Introduction to Nanoelectronics

1. Introduction (1 week)
    1. nanoscale science and technology, definition and impact
    2. what's new in nano?
    3. examples
2. Background on solid state devices (1 week)
    1. Fermi surface and band structures
    2. Envelope function
    3. Field-effect transistors, charge control model
3. Quantum vs. classical transport (1 week)
    1. Boltzmann Equation
    2. length scales
    3. ballistic transport
    4. phase coherence
4. Fabrication and characterization techniques of nanoscale building blocks (1 week)
    1. e-beam, AFM, STM, dip-pen, nanoimprint, self-assembly
    2. materials and device characterization, TEM, AFM, SEM, STM, SPM
5. Single electron devices (2 weeks)
    1. Coulomb blockade
    2. logic and memory applications
    3. quantum cellular automata
6. Carbon nanotubes (2.5 weeks)
    1. material structure and properties
    2. low-T electrical properties
    3. room-T properties and applications
        i. FET, inverter, oscillator, optics, emitters, chemical sensors
        ii. NEMS
7. Semiconductor nanowires (2.5 weeks)
    1. growth
    2. heterostructures/band structure engineering
    3. low-T electrical properties
    4. room-T applications
        i. FET, oscillators, assembly, biosensors
        ii. Environmental sensors, solar cells
        iii. Optics, lasers
        iv. NVMs
        v. NEMS
8. Molecular electronics (1 week)
    1. single molecule devices
    2. FET
    3. memory devices
9. Spintronics (1 week)
    1. spin-FET, coherent spin transport
    2. spin valves and MRAM
10. Quantum computing (1 week)

1. qubits
2. entanglement and logic operations

Class Style:

The class will be divided into 6 “teams” (though, they are noncompetitive).

On ***Thursdays***, I will give lectures on topics described above. If the lectures are given in powerpoint form, a copy of the lecture notes will appear on the course website following the class.
On ***Tuesdays***, a team will present a research paper associated with the topics covered on the previous Thursday. The paper will be available on the course website 2-3 weeks before class. The presenting team will be determined at random at the beginning of class. This means that each team should be prepared to make the presentation. Following the presentation, I will organize a discussion and summarize the topics. An introduction about the whole field such as competitive methods may also be given by me before the presentation.

The team will need to address the following points:

Background of this work.
What is new about this work (technique, methods, etc, why hasn't this been done before)?
What are the achievements and impacts?
Is there an alternate method (explanation)?
What are the next logical steps?

There will also be quizzes in basically every class (although not counted in the final grading) – bring in your calculators. The objective is to help you exercise important concepts which may not be covered in the homework or presentations. You will have a much deeper impression and learn the concepts much faster by getting the results yourself rather than seeing a result on the board.

Grading:

Presentation 40%
Term paper 30%
Homework 20%
Active Involvement 10%