Anthony Mancuso
ECE321
HW-3
5 Sep 2012

(2-1)

$n_i = 1.67\times10^{10}\left(\frac{\text{carriers}}{\text{cm}^3}\right)$

$$1.67\times10^{10}\left(\frac{\text{carriers}}{\text{cm}^3}\right) = BT^{3/2}e^{\frac{-E_g}{2(kT/q)}}$$

$$1.67\times10^{10} = (5.23\times10^{15})(T^{3/2})e^{\frac{-1.12\,eV}{2(86.17\mu eV)T}}$$

$$\boxed{T = 340.31\text{ K}}$$

(2-2) What fraction of Si atoms is ionized at $T = 100°C$
$= 373\text{K}$

$$n_i(373\text{K}) = 5.23\times10^{15}(373^{3/2})e^{\frac{-1.12\,eV}{2(86.17\mu eV)373}} = 1.02\times10^{12}\ \frac{\text{electrons}}{\text{cm}^3}$$

$$\frac{n_i(100°C)}{5\times10^{22}\frac{\text{atoms}}{\text{cm}^3}} = \boxed{2.04\times10^{-11}\ \frac{\text{electrons}}{\text{Si atom}}}$$

(2-3) $\frac{n_i(T_1)}{n_i(T_2)} = 303$, $T_2 = 300\text{ k}$

$$n_i(T_2) = 1.062\times10^{11}\ \frac{\text{electrons}}{\text{cm}^3}$$

$$n_i(T_1) = (303)\left(1.062\times10^{11}\ \frac{\text{electrons}}{\text{cm}^3}\right)$$

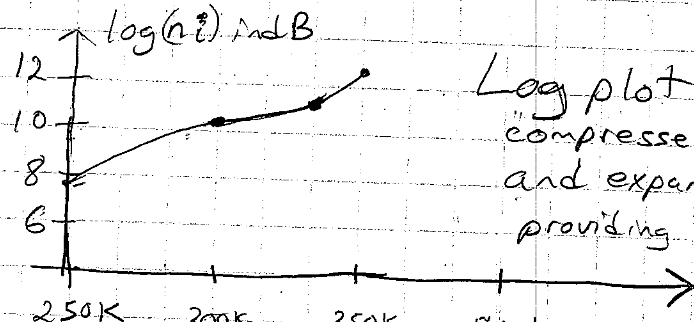
$$n_i(T_1) = 3.218\times10^{13}\ \frac{\text{electrons}}{\text{cm}^3}$$

$$3.218\times10^{12}\ \frac{\text{electrons}}{\text{cm}^3} = (5.23\times10^{15})(T_1^{3/2})\left(e^{\frac{-1.12\,eV}{2(86.17\mu eV)(T)}}\right)$$

$$\boxed{T_1 = 397\text{K}}$$

(2-4)
$n_i(250\text{K}) = 1.061\times10^{8}\ \frac{\text{electrons}}{\text{cm}^3}$
$n_i(300\text{K}) = 1.062\times10^{10}$ "
$n_i(350\text{K}) = 2.956\times10^{11}$ "
$n_i(400\text{K}) = 3.678\times10^{12}$ "

$\log_{10}[n_i(250\text{K})] = 8.02\text{dB}$
$\log_{10}[n_i(300\text{K})] = 10.03\text{dB}$
$\log_{10}[n_i(350\text{K})] = 11.47\text{dB}$
$\log_{10}[n_i(400\text{K})] = 12.57\text{dB}$




Log plot is preferred because it compresses changes at higher magnitudes and expands changes at lower magnitudes, providing better overall representation of response.
This plot is fairly linear over the range.

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(2-5) $T = 100°C = 373 K$

$$n_i(373k) = 1.022 \times 10^{12} \frac{electrons}{cm^3}$$

$$\frac{n_i(373 k)}{5} = 2.044 \times 10^{11} \frac{electrons}{cm^3}$$

$$2.044 \times 10^{11} \frac{electrons}{cm^3} = (5.23 \times 10^{15})(T^{3/2})\left(e^{\frac{-1.12 eV}{2(86.174 eV)T}}\right)$$

$$T_{(ni\text{-}reduced)} = \boxed{343.7 K} = \boxed{70.7°C}$$

(2-6)

$$N_A = 10^{17} cm^{-3} \text{ at } 300 K$$

$$n_o = \frac{n_i^2}{N_A} = \frac{(1.062 \times 10^{10} cm^{-3})^2}{10^{17} cm^{-3}} = \boxed{1.128 \times 10^3 \frac{electrons}{cm^3}}$$

(2-7)

$$\frac{Si(atoms)}{N_X(atoms)} = \frac{10{,}000}{1} \Rightarrow \frac{5 \times 10^{22} \left(\frac{atoms}{cm^3}\right)}{N_D} = 10{,}000$$

$$N_D = \frac{5 \times 10^{22} \frac{atoms}{cm^3}}{10{,}000} = 5 \times 10^{18} \frac{electrons}{cm^3}$$

$$p_o = \frac{(n_i)^2}{N_D} = \frac{\left(1.062 \times 10^{10} \frac{carriers}{cm^3}\right)^2}{5 \times 10^{18} \frac{electrons}{cm^3}} = \boxed{22.56 \left(\frac{holes}{cm^3}\right)}$$

(2-8) $T = 358 K,\ N_A = 6 \times 10^{18}$

$$n_o = \frac{[n_i(358 k)]^2}{N_A} = \boxed{3.573 \times 10^4 \frac{electrons}{cm^3}}$$

(2-9) electron concentration in Si at 300K $= 5 \times 10^4 cm^{-3}$
$n_i$ at 300k $= 1.5 \times 10^{10} cm^{-3}$

$$\text{hole concentration} = \frac{(1.5 \times 10^{10} cm^{-3})^2}{5 \times 10^4 cm^{-3}} = \boxed{4.5 \times 10^{15} \frac{holes}{cm^3}}$$
$\boxed{(p\text{-type})}$

(2-10) $n_o = 4.5 \times 10^4,\ N_A = 10^{18}$

$$n_i = \sqrt{n_o N_A} = 2.12e^{11} = (5.23e^{15})(T^{3/2})\left(e^{\frac{-1.12 eV}{2T(86.174 eV)}}\right) \Rightarrow T = \boxed{344 K}$$