EEL 6935 Computational Nanoelectronics

T (8:45-10:25), R (9:35-10:25), BEN 328

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Transistor

Field-effect transistor

Intel 2005
Transistor I-V

FET: a gate controlled switch
Moore’s Law

Scaling limit of Si transistor in sight: ~10nm
New Device Options

ITRS 2005 edition Emerging Research Devices
Challenges

Si MOSFETs scale below 100nm
- ballistic transport
- quantum effects

Emerging research devices:
- how to understand them?

Top-down view: 6397/6398

Molecular transistor

~ 2 nm
Bottom-up view

Example 1: Si MOSFETs
- what is the ballistic limit?
- how scattering affect the ballistic current?

Example 2: Carbon Nanotube FETs
Objectives

Materials:

- compute bandstructure of common semiconductors
  (e.g. GaAs, Si)
- compute bandstructure of new nanomaterials (e.g. CNT, CNR)

Devices:

- obtain a simple, quantitative picture for
  silicon nanotransistors
  and emerging research devices
Topics (Part I)

- Basics of Schrödinger Equation (chap. 2)
- Self-Consistent Electrostatics (chap. 3)
- Basis functions (chap. 4 )
- Calculation of Semiconductor Bandstructures (chap. 5)
- Simulations of Nanomaterial Bandstructures (chap. 6)
- Nanoscale MOS Capacitors (chap. 7)
Schedule (part I)

8/29: Lectures 6 & 7
9/5: Lectures 8 & 9
9/12: Lectures 10 & 11
9/19: Lectures 12 & 13
9/26: Lectures 14 & 15
10/3: Lectures 16, 17 & 18
10/10: Lectures 20, 21 & 22
10/17: Lectures 23, 24 & 25
10/24: Exam 1

http://www.nanohub.org/courses/quantum_transport
Topics (Part II)

- Nanoscale Si transistors (chap. 3)
- Scattering Theory for Nanotransistors (chap. 4)
- Device Physics of Carbon Nanotube Transistors (chap. 5)
- Molecular Conduction (chap. 6)
- Device Physics of Single Electron Transistors (chap. 6)
Project presentation

Define a topic: (e.g. strained Si, molecular memory etc.), 1 page report due 10/5

50% on review of the field

50% on solving a problem

End of semester presentation (25 min)
Grading

10% homework

45% Exam 1

45% Final presentation (including 5% peer review)

Office hours: 4-5pm T/R, NEB 551