材料導論 作業 2

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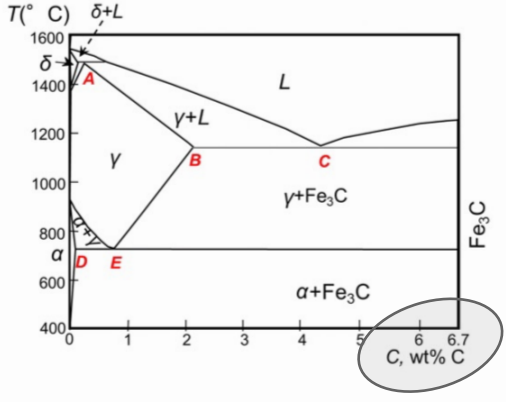
請用手寫回答，打字以零分計算

1. Refer to iron-iron carbide phase diagram below. (25%)

(a) What are eutectic, eutectoid and peritectic reaction? Select the corresponding point (A-E) for each reaction in the iron-iron carbide diagram. (15%)



C. 6.7 wt% C

Eutectic : Liquid transforms to two solid phases

$L \underset{\text{heat}}{\overset{\text{cool}}{\rightleftharpoons}} \alpha + \beta$ (C)

Eutectoid : one solid phase transforms to two other solid phases

$S_2 \rightleftharpoons S_1 + S_3$ $\quad \gamma \underset{\text{heat}}{\overset{\text{cool}}{\rightleftharpoons}} \alpha + Fe_3C$ (E)

Peritectic : Liquid and one solid phase transform to a second solid phase

$S_1 + L \rightleftharpoons S_2$ $\quad \delta + L \underset{\text{heat}}{\overset{\text{cool}}{\rightleftharpoons}} \gamma$ (A)

(b) Austenite with carbon content of 0.76 wt% can *completely* transformed to pearlite during cooling process. Please calculate the ratio of ferrite and cementite based on this composition, at the temperature just below the transformation temperature. (Hint: solubility limit of carbon in ferrite phase is 0.022 wt%) (10 %)

$$\frac{0.76 - 0.022}{6.7 - 0.022} = \frac{0.738}{6.678}$$

$\fallingdotseq 0.1105$

$100\% - 11.05\%$

$= 88.95\%$ 共析

Amount of Fe_3C

$= W_{Fe_3C} \fallingdotseq 11.05\%$ 共析

2. (50%)

(a) For the solidification of pure gold, using the following equation to calculate the critical radius *r and the activation free energy ΔG^* if nucleation is homogeneous. Values for the latent heat of fusion and surface free energy are -1.16×10^9 J/m^3 and 0.132 J/m^2, respectively. Given melting point and supercooling value of gold are 1064 °C and 230 °C, respectively. (25%)**

$$r^* = \left(-\frac{2\gamma T_m}{\Delta H_f}\right)\left(\frac{1}{T_m - T}\right) \qquad \Delta G^* = \left(\frac{16\pi\gamma^3 T_m^2}{3\Delta H_f^2}\right)\frac{1}{(T_m - T)^2}$$

γ = surface free energy = 0.132

T_m = melting temperature = 1064 °C

$\Delta T = T_m - T$ = supercooling = 230°C

latent heat of fusion = -1.16×10^9

$$r^* = \left(\frac{-2\gamma T_m}{\Delta H_f}\right)\left(\frac{1}{T_m - T}\right)$$

$$= \left(\frac{(-2)\cdot 0.132 \cdot 1064}{-1.16\times10^9}\right)\left(\frac{1}{230}\right)$$

$$= 1.052833358 \times 10^{-9}$$

$$\Delta G^* = \left(\frac{16\pi(0.132)^3 \times (1064)^2}{3\times(-1.16\times10^9)^2}\right)\left(\frac{1}{230}\right)^2$$

$$\fallingdotseq 44.8704\pi \times 10^{-18}$$

$$\fallingdotseq 4.4871\pi \times 10^{-17}$$

(b) Now, calculate the number of atoms found in a nucleus of critical size. Assume a lattice parameter of 0.413 nm for solid gold at its melting temperature. (Lattice structure of gold is FCC) (25%)

$$\frac{4}{3}\pi r^{*3} = \frac{4}{3}\pi (1.052\times10^{-7}\,cm)^3$$

$$= 4.87\times10^{-21}\,cm^3$$

$$(0.413\times10^{-9}\,m)^3 = 0.07\times10^{-27} = 7\times10^{-29}\,m^3$$

$$\frac{7\times10^{-29}\,m^3}{4} = 1.75\times10^{-23}\,cm^3\ 1\,atom$$

3. 25(%) $\frac{4.87\times10^{-21}}{1.75\times10^{-23}} = 278\ atoms$ 共

(a) Describe the difference between homogeneous nucleation and heterogeneous nucleation. (15%)

同質：少見、ΔG較大、過冷度較大

異質：常見、表面

homogeneous nucleation:

1. nuclei form in the bulk of liquid metal
2. requires considerable supercooling

heterogeneous nucleation:

1. much easier since stable "nucleating surface" is already present
2. only very slight supercooling

(b) Sketch and label on the same plot, schematic free energy-versus-nucleus radius curves for both homogeneous and heterogeneous nucleation. (10%)

$\Delta G^*_{het} = \Delta G^*_{hom} S(\theta)$