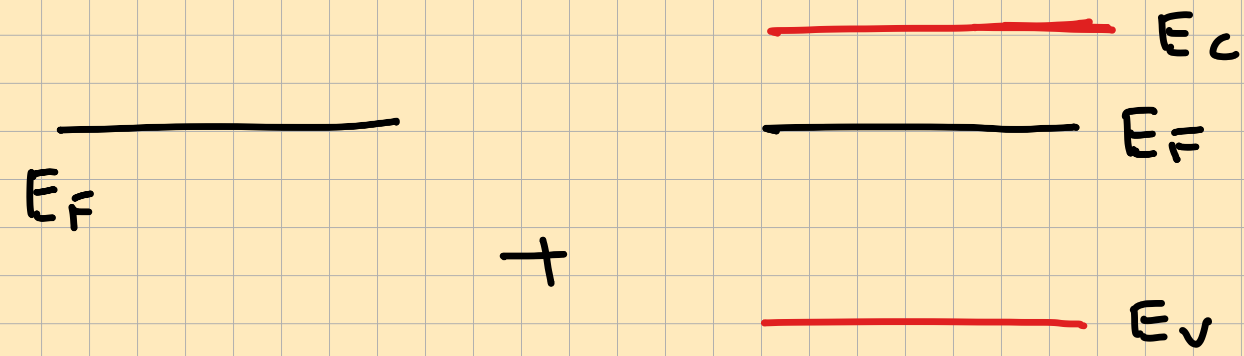
Schottky Diode & Contacts

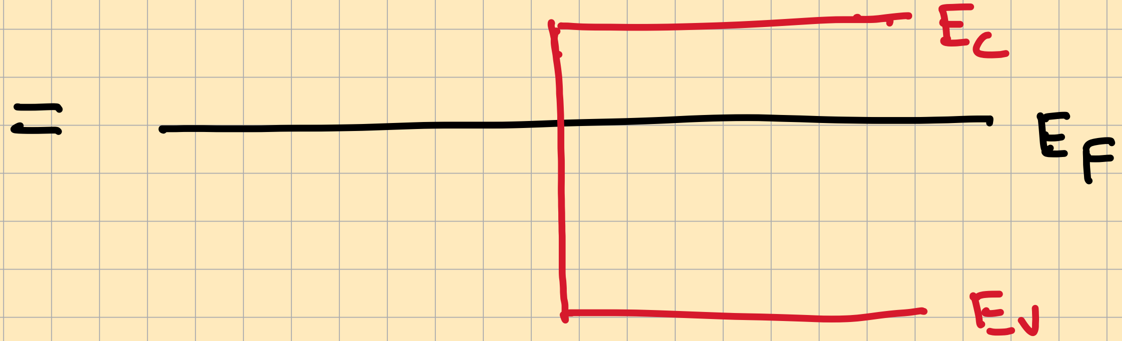
Metal – Semiconductor Junction ↳ Characterized by (E_c, E_F, E_v)

↓

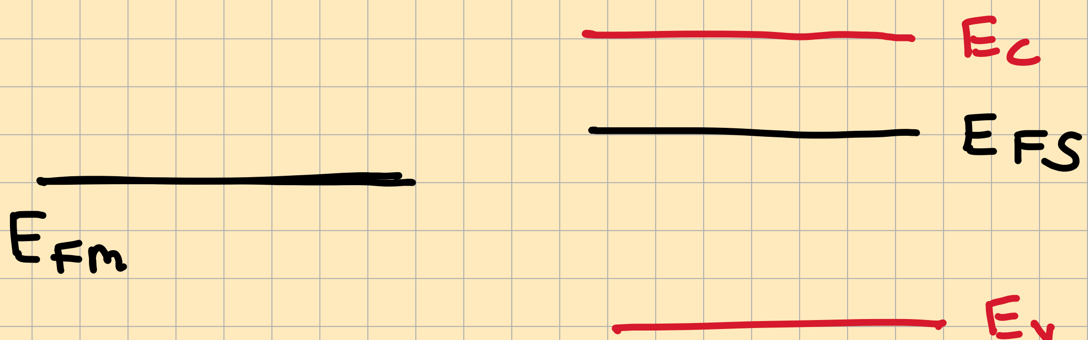
Characterized by E_F (Fermi level)

Case 1 ($E_{F,m} = E_{FS}$) [Fermi level is same]

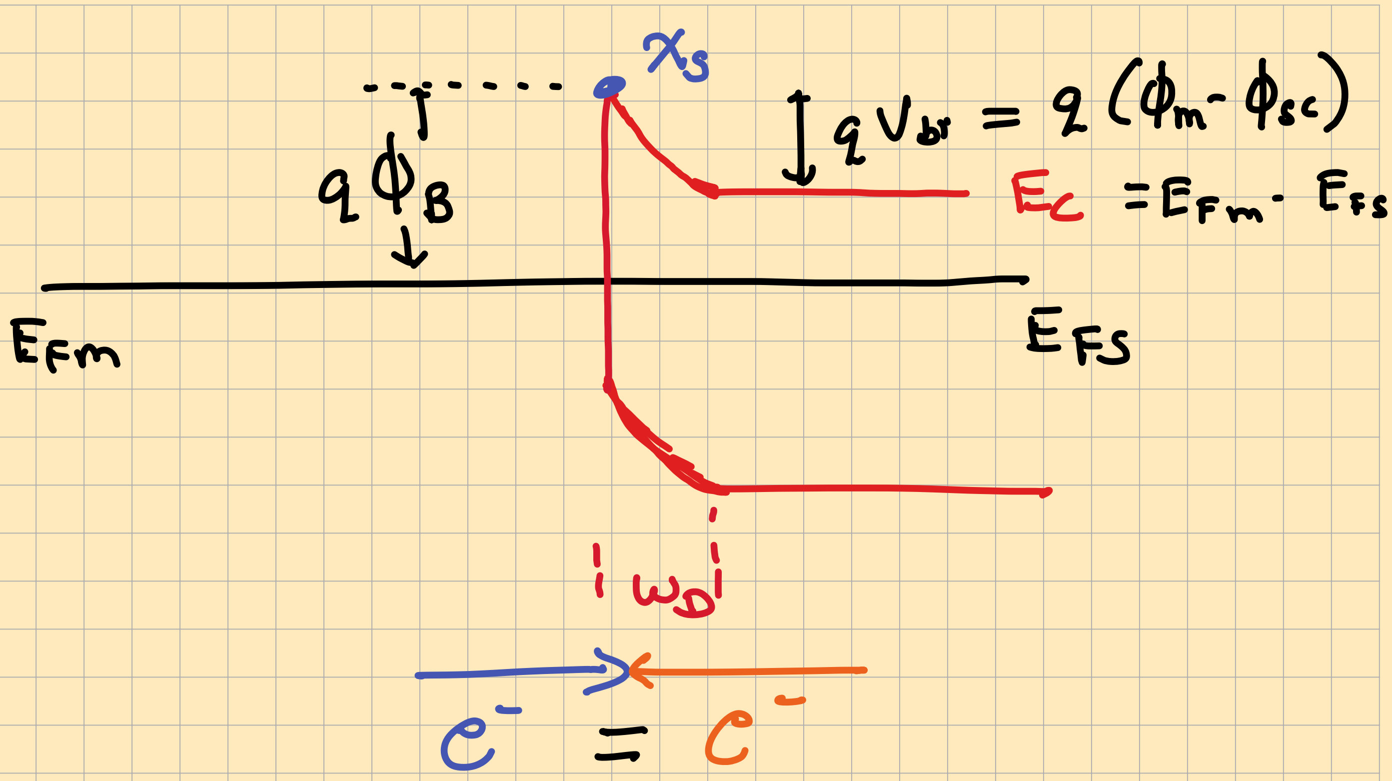




Case 2 : $E_{FS} < E_{Fm}$ (measured from vacuum level



← e^- diffuse (why??)



$\phi_B \rightarrow$ Schottky barrier height

$q\phi_B = q(\phi_m - \chi_s)$ (Schottky Mott limit)

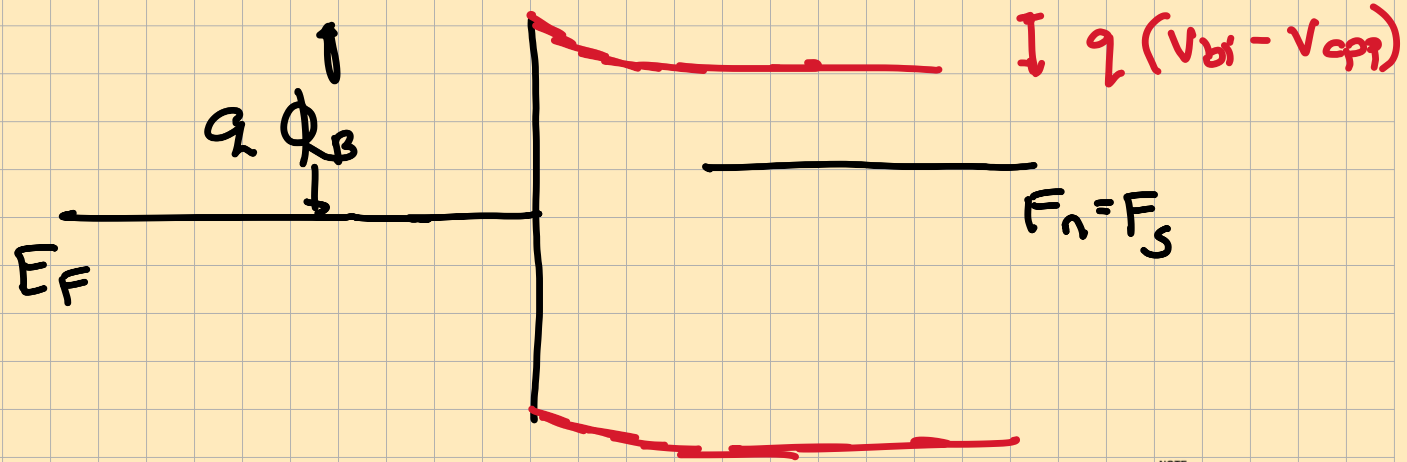
$\phi_m \rightarrow$ work function of the metal

$\chi_s \rightarrow$ Electron affinity of semiconductor

$qV_{bi} = (q\phi_B - qV_{bi})$

Changing the metal will affect the Schottky barrier

FORWARD BIAS $\rightarrow$ +ve bias on metal

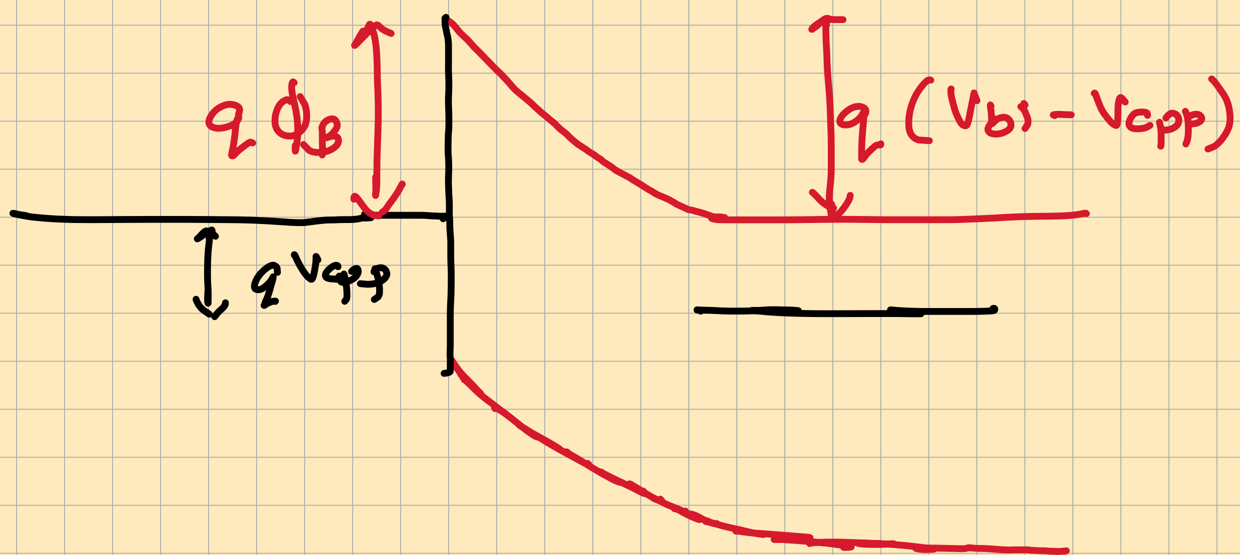


$q\phi_B \rightarrow$ Remains same

$q(V_{bi} - V_{app})$ reduces because of $V_{app} > 0$

$\rightarrow$ Net flow of e^- from semiconductor to metal $\rightarrow$ What will be the functional depen.

REVERSE BIAS $\rightarrow$ −ve bias on the metal



The electron injection from semiconductor reduces but the same from the metal remains same as (equilibrium)

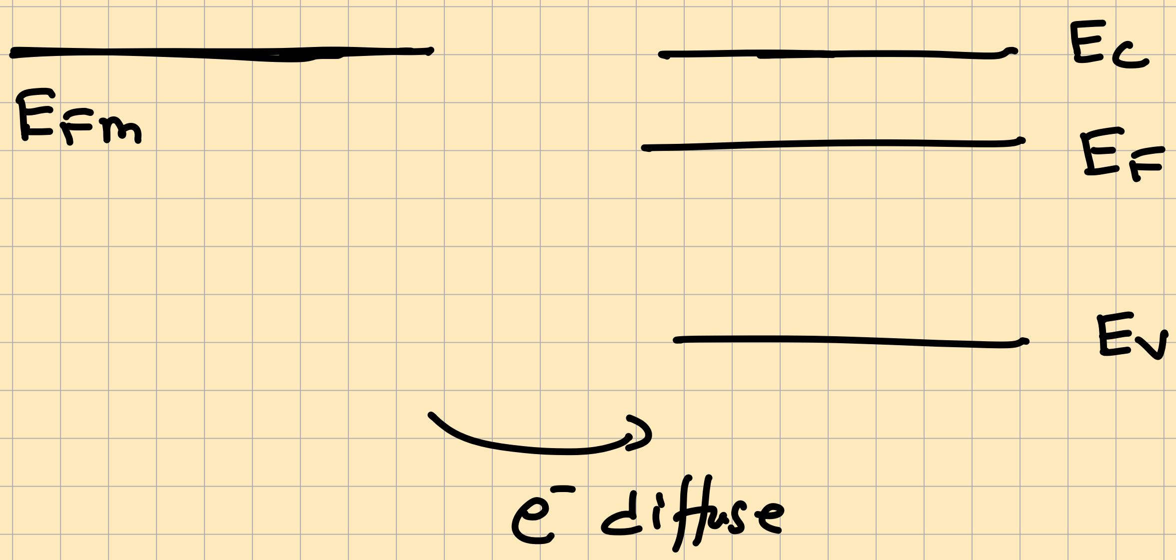
$$J = J_0\left(\exp\left[\frac{V_{app}}{V_T}\right] - 1\right)$$

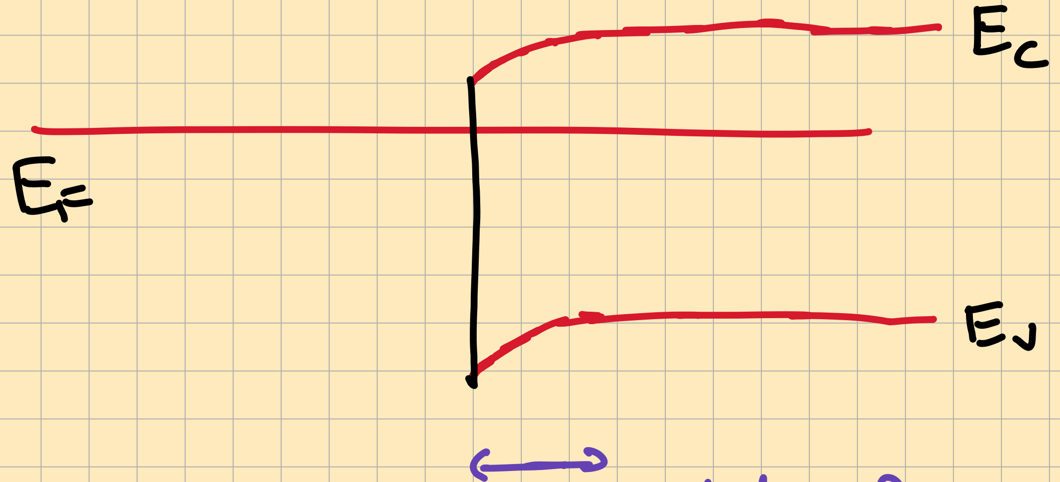
You can rationalize it

$J_0 \sim \exp[-\phi_B/V_T]$

↳ Why ?!

$E_{Fm} < E_{FS} \rightarrow$ Ohmic Contacts

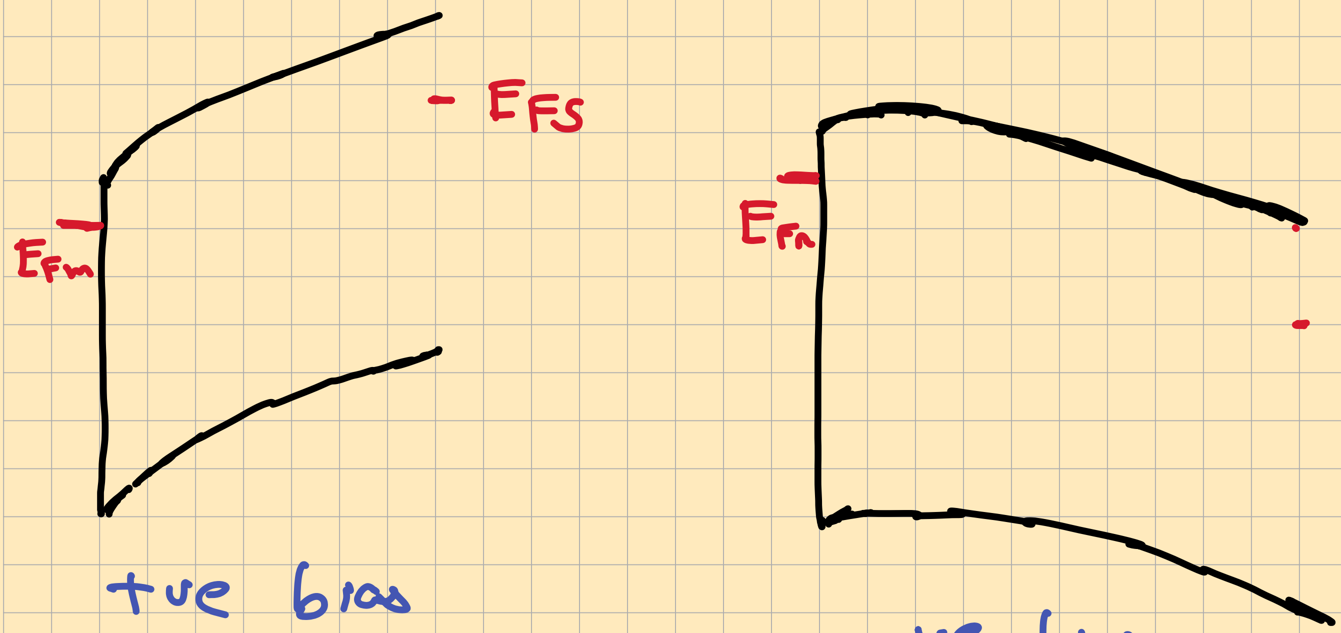




Accumulation of majority carriers

(NOT DEPLETION)

In this case the semiconductor metal junction is more conductive — so the applied bias drops across the entire semiconductor

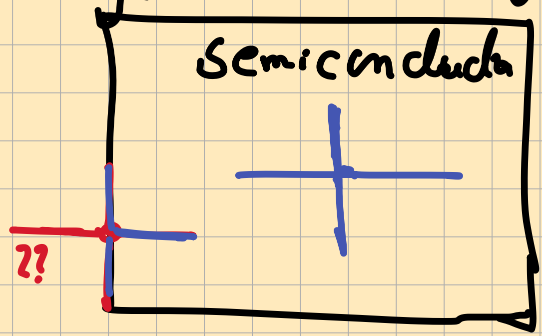


+ve bias

-ve bias

FERMI LEVEL SHIFTS BASED ON CHARGE EXCHANGE BETWEEN SEMICONDUCTOR & METAL

Practical Case : The semiconductor crystal edge → unsatisfied bonds



— The unsatisfied bond leads to states in the band gap

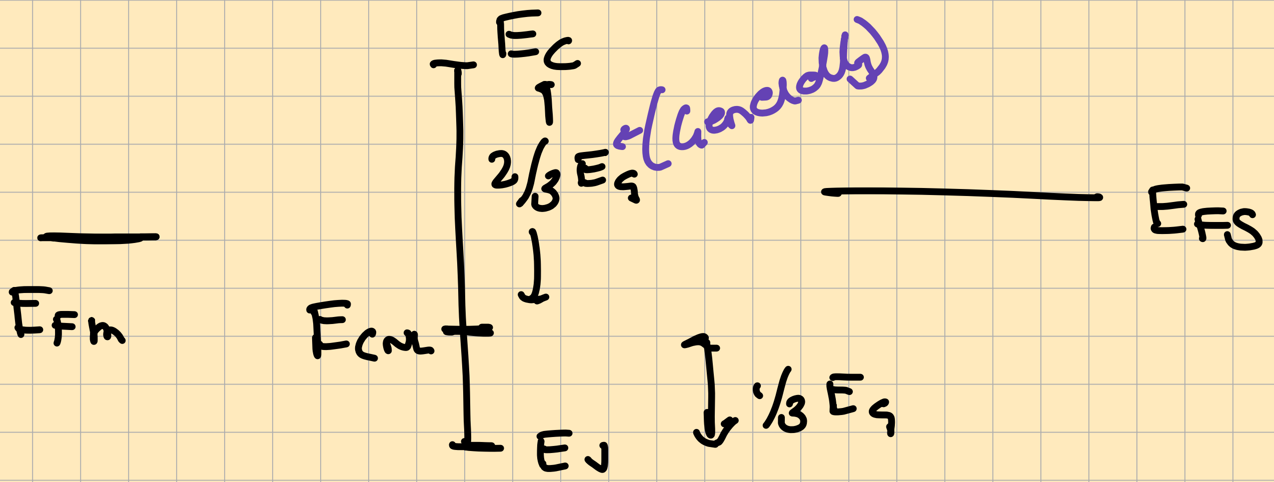
Recall bandgap appeared in Kronnig - Penny model → Assumption infinite - periodic chain

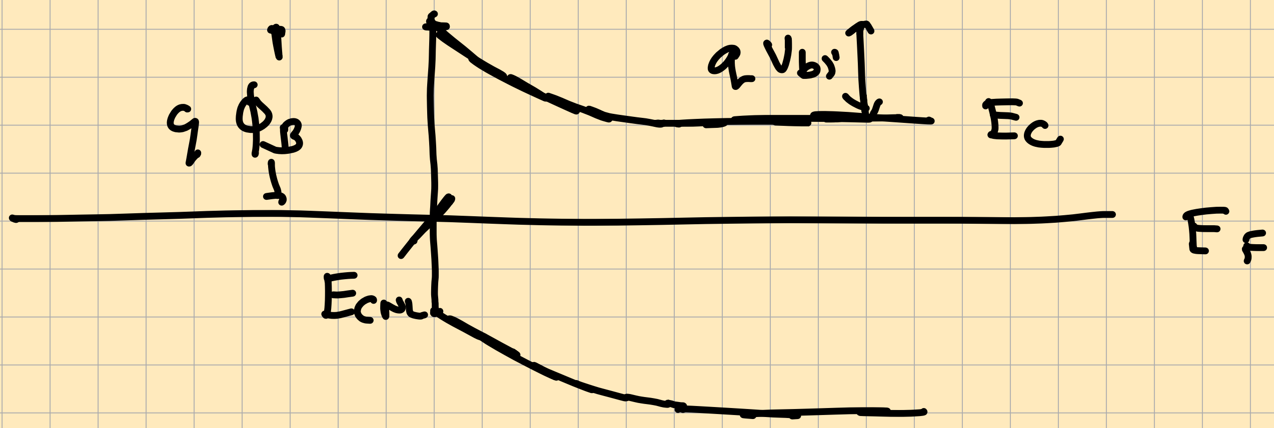
The states come in 2 flavours

↳ Donor traps → neutral when filled
+vely charged when empty

→ Acceptor traps → neutral when empty
-vely charged when filled

→ Energy level demarking them
↳ Charge neutrality level





The FERMI LEVEL IS PINNED
↳ THE INTERFACE SCREENS THE SEMICONDUCTOR

THE EXCHANGE OF ELECTRONS IS BETWEEN TRAPS & METAL

$\phi_B \Rightarrow \frac{2}{3} E_g$ (Bardeen limit)

How do we get good contacts.
↳ Dope the region near interface very heavily → Tunnelling

Applying bias causes the electrons to tunnel leading to current flow.