Lecture 9

• Last time:
  – Drift current density
  – Ohm’s law 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

Circuit Model

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

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

\[ Q (C/cm^2) \]

\[ V \]

\[ x \]

\[ t_\pi \]

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


\[ V = 0 \text{ V} \]

- p-type silicon (neutral)
- depleted of holes, charge per unit area \( Q_{p} = \phi \rho_{p} \)
- depleted of electrons, charge per unit area \( Q_{n} = \phi \rho_{n} \)
- n-type silicon (neutral)