EE 235/NSE 203 - Spring 2009
Course Title: Nanoscale Fabrication
University of California, Berkeley

Class Times: Mondays 2:40-5:30 pm (3 hours lecture)
2:40-4 pm first period
4:40-4:10 pm coffee break
4:10-5:30 pm second period

Classroom: 521 Cory
Discussion Session: TBA
Units: 4
Instructor: Connie Chang-Hasnain, 263M Cory, cch@eecs.berkeley.edu
Office Hour: Appointments only
GSI: Vadim Karagodsky, 258M Cory, 642-1023, vadimk@eecs.berkeley.edu
GSI Office Hours: TBA
Pre-requisite (can be taken concurrently): Phys 137A (upper division quantum mechanism or equivalent), EE 143 (Microfabrication or equivalent)

Description:
This course discusses various top-down and bottom-up approaches to synthesize and process nanostructured materials. The topics include fundamentals of self assembly, electron beam lithography, nano- wire/needle/tube and quantum dot 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 (20%)
- Active participation in class and attendance
- A sign-in sheet will be passed around at each lecture.

HW (20%)
- 2 HW sets; due 2/23 and 4/6 (tentative).

Class presentation (20%)
• Two individual class presentations on selected topic/journal paper (7+2 minutes each time per person)

**Term project presentation and paper (total 40%)**
• You are asked to form a team of three to decide on a specific topic.
• 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 total grade.
• A term paper manuscript worth of 20% of grade is due 11:59 pm on 5/15/08 by emailing both word and pdf files to Prof. Chang-Hasnain.

*Syllabus (each lecture is 3hr long):*

1. Introduction and Overview  
   • Review of Basic Physics  
   • Quantum mechanics: Schrodinger wave equation  
   • Solid state physics: crystal structure, band gap and band structure, Fermi-dirac distribution, density of states

2. Advanced Lithography

3. Nanofabrication Techniques

4. Photovoltaic and optoelectronic devices  
   • Semiconductor electronics: band diagram, heterojunction band diagram, p-n junction, metal-oxide-semiconductor field effect transistor (MOSFET)  
   • Solar cells  
   • Optoelectronics: Fermi’s golden rule, optical gain (loss), spontaneous emission and refractive index, semiconductor lasers and light emitting diodes

5. Raman Characteristics of Nanostructures  
   • Basic introduction (history and physical background)  
   • Measurement techniques  
   • Known molecules (chemistry and condense matter)  
   • Nanostructure measurements

6. Surface Enhanced Raman Scattering (SERS) and applications

7. Nanowires and Self-assembled Quantum Dots  
   • QD 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  
   • NW fabrication method: Vapor liquid solid (VLS) and CVD  
   • Solution-based method: colloidal QD fabrication; fabrication and purification methods; material characteristics; applications  
   • Properties: electrical, thermal, mechanical, optical  
   • Applications

8. Quantum Mechanical Treatment of Nanostructures

9. Advanced Characterization Techniques