Diffusion Influencing on Competition between the Volume Solution and the Surface Segregation of Solved Elements in α-Fe

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Concentration of an element is a function of the tempering time after exposing and quenching from higher temperature, $X_b(t)$, described with the Langmuir curve and the Fowler theory accounting inter-atomic interaction in the segregation field [1] looks like a curve with the saturation as that one in Fig. 1 presented by M.P.Seah in [1] as the equation (1). Another equation (2) proposed by M.P.Seah [1] was analyzed in this work and developed for multi-component systems, where the equilibrium concentration of the i-th component was represented as the temperature function $X^{\infty}{}_{b}{}^{i}(T)$: Fig.2. According to the above relationships (1), (2), the segregation rapidly reaches the equilibrium level under higher exposing temperatures, but its value is lower at higher temperatures than that one could be under lower temperatures. The latter was proposed in work [1] to be tied with the volume solubility increasing, as rule, under exposing temperature growth and being an opposite competitive process to equilibrium surface (interface) segregations formation. We proposed a certain temperature ($T_{seg}{}^{i}$) of observing a maximum segregation level for a solved element to exist. The value $T_{seg}{}^{i}$ in this work was determined mathematically from the maximum condition for relationship (2): $\partial X^{\infty}{}_{b}{}^{i}(T)/\partial T = 0$. We believed the following to be true at rather low

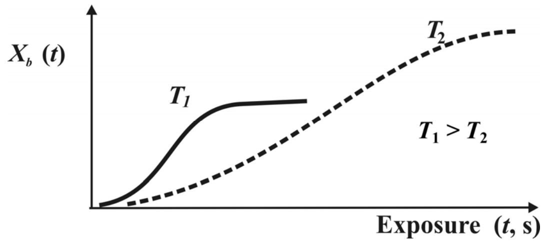

Figure 13: Surface segregations forming in solid solutions during isothermal exposing as a function on the time (t):

$$\frac{X_b(t)-X_b(0)}{X_b(\infty)-X_b(0)} = 1-\exp\left(\frac{FDt}{\beta^2 f^2}\right)\cdot erfc\left(\frac{FDt}{\beta^2 f^2}\right)^{1/2} \quad (1)$$

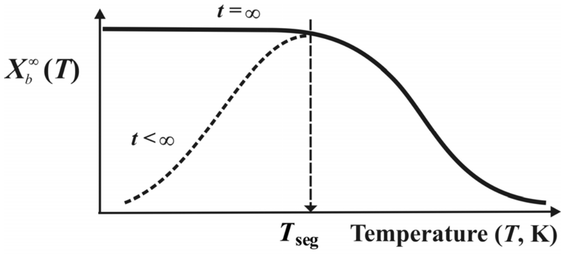

Figure 2: Equilibrium surface segregations $X_b^{\infty}(T)$ forming in solid solutions during isothermal exposing as a function on the temperature (T):

$$\frac{X_b^{\infty i}(T)}{X_{bo} - \sum_{i=1}^{N} X_b^{\infty i}(T)} = \frac{X_v^i}{X_{vo}^i(T)}\exp\left[\frac{-\Delta G^i{}_{seg}}{RT}\right] \quad (2)$$

temperatures and enough long time period of the isothermal exposing: $X^i_b(T) \cong X^{\infty}{}_b{}^i\,(T) = const$. The segregation concentration ($X^{\infty}{}_b{}^i\,(T)$) and the limiting volume solubility ($X_{vo}{}^i(T)$) in (2) are functions on the temperature. Other parameters in (2) are assumed to be independent on the temperature. So, it was found the approximate solution of $\partial X^i_b(T)/\partial T \cong 0$ as

$$(T_{seg}{}^{i})^2 = \frac{\Delta \mathrm{G}_{\mathrm{seg}}}{\mathrm{R}} \left[\mathrm{X}^{\mathrm{i}}{}_{\mathrm{vo}}\,(T) \middle/ \left(\frac{\partial \mathrm{X}^{\mathrm{i}}{}_{\mathrm{vo}}(T)}{\partial T} \right) \right] \qquad (3).$$

It was experimentally shown, using Auger-spectroscopy method, that there is the certain temperature interval of forming the surface segregation of an element *i* solved in α-Fe (*i*=C, N, B, P, Mo, Ti, Al, S, Sn, Cu). The latter was experimentally observed as the temperature interval of preferential surface enrichment. The values of ($T_{seg}{}^{i}$) simulated with (3) are in rather good agreement with the obtained experimentally.

This work was financially supported by the RFBR (Project #16-08-00599).

[1] M. P. Seah. *Auge Spectroscopy in Metallurgy*. In book: Practical Surface Analysis by Auger and X-ray Photoelectron Spectroscopy, edited by D. Briggs and M. P. Seah,-John Wiley & Sons, (1983).