ELCT 882- High-speed Semiconductor Devices

Instructor: Grigory Simin
simin@engr.sc.edu
High-speed Semiconductor Devices

The need for high-speed semiconductor devices:

• Wireless communications – high speed, high-power transistors
• Optical communications – high speed light emitters and photodetectors
• Computers – high-speed transistors (low-power)
• Electronic switching - high speed, high-power transistors
Bipolar Junction Transistors:

- Actual base transit time is usually small enough
- The response time is limited by E-B and C-B RC constants
- Solution – heterojunction bipolar transistors (HBTs)
Speed limitation in Semiconductor Devices

Field-Effect Transistors:

- The response time is limited by the electron drift time and access resistance
- Solution – submicron gate heterojunction FETs – HFETs (HEMTs)
Speed limitation in Semiconductor Devices

Light-emitters:

- The response time is limited by the electron–hole recombination within the diffusion length of the p-n junction
- Solution – Quantum-Well structures (heterojunction LEDs and Lasers)
Negative Resistance Microwave Devices

Gunn-effect, IMPATT, RTD and others

- High-speed performance achieved through fast electron transport
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Topics covered

1. Principles of heterojunctions and heterojunction technology
2. Heterojunction Bipolar transistors
3. Heterojunction Field-Effect Transistors
4. Ultra high-speed transistors: ballistic transistors, vertical FETs
5. Negative Differential Resistance effects in Semiconductors and NDR devices
6. Electronic and optical characteristics of Quantum Wells
7. Semiconductor Lasers physics and modulation principles.
8. High-speed Photodetectors: Avalanche detectors, Schottky detectors, Metal-Semiconductor-Metal detectors.
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Course Goals.

The purpose of the course is to provide students with the knowledge of modern high-speed semiconductor electronic and optoelectronic devices such that they will have the ability to design high-speed devices and integrated circuits as well as use these devices in various systems.

As a result of this course, students will be able to:

a) design, characterize and optimize the performance of high speed diodes and transistors, high speed optoelectronic components, such as lasers and photodetectors.

b) extract the device/material parameters from the experimental data.

c) use the high speed semiconductor electronic and optoelectronic devices in hybrid or monolithic integrated circuits.
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Syllabus (~14 class weeks):
Negative Differential Resistance effects in Semiconductors and NDR devices (~1 week);
Principles of heterojunctions and heterojunction technology (~2 weeks);
Heterojunction Field-Effect Transistors (~2 weeks);
Heterojunction Bipolar transistors (~2 weeks);
Ultra high-speed transistors: ballistic transistors, vertical FETs (~2 weeks);
Electronic and optical characteristics of quantum wells (~1 week);
Semiconductor Laser physics and modulation principles (~2 weeks);
High-speed Photodetectors: Avalanche detectors, Schottky detectors, Metal-Semiconductor-Metal detectors (~2 weeks);
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Text:

Modern Semiconductor Device Physics
S. M. Sze; John Wiley & Sons, NY-Chichester-Weinheim-Brisbane-

Supplemental Text:

666496-2.