PHYS 420 Nanoscience and Nanotechnology

Fall 2014

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Lectures: Monday 13:40-15:30 EB-101
Wednesday 15:40-17:30 EB-101

Objective: This course aims to present the background and the latest achievements in nanometer scale materials and devices. It will provide a comprehensive introduction to the rapidly developing field of Nanoscience and Nanotechnology. This is a lecture course designed to provide an introduction to the physics of nanostructured systems, their current roles in technology, and the likely future impact of such systems on industry. This course should be suitable for graduate students and as well as advanced undergraduates.

A nanostructure can be defined as an object possessing at least one critical dimension less than 100 nm in extent. That means one is dealing with number of atoms or molecules. As consequence, the properties of matter on the nanometer scale can be vastly different than those on the macroscopic scale. This can be a classical effect like the statistics of small number of atoms, i.e from the reduction in N, the number of atoms, from a thermodynamically large value to a small value. For example, in nanostructures the surface to volume ratio becomes very large. Or it can be quantum mechanical effects (e.g. tunneling, quantum interference), typically relevant at very short length scales, may become dominant when system sizes approach the nanometer regime. This course will try to touch and provide a brief introduction of such an extensive science of nanostructures.

Recommended book: Gabor L. Hornyak, Joydeep Dutta, Harry F. Tibbals and Anil K. Rao. *Introduction to Nanoscience*. CRC Press.

Grading: 10% Colloquium Attendance
30% Homework
30% Term paper, December 15, 2014
Search and decide about your term paper topic,
Send an e-mail for confirmation!
30% Final examination, to be announced

Syllabus:

1) Prespective of nanoscience and nanotechnology
   What's nano?
   History: Nano timeline
   Motivation towards nanotechnology
2) Atomic scale characterization and processes
   TEM/SEM

Scanning probe microscopies: STM/AFM
Atomic manipulation

3) Nanofabrication
   Top-down
   Bottom-up
   Self-assembly
4) Nanowires
   Properties
   Synthesis
   Applications
5) Carbon Nanotubes
   Properties
   Synthesis
   Applications: hydrogen storage, field emission, sensors, functionalization
6) Graphene
7) Transport in nanostructures
8) Nanoelectronics
   Molecular electronic
   Nanodevices
9) Nanomagnetism and sprintronics
10) Nanomedicine

Some Project-Term paper proposals:

Graphene
Manipulation of individual atoms and molecules by STM/AFM
Quantum confined nanostructures
Development of new local probes with nanoscale resolution
Nanosensors
Nanocatalysis
Bio-nanotechnology
  Protein, amino acid, nucleic acid and cell adsorption on surfaces
  Functionalization of surfaces by self-assembled monolayers (SAMs)
  Structure and function of biological macromolecules
  Membrane proteins, molecule pores, and pumps studied by XRD/NMR
  Transmission XM imaging of bio-nanostructural complexes in liquid
  Synthesis of biomimetic nanodevices for enzymatic/catalytic reactions
  Characterization of nucleic acids by AFM
  Drug delivery nano-particles
  Nano-motors
  Biosensors
Nanofabrication
  Self-assembly

- e-beam lithography
- Carbon Nanotubes
  - Synthesis of Carbon Nanotubes
  - hydrogen storage in Carbon Nanotubes
  - Carbon Nanotubes Transistors
  - field emission in Carbon Nanotubes
  - nanosensors
  - functionalization of Carbon Nanotubes
  - molecular motors with carbon nanotubes
  - heat conduction in carbon nanotubes
  - electrical conduction in carbon nanotubes
- BN nanotubes
- fullerenes
- quantum dots
- qubits
- Thermoelectric materials
- Magnetic nanomaterials
- Metal nanoparticles
- Nanocrystalline materials
- Nanocrystals in Si-based semiconductors
- Nanomechanics
  - New coatings for improved tribological properties
- nano-electro-mechanical structures
- polymer nanodevices
- biological nanodevices
- Atomic scale characterization and processes
- Nanowires
  - Melting of nanowires
  - exotic structures of nanowires
  - synthesis of nanowires
  - Atomic chains
- Transport in nanostructures
  - conduction in DNA
- Nanoelectronics
  - Molecular electronic
  - Nanodevices
- Nanomagnetism
  - molecular magnets
- Spintronics