EC481 Nanotechnology

Electrical & Computer Engineering

EC481 Fundamentals of nanomaterials and nanotechnology

Nanotechnology encompasses the understanding and manipulation of matter with at least one characteristic dimension measured in nanometers with novel size-dependent physical properties as a result. This course explores the electronic and optical properties of material at the nanoscale and applications of nano-scale devices. The parallels between light and electron confinement are emphasized, e.g. in terms of normal modes, resonances and resonators. Wave-mechanics is reviewed and used to understand confinement, and energy quantization. In particular, optica whispering gallery resonators, quantum dots and plasmonic nanoparticles and their applications are discussed. Fabrication using top-down and bottom-up methods are discussed, as well as characterization using scanning probe methods, microscopy, and spectroscopic techniques.

Course Organization

Contact info:  Professor Anna Swan
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Office hours: PHO 827: TBD

Course book (no required book)
Optional textbook:
• Introduction to Nanoscience, Stuart Lindsay
  – Amazon– paperback ~$60, Kindle ~$22
Reading material will be posted on Blackboard

Prerequisites
This course does not have any prerequisites. As a junior level course you are expected to have an adequate mathematical background for differential equations. You are also expected to be familiar with basic electrical knowledge such as concepts of electrical field, voltage, and basic laws (Ohms law, Kirchhoff’s laws). PY 313 Modern physics is not required as a prerequisite, However, it will be easier for you if you are already familiar with some of the PY 313 material on waves. Please see postings on blackboard for more details.

Blackboard
Communication: All communication will take place via Blackboard, e.g. change of class room, change of office hours, clarifications on homework, deadlines etc. You are responsible for keeping ajour with the course on Blackboard.
Course material: Coursematerial will be posted on Blackboard.
Discussion board: Please use the discussionboard for questions and comment to me and your peers, i.e. do not email me a general question, but post it on the discussionboard. (You can sign up for email notification)

Lectures
Tue and Th 12-2 pm. Room PHO202
It is important that you attend lectures, especially since there is reference material but no text book for the course.
If you miss a lecture, it is imperative that you find a way to cover the missed material before the next class, since the lectures build on concepts build on each other. You will be asked to read some scientific overview articles.

Assigned reading
A couple of scientific papers posted on blackboard will be assigned as reading for in class discussion.

Homework
Homework assignments will be posted on Blackboard. The presentation of your homework matters, as will be reflected in the HW grade. Please see guidelines posted on Blackboard. Homework grades are based on degree of correctness and presentation. You will be allowed to drop the lowest homework for your final homework grade.
Projects
You will work in groups of 2 people on a relevant nanotechnology project for a 10 min presentation and report near the end of the term.

Midterms
The exams will be closed book in-class exams. The 2 midterms will cover separate material (please note that similar concepts show up for both midterms). Requests for make-up exams before the exam will be judged on an individual basis.

Laboratory

Lab grade:
You need to complete all labs and turn in the lab report for all labs in this course, otherwise your course grade will be an automatic “F”. The lab grade constitutes 20% of your course grade. The lab grade is based on your quality of the labwork as judged by results and observation, and on the quality of your lab report.

Lab preparation:
In order to be able to finish a lab in the allotted 2 hour time slot, you are required to prepare for the lab by reading the Pre-Lab material, the Lab instruction and successfully passing the pre-lab quizz. You will not be allowed to do the lab without a prelab quizz pass grade.

Lab work:
You will work in groups of 2 students/per group. You should be well aquainted with the theory and procedures of the lab as you start. The labs will require efficient use of time in order to complete the lab in your 2 hour times slot. You need a dedicated lab notebook and you should bring a memorystick in order to save your data.

Lab reports:
After the lab you will complete a lab report which are due at the posted time. All lab reports are required to follow the posted LAB REPORT format, and should be typed, with accompanying data included in numbered and labeled figures. Your calculations of expected results and comparisons with experimental results should be presented via a program such as Matlab or Origin. No hand drawn figures will be accepted. If your data was poor, you are allowed to include data from another lab group in addition to your own for comparison. The data has to be clearly labeled as borrowed (and from whom) in figure captions, figure labels and in text. Failure to acknowledge borrowed data constitutes cheating, and will be dealt with according to the BU rules on academic conduct.

Grades
Your grade will be based on participation (10%), 2 midterms, each worth 20% of your final grade, homework (15%), final project presentations (15%) and and labs (20%).

Collaboration
Discussion with your peers of concepts covered in lectures, homework and labs are encouraged. However, homework solutions and reports needs to be fully done by yourself. Copying homework or lab-reports is considered cheating.

Academic conduct
Please see the university policy on proper academic conduct and what constitutes academic misconduct. In the case of academic misconduct in this class, established academic discipline procedures will be followed.
http://www.bu.edu/ceit/university-policies/academic-conduct/

Lecture topics
Week 1 Introduction
Week 2,3 General wave properties, Confined waves, Simple harmonic oscillator, Q factor
Week 4 Optical waves
Week 5 Confined optical waves, planar resonator and applications (David Freedman)
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Week 6  Optical Microring resonators
Week 7  **Columbus holiday**, Review & Midterm 1
Week 8  Plasmonic nanoparticles
Week 9  Nanofabrication, top down, bottom up.
Week 10 Biomimetics, Quantum dot fabrication (Prof Dennis)
Week 11 Quantum dot physics (confined electron waves) and applications
Week 12 Characterization methods (size and properties)
Week 13 Mechanical resonators (Ekinci Lab – Charlie Lissandrello), **Thanksgiving holiday**
Week 14 DNA characterization/ Review & Midterm 2
Week 15 Student project presentations

**Labs**

Week 3  Digital microfluidics
Week 5  Biosensors
Week 7  RSofT simulation - WGM
Week 9  Plasmonic gold nanoparticles
Week 12 QD fabrication and spectral analysis

Reports due the following week, Fridays at 5 pm.