EEE532: Semiconductor Device Theory II

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Meeting times: MWF 1:40 – 2:30
Classroom: SCOB 105
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Textbook: none
References:
D. K. Schroder, *Advanced MOS devices*, Addison-Wesley, 1987.
D.W. Greve, *Field effect devices and applications*, Prentice Hall, 1998.
K. F. Brennan and A. S. Brown, *Theory of modern electronic semiconductor devices*, Wiley, 2002.

Prerequisite:
EEE531 or equivalent. Knowledge of quantum mechanics (quantum confinement, tunneling, etc.) is also needed.

Objectives:
Gain deeper and broader knowledge of semiconductor device physics and device operation principles by covering special topics.

Topics will be selected from the following:
charge coupled devices, MOS memories, thin-film transistors, MESFETs, semiconductor heterostructures, HEMT and MODFETs, Heterojunction bipolar transistor, transferred electron devices, negative differential resistance and devices, resonant tunneling and devices, solar cells.

Class requirements: homeworks, one midterm and one final takehome exam.
Grading policy: midterm and final 35 % each, homework 30 % each.

Note: No makeup tests and exams. Late homeworks and term papers will not be accepted.

Detailed lecture notes:

1. Introductory concepts
2. Charge coupled devices
   - Introduction
   - The CCD concept
   - Charge confinement beneath an MOS gate
   - Input and output stages
   - Relaxation of the MOS capacitor in deep-depletion
   - Charge transfer efficiency
3. MOS Memory
   - Introduction
   - Memory organization
   - Read-only memories
   - Non-volatile memories
   - Random access memories (SRAM and DRAM)
4. Thin-film transistors
   - Introduction
   - Liquid crystals and displays
   - Thin-film transistors in general
   - Amorphous silicon TFT
   - Flat-panel displays and portable computers
   - Polysilicon TFTs
   - Polysilicon in small active matrix displays
5. MESFETs
   - Introduction
   - Structure of the GaAs MESFET
   - Metal-semiconductor contacts
   - Current-voltage characteristics of the MESFET
   - Capacitances in the MESFET
   - Comparison between GaAs MESFETS and silicon MOSFETs
   - MESFET applications
   - Other GaAs field-effect devices
6. Semiconductor heterostructures
   - Formation of heterostructures
   - Modulation doping
   - Two-dimensional subband transport at heterointerfaces
   - Perpendicular transport in heterostructures and superlattices
   - Heterojunction material systems: Intrinsic and extrinsic properties
7. Heterostructure Field-effect transistor (MODFET or HEMT)
   - Basics of the heterostructure field-effect transistor
   - Simplified long channel model of a MODFET
   - Physical features of advanced state-of-the-art MODFETs
   - High-frequency performance of MODFETs
   - Material properties and structure optimization for HFETs
8. Heterostructure bipolar transistor
   - Review of bipolar junction transistors
   - Emitter-base heterojunction bipolar transistor
   - Base transport dynamics
   - Non-stationary transport effects and breakdowm
   - High-frequency performance of HBTs
9. Transferred electron devices, Negative differental resistance and Devices
   - Introduction
   - K-space transfer
   - Real-space transfer
   - Consequences of NDR in a semiconductor
   - Gunn diodes
   - Negative differential resistance transistors
   - IMPATT diodes
10. Resonant tunneling and devices
    - Physics of resonant tunneling: qualitative approach
    - Physics of resonant tunneling: envelope approximation
    - Inelastic phonon scattering assisted tunneling: hoping conduction
    - Resonant tunneling diodes: High frequency applications
    - Resonant tunneling diodes: Digital applications
    - Resonant tunneling Transistors