ECE 340: Semiconductor Electronics
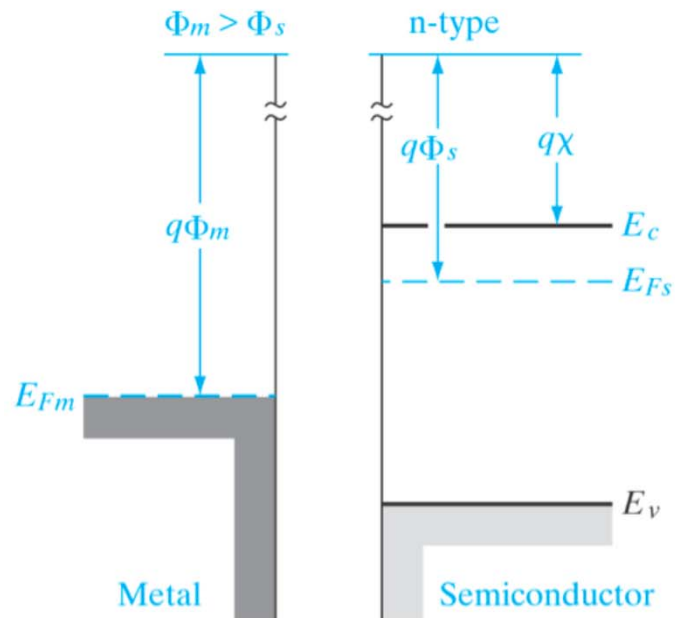
Chapter 5: Junctions (part IV)
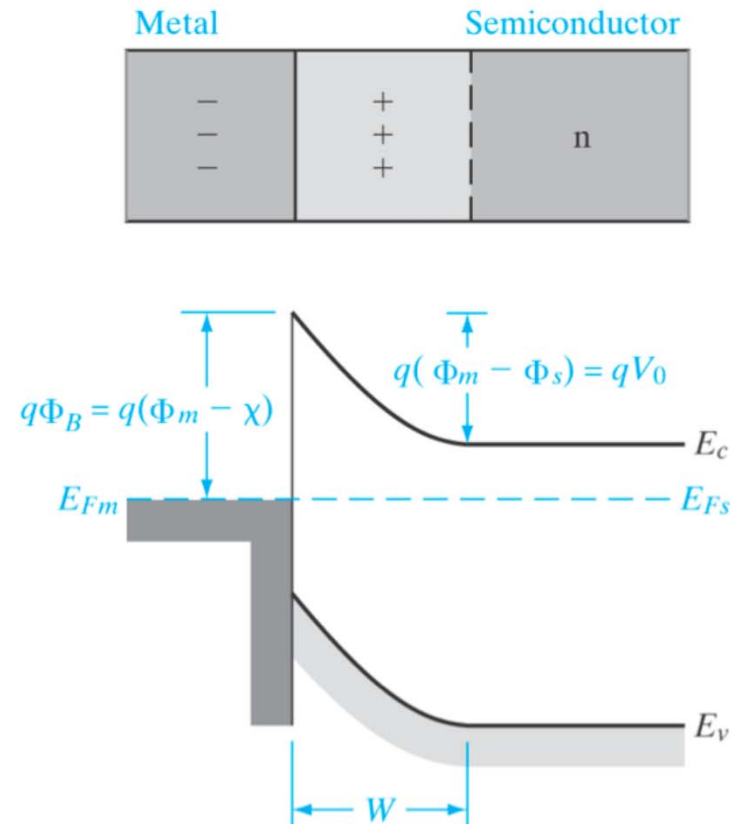
Wenjuan Zhu

Outline

- Metal-semiconductor junction
  - Schottky barrier
  - Rectifying contacts
  - Ohmic contacts

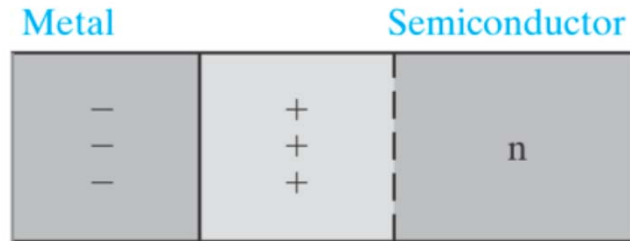# Schottky Barrier formation, n type semiconductor

Metal/Semiconductor in Contact
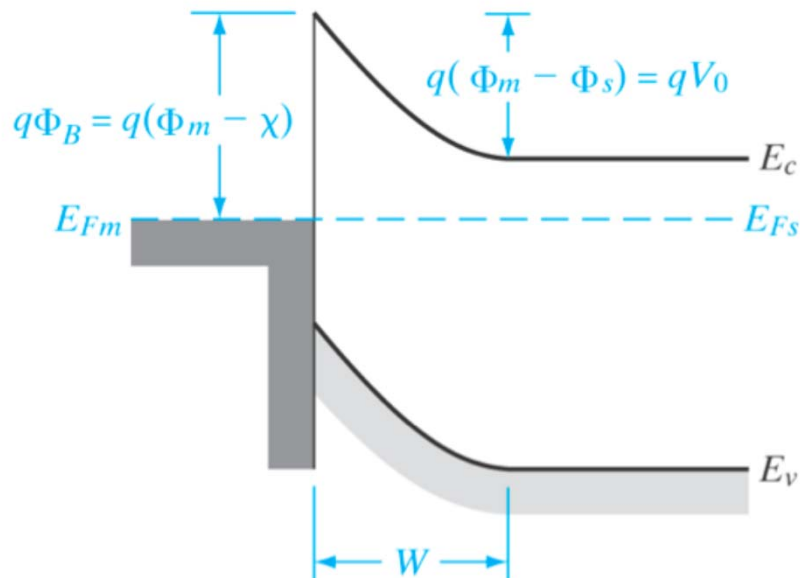
Metal/Semiconductor Not in Contact

- When a metal and a semiconductor are brought together, charge transfer occurs to align the Fermi levels

Schottky Barrier formation, n type semiconductor

Barrier height: $\Phi_B = \Phi_m - X$

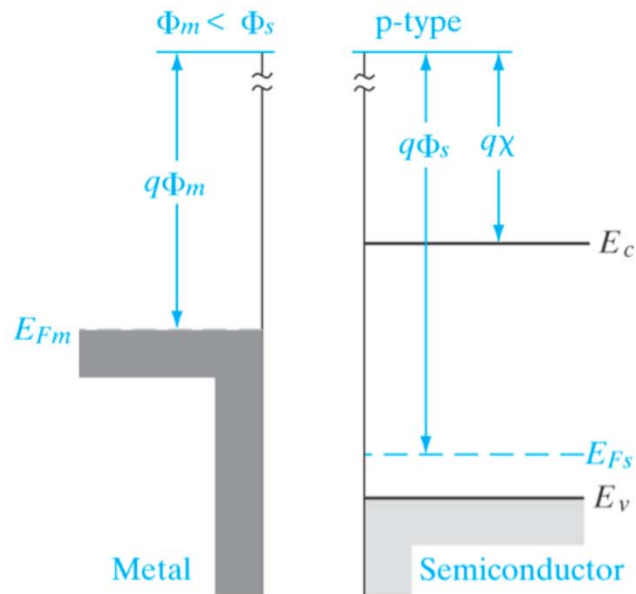**Built-in voltage:** $V_0 = \Phi_m - \Phi_s$

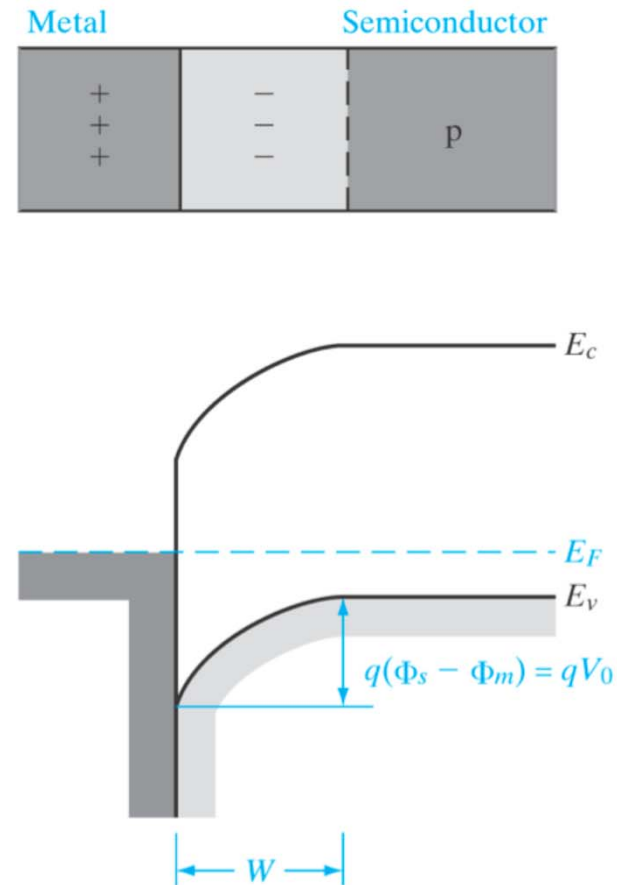**Depletion width:** $W = \sqrt{\dfrac{2\epsilon(V_0 - V_a)}{q} \dfrac{1}{N_d}}$

Junction capacitance: $C_j = \dfrac{\epsilon A}{W}$

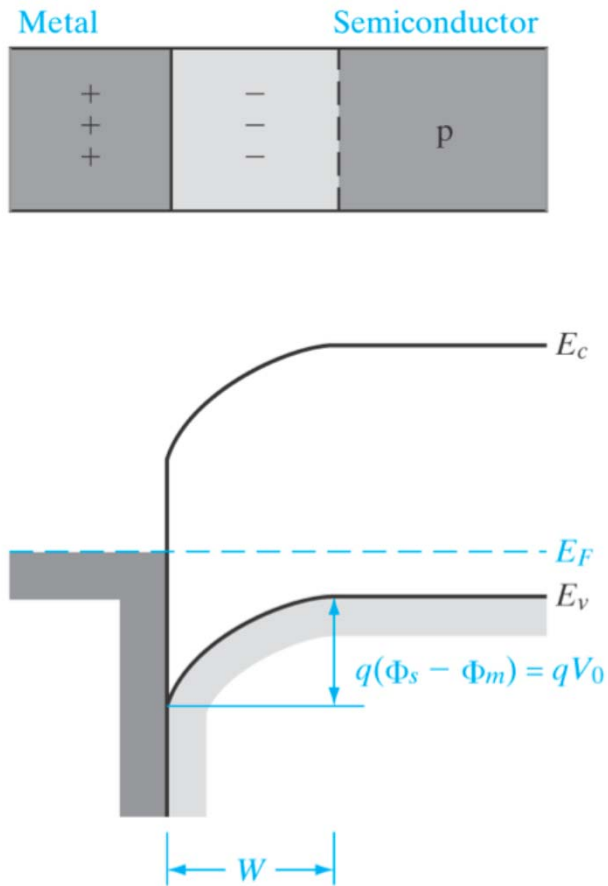# Schottky Barrier formation, p type semiconductor

Metal/Semiconductor Not in Contact

Metal/Semiconductor in Contact

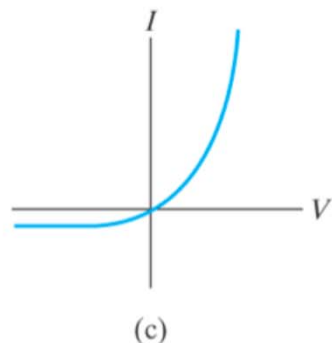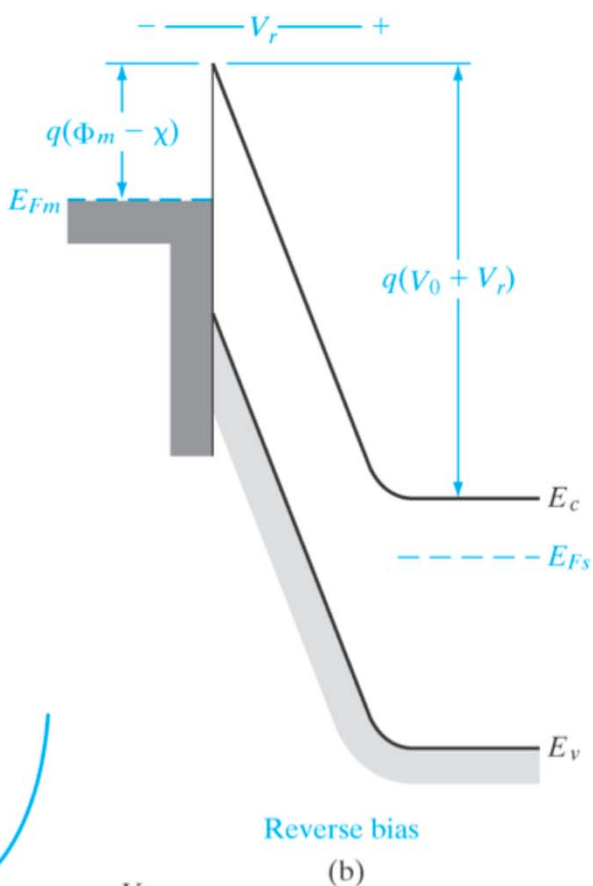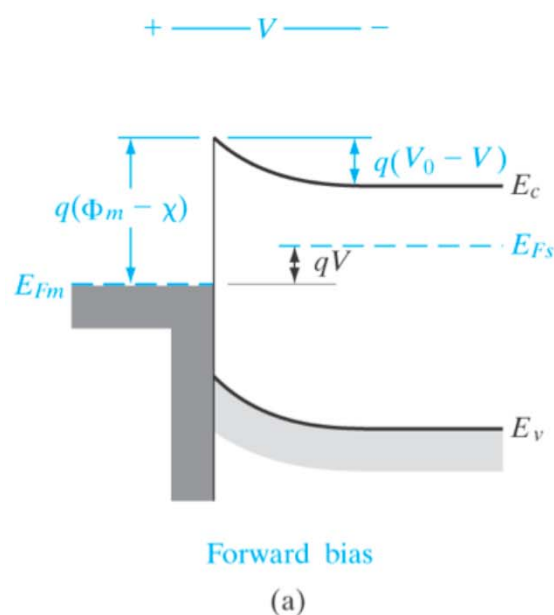# Schottky Barrier formation, p type semiconductor

Built-in voltage: $V_0 = \Phi_s - \Phi_m$

Depletion width: $W = \sqrt{\dfrac{2\epsilon(V_0 - V_a)}{q}\dfrac{1}{N_a}}$

Junction capacitance: $C_j = \dfrac{\epsilon A}{W}$

Rectifying Contacts

$q(\Phi_m - \chi)$

$q(V_0 - V)$

E_c

E_{Fs}

qV

E_{Fm}

E_v

Forward bias

(a)

$q(\Phi_m - \chi)$

E_{Fm}

$q(V_0 + V_r)$

E_c

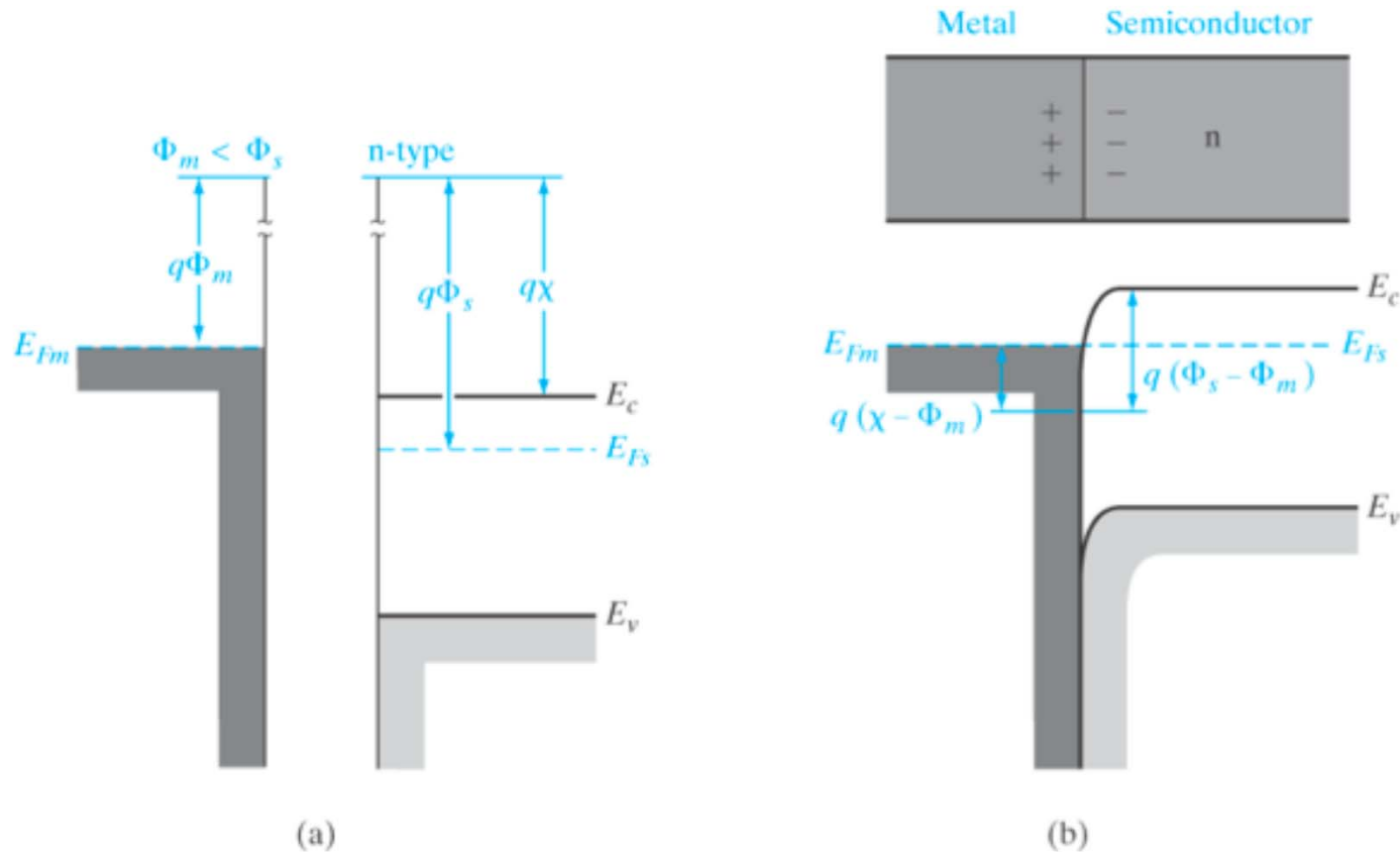E_{Fs}

E_v

Reverse bias

(b)

(c)

- Forward bias (negative on n side): reduce the barrier height causes majority carriers to be injected into the metal from the semiconductor.

$$I = I_0 \left(e^{qV/kT} - 1 \right)$$

$$where \; I_0 = e^{-q\Phi_B/kT}$$

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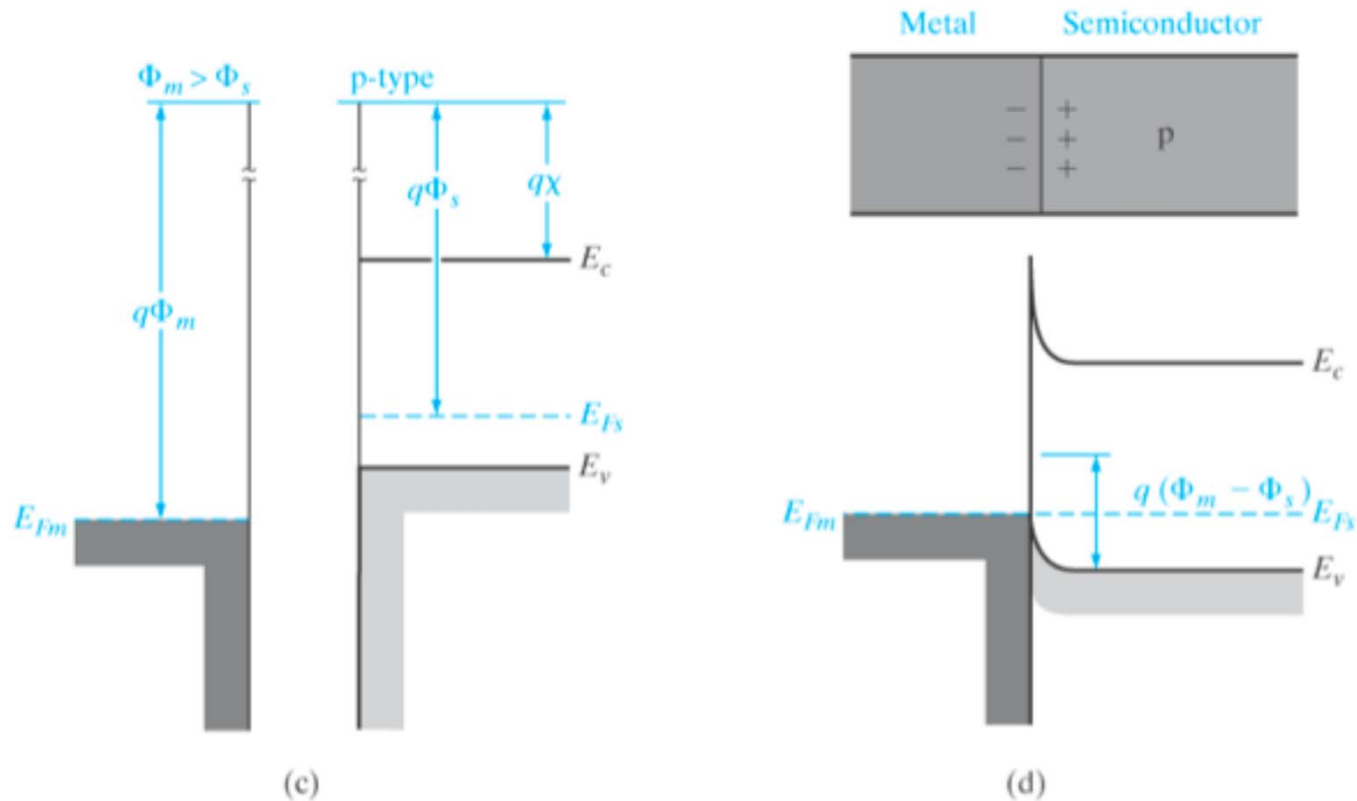
Ohmic contact

- Charge induced in the semiconductor in aligning the Fermi level is provided by majority carrier

Contact type: doping and work function

	$\Phi_m > \Phi_s$	$\Phi_s > \Phi_m$
n-type	Rectifying	Ohmic
p-type	Ohmic	Rectifying

Ohmic contact, another route:

- Heavily doping the semiconductor in the contact region→ depletion width is small enough for carrier to tunnel through the barrier