ECE 4244/ENGR 4244: Nanotechnology II

Credits and contact hours: 3 Credits (One 60-minute lecture and one 3-hour lab per week)

Instructor: Faquir Jain

Textbook: Nanotechnology Laboratory-II.
F. Jain (2018)

a. *Other supplemental materials*: Selected reference materials/articles distributed in class and posted on line.

***Specific course information*:**

a. *Catalog Description*: Growth and characterization of carbon nanotubes using vapor phase nucleation; growth of CdSe quantum dots using liquid phase precipitation and vapor phase MOCVD reactor; characterization using AFM and TEM and dynamic scattering techniques; device processing highlighting nanolithography (E-Beam), and self-assembly techniques; project work involving fabrication of devices such as LEDs, carbon nanotube based FETs, and biosensors using self-assembled quantum dots hosted in inorganic or organic/polymer layers.

b. *Prerequisite*: ECE 4211 or ECE/ENGR 4243.

c. *Required, elective, or selected elective:* Selected elective (EE)

***Specific goals for the course*:**

a. *Specific outcomes of instruction*: Students will be able to
   - Carry out the processing of nanoelectronic device fabrication and characterization and compare theoretical models and experimental data.
   - Perform wafer characterization using four-point probe, Hall Effect, thermoelectric probe, and crystal orientation; perform characterization of quantum dots using AFM, TEM, Raman spectroscopy, Dynamic light scattering.
   - Perform Quantum well/dot characterization using Photoluminescence and X-ray diffraction.
   - Fabricate discrete devices such as quantum dot diodes and solar cells, Quantum dot gate (QDG) FETs and nonvolatile memories, QDG protein sensors; analyze I-V, C-V characteristics using Parametric Analyzer and other instrumentation. Measure oxide thickness, junction depth and compare with theoretical models.
   - Select and design devices and simple integrated circuits.
   - Communicate via oral presentation and written report the project including processing steps, device/circuit performance and compare with analytical models.
   - Search for, acquire and use new knowledge from multiple sources.

b. *ABET Criterion 3 Student Outcomes addressed by the course*:

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
Students learn to analyze fabricated semiconductor devices by applying techniques from mathematics, science and engineering.

(2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
Students formulate and implement design to provided specifications.

(3) an ability to communicate effectively with a range of audiences
Students write pre and post lab technical report; also present the results of their project to the class.

(4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
n/a

(5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
n/a

(6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
n/a

(7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
Students use the web, library databases, and other resources for their technical reports.

Topics covered:

- Semiconductor wafer characterization: Measurements of mobility, resistivity, doping type, crystal orientation; learn characterization of quantum dots using AFM, TEM, Raman spectroscopy, Dynamic light scattering.
- Diffusion of p- and n-type dopants in Si to form unction diodes and solar cells; dry and wet oxidation of Si to fabricated MOS capacitors and FETs,
- Fabricate discrete devices such as quantum dot diodes and solar cells, Quantum dot gate (QDG) FETs and nonvolatile memories, QDG protein sensors; analyze I-V, C-V characteristics using Parametric Analyzer and other instrumentation. Measure oxide thickness, junction depth and compare with theoretical models.
- Project work include fabrication of inverters using FETs, nonvolatile memories, SRAMs and biosensors.