NE205 Aug 3:0

Semiconductor Devices and IC Technology

Instructor

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Department: CeNSE

Course Time: Mon, Wed, Fri, 9 - 10 am

Lecture venue: CeNSE, FF-11/MMCR

Detailed Course Page: https://sites.google.com/site/ne205cense2017/

Announcements

Brief description of the course

This course covers the fundamentals of semiconductor physics and carrier transport needed to analyze and design semiconductor devices. Students learn the concepts underlying virtually every solid state electronic device today, including transistors, solar cells, LEDs, and photodetectors. Undergrad/postgrad students with some background on solid state physics and semiconductors can take the course.

Prerequisites

A background in solid state physics/semiconductors at a preliminary level.

Syllabus

Energy bands in solids: tight binding approach, one electron approach (motion in a periodic potential), crystal momentum/effective mass, E-k diagram, Fermi-Dirac distribution & Fermi level, Intrinsic & extrinsic semiconductors, doping, Impurity levels & dopant population, Density of states, Effective density of states, Equilibrium electron-hole concentration, temperature dependence of carrier concentration, degenerate/highly doped semiconductor, Joyce-Dixon, Carrier freeze-out, Low-field transport: Scattering mechanisms, phonon/impurity, relaxation time & mobility, Hall Effect, carrier flow by Diffusion, Drift & conductivity, Einstein relation,

Excess carriers, recombination processes, Surface states (acceptor & donor states), Static behavior of PN junction at thermal equilibrium, PN junction under forward & reverse bias, generation & recombination currents

Charge injection & Quasi-Fermi levels, current continuity & Ambipolar transport equations, decay of excess carriers, Metal-semiconductor junctions, Schottky/Ohmic, Thermionic current, Fermi pinning & surface states, High level injection, Zener & avalanche Breakdown, junction C-V,

BJT: current, DC parameters, base transport factor, Early Effect,

BJT: current crowding, charge control equation & current gain, CE & CB, Eber Moll, BJT: small-signal, delay analysis, space-charge transport,

HBT: need for HBT, gain, current equations, Compound semiconductors. Devices based on III-V, III-nitrides, alloys, epitaxy, heterostructures

Heterostructure physics, band-diagrams under equilibrium,

Current flow in abrupt Heterojunctions, graded junction and quasi-electric field,

Heterojunction FET & HEMT: principle, band diagram, estimation of threshold, 2DEG, Photodetectors: operation, responsivity, QE, bandwidth, noise, Detectivity

Solar cells: principle, efficiency, Fill factor, silicon solar cells, multi-junction solar cell. MOS capacitor, charge/field/energy bands, accumulation, inversion, C-V (high F and low F), deep depletion, Real MOS cap: Flatband & threshold voltage, Si/SiO2 system.

MOSFET: structure and operating principle

MOSFET: derivation of I-V, GCA, substrate bias effect, sub-threshold currents, gate oxide breakdown mobility in inversion layer, VT control,

MOSFET: Pao-Sah double integral model;

Short channel effects â€“ charge sharing, velocity overshoot, channel length modulation, DIBL, LEDs: operation, quantum well LED, EQE, WPE, IQE

CMOS scaling, constant field/voltage scaling, Mooreâ€™s Law, DGFET, FinFET

CMOS process flow: implantation, oxide deposition, etching etc.

Small-signal behavior of PN junction, diffusion capacitance (short base, long base), switching transients,

Course outcomes

Students would learn fundamentals as well as advanced concepts in semiconductors and semiconductor devices.

Grading policy

1) In-class tests = 25%

2) Homework = 45%

3) End-term = 30%

Assignments

Resources