Lecture 9

• Last time:
  – Drift current density
  – Ohm’s and resistivity

• Today :
  – IC resistors
  – IC capacitors: metal-metal and pn junction
Using Sheet Resistance

- Ion-implanted (or “diffused”) IC resistor
Idealizations

• Why does current density $J_n$ “turn”?  
• What is the thickness of the resistor?  
• What is the effect of the contact regions?
IC Capacitors

Metal layers separated by insulators $\rightarrow$ get intentional (or parasitic) capacitor

$$C = \frac{\varepsilon d}{t_d}$$
Metal-Metal Capacitor Layout

Overlapping area $A_{12}$
Circuit Model

- Capacitance between metal 1 and metal 2:
  \[ C_{12} = \left( \frac{\varepsilon d}{t_d} \right) A_{12} \]

- Other capacitors: what is terminal 3?
Surface Charge and Electric Field

\[ Q \text{ (C/cm}^2\text{)} \]

\[ V \]

\[ x \]

\[ 0 \]

\[ t_d \]
pn Junction

- Present in most IC structures
Junction in Thermal Equilibrium

• Mobile electrons and holes can cross junction (huge concentration difference)
• Process creates balanced + / - charge layers because the donors and acceptors are “stuck” in the lattice and can’t move
• Limiting state with $V_D = 0 \text{ V} \rightarrow$ thermal equilibrium
• “Built-in voltage” is about 1 V
At \( V_D = 0 \) V, the depletion region is depleted of holes and electrons. The charge per unit area of holes is given by \( qN_a \cdot x_{po} \) and the charge per unit area of electrons is given by \( qN_d \cdot x_{no} \). The diagram shows the p-type and n-type silicon regions.