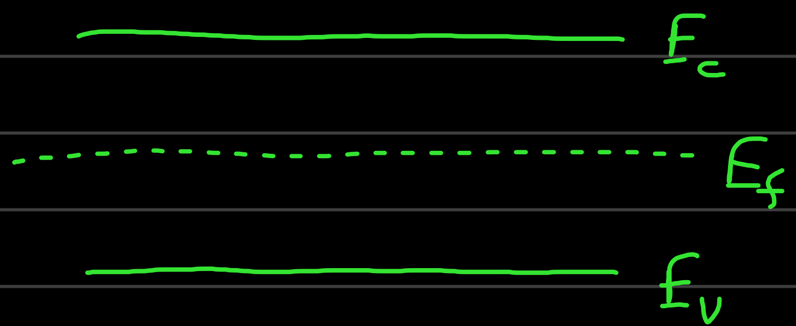
Lecture 17

Intrinsic: thermally generated carrier densities is much more dominant in species.

$$n_i = \int_{E_c}^{\infty} P(E)\,D(E)\,dE$$

Total no. of electrons in conduction band.

$n = p = n_i$ carrier density

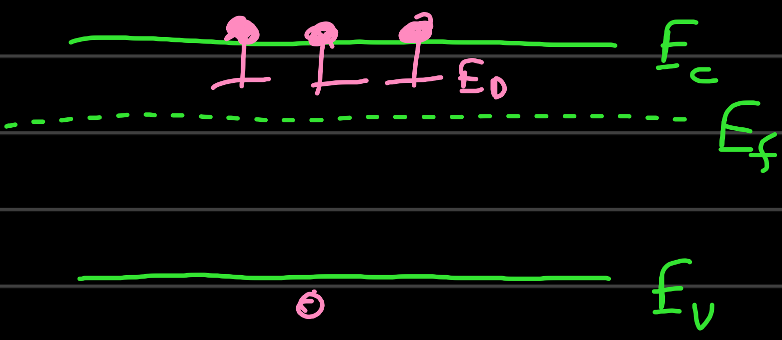


$$E_f = \frac{E_c + E_v}{2}$$

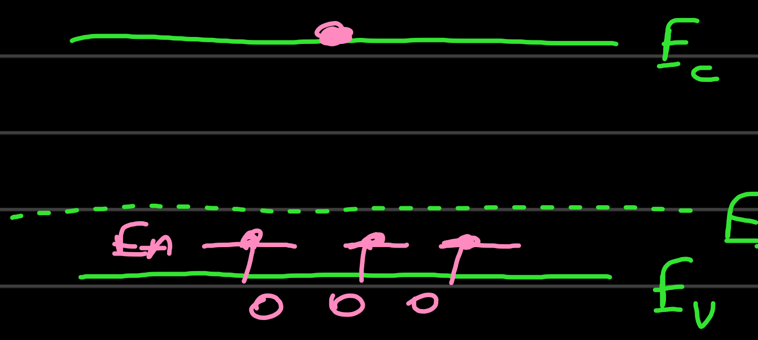
$$n = N_c\, e^{-[E_c - E_f]\beta}$$

$$p = N_v\, e^{-[E_f - E_v]\beta}$$

$$N_c \approx N_v$$



n - type



p-type.

Law of Mass Action: $\underline{\underline{np = n_i^2}}$

$n = n_i + \Delta n$ If $\Delta n > 0$ $\Delta p < 0$

$p = n_i + \Delta p$ and vice versa

$N_D > 0 \Rightarrow \Delta n > 0 \rightarrow \Delta p < 0$ more e^-

$N_A > 0 \Rightarrow \Delta p > 0 \rightarrow \Delta n < 0$ more holes.

Electrical Neutrality: $n + N_A^- = p + N_D^+$

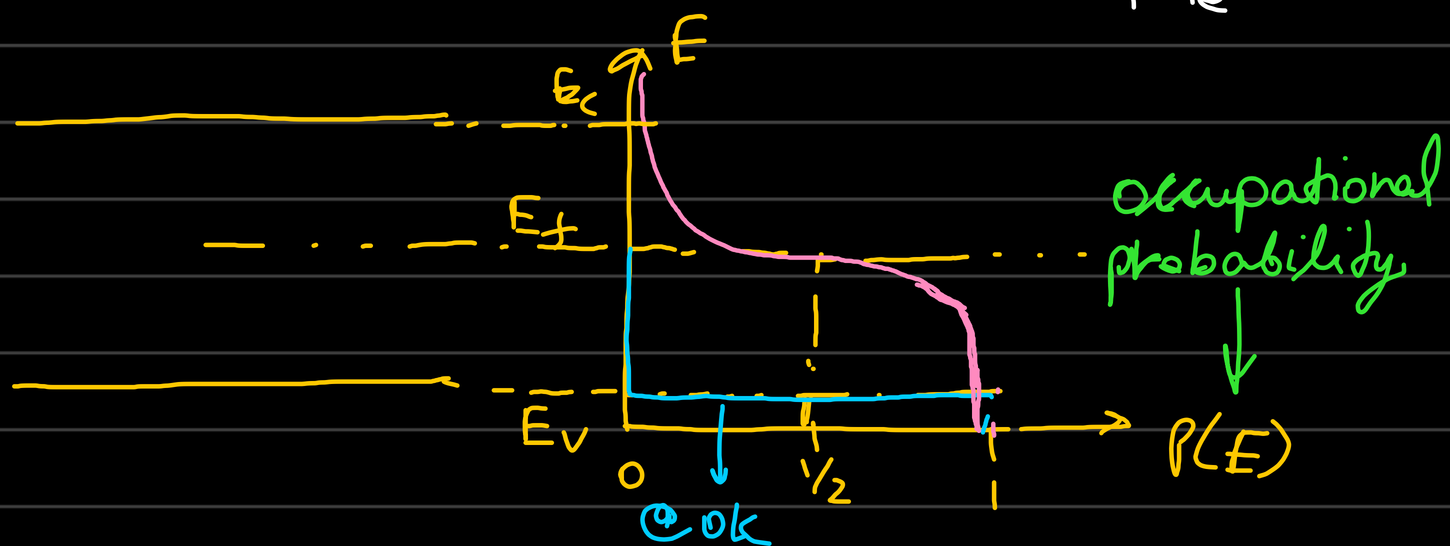
$N_A \to 0 \rightarrow n = p + N_D^+$

(regular)
$n_{metal} \Rightarrow 10^{22} - 10^{23}\ cm^{-3}$

$\rightarrow$ In Si, about 1 in a million atom has a broken bond.

$n_{semiconductor} \Rightarrow 10^{16}\ cm^{-3}$
(n-type)

$\sigma_{semi} = ne\mu_n + pe\mu_p$; $\mu_n = \dfrac{e\tau_n}{m_e}$

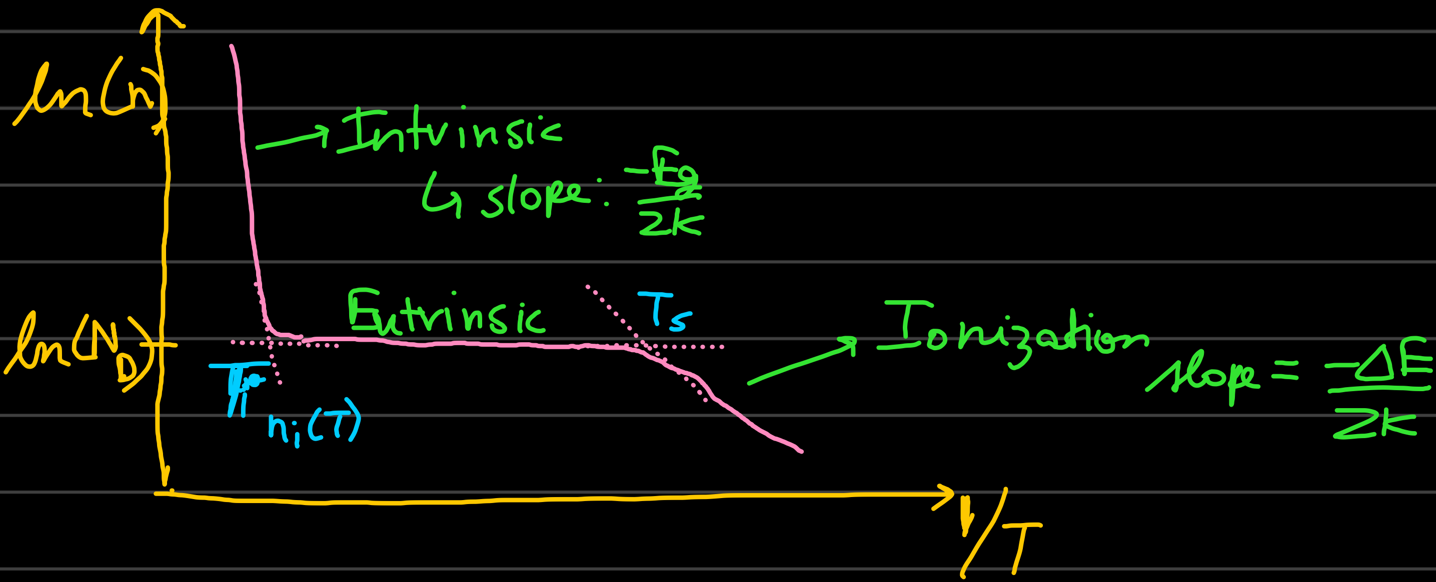


$$\langle E \rangle = \int E \cdot n(E)\, dE$$

expectation energy

$$n(E) = \rho(E)\, d(E)$$

Extrinsic Semiconductor:



Advantages:

i) higher conductivity

ii) T-range where : $n \rightarrow$ invariant

$\sigma \rightarrow$ invariant

Mobility in Doped semiconductors:

mobility $\mu = \dfrac{e\tau}{m_e}$ $\qquad \mu_{n/p} = \dfrac{e\,\tau_{n/p}}{m_{e/h}}$

$\tau =$ mean time to scatter

↳ depends on scatterers

→ for n scatterers: $\boxed{\dfrac{1}{\tau_{eff}} = \sum_i \dfrac{1}{\tau_i}}$

Mattheisen's rule:

i → kinds of scatterers

- ↳ ionic (τ_1)
- ↳ impurity (τ_2)
- ↳ surface (τ_3)

$$\frac{1}{\tau_{eff}} = \frac{1}{\tau_1} + \frac{1}{\tau_2} + \frac{1}{\tau_3}$$

↓ effective mean time to scatter.

Temperature dependence of resistivity: