ECE440 Nanoelectronics

Course Information

- **Title:** ECE440 Nanoelectronics
  - CRN 35565 and 5 credits for undergraduates; CRN 35566 and 4 credits for graduate students.
  - Required for BS in Engineering Physics, Technical Electives for BS in Electrical Engineering.
- **Schedule:** 11:00 am–12:15 pm, Tuesday and Thursday (08/23–12/01, 2016)
- **Location:** Lecture Center Building A A007.
- **Instructor:** Zheng Yang (Email: yangzhen@uic.edu; Phone: 312-996-8367; Office: ERF3017)

Prerequisites:

- ECE346 for undergraduate students
- ECE346 or instructor’s consent for graduate students
  - Need to be strictly fulfilled.

Office Hours

- Regular office hours: 9 am–10:30 am, Tuesday and Thursday (08/25–12/01, 2016).
- Additional office hours: Please send your requests to the instructor by email.

Course Materials and Website

- **Course materials:** Lecture slides & notes.
- **Course Website:** [http://www.ece.uic.edu/~zyang/Teaching/20162017Fall/index.html](http://www.ece.uic.edu/~zyang/Teaching/20162017Fall/index.html)


Additional information can be found at the textbook website:


Reference Book


Further-reading books (for students with additional interests only)

Quantum Mechanics


Solid-state physics


Semiconductor physics and devices


Course descriptions: In the course, elementary level of quantum mechanics, fundamental knowledge of nanotechnology, preparation, fabrication and characterization techniques of nano-materials and nano-devices are discussed. Recent research progresses in nanotechnology-related topics are also briefly covered in the class. Representative two-dimensional (e.g. 2DEG in quantum wells, graphene, etc), one-dimensional (e.g. nanowire, nanotube), and zero-dimensional (e.g. quantum dots) nano-material systems are presented.
Specific goals and outcomes for the course
The student will be able to explain the significance of current research about a particular topic; to learn a knowledge of contemporary issues; to gain the ability to oral and written communicate effectively; to gain the ability to apply knowledge of mathematics, science, and engineering; to gain the ability to identify, formulate, and solve engineering problems; and to achieve a recognition of the need for, and an ability to engage in life-long learning.

Brief list of topics covered Wave-particle duality, Schrödinger equation, atomic orbitals, band theory of solids, semiconductors, nanoelectronic materials preparation, nanoelectronic device fabrication and measurements, fullerenes, quantum dots, carbon nanotubes, nanowire, graphene quantum wells, two-dimensional electron gas.

Grading The grading is based on three 60-min exams and one cumulative 120-min final exam. The lowest-score one of the three 60-min exams is dropped, while the other two 60-min exam count 30% each for the overall score of the course. The 120-min final exam count 40% for the overall score of the course.

No MAKEUP EXAMS will be given! The tentative schedules of the exams are listed below.
Exam #1 (60 minutes) 11am-12pm, 09/20/2016, Tuesday
Exam #2 (60 minutes) 11am-12pm, 10/13/2016, Thursday
Exam #3 (60 minutes) 11am-12pm, 11/22/2016, Tuesday
Final Exam (120 minutes) 10:30am-12:30pm, 12/05/2016, Monday

Professional and Ethical Responsibility
- Attend all lectures. Take exams on scheduled dates. No make-up exams or alternate arrangements will be allowed unless for reasons beyond a student’s control (supporting documents required).
- Read notice emails from the instructor regularly.
- Review lecture slides and notes posted/sent by the instructor.
- Policy on cheating and plagiarism: Dishonest actions by students will result in appropriate disciplinary action. Intentional use or attempt to use unauthorized assistance, materials, or information, in any quiz, examination, or assignment and plagiarism in literature review report may lead to penalties such as a failing grade. College of Engineering and University guidelines will be followed.

Religious Holidays
Students who wish to observe their religious holidays shall notify the instructor by the tenth day of the semester of the date(s) when they will be absent unless the religious holiday is observed on or before the tenth day of the semester. In such cases, the students shall notify the instructor at least five days in advance of the date when he/she will be absent.
# Course Content and Tentative Schedules of ECE440 Nanoelectronics (Fall Semester, 2016)

<table>
<thead>
<tr>
<th>Date</th>
<th>Course Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/25/2016</td>
<td>Introduction/Discussion of course introduction, prerequisites requirements, and overview of nanotechnology and the Nobel prize, break down of classical mechanics.</td>
</tr>
<tr>
<td>08/25/2016</td>
<td>Introduction to quantum mechanics: The basic of quantum mechanics, wave-particle duality, quantum well vs. classical potential well.</td>
</tr>
<tr>
<td>09/05/2016</td>
<td>Postulates of quantum mechanics, mathematical foundation of quantum mechanics, introduction to Schrödinger equation.</td>
</tr>
<tr>
<td>09/06/2016</td>
<td>Schrödinger equation and its application (1) [Infinite square shape one-dimensional potential well]</td>
</tr>
<tr>
<td>09/06/2016</td>
<td>Schrödinger equation and its application (2) [Finite square shape one-dimensional potential well]</td>
</tr>
<tr>
<td>09/08/2016</td>
<td>Dirac notation, second quantization</td>
</tr>
<tr>
<td>09/13/2016</td>
<td>Schrödinger equation and its application (3) [One-dimensional Harmonic Oscillator]</td>
</tr>
<tr>
<td>09/15/2016</td>
<td>Schrödinger equation and its application (4) [Summary for low-dimensional systems, quantum wires and quantum dots]</td>
</tr>
<tr>
<td>09/20/2016</td>
<td>Exam #1 (60 mins, 11am-12pm), exam discussion</td>
</tr>
<tr>
<td>09/22/2016</td>
<td>Schrödinger equation and its application (5) [Quantum barrier, WKB approximation]</td>
</tr>
<tr>
<td>09/27/2016</td>
<td>Atomic and atomic subshells</td>
</tr>
<tr>
<td>09/29/2016</td>
<td>Electronic configuration in a quantum mechanics view</td>
</tr>
<tr>
<td>10/04/2016</td>
<td>Review of solid-state physics fundamentals [Crystal lattice and reciprocal lattices, energy bands]</td>
</tr>
<tr>
<td>10/06/2016</td>
<td>Review of semiconductor physics, Density of states, electron transport in nanostructures</td>
</tr>
<tr>
<td>10/11/2016</td>
<td>Video tutorial on microelectronic and nanoelectronic fabrication</td>
</tr>
<tr>
<td>10/13/2016</td>
<td>Exam #2 (60 mins, 11am-12pm), exam discussion</td>
</tr>
<tr>
<td>10/18/2016</td>
<td>Introduction to the growth of nanostructures, introduction to micro/nano fabrication</td>
</tr>
<tr>
<td>10/20/2016</td>
<td>Introduction to microscopy for nanotechnology</td>
</tr>
<tr>
<td>10/25/2016</td>
<td>0D nanoelectronics topic I: Optical properties Si/Ge quantum dot superlattices</td>
</tr>
<tr>
<td>10/27/2016</td>
<td>0D nanoelectronics topic II: Nanocrystal floating gate MOSFET memory</td>
</tr>
<tr>
<td>11/04/2016</td>
<td>1D nanoelectronics topic I: Overview of carbon nanostructures and introduction to carbon nanotubes</td>
</tr>
<tr>
<td>11/05/2016</td>
<td>2D nanoelectronics topic I: Geometric structure and band structure of graphene, Tight-binding approximation for band structure calculation</td>
</tr>
<tr>
<td>11/08/2016</td>
<td>1D nanoelectronics topic II: Geometry structure and band structure of carbon nanotubes</td>
</tr>
<tr>
<td>11/10/2016</td>
<td>Carrier statistics in low-dimensional nanostructures</td>
</tr>
<tr>
<td>11/15/2016</td>
<td>1D nanoelectronics topic III: Introduction to nanotube and nanowire growth</td>
</tr>
<tr>
<td>11/17/2016</td>
<td>1D nanoelectronics topic IV: Nanowire for nanoelectronics</td>
</tr>
<tr>
<td>11/22/2016</td>
<td>Exam #3 (60 mins, 11am-12pm), exam discussion</td>
</tr>
<tr>
<td>11/24/2016</td>
<td>Thanksgiving break, no class</td>
</tr>
<tr>
<td>11/29/2016</td>
<td>2D nanoelectronics topic II: Introduction to graphene and graphene for nanoelectronics</td>
</tr>
<tr>
<td>12/01/2016</td>
<td>Video tutorial on microelectronic and nanoelectronic fabrication II, Tour of Nanotechnology Core Facility</td>
</tr>
<tr>
<td>12/05/2016</td>
<td>Final Exam (Cumulative, 120 mins, 10:30am-12:30pm)</td>
</tr>
</tbody>
</table>
ECE440 Nanoelectronics

Name ___________________________ UIC email ___________________________

Program ___________________________ (choose from BS, MS, PhD)

Advisor ___________________________

Prerequisite Survey

Have you learned “ECE 346 Solid State Device Theory”? Yes No

Have you learned “ECE 448 Transistors”? Yes No

If you answered “No” for both questions above, please discuss with the instructor to see your eligibility to enroll ECE440 course.

Background Survey

Any background knowledge on quantum mechanics Yes No

Any background knowledge on solid state physics Yes No

Any background knowledge on semiconductor physics Yes No

Any background knowledge on semiconductor devices Yes No

Any other course on nanotechnology learned before Yes No

Course description if yes ___________________________

What is your current research topic? (Please write down N/A if none.)

Any specific interests or requirements for this course? (e.g. graphene, quantum dot, nanowires, superlattices, etc.)

Open question: Any previous Nobel prize in your mind was relevant to “nanotechnology”? (List as many as you know)
ECE 340 vs ECE 346

- ECE 340
  - How diodes, BJT, works

- ECE 342
  - Circuits

- ECE 346
  - Why diode works in this way
  - \( I = I_0 \exp\left(\frac{qV}{kT}\right) - 1 \)
  - Electrons, holes

- ECE 347
- ECE 449
  - How to make a diode & ICs