3.091 Fall Term 2002

Homework Quiz #9A

solution outline

You wish to dope a single crystal of silicon with boron. The specification reads 5.55×10^{16} boron atoms cm^{-3} at a depth of 25 μm from the surface of the silicon. The effective surface concentration of boron is 6.66×10^{16} atoms cm^{-3}. How long must the silicon be processed to meet specification? Assume that initially the concentration of boron in the silicon crystal is zero. The diffusion coefficient of boron in silicon has a value of 7.77×10^{-9} cm^2 s^{-1} at the processing temperature.

Error Function Values

use the approximation erf (z) = z, for $0 < z < 0.6$

erf (1.0) = 0.84 erf (1.5) = 0.97 erf (z) = 1.00, for $z > 1.9$

$$\frac{c}{c_s} = erfc\frac{x}{2\sqrt{Dt}} = 1 - erf\frac{x}{2\sqrt{Dt}}$$

$$\therefore\ erf\frac{x}{2\sqrt{Dt}} = 1 - \frac{c}{c_s}$$

$$\therefore\ \frac{x}{2\sqrt{Dt}} = erf^{-1}\left(1 - \frac{c}{c_s}\right)$$

$$\therefore\ \frac{x^2}{4Dt} = \left[erf^{-1}\left(1 - \frac{c}{c_s}\right)\right]^2$$

$$\therefore\ t = \frac{x^2}{4D\left[erf^{-1}\left(1 - \frac{c}{c_s}\right)\right]^2}$$

$$= \frac{(25\times10^{-4})^2}{4(7.77\times10^{-9})\left[erf^{-1}\left(1 - \frac{5.55\times10^{16}}{6.66\times10^{16}}\right)\right]^2} \quad (\textit{use the approximation erf } z = z)$$

$$= 7.24\times10^3\ s = 2.01\ hr$$