Série 4

P1

From table (aula 7, slide 23) we know that the segregation coefficient for boron is 0,8

Since we know $C_s = k_0 C_\ell$ (the definition of segreg. coefficient)

it means we must have $\frac{10^{16}}{0,8} = 1,25 \times 10^{16}$ boron/cm3 in the

liquid.

What is the volume of the material?

Since we know the density of silicon and we have 60 kg

by using $\underbrace{M}_{\text{mass}} = \underbrace{\rho}_{\text{density}} \underbrace{V}_{\text{volume}}$ we obtain $V = 2,37 \times 10^4$ cm^3

Since the boron concentration must be $1,25 \times 10^{16}$ at/cm^3 it means that in this volume we must have a total amount

of $1,25 \times 10^{16} * \underbrace{V}_{2,37 \times 10^4} = 2,96 \times 10^{20}$ atoms of boron.

By knowing the atomic weight we can calculate the mass of boron using

$$\frac{2,96 \times 10^{20} \times 10,8}{\underbrace{N_A}_{\substack{\text{Avogadro number} \\ (6,02 \times 10^{23})}}} = 5,31 \times 10^{-3} \text{ grams of boron}$$

So we only need 5,31 mg to achieve that doping level!

Série 4

P2

At 1000 C the diffusion coefficient is $1 \times 10^{-14}\ \mathrm{cm^2/s}$ (from table aula 8, slide 17)

The constant surface concentration is $C_s = 4 \times 10^{22}\ \mathrm{at/cm^3}$

a) $C(x,t) = C_s \ \mathrm{erfc}\left(\dfrac{x}{2\sqrt{Dt}}\right)$

using the values we obtain $\dfrac{x}{2\sqrt{Dt}} = 1{,}7 \rightarrow \mathrm{erf}(1{,}7) = 0{,}9838$

$\Rightarrow \mathrm{erfc}(1{,}7) = 1 - 0{,}9838 = 0{,}0162 \rightarrow C(x,t) = 4 \times 10^{22} * 0{,}0162$

$C(x,t) = 6{,}48 \times 10^{20}\ \mathrm{at/cm^3}$

b) at 1200 C $D_{phosp} = 1 \times 10^{-12}\ \mathrm{cm^2/s}$

So $\dfrac{x}{2\sqrt{Dt}} = 0{,}17 \rightarrow \mathrm{erf}(0{,}17) \simeq 0{,}19 \rightarrow \mathrm{erfc} = 0{,}81$

$\Rightarrow C(x,t) = 4 \times 10^{22} * 0{,}81 = 3{,}24 \times 10^{22}\ \mathrm{at/cm^3}$

P3

We know $C(x,t) = C_s \ \mathrm{erfc}\left(\dfrac{x}{2\sqrt{Dt}}\right) \Rightarrow \dfrac{10^{22}}{10^{24}} = \mathrm{erfc}\left(\dfrac{x}{2\sqrt{Dt}}\right) \Rightarrow$

$\Rightarrow 0{,}01 = 1 - \mathrm{erf}\left(\dfrac{x}{2\sqrt{Dt}}\right) \Rightarrow \mathrm{erf}\underbrace{\left(\dfrac{x}{2\sqrt{Dt}}\right)}_{z} = 0{,}99$

By looking at the erf table we find $z = 1{,}9$

So $\dfrac{x}{2\sqrt{Dt}} = 1{,}9 \Rightarrow x = 1{,}9 \times 2 \times \sqrt{Dt} = 3{,}32\ \mu m$