ECE 471B: Semiconductor Junctions

**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

**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

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**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 minimum grade of C

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**OUT**

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