the instructor but not to exceed one year from the close of the term in which the course was taken, *or graduation*, whichever occurs first. Should the student fail to complete the course within the time period designated, not to exceed one year, or graduation, whichever comes first, the incomplete will be converted to a grade of *F* and the grade will be computed in the student's grade point average. Students should not reregister for courses in which an *INC* has been assigned with the intent of changing the *INC* grade. Re-registration will not prevent the *INC* from being changed to an *F*.
- B. **Academic Integrity:** You are expected to submit your original work and adhere to the academic policies as stated in the SIU Student Conduct Code: <http://srr.siu.edu> (listed under Additional Links). Any act of academic dishonesty, cheating, or plagiarism in any form, including anonymous internet sources used in student papers, will be reported. These acts are taken seriously and the consequences may range from failing an assignment to expulsion from the university.
- C. **SIU Email:** Your SIU email account is an official form of University communication. Your instructor will use SIU email as a primary means of electronic communication with students. Please make sure that you maintain a valid password and acquire the habit of regularly checking your SIU email account for important instructor and University announcements. You may view the official SIU Student Email Policy at: <http://policies.siu.edu/policies/email.html>.
- D. **Emergency Procedures:** SIU is committed to providing a safe and healthy environment for study and work. Because some health and safety circumstances are beyond our control, we ask that you become familiar with SIU Emergency response Plan and building Emergency Response Team (BERT) program. Emergency response information is available on posters in buildings on campus, available on BERT's website at <http://www.bert.siu.edu/>, the SIU Department of Public Safety's website www.dps.siu.edu (disaster dropdown and video, "Shots Fired"), and in the Emergency Response Guideline pamphlet. Know how to respond to each type of emergency. Instructors will provide guidance and direction to students in the classroom in the event of an emergency affecting your location. **It is important that you follow these instructions and stay with your instructor during an evacuation or sheltering emergency.** The Building Emergency Response Team will provide assistance to your instructor in evacuating the building or sheltering within the facility.
- E. **Supplementary Assistance:** SIU is committed to assisting students with disabilities. With the cooperation of SIU's Disability Support Services (DSS), each student who qualifies for reasonable supplementary assistance has the right to receive it. Students requesting supplementary assistance must first register with DSS in Woody Hall, B-150, 618-453-5738 or 618-453-2293 (TTY), by email DSS@siu.edu, or <http://disabilityservices.siu.edu/>. Notice: If you have any type of special need(s) or disability for which you require accommodations to promote your learning in class, please contact me as soon as possible. The Office of Disability Support Services (DSS) offers various support services and can help you with special accommodations. You may wish to contact DSS to verify your eligibility and options for accommodations related to your special need(s) or disability.

Student Services

- A. **Learning Support Services:** The Center for Learning Support Services (CLSS) assists students of all cultures, abilities, backgrounds and identities with enhancing their self-management and interdependent learning skills. Programs offered by CLSS include: group study sessions; math tutoring; academic coaching; early intervention program; and study skills seminars. For additional information please contact CLSS in Woody Hall, Room A-313, 618-453-2925, or www.tutoring.siu.edu.
- B. **Writing Center:** The Writing Center offers free tutoring services and assistance with improving writing skills to all SIU undergraduate students and faculty. For center locations and hours, to schedule an appointment online, and to view information regarding the Online Writing Lab (OWL) contact the Writing Center at 618-453-1231 (Morris Library location); 618-453-2927 (Trueblood location), or www.write.siu.edu.
- C. **Saluki Cares:** The purpose of Saluki Cares is to develop, facilitate and coordinate a university-wide program of care and support for students in any type of distress-physical, emotional, financial or personal. By working closely with faculty, staff, students and their families, SIU will continue to display a culture of care and demonstrate to our students and their families that they are an important part of the community. To make a referral to Saluki Cares click, call or send: <http://salukicare.siu.edu/index.html>; 618-453-5714, or siucares@siu.edu.