[86.03/66.25] Dispositivos Semiconductores

1er Cuatrimestre 2020

Física de Semiconductores

1. **Concentración de portadores, movilidad y conductividad**
2. Corriente de difusión
3. Relaciones de Boltzmann y diferencia de potencial

Calcular n_i, n_o, p_o y σ para un bloque de Si uniformemente dopado con $N_A = 2 \times 10^{13}\ cm^{-3}$ a temperatura ambiente $T_o = 27°C$ y $T_1 = 150°C$

$$\sigma = q(\mu_n n_0 + \mu_p p_0) \rightarrow f(T)$$

$$p_0 = \frac{N_A - N_D}{2} + \sqrt{\left(\frac{N_A - N_D}{2}\right)^2 + n_i^2}$$

$$n_0 p_0 = n_i^2 \Rightarrow n_0 = \frac{n_i^2}{p_0}$$

$$n_i = 2\left(\frac{2\pi \sqrt{m_n^* m_p^*}\, kT}{h^2}\right)^{3/2} e^{\left(-\frac{E_g}{2kT}\right)}$$

¿Cuánto vale la densidad intrínseca de portadores libres?

$$n_i = 2\left(\frac{2\pi\sqrt{m_n^* m_p^*}\,kT}{h^2}\right)^{3/2} \exp\left(-\frac{E_g}{2kT}\right)$$

Silicio

$E_g = 1.1\,\text{eV}$

$m_n^* = 1.1\,m_0$

$m_p^* = 0.56\,m_0$

Constantes

$m_0 = 9.109\times10^{-31}\,\text{kg}$

$k = 1.38\times10^{-23}\,\text{J/K}$

$h = 6.626\times10^{-34}\,\text{Js}$

$J = Nm = kg\frac{m^2}{s^2}$

$[E_g] = eV$

$[kT] = J$ (×q)

$$[n_i] = \left(\frac{[\sqrt{m_n m_p}][k][T]}{[h]^2}\right)^{3/2} = \left(\frac{kg\,J\,K}{K\,J^2\,s^2}\right)^{3/2} = \left(\frac{kg\,s^2}{kg\,m^2\,s^2}\right)^{3/2} = \left(\frac{1}{m^2}\right)^{3/2}$$

$$[n_i] = m^{-3} = (100\,cm)^{-3} = \frac{1}{1000000\,cm^3}$$

$T_K = T_{°C} + 273$

27°C → 300 K

150°C → 423 K

$n_i = 10^{10}\,cm^{-3}$ (27°C)

$n_i = 8{,}283\times10^{12}\,cm^{-3}$ (150°C)

¿Cuánto vale la densidad de portadores libres cuando $N_A = 2 \times 10^{13}\ \text{cm}^{-3}$?

$$p_o = \frac{N_A - N_D}{2} + \sqrt{\left(\frac{N_A - N_D}{2}\right)^2 + n_i^2} \quad ; \quad n_o = \frac{n_i^2}{p_o}$$

$T_o = 27\,°\text{C}$; $n_i = 10^{10}\ \text{cm}^{-3}$

$$N_A \gg n_i \Rightarrow p_o \cong N_A$$

$$n_o = \frac{n_i^2}{p_o} \approx \frac{n_i^2}{N_A} = 5 \times 10^{6}\ \text{cm}^{-3}$$

$T_o = 150\,°\text{C}$; $n_i = 8.3 \times 10^{12}\ \text{cm}^{-3}$

$$p_o = \frac{N_A}{2} + \sqrt{\left(\frac{N_A}{2}\right)^2 + n_i^2} = 2{,}3 \times 10^{13}\ \text{cm}^{-3}$$

$$n_o = \frac{n_i^2}{p_o} = 2{,}99 \times 10^{12}\ \text{cm}^{-3}$$

¿Cuánto vale la conductividad?

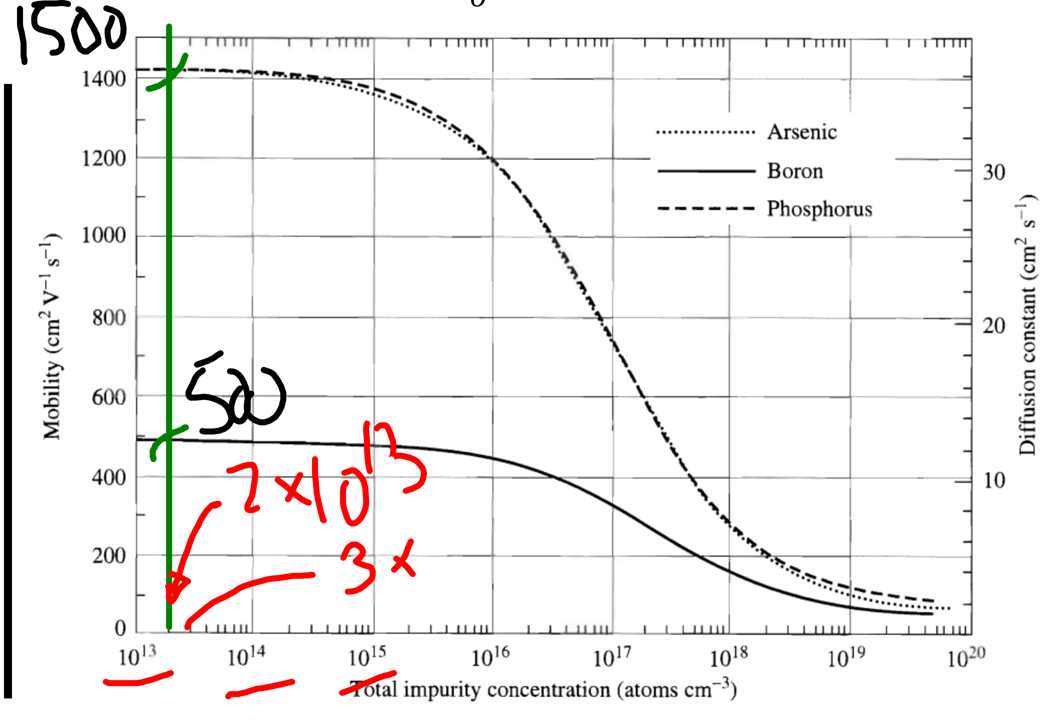
$$\sigma = q\left(\mu_n n_o + \mu_p p_o\right)$$

$\mu_n = 1500\ cm^2/Vs$, $\mu_p = 500\ cm^2/Vs$ } $27°C$

$\mu = \mu_o \left(\frac{T}{T_o}\right)^{-3/2}$, $T = 473K$, $T_o = 300K$

$\mu_n = 900\ cm^2/Vs$, $\mu_p = 300\ cm^2/Vs$ } $150°C$

$T_o = 27\,°C$



Cálculos finales

$$\sigma = q(\mu_n n_o + \mu_p p_o)$$

$T_o = 27\,°C$

$p_o \approx 2\times10^{13}\,\mathrm{cm}^{-3}$; $n_o \approx 5\times10^{6}\,\mathrm{cm}^{-3}$

$\mu_n \approx 1500\,\mathrm{cm}^2/\mathrm{Vs}$; $\mu_p \approx 500\,\mathrm{cm}^2/\mathrm{Vs}$

$\sigma = q\mu_p p_o = 1{,}6\times10^{-3}\,(\Omega\mathrm{cm})^{-1}$

$T_o = 150\,°C$

$p_o \approx 2.3\times10^{13}\,\mathrm{cm}^{-3}$; $n_o \approx 2.9\times10^{12}\,\mathrm{cm}^{-3}$

$\mu_n \approx 900\,\mathrm{cm}^2/\mathrm{Vs}$; $\mu_p \approx 300\,\mathrm{cm}^2/\mathrm{Vs}$

$\sigma = 1{,}5\times10^{-3}\,(\Omega\mathrm{cm})^{-1}$

Observaciones finales