

EE 396N – Semiconductor nanostructures

Fall 2019

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

Class hours: MW 1:30pm - 3:00pm, EER 1.512;

Office hours: EER 3.890, W 10:30 am – 12:30 pm, or by appointment.

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. In this regime the structure and geometry intimately determine the device electronic properties. This course covers the theoretical framework for understanding the electronic properties, a review of state of the art fabrication techniques and reviews recent experimental results of 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 these nanostructures devices.
- Explore possible applications of semiconductor nanostructure devices.

Prerequisites:

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

Tentative course topics:

- Review of quantum mechanics and solid state physics concepts (5 lectures)
- Band structure of graphene and carbon nanotubes (2 lectures)
- One dimensional transport, quantum point contact, conductance quantization (2 lecture)
- Diffuse and ballistic transport, diffusive to ballistic crossover (2 lectures)
- Phase coherence length, localization (2 lectures)
- Two dimensional systems: band engineering, doping modulation (3 lectures)
- Semiconductor growth techniques: molecular beam epitaxy, chemical vapor deposition (1 lecture)
- Physics of the nanotransistor, quantum capacitance, electrical characteristics of the ballistic transistor (3 lectures)
- Quantum dots, single electron transistor, Coulomb blockade (2 lectures)
- Spin injection and transport, spin based devices (3 lectures)

Recommended references:

- *The physics of low-dimensional semiconductors*, by John H. Davies
- *Quantum transport: Atom to transistor*, by S. Datta
- *Transport in nanostructures*, by D. K. Ferry and S. M. Goodnick

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: Oct 23rd, 2019.

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/>.

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