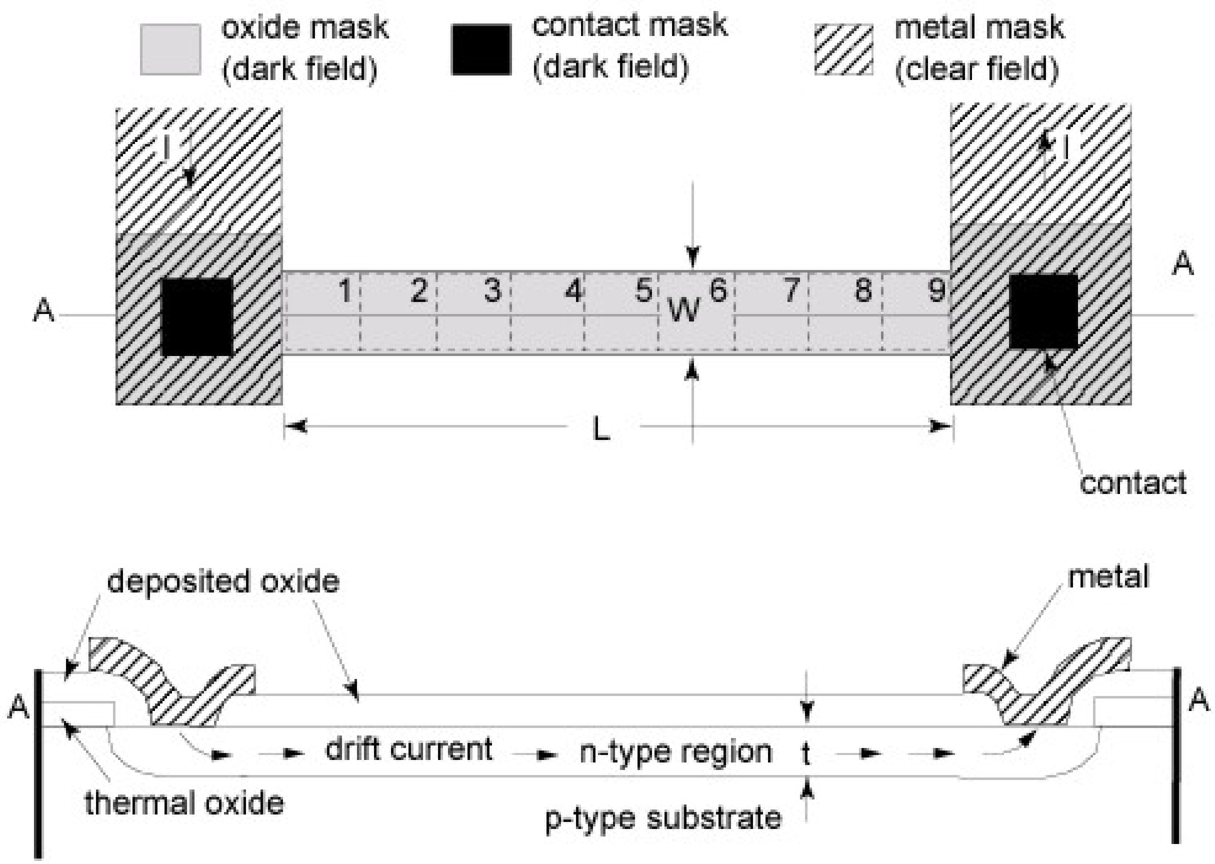
Lecture 9

- Last time:
  - Drift current density
  - Ohm's and resistivity
- Today :
  - IC resistors
  - IC capacitors: metal-metal and pn junction

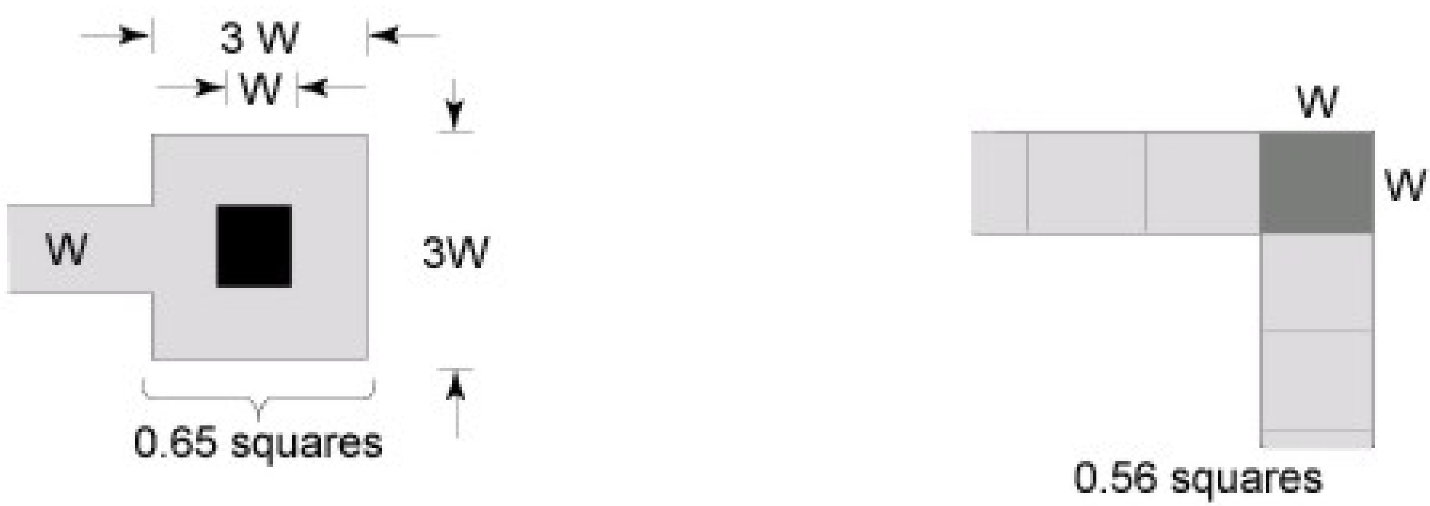
Using Sheet Resistance

- Ion-implanted (or "diffused") IC resistor



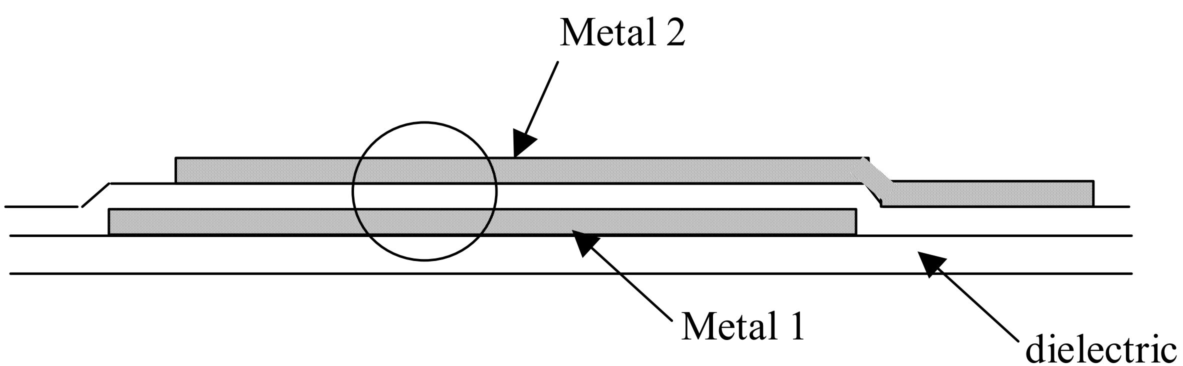
Idealizations

- Why does current density J_n "turn"?
- What is the thickness of the resistor?
- What is the effect of the contact regions?



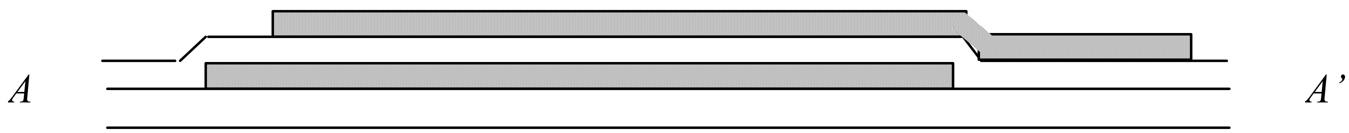
IC Capacitors

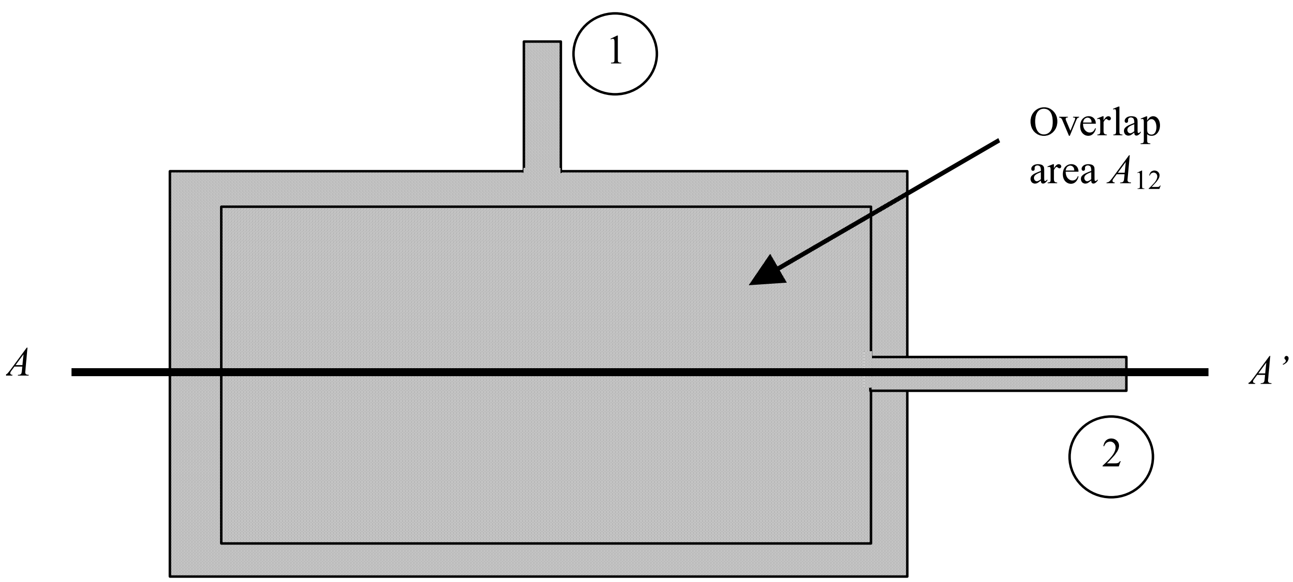
Metal layers separated by insulators → get intentional (or parasitic) capacitor



$$C = \frac{\varepsilon_d}{t_d}$$

Metal-Metal Capacitor Layout





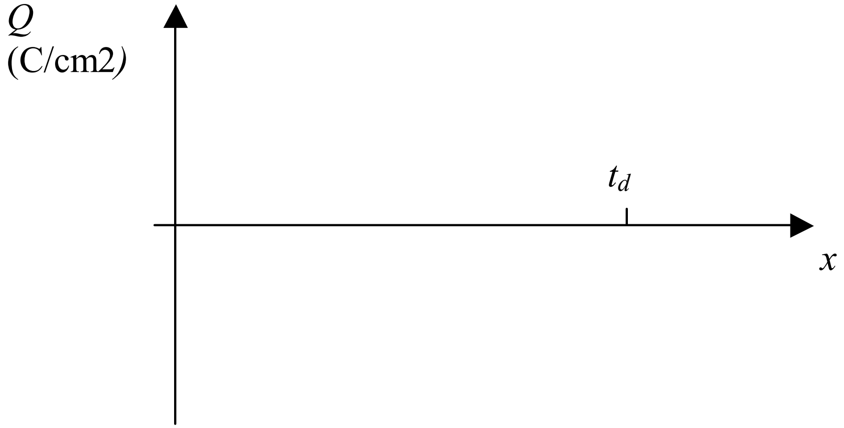
Circuit Model

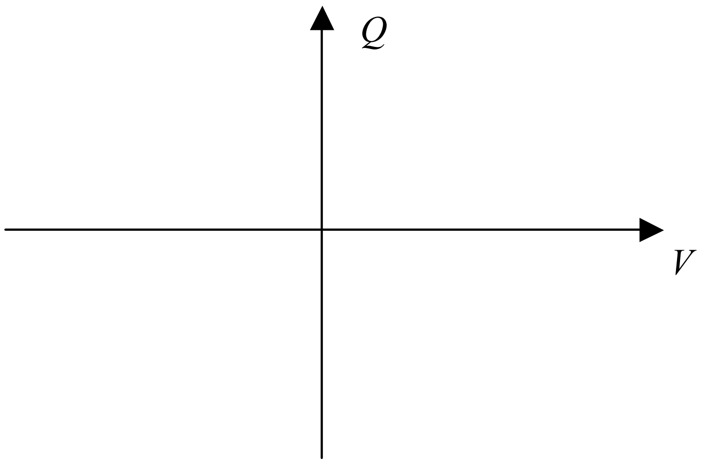
- Capacitance between metal 1 and metal 2:

$$C_{12} = \left(\frac{\varepsilon_d}{t_d} \right) A_{12}$$

- Other capacitors: what is terminal 3?

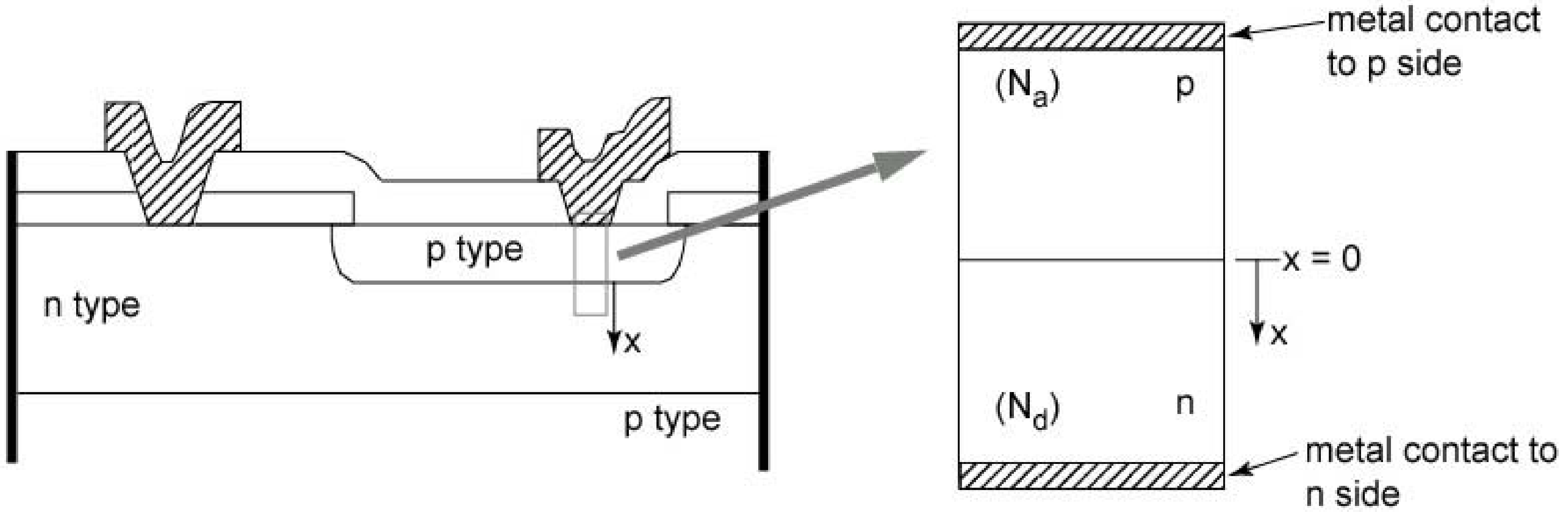
Surface Charge and Electric Field

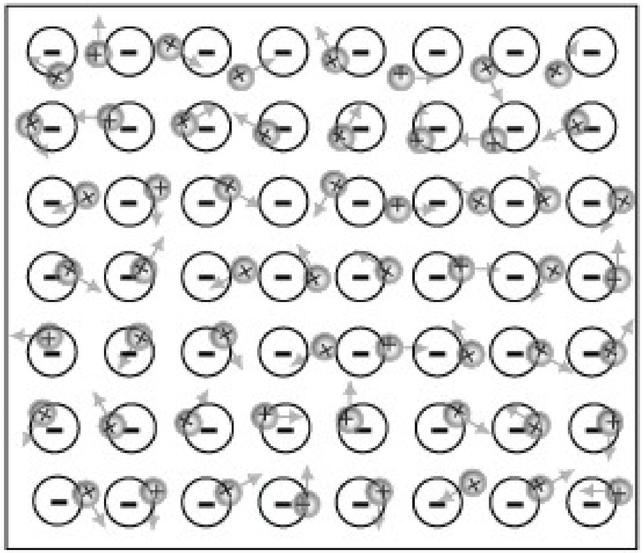




pn Junction

- Present in most IC structures

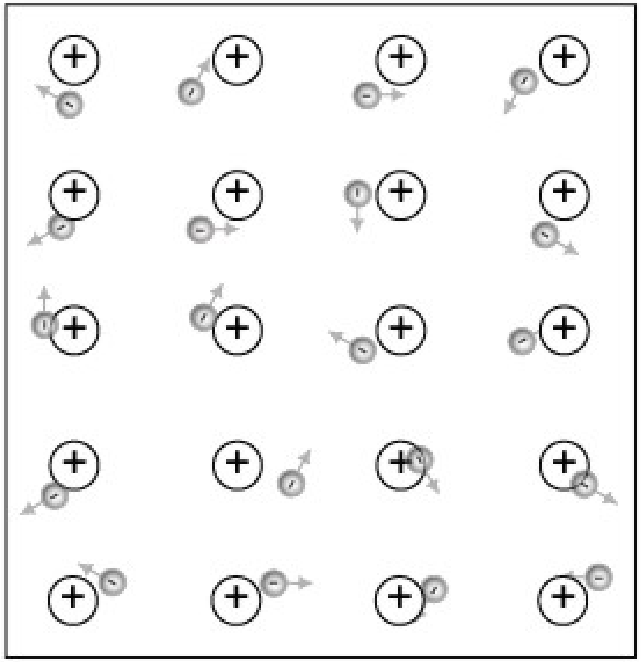




p-type silicon

(−) ionized acceptor (fixed)

(+) hole (mobile)



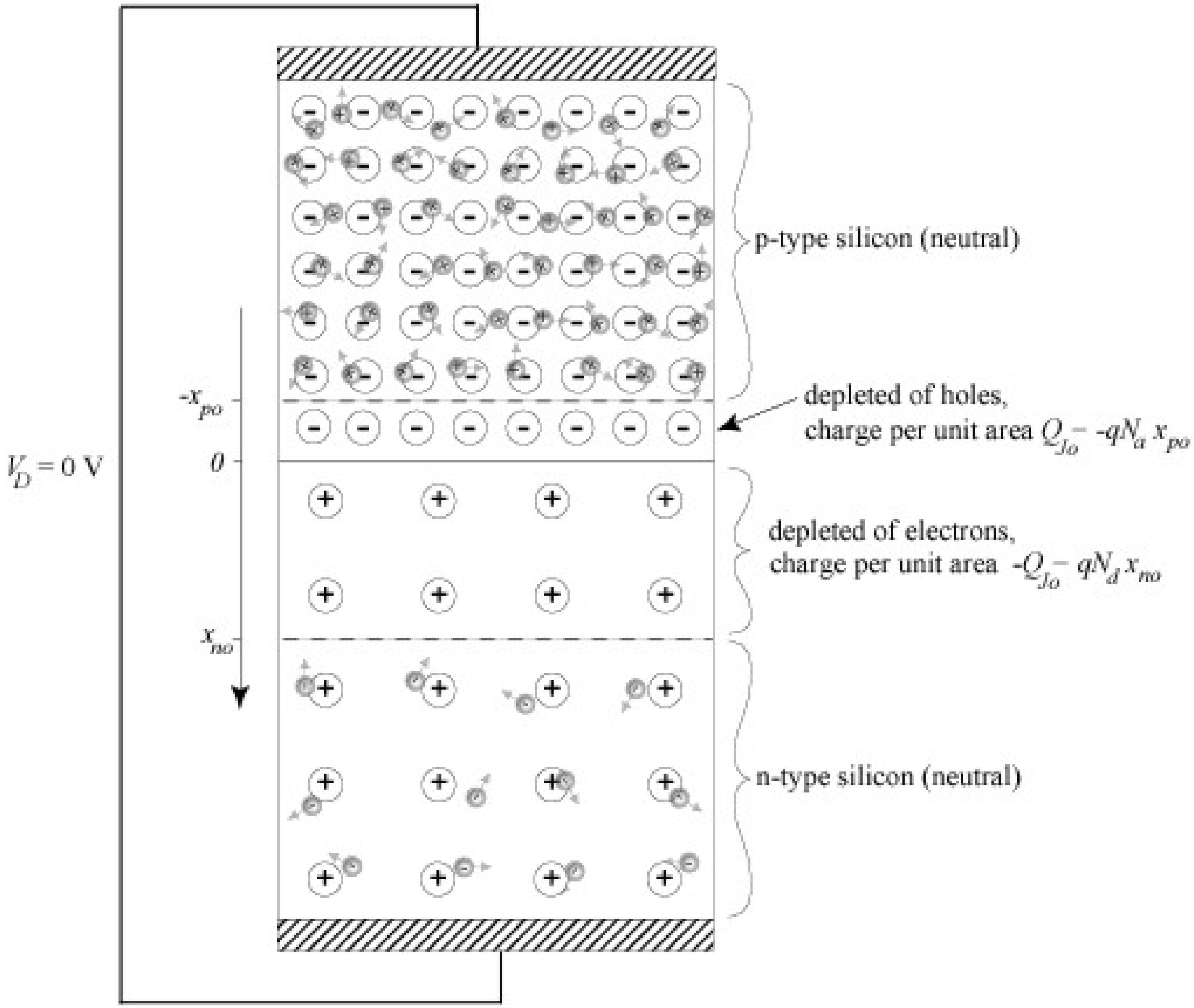
n-type silicon

(+) ionized donor (fixed)

(−) electron (mobile)

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 $V_D = 0$ V → thermal equilibrium
- "Built-in voltage" is about 1 V



$V_D = 0$ V
$-x_{po}$
0
x_{no}
p-type silicon (neutral)
depleted of holes,
charge per unit area $Q_{Jo} = -qN_a x_{po}$
depleted of electrons,
charge per unit area $-Q_{Jo} = qN_d x_{no}$
n-type silicon (neutral)