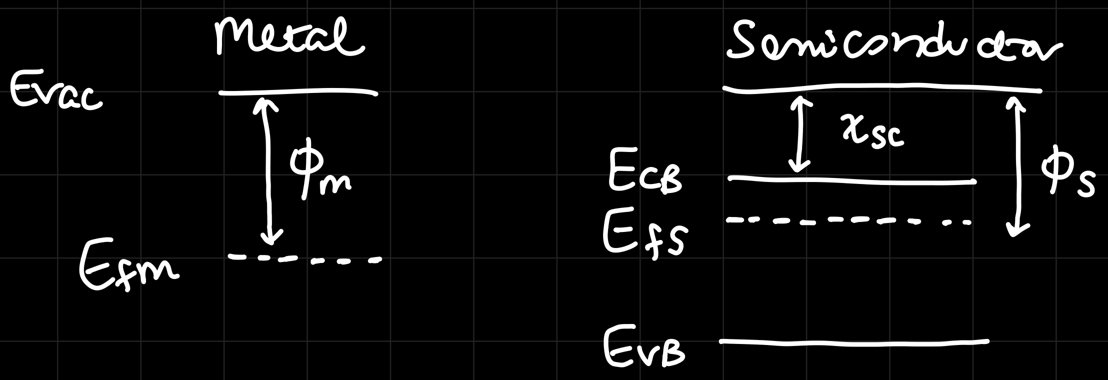
Ideal MS contact

- → no oxide layer between the metal & the semiconductor (no gap)
- → no inter mixing and no inter diffusion between the metal and the semiconductor
- → no impurities at the MS interface

Individually, M and S are at equilibrium but as a single system (junction), it is at non equilibrium state because there are 2 E_f levels.



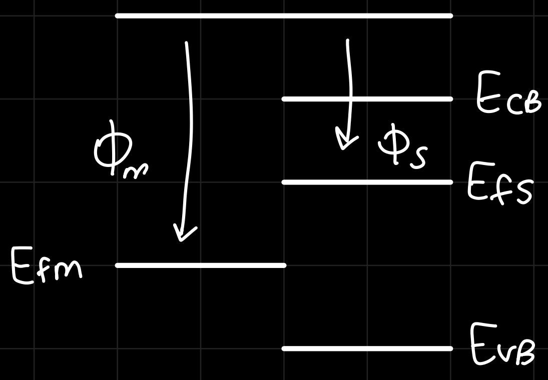
for equilibrium → $E_{fm} = E_{fs}$
↳ tries to attain lowest energy level if not at equilibrium

either E_{fm} ↑ OR E_{fs} ↓ or simultaneously

metals have e^- and hence taking out e^- will not make much diff in E_{fm}

but for semiconductors, E_{fs} can easily move

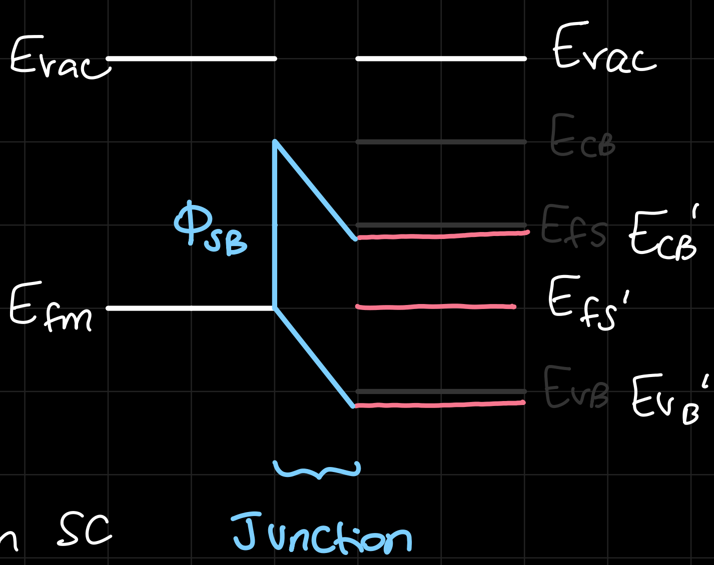
So, we assume E_{fm} as static and E_{fs} moves ↓



assuming n type semiconductor so,

$\phi_m > \phi_s$

if we want E_{fs} to go down, E_{CB}, E_{VB}, E_g, χ_e and even intrinsic fermi level should also go down that much so that the properties of the semiconductor remains the same.

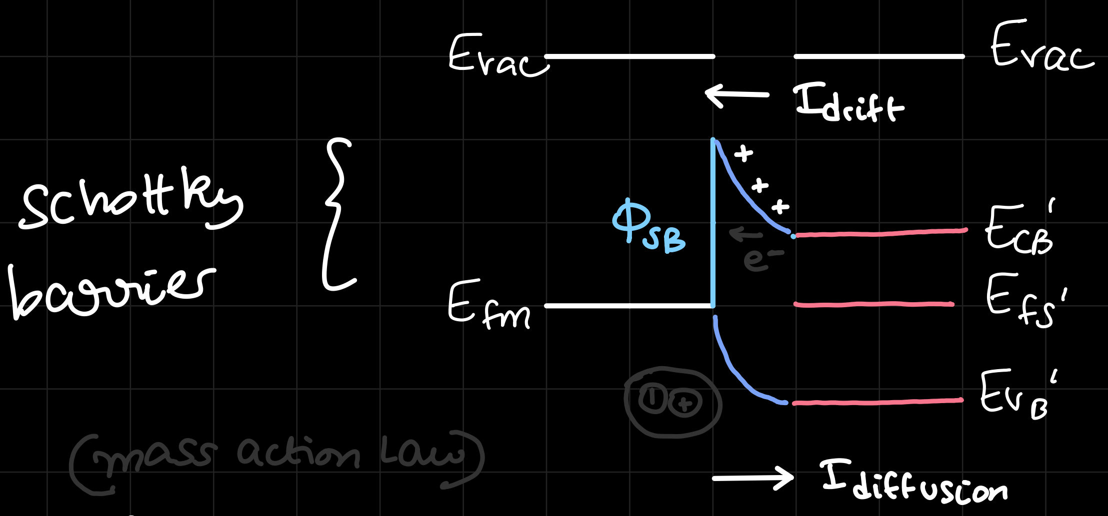


We need to remove e⁻ from SC to make E_f go ↓ and those e⁻ move from SC to e⁻ until equilibrium is reached

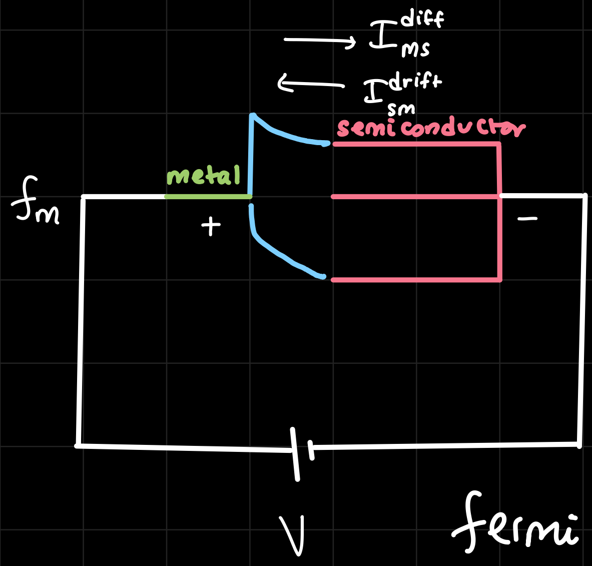
e^- from semiconductor side diffuse to the metal side
↳ static ions appear
↳ band bending takes place

diffusion current is generated from SC → M
(opposite to flow of e^-)

drift current generated from M → S

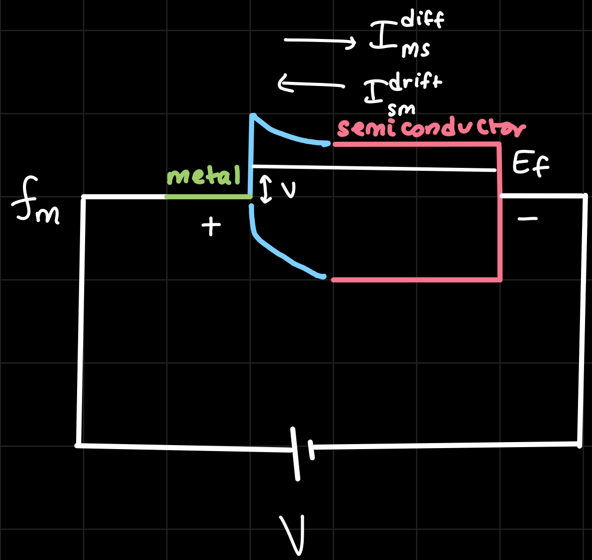


(mass action law)
M → S
to maintain equilibrium,
holes are being generated
at the E_{VB} side



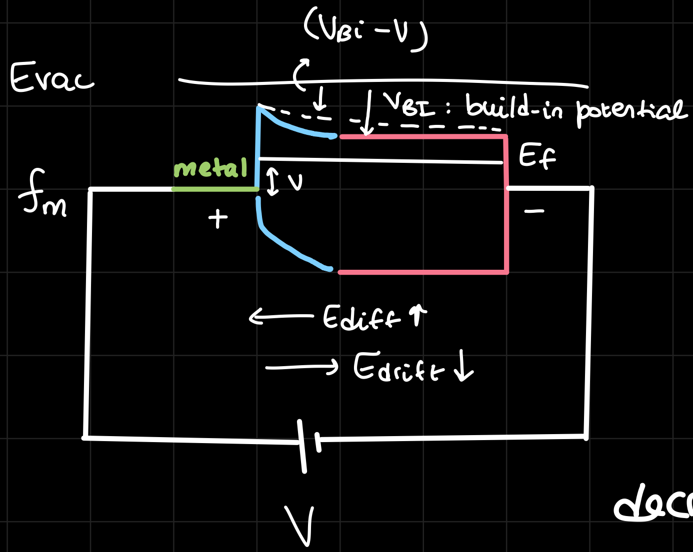
fermi level shifts due to this
chemical potential

$$f(E) = \frac{1}{1 + e^{(E-E_f)/k_bT}}$$



→ non equilibrium state

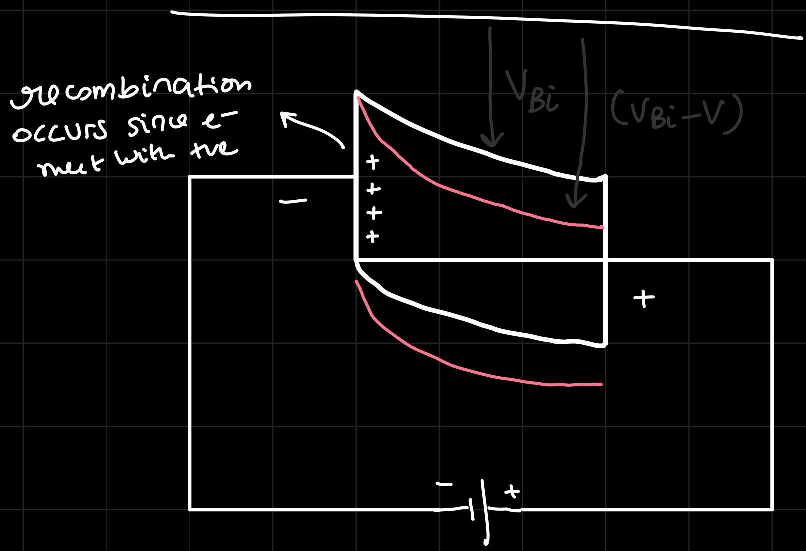
So other properties must change as well like the band bending



$$\bar{E} = \frac{dE_c(k)}{dk}$$

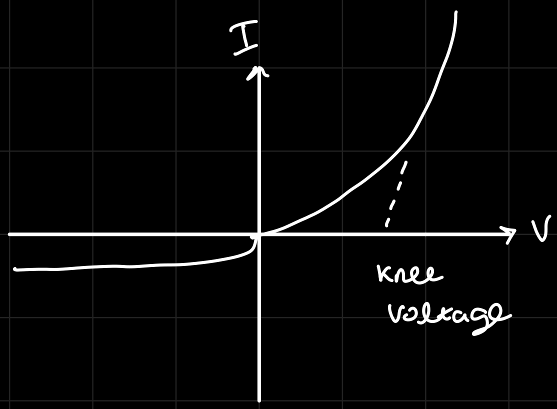
$\bar{E}$ is defined by the band bending and since the bending decreases when we apply a potential bias, and hence I_{drift} ↓ and since the barrier height ↓, e- faces less barrier and hence diffusion current ↑.

Reverse Bias Potential



reverse bias: intuitively $f_m \uparrow$ but it is ez to see $f_{sc} \downarrow$ rather than $f_m \uparrow$ and hence band bending $\uparrow$

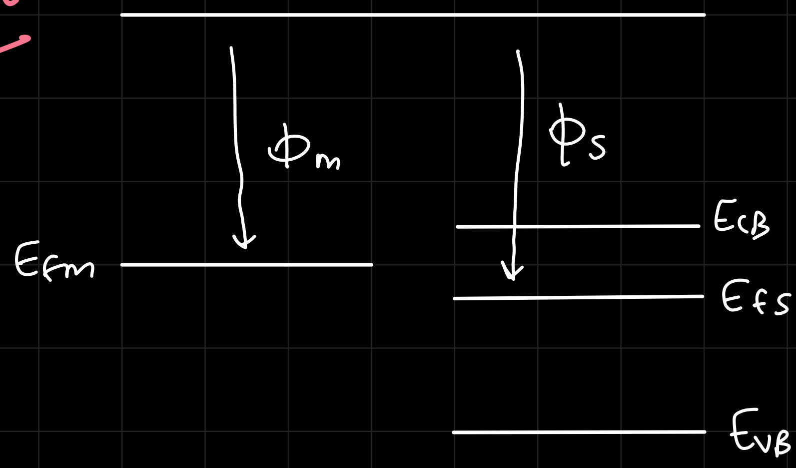
Idiffusion: negligible



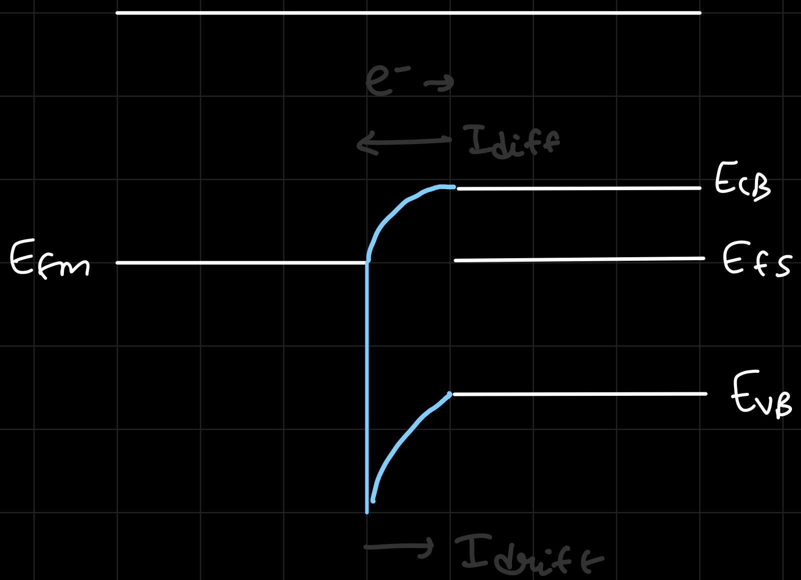
Schottky barrier

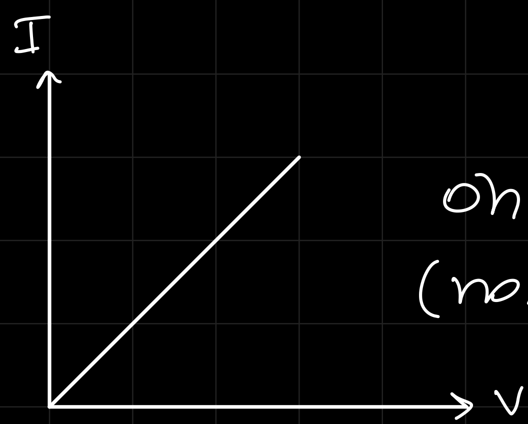
A PN Junction has a similar IV characteristic graph but a higher knee voltage

$\phi_m < \phi_s$



now E_{fs} should go up ↑
needs e^-
so, e^- travels from $m \to s$





ohmic
(non rectifying)

$\phi_m < \phi_s \rightarrow$ Ohmic

$\phi_m = \phi_s \rightarrow$ Ohmic (~0 drift current)

$\phi_m > \phi_s \rightarrow$ Schottky

We have taken lightly doped n type semiconductor