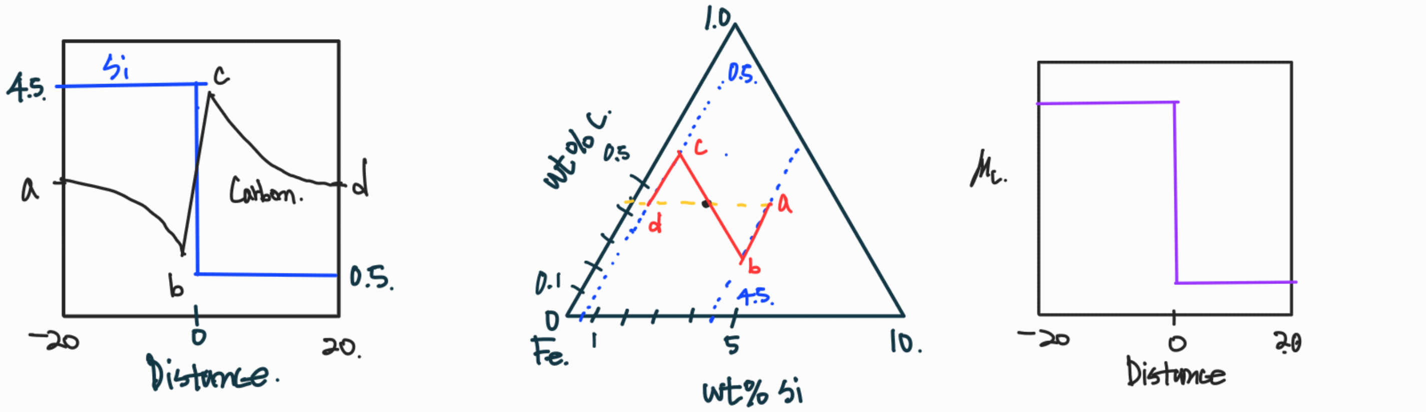
HW3 신소재공학과 20222571 최찬식

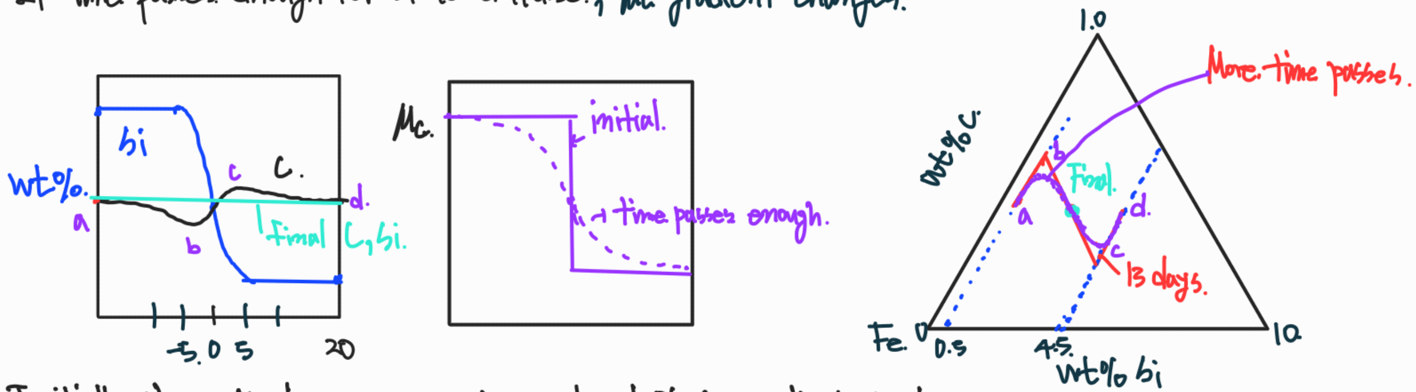
1. For the 13 days annealing time Si doesn't diffuse much so that abrupt Si concentration change would be observed at the interface.



(Assuming initial carbon concentration 0.45 wt%, silicon concentration for the site a 4.5 wt% and site b 0.5%.)

initially Si-rich region (-20 to 0 mm) carbon has higher chemical potential than Si-poor region. The μ_c gradient drives diffusion of carbon from a to d.

If time passes enough for Si to diffuse, μ_c gradient changes.



Initially sharp μ_c become smooth and wt% C gradient reduces.

The diffusion profile no more keeps constant 5mm from interface both sides.

When equilibrium is reached, the composition is uniform at whole region of the sample.

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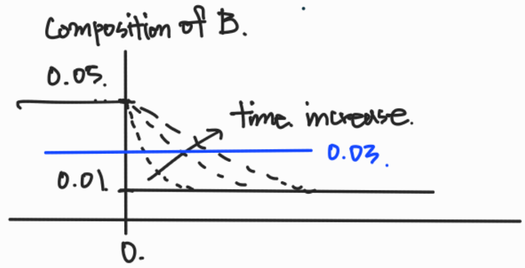
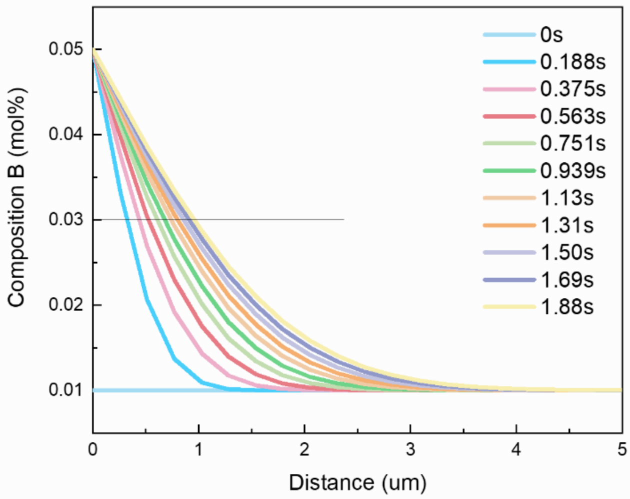
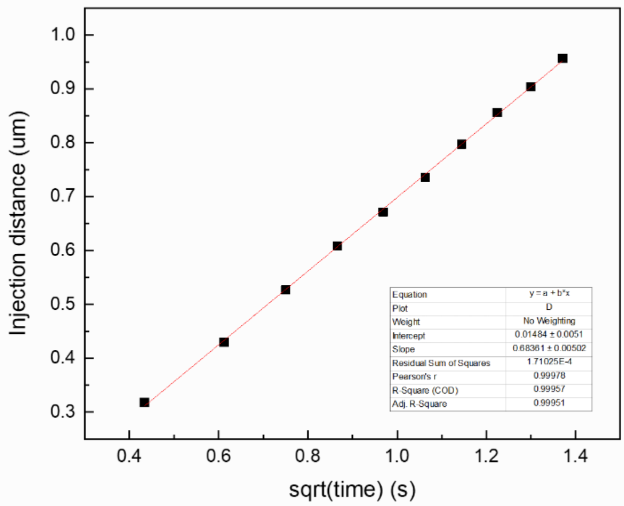
2. $C_{B0} = 0.01$. $C_{Bs} = 0.05$. $D_B = 5.254\times10^{-13}\ m^2/s = 5.254\times10^{-9}\ cm^2/s$. at 1300K.

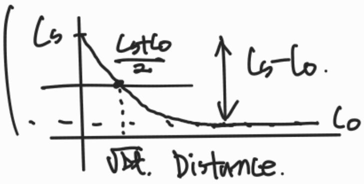


(a).





It is well known that injection distance l is proportional to $\sqrt{Dt}$



$$\frac{C-C_0}{C_s-C_0} = 1-\mathrm{erf}\left(\frac{l}{2\sqrt{Dt}}\right), \quad C(x,t) = C_0 + (C_s-C_0)\,\mathrm{erfc}\left(\frac{x}{2\sqrt{Dt}}\right).$$

$$\mathrm{erf}\left(\tfrac{1}{2}\right) \sim \tfrac{1}{2}. \quad C\left(\tfrac{1}{2},t\right) = C_0 + (C_s-C_0)\cdot\tfrac{1}{2} = \frac{C_0+C_s}{2}, \quad \therefore l \sim \sqrt{Dt}.$$

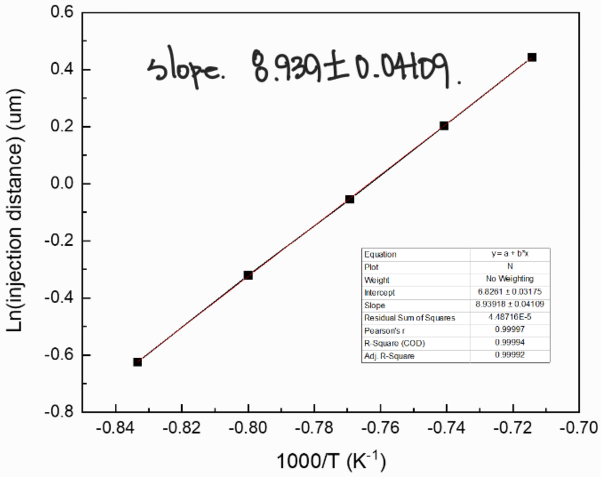
At constant temperature, the diffusion coefficient is constant.
The injection distance l has linear relationship with $\sqrt{t}$.

(b). Diffusion coefficient. $D = D_0\exp\left(-\frac{Q}{RT}\right) \propto l^2/t$

injection distance l is proportional to $\sqrt{D}$ for same diffusion duration.

$\sqrt{D} = \sqrt{D_0}\exp\left(-\frac{Q}{2RT}\right)$, in other expression. $\ln l = \frac{1}{2}\ln D_0 - \frac{Q}{2RT}$

$\ln l$ vs. $\left(-\frac{1}{T}\right)$ graph should be linear.



(c). When the reaction is plotted as $\ln l$ vs. $\left(-\frac{1}{T}\right)$ graph, slope is $-\frac{Q}{2R}$.

If the graph shows linearity, activation energy $Q = -2R \times (\text{slope})$.

$Q = 1000 \times 8.94 \times 2 \times 8.314 = 148\,\mathrm{kJ}$