ESE 331
SEMICONDUCTOR DEVICES
Fall 2022

Stony Brook University
Department of Electrical and Computer Engineering

Part 1: Course Information

COURSE DESCRIPTION

The course covers physical principles of operation of semiconductor devices. Energy bands, transport properties and generation recombination phenomena in bulk semiconductors are covered first. Junctions between semiconductors and metal-semiconductor will then be studied. Equipped with an understanding of the character of physical phenomena in semiconductors, students learn the principles of operation p-n junction diodes, metal-semiconductor contacts, bipolar junction transistors, field effect transistors. This course will provide general background for subsequent courses in electronics.

Prerequisites: AMS 361 or MAT 303; PHY 127/134 or PHY 132/134 or PHY 142

Credits: 3

Instructor	Ridha Kamoua, 237 Light Engineering ridha.kamoua@stonybrook.edu (631) 632 8406
Office Hours	Mondays 12:30pm – 2:30pm Wednesdays 12:30pm – 2:30pm
Class Time	M, W 2:40pm – 4:00pm Frey Hall 205

TEXTBOOK

"An Introduction to Semiconductor Devices" Donald Neamen, McGraw Hill, 2006, ISBN 9780072987560

Course Delivery Mode and Structure:

This is an online course delivered in the blackboard learning management system (LMS). Students must be mindful of all course expectations, deliverables, and due dates, especially because the online course requires significant time management. All assignments and course interactions will utilize internet technologies. See "Technical Requirements" section for more information. In Blackboard, you will access online lectures, course materials, and resources.

On-line Blackboard site:

You can access Blackboard at: http://blackboard.sunysb.edu. Homework assignments, homework and exam solutions, and other pertinent information will be posted on the course's Blackboard site. You can access blackboard using your Net ID username and password. To look up or set your Net ID, you need to login to SOLAR. For help or more information see:
https://tlt.stonybrook.edu/support/Pages/support.aspx

Technical Assistance:

If you need technical assistance at any time during the course or to report a problem with Blackboard you can contact blackboard@stonybrook.edu or (631) 632-2777.

How We Will Communicate:

Course-related questions should be posted in the General Questions Forum in the course Discussion board. For personal/private issues, email me directly. If you use Blackboard's **email tool** from the course site, it will automatically include your full name, course name and section when you send me an email. **Please allow between 24-48 hours for an email reply.** Your Stony Brook University email must be used for all University-related communications. You must have an active Stony Brook University email account and access to the Internet. All instructor correspondence will be sent to your SBU email account. **Plan on checking your SBU email account regularly for course-related messages.** To log in to Stony Brook Google Mail, go to http://www.stonybrook.edu/mycloud and sign in with your NetID and password.
Regular announcements will be sent from Blackboard. These will be posted in the course site and may or may not be sent by email.
Regular communication is essential. Logging in once a day, checking the discussion board and participating with your peers ensures that you can remain an active member of the class and earn full points for participation.

Office hours will be held using zoom.

Technical Requirements:

This course uses Blackboard for the facilitation of communications between faculty and students, submission of assignments, and posting of grades and feedback.

You are responsible for having a reliable computer and Internet connection throughout the term. **Caution!** You will be at a disadvantage if you attempt to complete all coursework on a smartphone or tablet. It may not be possible to submit the files required for your homework assignments.

Students should be able to use email, a word processor, spreadsheet program, and presentation software to complete this course successfully.

The following list details a minimum recommended computer set-up and the software packages you will need to have access to, and be able to use:

- PC with Windows 10 or higher (we recommend a 3-year Warranty)
- Macintosh with OS 10.11 or higher (we recommend a 3-year Warranty)
- Intel Core i5 or higher
- 250 GB Hard Drive
- 8 GB RAM
- Latest version of Chrome or Firefox; Mac users may use Chrome or Firefox. (A complete list of supported browsers and operating systems can be found on the My Institution page when you log in to Blackboard.)
- High speed internet connection
- Word processing software (Microsoft Word, Google Docs, etc.)
- Headphones/earbuds and a microphone
- Webcam (recommended)
- Printer (optional)
- Ability to download and install free software applications and plug-ins (note: you must have administrator access to install applications and plug-ins).

Part 2: Course Learning Objectives and Assessments

Course Objectives:

To teach properties, models, and concepts associated with semiconductor devices. Provides detailed insight into the internal workings of basic semiconductor devices such as the pn-junction diode, Bipolar Junction Transistor, and MOSFET. Systematically develops the analytical tools needed to solve practical device problems.

Student Outcomes (SO):

Course Learning Outcome	ABET Student Outcome	Assessment Method
knowledge of semiconductor bonding and energy band models	(1)	Exams, final, and homework
knowledge of semiconductor carrier properties and statistics	(1)	Exams, final, and homework
knowledge of semiconductor carrier action	(1)	Exams, final, and homework
ability to apply standard device models to explain/calculate critical internal parameters and standard characteristics of the pn-junction diode	(1)	Exams, final, and homework
ability to apply standard device models to explain/calculate critical internal parameters and standard characteristics of the Bipolar Junction Transistor	(1)	Exams, final, and homework
ability to apply standard device models to explain/calculate critical internal parameters and standard characteristics of the Metal-Oxide-Semiconductor Field Effect Transistor	(1)	Exams, final, and homework

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

How to Succeed in this Course:

- Complete all assigned readings in the course
- Start homework assignments early
- Take notes and prepare formula sheets to be used in exams
- Use the office hours for one-on-one help

Part 3: Course Outline and Schedule

COURSE OUTLINE

1. ***Introductory Physical Concepts*** ***Chapters 1, 2, 3***
   - Crystal Structure of Semiconductors
   - Energy Band Model
   - Fermi Energy Level
   - Semiconductor Doping
2. ***Carrier Transport and Excess Carriers in Semiconductors*** ***Chapters 4,8***
   - Carrier Drift
   - Carrier Diffusion
   - Generation and Recombination
   - Continuity Equation
3. ***Junction Diodes*** ***Chapters 5,9***
   - ***p-n*** Junction
   - Metal-Semiconductor Junction

- I-V Characteristics

4. ***Bipolar Junction Transistors*** ***Chapters 10***

- Operating Principles
- Minority Carrier Distribution
- Ideal I-V Characteristics
- Non-Ideal Effects
- Small-Signal Models

5. ***MOS Transistors*** ***Chapters 6,7***

- Operation Principles
- MOS Capacitor
- Metal Oxide Field Effect Transistor (MOSFET)
    a) Enhancement Type
    b) Depletion type
    c) Current-Voltage Characteristics
- MOSFET Fabrication

Course Schedule: Please refer to the schedule in blackboard under Course Documents

Part 4: Grading System and Exam Schedule

Your grade will be based on attendance and participation, homework assignments, research paper, two exams, and a final exam.

Attendance, Participation, Homework	10%	weekly
Research paper (Extra credit)	5%	
Exam 1	25%	October 5, 2:40pm EST
Exam 2	25%	November 9, 2:40pm EST
Final Exam	40%	December 7, 5:30pm – 8:00pm

Part 5: University and Course Policies

University Policies

Student Accessibility Support Center Statement:

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, Stony Brook Union Suite 107, (631) 632-6748, or at sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Academic Integrity Statement:

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

Important Note: Any form of academic dishonesty, including cheating and plagiarism, will be reported to the Academic Judiciary.

Critical Incident Management:

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Student Conduct and Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Until/unless the latest COVID guidance is explicitly amended by SBU, during Spring 2022 "disruptive behavior" will include refusal to wear a mask during classes.

Course Policies

Understand When You May Drop This Course:

It is the student's responsibility to understand when they need to consider withdrawing from a course. Refer to the Stony Brook Academic Schedule for dates and deadlines for registration: http://www.stonybrook.edu/commcms/registrar/calendars/academic_calendars.

- Undergraduate Course Load and Course Withdrawal Policy
- Graduate Course Changes Policy

Course Materials and Copyright Statement:

Course material accessed from Blackboard, SB Connect, SB Capture or a Stony Brook Course website is for the exclusive use of students who are currently enrolled in the course. Content from these systems cannot be reused or distributed without written permission of the instructor and/or the copyright holder. Duplication of materials

protected by copyright, without permission of the copyright holder is a violation of the Federal copyright law, as well as a violation of Stony Brook's Academic Integrity.

Online Communication Guidelines and Learning Resources:

Maintain professional conduct both in the classroom and online. The classroom is a professional environment where academic debate and learning take place. I will make every effort to make this environment safe for you to share your opinions, ideas, and beliefs. In return, you are expected to respect the opinions, ideas, and beliefs of other students—both in the face-to-face classroom and online communication. Students have the right and privilege to learn in the class, free from harassment and disruption. The course follows the standards set in the Student Code of Conduct, and students are subject to disciplinary action for violation of that code. If your behavior does not follow the course etiquette standards stated below, the grade you receive for a posting may suffer. I reserve the right to remove any discussion messages that display inappropriate language or content.

Online Etiquette:

- Offensive language or rudeness will not be tolerated. Discuss ideas, not the person.
- Avoid cluttering your messages with excessive emphasis (stars, arrows, exclamations).
- If you are responding to a message, include the relevant part of the original message in your reply, or refer to the original post to avoid confusion,
- Be specific and clear, especially when asking questions.
- Use standard punctuation and capitalization. Using all UPPERCASE characters gives the appearance of shouting and makes the message less legible;.
- Remember that not all readers have English as their native language, so make allowances for possible misunderstandings and unintended discourtesies.

Online Classes Require Better Communication:

It is important to remember that we will not have the non-verbal cues that occur in a face-to-face classroom. I cannot see the confused, frustrated, or unhappy expressions on your face if you encounter problems. You MUST communicate with me so that I can help. To make the experience go smoothly, remember that you're responsible for initiating more contact, and being direct, persistent, and vocal when you don't understand something.

My Role as the Instructor:

As the instructor, I will serve as a "guide" in our online classroom. While I will not respond to every post, I will read what is posted, and reply when necessary. Expect instructor posts in the following situations:

- To assist each of you when it comes to making connections between discussion, lectures, and textbook material.
- To fill in important things that may have been missed.
- To re-direct discussion when it gets "out of hand."
- To point out key points or to identify valuable posts.

Part 6: Student Resources

Academic and Major Advising (*undergraduate only*): Have questions about choosing the right course? Contact an advisor today. Phone and emails vary-please see website for additional contact information; website: https://www.stonybrook.edu/for-students/academic-advising/

Academic Success and Tutoring Center *(undergraduate only)*: https://www.stonybrook.edu/tutoring/

Amazon @ Stony Brook: Order your books before classes begin. Phone: 631-632-9828; email: Bookstore_Liaison@stonybrook.edu; website: http://www.stonybrook.edu/ bookstore/

Bursar: For help with billing and payment. Phone: 631-632-9316; email: bursar@stonybrook.edu; website: http://www.stonybrook.edu/bursar/
Career Center: The Career Center's mission is to support the academic mission of Stony Brook University by educating students about the career decision-making process, helping them plan and attain their career goals, and assisting with their smooth transition to the workplace or further education. Phone: 631-632-6810; email: sbucareercenter@stonybrook.edu; website: http://www.stonybrook.edu/career-center/
Counseling and Psychological Services: CAPS staff are available by phone, day or night. http://studentaffairs.stonybrook.edu/caps/
Ombuds Office: The Stony Brook University Ombuds Office provides an alternative channel for confidential, impartial, independent and informal dispute resolution services for the entire University community. We provide a safe place to voice your concerns and explore options for productive conflict management and resolution. The Ombuds Office is a source of confidential advice and information about University policies and procedures and helps individuals and groups address university-related conflicts and concerns. http://www.stonybrook.edu/ombuds/
Registrar: Having a registration issue? Let them know. Phone: 631-632-6175; email: registrar_office@stonybrook.edu; http://www.stonybrook.edu/registrar/
SBU Libraries: access to and help in using databases, ebooks, and other sources for your research.

- Research Guides and Tutorials: http://guides.library.stonybrook.edu/
- Getting Help: https://library.stonybrook.edu/research/ask-a-librarian/

Student Accessibility Support Center: Students in need of special accommodations should contact SASC. Phone: 631-632-6748; email: sasc@stonybrook.edu; https://www.stonybrook.edu/sasc/
Support for Online Learning: https://www.stonybrook.edu/online/
Writing Center: Students are able to schedule face-to-face and online appointments. https://www.stonybrook.edu/writingcenter/