THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

Fundamentals of Semiconductors for Microelectronics and Photonics

ECE 5530

Credit Hours:
3.00

Course Levels:
Undergraduate (1000-5000 level)
Graduate (5000-8000 level)

Course Components:
Lecture

Course Description:
Crystal structure, semiconductor energy band structure, electron transport and carrier recombination, heterostructures, and optical and dielectric properties.

Prerequisites and Co-requisites:
Prereq: 3030 (432), or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences.

Course Goals / Objectives:
- Become competent with quantum mechanics necessary to understand electronic properties of semiconductors
- Gain mastery of concepts related to electrons in periodic potentials, and carrier statistics in 1D, 2D, and 3D systems
- Become familiar with fundamentals of mathematical description of crystal structure and the reciprocal lattice
- Master concepts related to doping and compensation in semiconductors
- Gain competence in understanding excess carrier band to band, impurity, and Auger recombination in semiconductors
- Mastery analysis of charge, field, and energy band profiles in semiconductor homojunctions, heterojunctions, and metal-semiconductor junctions
- Gain competence in analysis of drift, diffusion, and ambipolar transport equations in semiconductors
- Be exposed to tunneling, space-charge limited, and quantum transport in semicondcutors
- Be familiar with non-equilibrium transport in semiconductor PN junctions and metal-semiconductor junctions

Course Topics:

- Motivation
- Chemical bonding, crystallography, reciprocal lattice
- Free electron model, Density of states (1D, 2D, 3D), periodic boundary conditions, plane-wave states
- Nearly free electron model, Bloch theorem, periodic bandstructure and bandgap, band transport and effective mass, Fermi velocity and wavevector
- Statistics and doping, Fermi Dirac distribution, density of states for ellipsoidal bands, electrons and holes, donors and acceptors, deep donors and acceptors
- Electron transport, Boltzmann transport equation, excess carriers, recombination/generation, Ambipolar transport equation, drift diffusion equation, phonons, scattering
- Relaxation time, velocity saturation, high-field transport, inter-valley scattering, ballistic transport
- Surface defects and termination, electron affinity, ionization energy, work function, metal-semiconductor junctions, thermionic emission, tunneling
- P-n junction, band diagram and electrostatics, depletion approximation and limitations, current in a p-n junction, high level injection, SRH recombination theory, recombination in a p-n junction
- Heterojunctions, band diagrams and electrostatics, QW formation, 2DEG, quantum dots, occupation
- Wide bandgap semiconductors, piezoelectric and spontaneous polarization, polarization-induced doping
- Optical properties, absorption and emission, emission from quantum wells

Designation:

Elective