Example 2.11

Calculate the electron and hole densities in an n-type silicon wafer ($N_d = 10^{17}$ cm^{-3}) illuminated uniformly with 10 mW/cm^2 of red light (E_{ph} = 1.8 eV). The absorption coefficient of red light in silicon is 10^{-3} cm^{-1}. The minority carrier lifetime is 10 μs.

Solution

The generation rate of electrons and holes equals:

$$G_n = G_p = a\,\frac{P_{opt}}{E_{ph}A} = 10^{-3}\,\frac{10^{-2}}{1.8\times1.6\times10^{-19}} = 3.5\times10^{13}\ \text{cm}^{-3}\text{s}^{-1}$$

where the photon energy was converted into Joules. The excess carrier densities are then obtained from:

$$d\,n = d\,p = t_p G_p = 10\times10^{-6}\times3.5\times10^{13} = 3.5\times10^{8}\ \text{cm}^{-3}$$

So that the electron and hole densities equal:

$$n = n_o + d\,n = 10^{17} + 3.5\times10^{8} = 10^{17}\ \text{cm}^{-3}$$

$$p = \frac{n_i^2}{n_o} + d\,p = \frac{(10^{10})^2}{10^{17}} + 3.5\times10^{8} = 3.5\times10^{8}\ \text{cm}^{-3}$$