ECE-597NE: Nanoelectronics

Prof. Polizzi
- A nanometer is \textbf{1/150,000} of the width of a hair
- A water molecule sitting on the surface of your brain has the same size perspective as a person on the surface of the Earth
- Nails grow at an average rate of 3 mm a month, how long will it take to grow by 1 nm?
- The nanoscale is the smallest scale at which matter can be manipulated
- \textbf{Range of the nanoscale action is defined between 0.1 nm to 100 nm (atomic or molecular domain).}
Nanoelectronics?

- Aggressive downscaling causes traditional transistor devices to reach their physical limits and create many problems (physical: quantum effects and heat, technical: fabrication process, financial: fabrication cost).
- Nanoelectronics is sometimes considered as disruptive technology because present candidates (emerging devices) are significantly different from traditional transistors and/or materials (post-CMOS).
Beyond 344-609

- Are traditional textbook for modeling device engineering (semiconductor materials and devices) relevant for nanoelectronics?

*Effective Mass....
*Drift-Diffusion...
*Shockley-Reed-Hall (SRH) RG...
*FET Square Law theory...
*Ohm’s Law...
Towards nanoeletronics

- **The “top-down” approach**
  - Include “quantum corrections” to classical physical models, or jellium description of the matter.
  - Achieving better resolution with “optical lithography”, electron beam, etc.

- **The “bottom-up” approach**
  - Richard Feyman (1959) "There is plenty of room at the bottom"; creating new technology by manipulating atoms one by one?
  - New instruments: SEM, STM, TEM, AFM (Ex: IBM logo in 1989 using STM)
  - Radical technology shift
  - Nanostructures present in nature: Carbon nanotube (CNT), molecules, DNA, etc.
  - Understanding electronic structures, quantum effects and electron transport from the bottom-up
Nanoelectronics potential

- **Computing**
  - Devices
  - Architectures: New fabrics, New computing paradigms (QCA, etc.)
  - Memory: nanomagnetic quantum dots, molecular memory, CNT memory

- **Energy**
  - Nanostructure photovoltaics (cost effective solar cells)
  - Battery (ultra-capacitors CNT)

- **Sensors**
  - CNT-based Terahertz (THz) detectors (applications to medical imaging, skin cancer detection, airport security)
  - Bio-sensors