4. $G = 10^{13}/cm^3/\mu s \quad \tau = 2\mu s. \quad N_d \sim n_o = 10^{14}/cm^3.$

$\frac{\Delta n}{\tau} = G \Rightarrow \Delta n = 2\times10^{13}/cm^3;$

$P = P_o + \Delta n = \frac{n_i^2}{n_o} + \Delta n = 10^6 + \Delta n \sim \Delta n = 2\times10^{13}/cm^3.$

$n = n_o + \Delta n = 1.2\times10^{14}/cm^3.$

$n = n_i e^{(F_n - E_i)/kT}$

$F_n - E_i = kT \ln\left(\frac{n}{n_i}\right)$

$= 0.0256 \ln\left(\frac{1.2\times10^{14}}{10^{10}}\right)$

$= 0.240\ eV.$

$F_n = E_i + 0.240 eV.$

$P = n_i e^{(E_i - F_p)/kT}.$

$E_i - F_p = kT \ln(P/n_i).$

$= 0.0256 \ln\left(\frac{2\times10^{13}}{10^{10}}\right)$

$= 0.1945 eV. \Rightarrow F_p = E_i - 0.1945 eV.$

5. Assume $E_T \sim E_i$.

a). $G = k((n_o+\Delta n)(p_o+\Delta p) - n_i^2).$

$N_D \sim n_o = 10^{13}/cm^3$; $n_i = 10^{10}/cm^3$ ∴ $P_o = \frac{n_i^2}{N_d} = 10^7/cm^3$; $G = 10^{15}$; $k = 10^{-14}$

Assume low level. injection

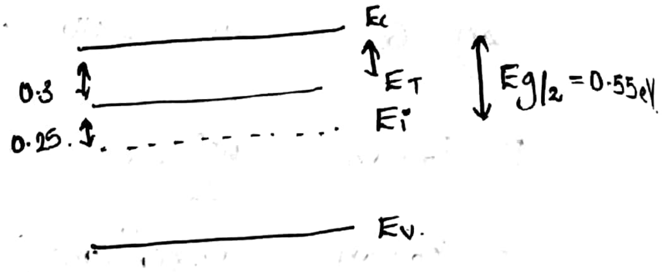
$\cancel{10^{15}} = \cancel{10^{-14}} \cancel{(\Delta n_o t}$

$10^{15} = 10^{-14}(\Delta n(n_o + P_o)) = 10^{-14}(\Delta n\, n_o).$

$\Rightarrow \Delta n = \frac{10^{15}}{10^{-14}.\ 10^{13}} = 10^{16}/cm^3 \Rightarrow$ high level injection.

∴ $G = k\Delta n^2 \Rightarrow \Delta n = \sqrt{G/k} = \sqrt{\frac{10^{15}}{10^{-4}}} = 3.16\times10^{4}$

$\tau = \frac{1}{k\cdot\Delta n} = \frac{1}{3.16}$ s (b). $$G = \frac{np - n_i^2}{(n+n_T)\tau_p + (p+p_T)\tau_n}.$$



$$n_T = n_i e^{(E_T - E_i)/kT}.$$

$$= 10^{10} e^{0.25/0.0256}$$

$$= 1.74 \times 10^{14}/cm^3.$$

$n_o = 10^{13}/cm^3$ $\quad P_o = 10^{7}/cm^3$.

Assume low level, injection,

$$G = \frac{(n_o+\Delta n)(P_o+\Delta P) - n_i^2}{((\Delta n + n_o) + n_T)\tau_p + ((P_o+\Delta P)+P_T)\tau_n}.$$

; ~~$P_t \approx E_i$~~ . $P_t \approx n_p$

$\tau_n = \tau_p$

$= 10\mu s$.

$$= \frac{n_o \Delta n}{(n_o + n_T)\tau_p}.$$

$$10^{15} = \frac{10^{13}\Delta n}{1.8 \times 10^{14} \times 10^{-5}} \Rightarrow \Delta n = 1.8 \times 10^{11} \Rightarrow \text{Low level injection.}$$

(c). $$\frac{1}{\tau_T} = \frac{1}{\tau_{SRH}} + \frac{1}{\tau_{RR}}.$$

$$= \frac{1}{10 \cdot 10^{-6}} + 3.16 \;\Rightarrow\; \tau_T = 10^{-5}\,s$$