ECE 471B: Semiconductor Junctions

IN

Math

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

Electrostatics

- Write integral & differential forms of Gauss's law and Poisson's equation
- Solve for E-field and electrostatic potential for arbitrary 1-D charge distributions
- Understand concepts of dielectric permittivity and electrostatic potential

Semiconductor Physics

- Solve for carrier concentrations and Fermi levels from each other
- Calculates intrinsic, doped, equilibrium, and non- equilibrium carrier concentrations.
- Describe factors driving drift and diffusive transport and calculate associated current densities
- Discuss the structure of electron states in semiconductors

Pre-requisites

- ECE 471A, may be taken concurrently; ECE 331 with a C or higher

Concepts:

- Generation and recombination
  - Non-equilibrium, excess carriers
  - Total and net G&R
  - Low level injection
  - Recombination lifetime
- Ambipolar transport equation
  - Unipolar continuity equations
  - Ambipolar transport
  - Conditions for neglecting terms
  - Diffusion length
  - Solutions for varying circumstances
- Reverse biased p-n junctions
  - Formation of depletion region
  - Charge, E-field and potential distribution
  - Depletion capacitance, C-V (control vertices) curves
  - Tunneling and avalanche currents
- Forward biased p-n junctions
  - Law of the junction
  - Carrier & current distributions
  - Diffusion capacitance
  - Sources of non-ideal currents
  - Ideality factor, *n*

Applications:

- Microelectronics
- Optoelectronics including solar cells
- Semiconductor components

Tools:

- MATLAB or other CAE packages for equation solution and plotting

OUT

Physical Properties of Semiconductor Junctions

- Define non-equilibrium & excess carriers
- Discuss low-level injection approximation and its consequences
- Write continuity equations and states assumptions for neglecting terms
- 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
- Applies approximations for one-sided junctions
- Extract built-in voltage and doping levels from C-V (control vertices) plots
- Determine carrier distributions in p-n junctions for a range of bias voltages
- Describe causes of ideality factors >1

Electronic Properties of p-n Junctions

- Describe consequences of various junction doping schemes on current, electron/hole current ratio and capacitance
- Explain the operation of a p-n junction in forward and reverse bias
- Know how to calculate junction capacitance
- Discuss impact of junction dimensions and imperfections on ideality factor

Revised 4/2019