ECE 415: Semiconductor Physics & Junctions

IN

Math

- Apply differential & integral calculus to engineering problems
- Solve 2nd order non-homogeneous differential equations given mixed boundary conditions

Electro-dynamics

- Familiar with Poisson equation
- Write integral & differential forms of Gauss's law and Poisson's equation
- Understand concepts of dielectric permittivity and electrostatic potential
- Familiar with Maxwell equations

Pre-requisites

- MATH340 or MATH345; PH142

Concepts:

- Introduction to Quantum theory of solids
  - Crystal structure of solids
  - Schrodinger equation for free electron and different potentials of interaction.
- Basic semiconductor band structure
  - Conduction and valence bands
  - Density of states
  - E vs k diagram, energy gap and effective mass
- The semiconductor in equilibrium
  - Intrinsic concentration, and doping.
  - Fermi-Dirac and Maxwell-Boltzmann distributions
  - The extrinsic semiconductor
- Carrier transport phenomena
  - Drift, mobility
  - Diffusion, Einstein relation
  - Generation and recombination
- Non-equilibrium, excess carriers in semiconductors
  - Characteristics of excess carriers
  - Continuity equation
  - Ambipolar transport
- The p-n junction
  - Basic structure of the p-n junction
  - Zero and reverse bias
  - Junction Breakdown
- The p-n junction diode
  - Current-voltage behavior
  - Small signal model of the p-n junction
  - High level injection

Applications:

- Microelectronics
- Semiconductor processing
- VLSI
- Optoelectronic active and passive devices
- Semiconductor devices, including sensors

Tools:

- Calculus, algebra

OUT

Basic Physics of Semiconductors

- Understand how the electronic structure of solids
- Understand the concept of electron and hole states
- Understand effective mass
- Calculate density of states
- Calculate intrinsic, doped, equilibrium, and non-equilibrium carrier concentrations
- Understand Fermi-Dirac distribution and assumptions that lead to the Maxwell-Boltzmann approximation
- Understand carrier transport
- Solve for steady state carrier distributions with localized carrier diffusion
- Solve for carrier concentration dynamics in uniform systems
- Calculate depletion widths, capacitance, maximum E-field, built in potential and potential distributions

Physical Properties of Semiconductor Junctions

- Explain basic structure of the p-n junction
- Know how to derive current-voltage relationship for a p-n junction
- Calculate depletion widths, capacitance, maximum E-field, built in potential and potential distributions

Electronic Properties of p-n Junctions

- Explain the operation of a p-n junction in forward and reverse bias
- Know how to calculate junction capacitance
- Understand the small signal model and know how to use it.

Revised 2/2024