材料導論 作業 3

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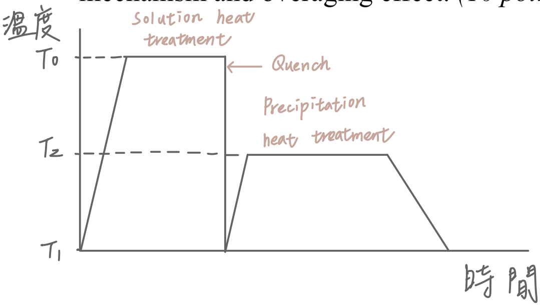
請用手寫回答，打字以零分計算

1. Describe the heat treatment process of precipitation hardening. And explain the hardening mechanism and overaging effect. *(10 point)*



$\boxed{\text{Step}}$ Precipitation hardening $\begin{cases} \text{1. Annealing} \\ \text{2. Quenching} \\ \text{3. Aging} \end{cases}$

1、Solution treatment, in which the alloy is heated to a temperature above the solvus line into the alpha phase and held for a period sufficient to dissolve the beta phase.

2、Quenching to room temperature to create a supersaturated solid solution.

3、Precipitation treatment ; alloy is heated to a temperature bellow Ts to cause precipitation of fine particles of beta phase.

Overaging effect:

當 strength / hardness 隨著時間到 max 時會降低

Mechanism:

利用溫度變化產生雜質相的小顆粒、進而阻礙位錯 ⇒ 需更多應力去 dislocation

⇒ 整體硬度↑

2. Determination of Electrochemical Cell Characteristics

One-half of an electrochemical cell consists of a pure nickel electrode in a solution of Ni^{2+} ions; the other half is a cadmium electrode immersed in a Cd^{2+} solution.

(a) If the cell is a standard one, write the spontaneous overall reaction and calculate the voltage that is generated (the half-cell potentials for cadmium and nickel are -0.403 V and -0.250 V, respectively) *(15 points)*

Hint: $\Delta V^0 = V_2^0 - V_1^0$

$$Cd \rightarrow Cd^{2+} + 2e^- \quad -0.403\ V_1^0$$

$$+)\ Ni^{2+} + 2e^- \rightarrow Ni \quad -0.250\ V_2^0$$

$$Ni^{2+} + Cd \rightarrow Cd^{2+} + Ni$$

$$\Delta V_0 = -0.250 - (-0.403)$$
$$= 0.153\ V \#$$

(b) Compute the cell potential at 25°C if the Cd^{2+} and Ni^{2+} concentrations are 0.5 and 10^{-3} *M*, respectively. Is the spontaneous reaction direction still the same as for the standard cell? *(15 points)*

Hint: $$\Delta V = (V^0_{Cd} - V^0_{Ni}) - \frac{RT}{n\mathcal{F}} \ln \frac{[Ni^{2+}]}{[Cd^{2+}]}$$ where's $\frac{RT}{n\mathcal{F}} \ln = \frac{0.0592}{2} \log$

$$[0.403 - 0.250] - \frac{0.0592}{2} \cdot \log \frac{10^{-3}}{0.5}$$

$$= 0.153 - 0.0296 \cdot \log 2 \times 10^{-3}$$

$$= 0.153 - 0.0296 \times 2.69897$$

$= 0.231\text{ V}$ # same #

3. An n-type semiconductor is known to have an electron concentration of 3×10^{18} m^{-3}. If the electron drift velocity is 100 m/s in an electric field of 500 V/m, calculate the conductivity of this material. (20)%

$$\sigma = n|e|\mu_e$$

$$= 3 \times 10^{18} \cdot |1.6 \times 10^{-19}| \times \frac{100}{500}$$

$$= 4.8 \times 10^{-1} \times \frac{1}{5}$$

$$= 0.96 \times 10^{-1}$$

$$= 9.6 \times 10^{-2}\ (\Omega m)^{-1}$$

4. A metal alloy is known to have electrical conductivity and electron mobility values of 1.5 × 10^7 $(\Omega\text{-m})^{-1}$ and 0.0020 m^2/V-s, respectively. A current of 45 A is passed through a specimen of this alloy that is 35 mm thick. What magnetic field would need to be imposed to yield a Hall voltage of -1.0 × 10^{-7} V? (20%)

$$V_H = \frac{R_H I_x B_z}{d}$$

$$-1 \times 10^{-7} = \frac{1.33 \times 10^{-10} \times 45 \times B}{35 \times 10^{-3}}$$

$$B = \frac{-35 \times 10^{-10}}{1.33 \times 10^{-10} \times 45}$$

$$= -0.58 \text{ tesla (反向)}$$

$$|R_H| = \frac{1}{n|e|} = \frac{1}{\frac{\sigma}{\mu_e}} = \frac{\mu_e}{\sigma}$$

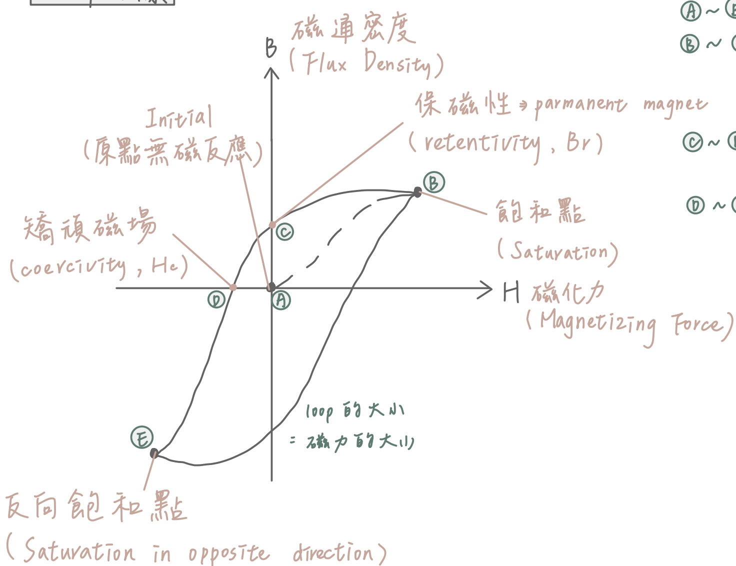
$$= \frac{2 \times 10^{-3}}{1.5 \times 10^{7}}$$

$$= 1.33 \times 10^{-10} \ (\text{V·m/A·tesla})$$

5. Describe the phenomenon of magnetic hysteresis and why it occurs for ferromagnetic and ferrimagnetic materials. (20%)

Magnetic hystersis phenomenon (磁滯)

$\boxed{\text{磁滯曲線}}$

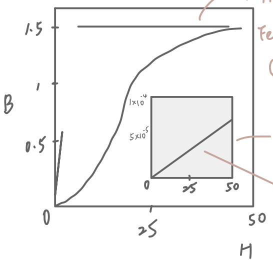


Ⓐ ~ Ⓑ 磁場↑達飽和

Ⓑ ~ Ⓒ 反向磁場↓ (去除外加磁場)、但已受磁反應了、所以仍保有磁性 (磁反應仍有殘留)

Ⓒ ~ Ⓓ 加入反向磁場 → 消除殘留的部分 (矯正到沒有磁性)

Ⓓ ~ Ⓔ 持續加入反向磁場



nonlinear

Ferromagnetic and ferrimagnetic

(磁性強、Flux density 遠超過 Diamagentic and paramagnetic

Diamagentic and paramagnetic

linear

B (Flux density)

H (Magnetic field strength)