PENNSTATE

Schokley-Read-Hall Recombination

- **Rate at which electrons from conduction band will be captured by traps is ~ no of conduction band electrons, no of empty traps**

$$f(E_t) = \frac{1}{1+\exp\left(\frac{E_t - E_F}{kT}\right)}$$

$$R_{cn} = C_n N_t [1 - f(E_t)] n$$

$$R_{En} = E_n N_t f(E_t)$$

At thermal equilibrium,
R_{cn}* = *R_{en}* for *n_o

$$C_n N_t [1 - f(E_t)] n_o = E_n N_t f(E_t)$$

$$n_1 = n_o \exp\left(\frac{E_t - E_F}{kT}\right)$$

$$E_n = n_o C_n \left[\frac{1 - f(E_t)}{f(E_t)}\right] = n_o C_n \exp\left(\frac{E_t - E_F}{kT}\right) = n_1 C_n$$

Thus, the net rate at which electrons are being captured from the conduction band

From processes 3 and 4, similarly, the net rate at which holes are being captured from the valence band

Schokley-Read-Hall Recombination

- Only when N_t is low compared to the doping level, we can assume

Equating the two expressions for R_n and R_p in the previous slide,

$$np - n_i^2$$
$$= (n_0 + \delta n)(p_0 + \delta p) - n_i^2$$
$$= \delta p \, (n_0 + p_0 + \delta p)$$

N_t $\quad$ N_t

$$= \frac{C_n C_p N_t (n_0 + p_0)}{C_n (n_0 + n_1) + C_p (p_0 + p_1)}$$

low level injection

Schokley-Read-Hall Recombination

- In the limit when $n_o >> p_o$, δp, then

n type sample

$$\tau = \tau_{p0} = \frac{1}{C_p N_t}$$

- In the limit when $p_o >> n_o$, δn, then

p type sample

$$\tau = \tau_{n0} = \frac{1}{C_n N_t}$$

- In between for small values of δp and δn (low level injection), we have

$$n_0 = p_0 = n_i >> \delta n, \delta p$$

$$\tau = \frac{\tau_{p0}(n_0 + n_1)}{(n_0 + p_0)} + \frac{\tau_{n0}(p_0 + p_1)}{(n_0 + p_0)}$$

$$E_t = E_i$$

$$n_0 = p_0 = n_i$$

$$n_1 = p_1 = n_i$$

$$\tau = \tau_{p0} + \tau_{n0}$$