EE 235/NSE 203 - Spring 2008
Course Title: Nanoscale Fabrication
University of California, Berkeley

Class Times: MW 2-3:30 pm (3 hours lecture) per week
Classroom: 521 Cory
Discussion Session: M 4-5, 521 Cory
Units: 4
Instructor: Connie Chang-Hasnain, 263M Cory, cch@eecs.berkeley.edu
Office Hour: W 11 am -12 pm or by appointment
GSI: Linus Chuang, 258M Cory, 642-1023, linus@eecs.berkeley.edu
GSI Office Hours: Th 11 am -12 pm or by appointment
Pre-requisite: Phys 137A (upper division quantum mechanism or equivalent), EE 143 (Microfabrication or equivalent; can be taken concurrently)

Description:

This course discusses various top-down and bottom-up approaches to synthesize and process nanostructured materials. The topics include fundamentals of self assembly, nanoimprint lithography, electron beam lithography, nanowire and nanotube synthesis. The synthesis methods include, molecular beam epitaxy, metal-organic chemical vapor deposition (CVD), catalyst CVD, vapor liquid solid, electrodeposition, pulsed laser synthesis, solution-based synthesis etc. Topics on post-synthesis modifications will include oxidation, doping, diffusion, surface interactions, and nonequilibrium processing (laser, ion-beam and plasma). In addition, techniques to bridging length scales such as heterogeneous integration will be discussed. We will discuss new electronic, optical, thermal, mechanical and chemical properties brought forth by the very small sizes. This new course is designed to bring forth understanding of frontiers of 21st-century research, with implications for electronics, optics, material design, computers, and biology.

Grading Policy:

Class participation (10%)
- Participation includes active participation in class and attendance
- A sign-in sheet will be passed around at each lecture.

HW (20%)
- 2 HW sets; due time will be announced.

Class presentation (30%)
- Two individual class presentations on selected topic/journal paper (5+2 minutes each time per person)

Term paper (total 40%)
• You are asked to form a team of three to decide on a specific topic for term paper.
• The subject should be chosen among the topics covered in the class.
• Each team is required to make a 30 minute oral presentation during the last four lectures (2 weeks of class). All members should participate in the presentation. This represents 20% of the grade.
• A term paper manuscript worth of 20% of grade is due 11:59 pm on 5/16/08 by emailing both word and pdf files to Prof. Chang-Hasnain.

Syllabus (each lecture is 1hr long):

1. Introduction and Overview
2. Review of Microfabrication principles (1 week)
3. Review of Basic Physics (1 week)
   • Quantum mechanics: Schrodinger wave equation
   • Solid state physics: crystal structure, band gap and band structure, Fermi-dirac distribution, density of states
4. Semiconductor electronic and optoelectronic device physics (1 week)
   • Semiconductor electronics: band diagram, heterojunction band diagram, p-n junction, metal-oxide-semiconductor field effect transistor (MOSFET), single electron transistor (SET)
   • Semiconductor optoelectronics: Fermi’s golden rule, optical gain (loss), spontaneous emission and refractive index, semiconductor lasers and light emitting diodes
5. Nanowires (1 week)
   • Fabrication method: Vapor liquid solid (VLS) and CVD
   • Properties: electrical, thermal, mechanical, optical
   • Applications
6. Self-assembled quantum dots (QD) (1 week)
   • Epitaxial method: molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD) systems; Stranski-Krastanov growth method and atomic layer deposition; material and device characteristics; applications
   • Solution-based method: colloidal QD fabrication; fabrication and purification methods; material characteristics; applications
7. Carbon nanotubes (1 week)
   • Fabrication method: Carbon Arc or Arc Discharge, Laser Ablation or Pulsed Laser Vaporization, Chemical Vapor Deposition (CVD), High pressure CO (HiPCO)
   • Purification
   • Properties: electrical, thermal, mechanical, optical
   • Applications
8. Lithography (1 week)
9. Stamping and Nano-imprint (1 week)
   • Micro-contact printing and nano-stamping techniques
   • Nano-Imprint lithography and Step and Flash Imprint Lithography
10. Advanced Characterization Techniques (1 week)