Generation – Recombination Currents within SCR

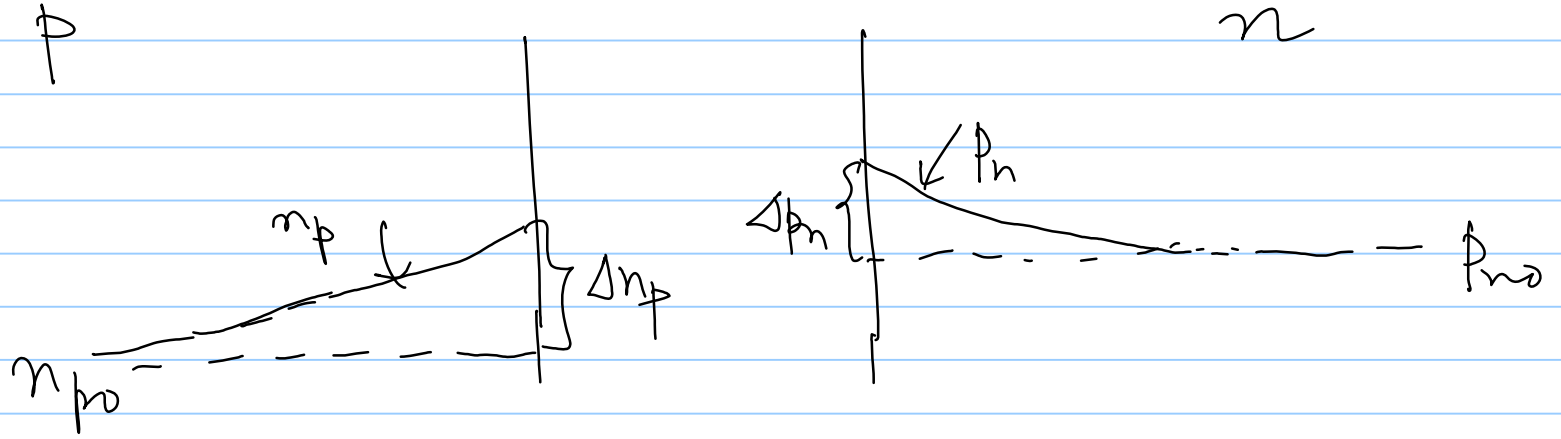
22/9/2014

$I = I_0 (e^{V/V_T} - 1)$ → Ideal diode current

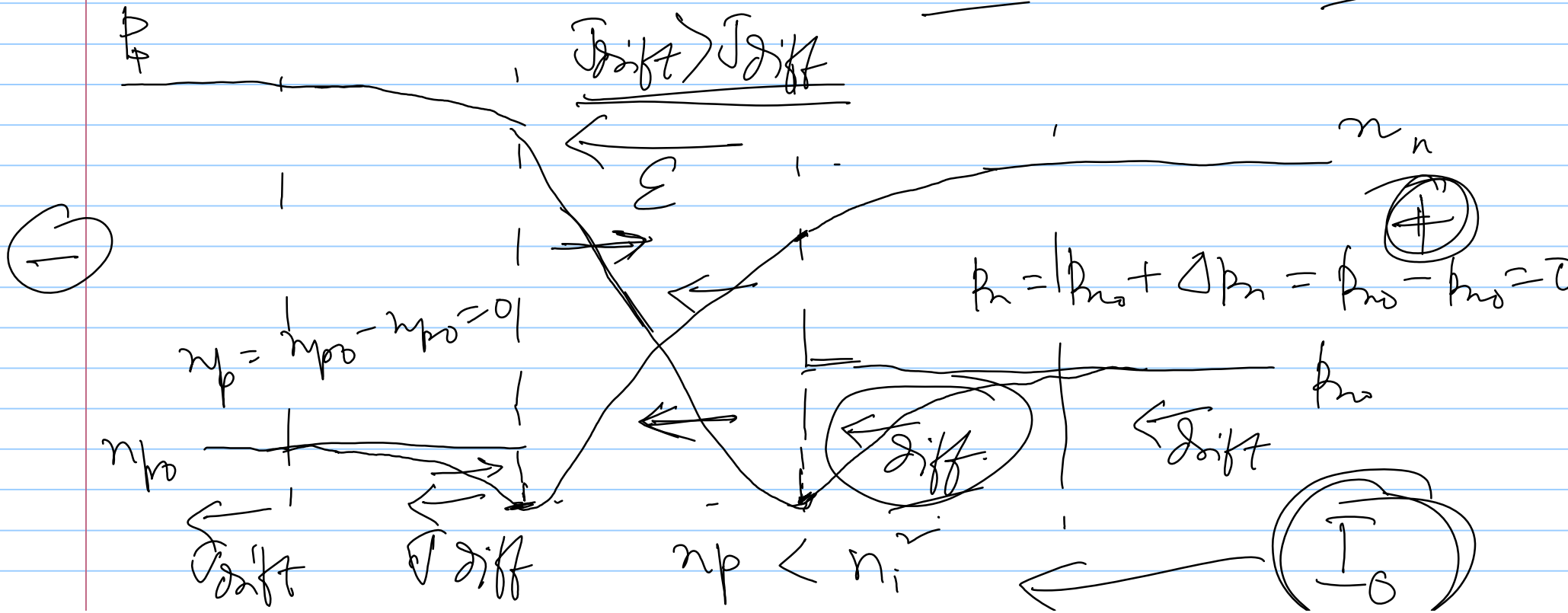
$= -I_0$ for 'V' negative

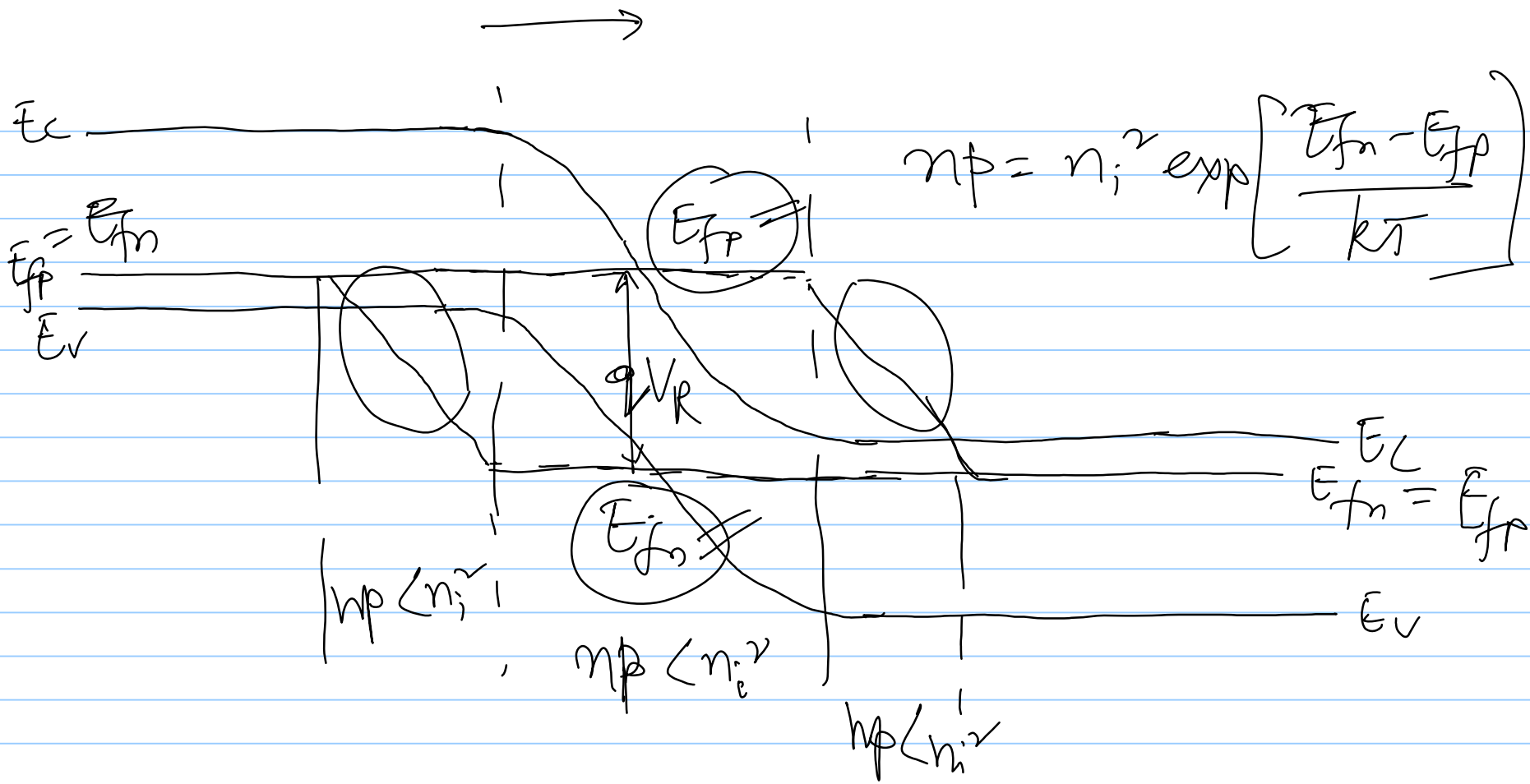
$n_p = n_i^2$

Generation dominates if $n_p < n_i^2$



$$\Delta p_n = p_{no}\left(e^{V/V_T} - 1\right) \simeq -p_{no}$$
$$\Delta n_p = n_{po}\left(e^{V/V_T} - 1\right) \simeq -n_{po}$$
} for negative 'V'




E_c
$E_{fn} = E_{fp}$
E_v
E_{fp}
qV_R
E_c
$E_{fn} = E_{fp}$
E_v
$np < n_i^2$
$np < n_i^2$
$np < n_i^2$
$np = n_i^2 \exp\left[\frac{E_{fn} - E_{fp}}{kT}\right]$

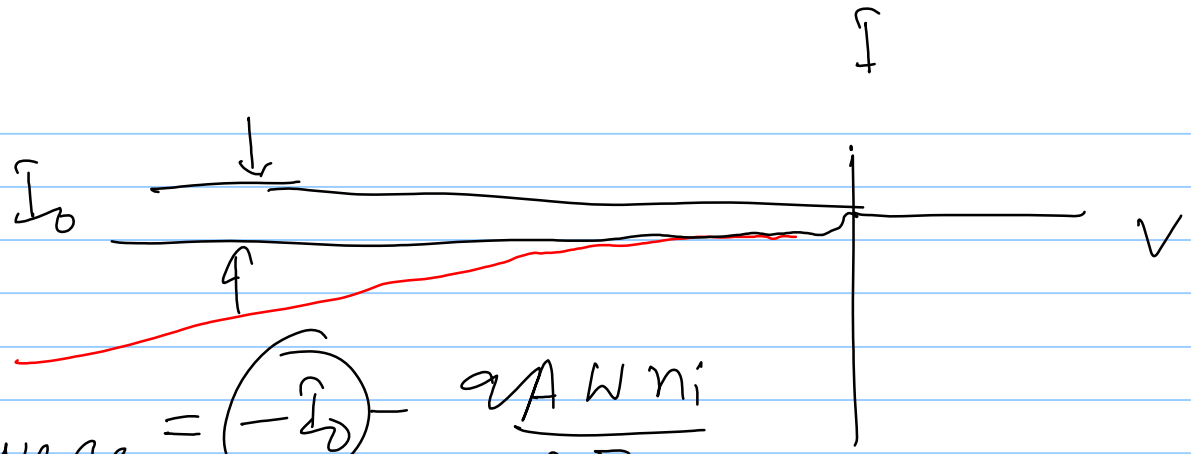
$n_p < n_i^2$ → Generation dominates

Shockley - Read - Hall Generation - Recombination

Traps within SCR

$$R - G = (-)\frac{n_i}{2\tau_0} \qquad \tau_0 = \tau_n = \tau_p$$

$$qA \int_0^{W(V)} (R - G) = I_{gen} = \frac{qA\, W\, n_i}{2\tau_0}$$



$$I_{reverse} = -I_0 - \frac{qAWn_i}{2\tau_0}$$

$$= -qA\left(\frac{D_p p_{n0}}{L_p} + \frac{D_n n_{p0}}{L_n}\right) - \frac{qAWn_i}{2\tau_0}$$

$$= -qAn_i^2\left(\frac{D_p}{L_p N_D} + \frac{D_n}{L_n N_A}\right) - \frac{qAWn_i}{2\tau_0}$$

$$p_{n0} = \frac{n_i^2}{N_D}$$

$$n_{p0} = \frac{n_i^2}{N_A}$$

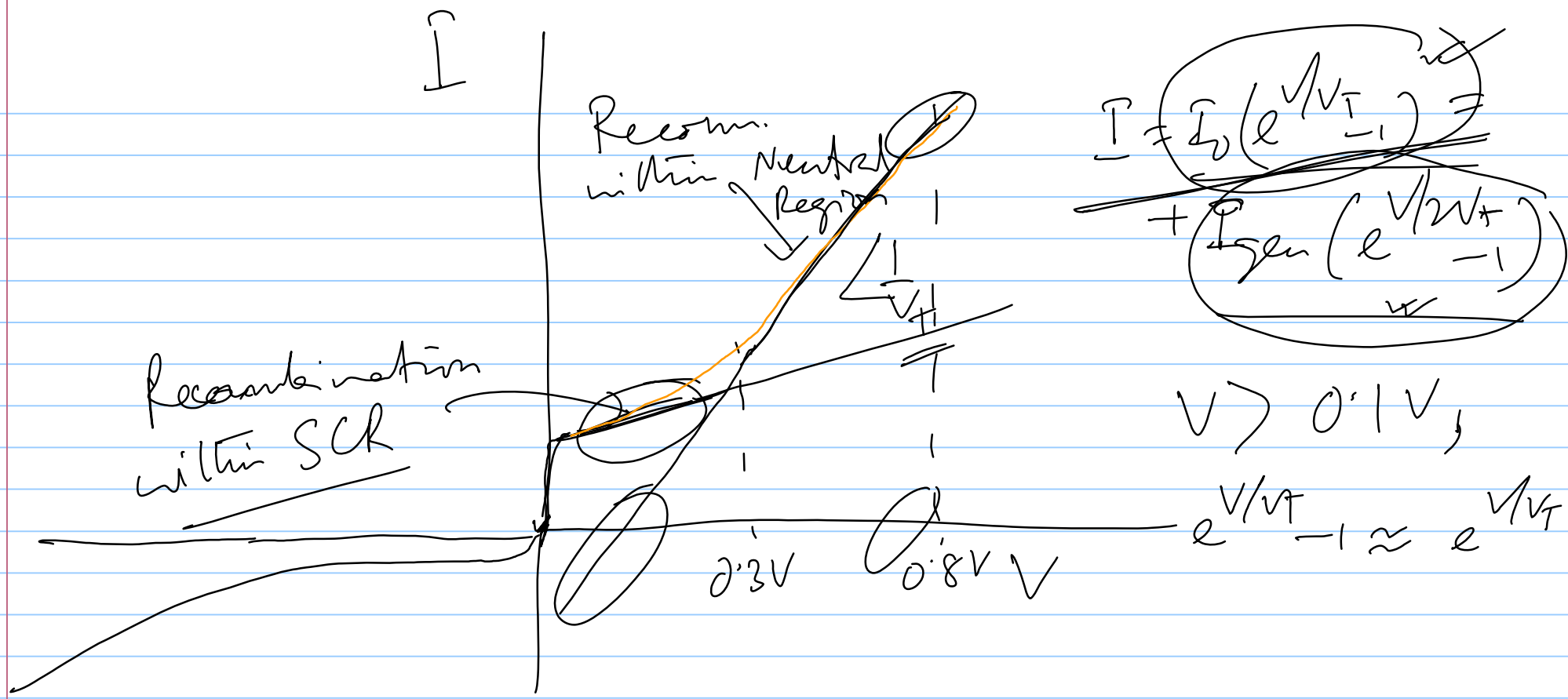
In forward bias $E_{fn} > E_{fp}$

$np > n_i^2$

recombination > Generation within SCR

$$I_{recom} = \frac{qAWn_i}{2\tau_0}\left(e^{V/2V_T} - 1\right)$$

$$= I_{gen}\left(e^{V/2V_T} - 1\right)$$



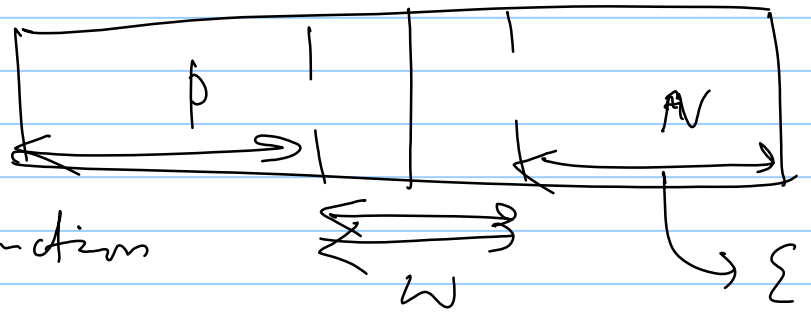
$$I = I_0\left(e^{V/V_T} - 1\right) + I_{gen}\left(e^{V/2V_T} - 1\right)$$

$V > 0{\cdot}1\,V$,

$e^{V/V_T} - 1 \approx e^{V/V_T}$

$V > 0.8V$

$(R_s \cdot I) = V_{drop}$



$$I = I_0 \left[\exp\left[\frac{V - IR_s}{V_T} \right] - 1 \right]$$

$V_{junction} = V - IR_s$

$p^+ N$ - junction

$N_D = 10^{15}/cm^3$

$N_A = 10^{18}/cm^3$

$A = 10^{-3} cm^2$

$2 \times 10^{-2} cm = L$

n-side →

$\mu_n = 1280 cm^2/V-s$

$\mu_p = 480 cm^2/Vs$

$D_n = 33 cm^2/sec$

$D_p = 12.4 cm^2/sec.$

p-side →

$\mu_n = 280 cm^2/Vs$

$\mu_p = 110 cm^2/Vs$

$D_n = 7.25 cm^2/sec$

$D_p = 2.8 cm^2/sec$

$\tau_0 = \tau_n = \tau_p = 1\,\mu sec$

n-side $\longrightarrow$ $L_p = \sqrt{D_p \tau_p} = 3.5 \times 10^{-3}$ cm

p-side $\longrightarrow$ $L_n = \sqrt{D_n \tau_n} = 2.7 \times 10^{-3}$ cm

$$I_{reverse} = -I_0 - \frac{qA(W)n_i}{2\tau_0}$$

$$= -qAn_i^2\left(\frac{D_p}{L_p N_D} + \frac{D_n}{L_n N_A}\right) - \frac{qA(W)n_i}{2\tau_0}$$

$\varepsilon_{Si} = 11.8 \times 8.85 \times 10^{-14}$ F/cm