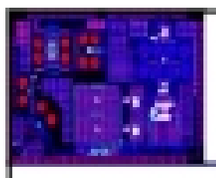
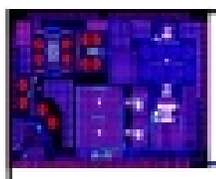


EE105 - Fall 2006
Microelectronic Devices and Circuits

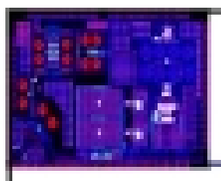
Prof. Jan M. Rabaey (jan@eecs)

Lecture 5: Diode Operation



Overview

- **Last lecture**
  - Capacitance
  - pn Junction
- **This lecture**
  - pn Junction (cntd)
  - Diode operation and models



Administrativia

- Labs starting tomorrow!

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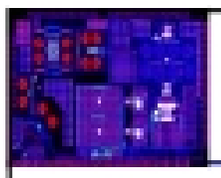
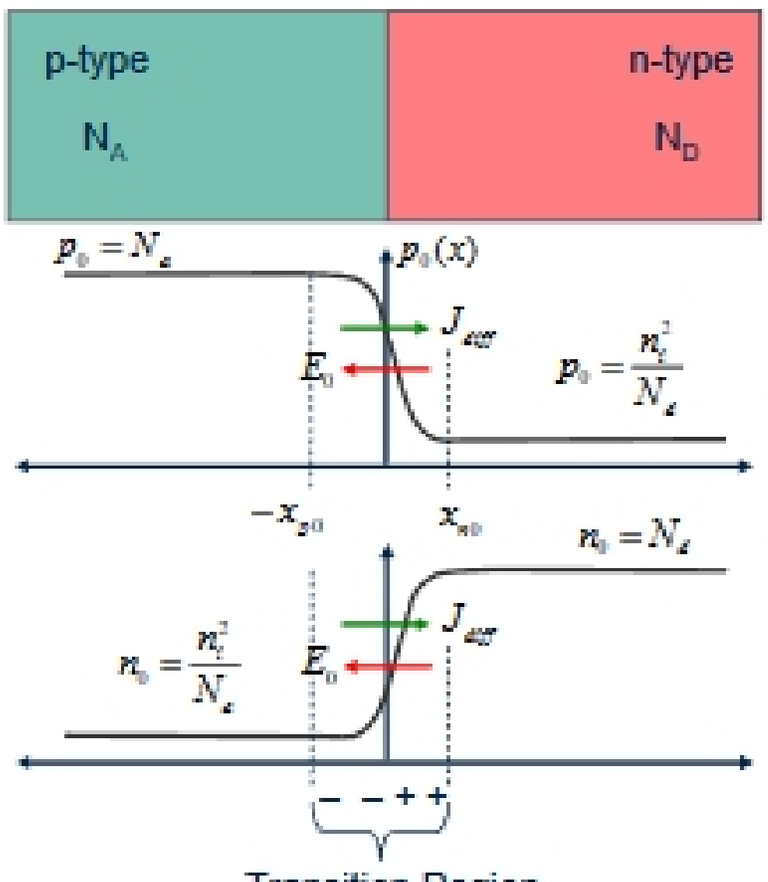


PN Junction – Summary so far



- The most important device is a junction between a p-type region and an n-type region
- When the junction is first formed, due to the concentration gradient, mobile charges transfer near junction
- Electrons leave n-type region and holes leave p-type region
- These mobile carriers become minority carriers in new region (can't penetrate far due to recombination)
- Due to charge transfer, a voltage difference occurs between regions
- This creates a field at the junction that causes drift currents to oppose the diffusion current
- In thermal equilibrium, drift current and diffusion must balance

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Question: width of depletion region

Depletion Approximation

- Let's assume that the transition region is completely depleted of free carriers (only immobile dopants exist)
- Then the charge density is given by

$$\rho_0(x) \cong \begin{cases} -qN_a & -x_{p0} < x < 0 \\ +qN_d & 0 < x < x_{n0} \end{cases}$$

- The solution for electric field is now easy

$$E_0(x) = \int_{-x_{p0}}^{x} \frac{\rho_0(x')}{\varepsilon_s} dx' = -\frac{qN_a}{\varepsilon_s}(x + x_{p0}) \qquad E_0(x) = -\frac{qN_d}{\varepsilon_s}(x_{n0} - x)$$

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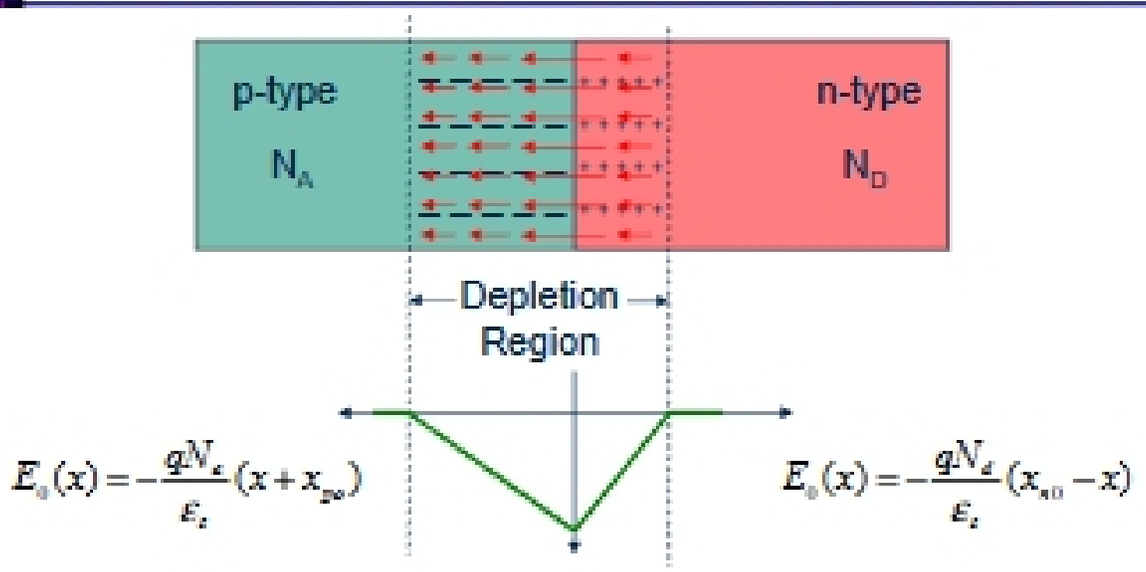
Plot of Fields In Depletion Region



- E-Field zero outside of depletion region
- Note the asymmetrical depletion widths
- Which region has higher doping?
- Slope of E-Field larger in n-region. Why?
- Peak E-Field at junction. Why continuous?

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