

ECE 396N – Semiconductor nanostructures

Fall 2024

Instructor: Prof. Emanuel Tutuc; Office: EER 3.890, MER 2.606E; E-mail: etutuc@mail.utexas.edu.

Class hours: MW 1:30pm – 3:00pm, ECJ 1.306

Office hours: W 3:30 pm – 5 pm, EER 3.890.

Teaching Assistant: TBD

Description:

Advances in technology and fabrication of semiconductor structures have led to devices with size smaller than the electron mean free path. This course covers the theoretical framework for understanding the electronic properties of low-dimensional semiconductor structures, electron transport in quantum confined devices, such as semiconductor heterostructures, quantum wires and quantum dots.

Objectives:

- Review a number of key nanoscale, quantum confined electronic devices.
- Understand the electronic properties of nanostructures.
- Understand the device physics of semiconductor nanotransistors.

Prerequisites:

Quantum mechanics and solid state physics (undergraduate level) are strongly recommended.

COURSE FORMAT FOR FALL 2022:

This course will be offered face-to-face for Fall 2024. Regular class meetings (MW 1:30 PM - 3:00 PM) will be conducted in ECJ 1.306. The instructor regularly scheduled office hours (W 3:30PM - 5:00PM) will be conducted in EER 3.890.

Tentative course topics:

- Review of quantum mechanics and solid state physics concepts (5 lectures)
- Bloch's theorem, tight binding model, application to graphene band structure (2 lectures)
- One dimensional transport, conductance quantization (2 lecture)
- Diffuse and ballistic transport, diffusive to ballistic crossover (2 lectures)
- Two dimensional systems: band engineering, doping modulation (2 lectures)
- Metal-insulator-semiconductor structure, triangular quantum well, 2D electron gas, capacitance (2 lectures)

- Characterization of the MOS interface, capacitance – voltage characteristics, experimental methods to determine the density of interface traps (3 lectures)
- Physics of the nanotransistor, quantum capacitance, electrical characteristics of the ballistic transistor (3 lectures)
- Energy levels in carbon nanotubes, carbon nanotube transistors (2 lectures)
- Quantum dots, single electron transistor, Coulomb blockade (2 lectures)

Recommended references:

- *The physics of low-dimensional semiconductors*, by John H. Davies
- *Quantum transport: Atom to transistor*, by S. Datta

Grading:

30% Homework, 30% Midterm, 40% Final.

Homework questions will be assigned throughout the class term, and will be due one to two weeks after being assigned.

Late homework will be accepted at instructor's discretion. Discussion of homework questions is encouraged. Please be sure to submit your own independent homework solution.

Midterm exam date: TBD.

The final exam dates are set by the registrar's office, and made public four weeks before the semester ends <http://registrar.utexas.edu/students/exams/>.

This course counts toward the Graduate Portfolio in Nanomanufacturing (<https://nascent.utexas.edu/nanomanufacturing-portfolio-program>)

Course notes:

Course notes will be provided for most lectures. The web-based course management system "Canvas", available at <https://canvas.utexas.edu/> will be used to post course notes, homework assignments and solutions.

College Drop/Add Policy:

An engineering student must have Dean's approval to add/drop after the fourth class day of the semester.

Academic dishonesty:

Plagiarism or any form of academic dishonesty (cheating includes, but is not limited to, copying another student's work, bringing notes into a test and copying material directly from a book, article or web site without including appropriate references, falsifying data, doing someone's work) is a violation of University rules and may return a grade of zero for each assignment in which it is detected or may incur even steeper penalties. For University policies see: <http://registrar.utexas.edu/catalogs/gi09-10/ch01/index.html>

Class Web sites and student privacy:

Web-based, password-protected class sites are associated with all academic courses taught at The University. Syllabi, handouts, assignments and other resources are types of information that may be available within these sites. Site activities could include exchanging e-mail, engaging in class discussions and chats, and exchanging files. In addition electronic class rosters will be a component of the sites. Students do not want their names included in these electronic class rosters must restrict their directory information in the Office of the Registrar, Main Building, Room 1.

Students with Disabilities:

The University of Texas at Austin provides upon request appropriate academic accommodations for qualified students with disabilities. For more information, contact the Division of Diversity and Community Engagement, Services for Students with Disabilities at 471-6259 (<http://www.utexas.edu/diversity/ddce/ssd/>).

Accommodations for religious holidays:

Section 51.911 of the Texas Education Code addresses absence by students for observance of religious holidays. Section 51.911 states that a student shall be excused from attending classes or other required activities, including examinations, for the observance of a religious holy day, including travel for that purpose. A student whose absence is excused under this subsection may not be penalized for that absence and shall be allowed to take an examination or complete an assignment from which the student is excused within a reasonable time after the absence. University policy requires students to notify each of their instructors as far in advance of the absence as possible so that arrangements can be made. By UT Austin policy, you must notify the instructor of your pending absence at least fourteen days prior to the date of observance of a religious holiday.

Recommendations regarding emergency evacuation from the Office of Campus Safety and Security (<http://www.utexas.edu/safety/>):

- Occupants of buildings on The University of Texas at Austin campus are required to evacuate buildings when a fire alarm is activated. Alarm activation or announcement requires exiting and assembling outside.
- Familiarize yourself with all exit doors of each classroom and building you may occupy. Remember that the nearest exit door may not be the one you used when entering the building.
- Students requiring assistance in evacuation shall inform their instructor in writing during the first week of class.
- In the event of an evacuation, follow the instruction of faculty or class instructors; exit in an orderly fashion and assemble outside.

- Do not re-enter a building unless given instructions by the following: Austin Fire Department, The University of Texas at Austin Police Department, or Fire Prevention Services office.
- Behavior Concerns Advice Line (BCAL): 512-232-5050
- Link to information regarding emergency evacuation routes and emergency procedures can be found at: www.utexas.edu/emergency