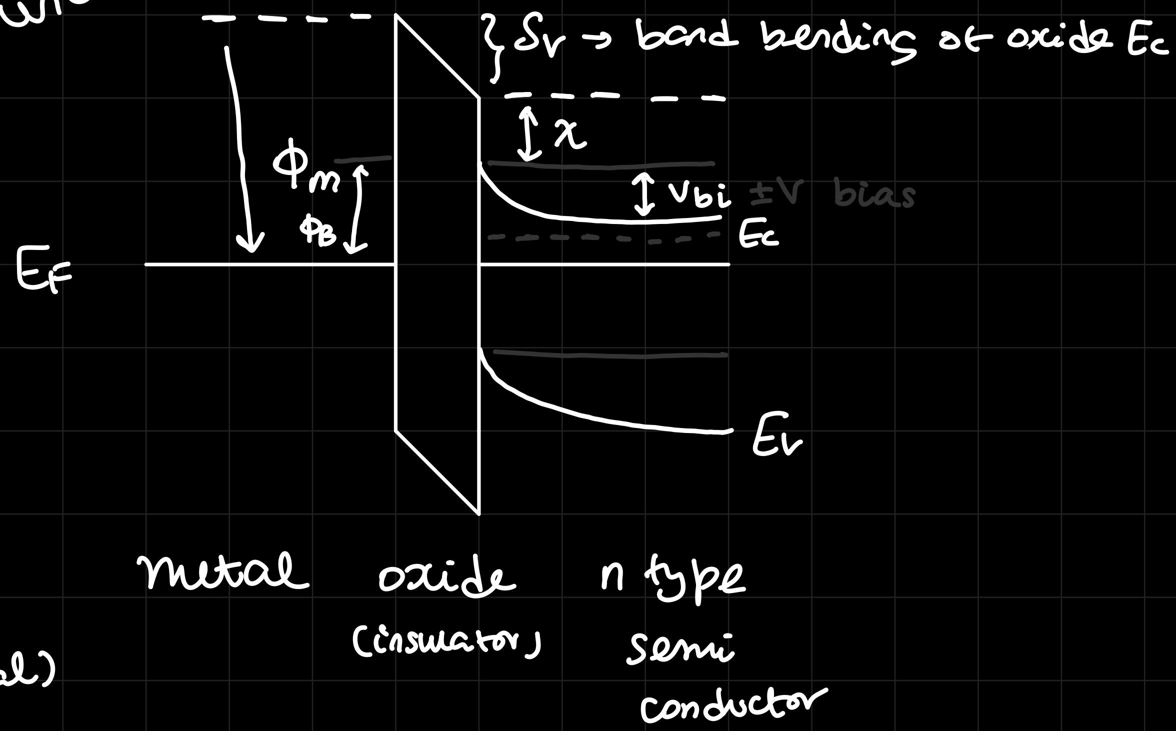
MOS Junction



lowers schottky barrier height (not ideal)

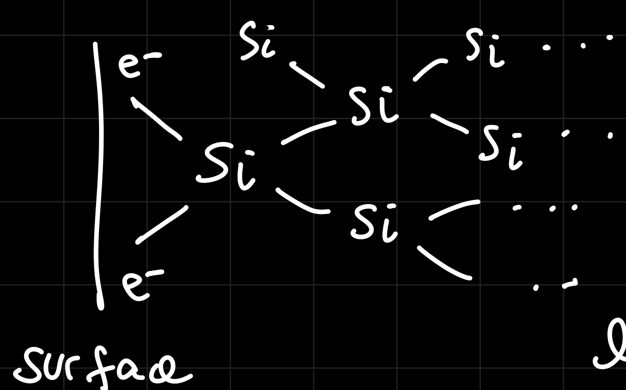
Fermi Level Pinning

metal induced gap states (≃ impurities)
↳ another origin of interface states that results in "metallic" screening
↳ FERMI LEVEL PINNING

Interface unsaturated bonds 2

possibility of dangling bonds at the surface ⟶ excess e- → results in extra states/bonds/levels

eg



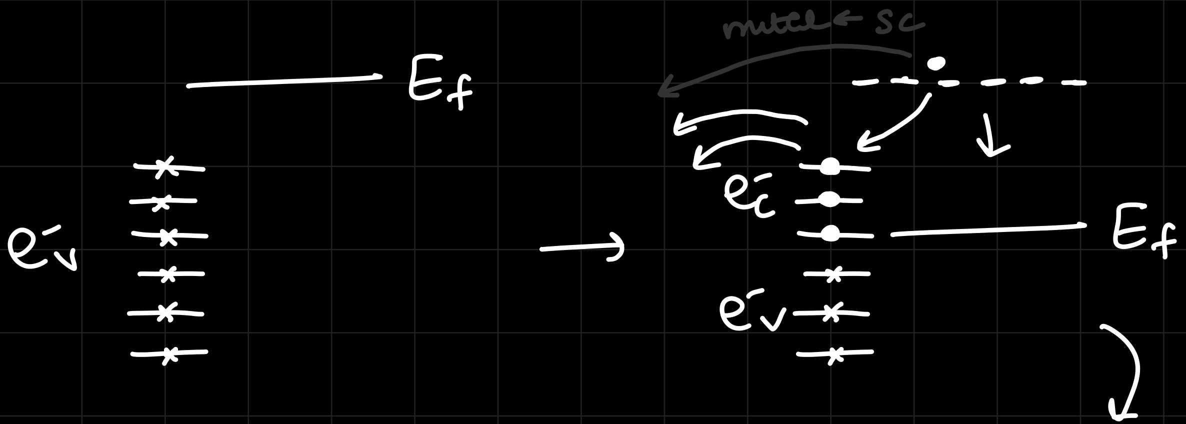
↓ these extra levels remain within the band gap
↓

it is observed that the impurity states take up 1/3rd of the band gap

we have the fermi level at the mid band of band gap → at $\frac{E_g}{2}$

and we are shifting this E_f

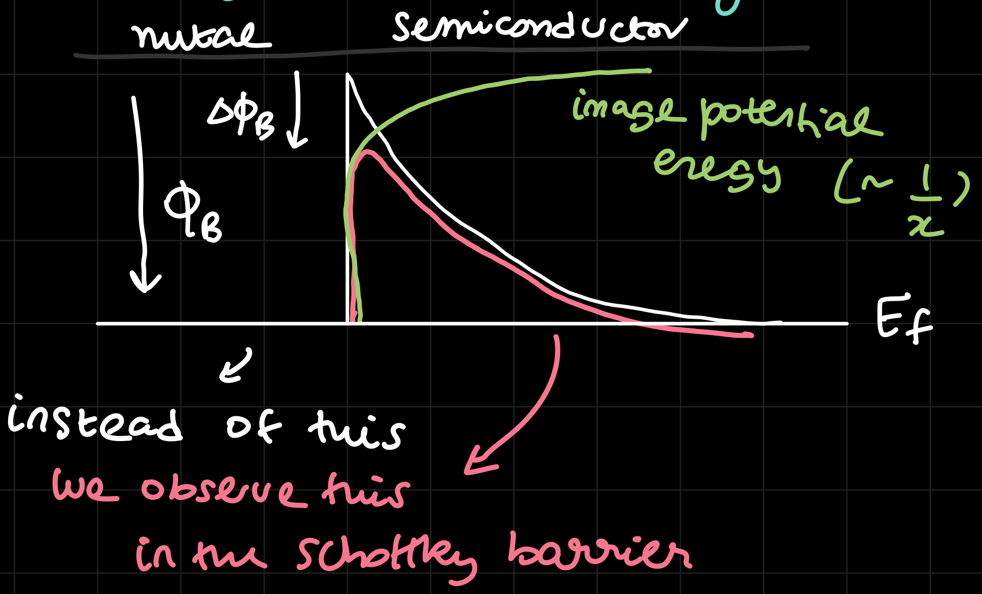
at equilibrium in the m-s junction, the system must maintain charge neutrality and hence some of the conduction e⁻ (free e⁻) go to the metal side after the fermi level converts the valence e⁻ to conduction e⁻ when coming down.

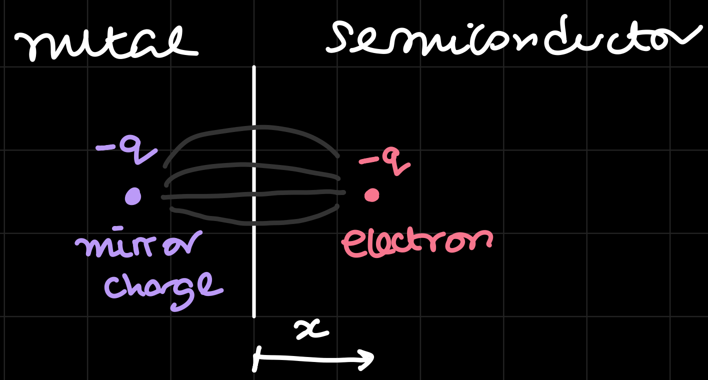


those e⁻ that leave E_f and fill the upper positions, due to them the E_f thinks it is filled and hence E_f goes up ↑

Due to this, the fermi level is restricted

Modification to the Barrier Potential due to Image Force Lowering



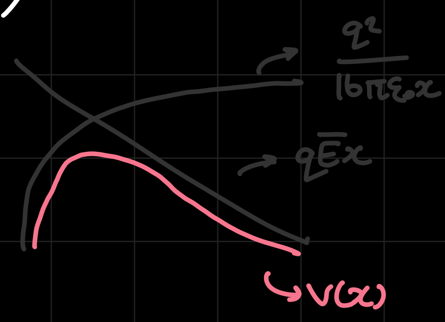


$$F = \frac{1}{4\pi\varepsilon_0} \times \frac{q^2}{(2x)^2} = \frac{q^2}{16\pi\varepsilon_0 x^2}$$

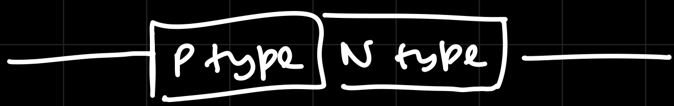
$$V = -\int \bar{F} \cdot dx$$

$$V(x) = \left(\frac{q^2}{16\pi\varepsilon_0 \cdot x} - q\bar{E}x \right)$$

under an Electric Field

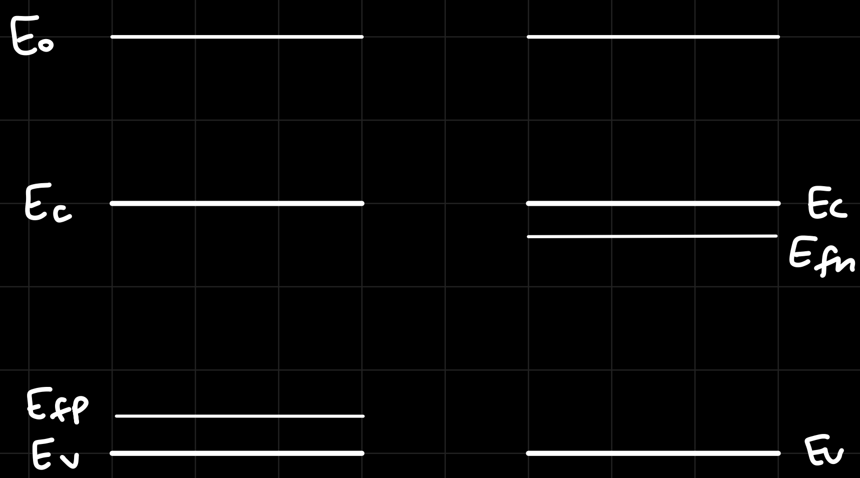


Homojunction

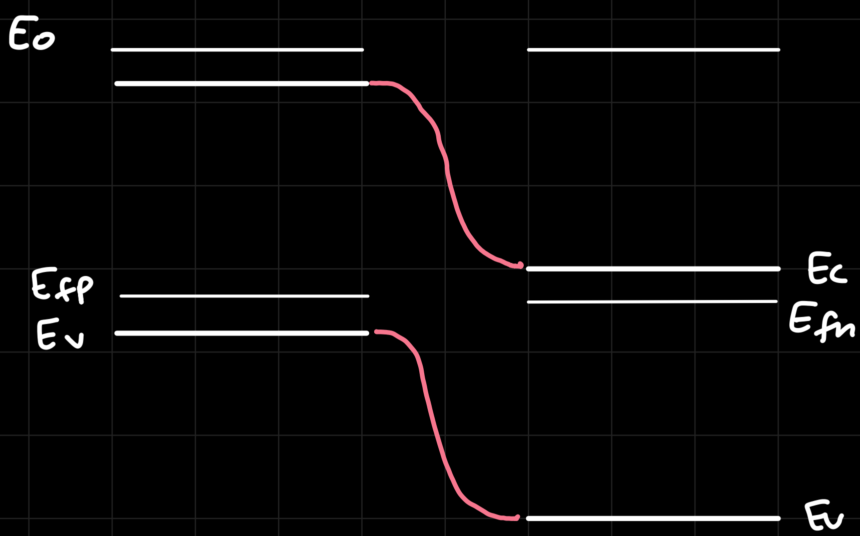


Heavily Doped Case

NON EQUILIBRIUM

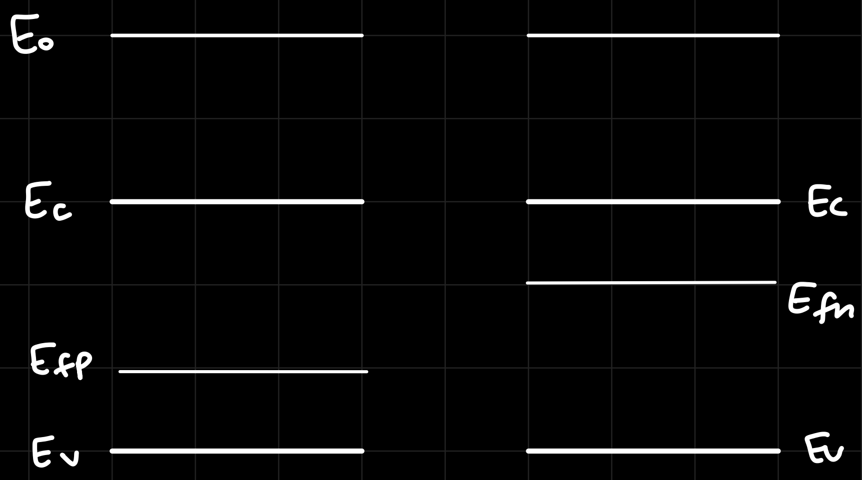


EQUILIBRIUM

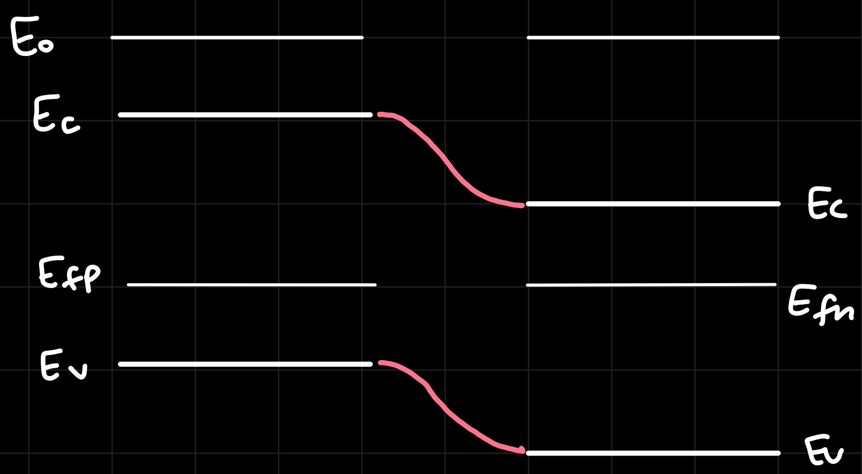


moderately doped case

NON EQUILIBRIUM

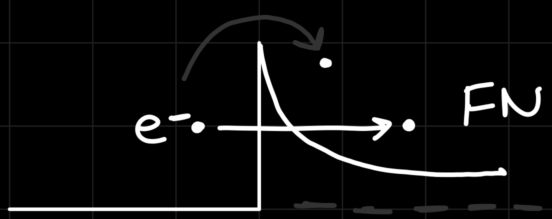


EQUILIBRIUM



The heavily doped one will have a higher $\bar{E}$ and drift current because of more band bending

In the case of MS Junction, heavily doped → band bending ↑ → $\bar{E}$ ↑ → drift current ↑ (easier to drift to the SC side)
↳ high amount of force on e- on metal side
↓
Instead of all e- passing the potential barrier from above, some "tunnel" through barrier



Homojunctions usually dont have dangling bonds and hence no (less) impurity
↳ lesser probability of observing fermi level pinning

$ GaAs → 3,5 system
↳ too much impurity levels
↳ not ideal

e^- movement

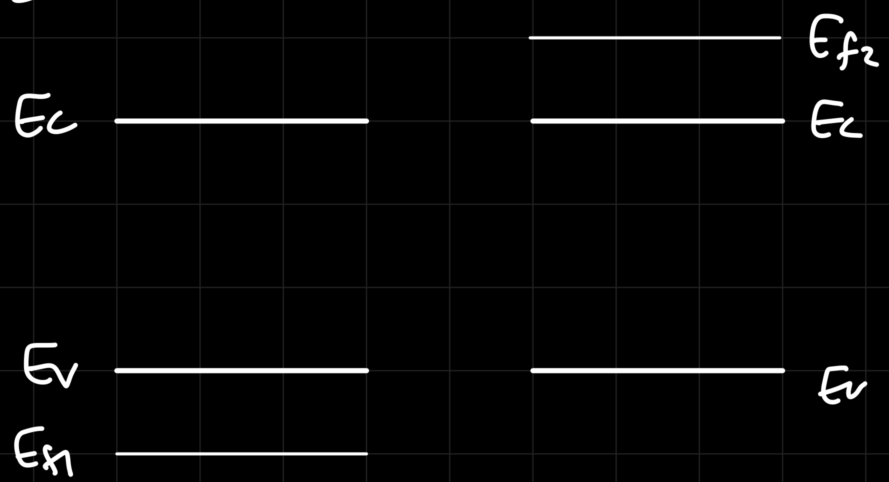
↳ drift

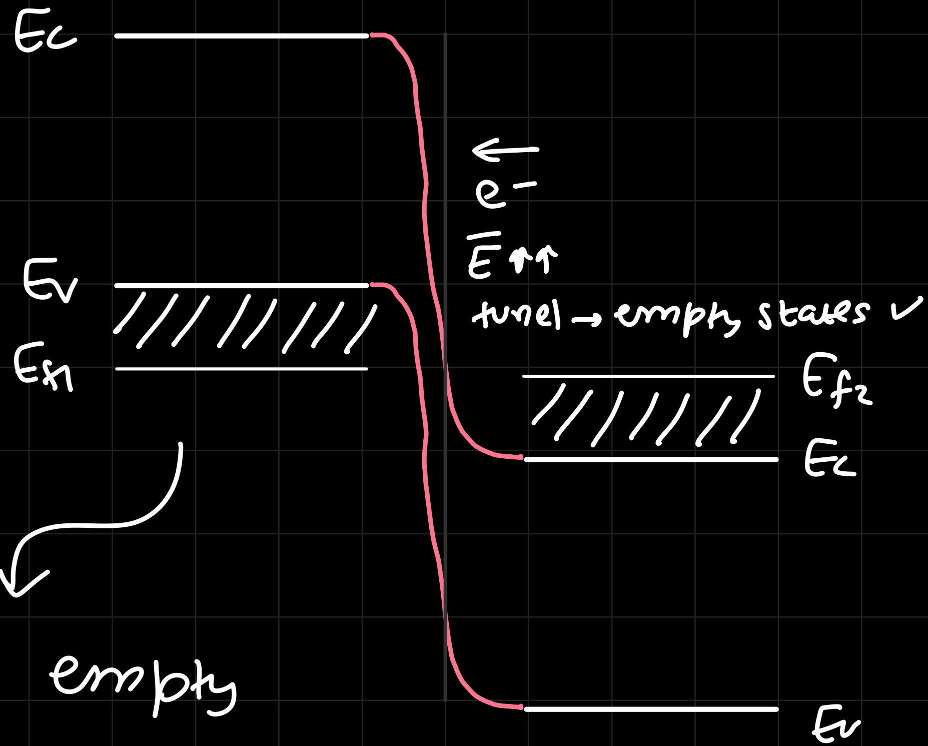
↳ diffusion

↳ tunelling

Zener diode: reverse bias
heavily doped
very high band bending
very high $\bar{E}$
tunneling ✓
in break down region

non equilibrium





above E_f, empty states (no holes)

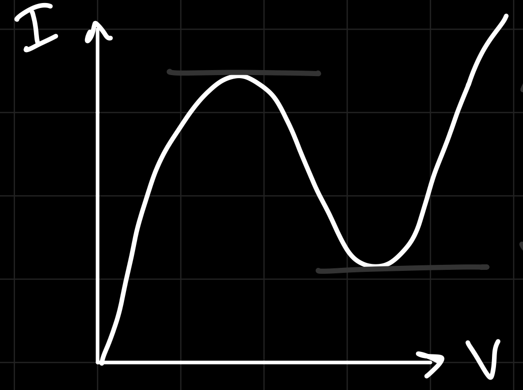
below E_f, filled e^- states

barrier height is very high (V_{bi})
↳ ~ no drift current

Apply a small amount of forward bias, E_f at the n side goes up along with its E_c and E_v to maintain band gap

or with n type at reference, p type goes down

due to the high $\bar{E}$ the free e^- go toward the p types' empty states



ISAKI diode

non linear characteristics

absolute Resistance $= \frac{V}{I}$

differential Resistance $= \frac{dV}{dI}$

for the above characteristic, we have a region where current is reducing with increase in potential

so, we get $R = \frac{dv \ (+)}{dI \ (-)}$

$\equiv$ Negative Differential Resistance
$\equiv$ NDR diode

useful for amplifiers