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Exámenes resueltos 2012-2016

2° Materiales Aeroespaciales I

Grado en Ingeniería Aeroespacial

Escuela Politécnica Superior
Universidad Carlos III de Madrid



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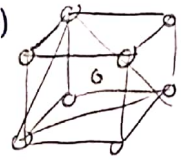
①

a) When the concentration of defects on a material increases, diffusion also increases since because of the point defects we have more "free" space in the crystal which enables the diffusion phenomena

b) The lower the packing factor, the faster the diffusion because the packing factor is a way of measuring how much space is occupied and, therefore, the less space is occuppied, the easier the diffusion is.

②

a) BCC





$h = \sqrt{2a^2 - \frac{2}{4}a^2} = \frac{\sqrt{6}}{2}a$

$A = \frac{b \cdot h}{2} = \frac{r_{2a} \cdot \frac{\sqrt{6}}{2}a}{2} = \frac{\sqrt{3}}{2}a^2$

$\rho_{(111)} = \frac{n^{\circ}at_{(111)}}{A_{(111)}} = \frac{3 \times 1/6}{r\sqrt{3}/2\, a^2} = 7.04 \cdot 10^{14} \frac{at}{cm^2} \rightarrow a = 2.86 \cdot 10^{-8}\, cm$

$\boxed{V_{BCC} = a^3 = 2.35 \cdot 10^{-23}\, cm^3}$

b)

$d_{114} = \frac{a'}{\sqrt{1^2+1^2+4^2}} = 0.846\,\text{Å} \rightarrow a' = 3.59 \cdot 10^{-8}\, cm \rightarrow \boxed{V_{FCC} = a^3 = 4.624 \cdot 10^{-23}\, cm^3}$

$0.846 \cdot 10^{-9}\, cm$

c)

BCC → 2 atom / cell
FCC → 4 atom / cell
1 FCC = 2 BCC

$\#cells\ initial = \frac{1\, cm^3}{2.35 \cdot 10^{-23}\, cm^3} = 4.255 \cdot 10^{22}$ cells initially

$\Delta V_c = |V_{BCC} - V_{FCC}| = 2.274 \cdot 10^{-23}\, cm^3/cell$

$\Delta V_T = 4.255 \cdot 10^{22}\, cell \times 2.274 \cdot 10^{-23} \frac{cm^3}{cell} = 0.97\, cm^3$

change in volume = $1 - 0.97 = 0.03 \rightarrow$ 3% change in volume

d)

$\rho_{BCC} = \frac{nM}{V_{BCC} N_A} = \frac{(8 \cdot \frac{1}{8} + 1) \cdot 55.84}{2.35 \cdot 10^{-23} \cdot 6.023 \cdot 10^{23}} = 7.89\, g/mol$

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https://amzn.to/2Lg6wRM

③ $V_f = 0.68$

a) $\rho_c = V_f \rho_f + V_c \rho_c = 0.68 \cdot 1.79 + 0.32 \cdot 1.2 = 1.6012 \ g/cm^3$

b) $W_f = \frac{V_f \rho_f}{\rho_c} = \frac{0.68 \cdot 1.79}{1.6012} = 0.76$

$W_m = 0.24$

c) $E_{long,c} = V_f E_f + E_m V_m = 0.68 \cdot 220 + 0.32 \cdot 3 = 150.56 \ GPa$

$\frac{1}{E_{tra,c}} = \frac{V_f}{E_f} + \frac{V_m}{E_m} = \frac{0.68}{220} + \frac{0.32}{3} = 0.10975 \rightarrow E_{tra,c} = 9.11 \ GPa$

d) isostrain → longitudinal

$\frac{F_f}{F_c} = \frac{E_f V_f}{E_c V_c} = \frac{220 \cdot 0.68}{150.56} = 0.9936$ (con $V_c = 1$)

$\sigma_c = \frac{F_c}{A} \rightarrow F_c = \sigma_c A = 90 \cdot 10^6 \ Pa \ \frac{\pi}{4} (20 \cdot 10^{-3} m)^2 = 28274 N$

$F_f = 0.9936 \cdot 28274 N = \boxed{28093 N}$

$\frac{F_m}{F_c} = \frac{E_m V_m}{E_c V_c} = \frac{3 \cdot 0.32}{150.56} = 6.376 \cdot 10^{-3}$

$F_m = 6.376 \cdot 10^{-3} \cdot 28274 = \boxed{180 N}$

e) $\bar{\sigma}_c = V_f \sigma_f + V_m \sigma_m = 0.68 \cdot 2500 + 0.32 \cdot 70 = \boxed{1722.4 MPa}$

④ $\phi = 10mm$ — 204mm $\quad \sigma_y = 345 MPa \quad E = 110 GPa \quad \nu = 0.3$

a) plastically? 2.2KN $\quad F = 2200N$

$\sigma = \frac{F}{A} = \frac{2200N}{\frac{\pi}{4}(10 \cdot 10^{-3} m)^2} \times 10^{-6} \frac{MPa}{Pa} = 28 MPa < \sigma_y \rightarrow$ It does not deform plastically

b) length? diameter?

$\sigma = E \varepsilon \rightarrow \varepsilon = \frac{\sigma}{E} = \frac{28 \ MPa}{110 \cdot 10^3 \ MPa} = 2.55 \cdot 10^{-4}$

$\varepsilon = \frac{\Delta l}{l_0} = \frac{l - 204}{204} = 2.55 \cdot 10^{-4} \rightarrow \boxed{l = 204.052 mm}$

$\nu = \frac{-\frac{\Delta \phi}{\phi_0}}{\frac{\Delta l}{l_0}} = \frac{-\frac{\phi - 10}{10}}{2.55 \cdot 10^{-4}} = 0.3 \rightarrow \frac{10 - \phi}{10} = 0.3 \cdot 2.55 \cdot 10^{-4} \rightarrow \boxed{\phi = 9.999235 mm}$

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⑤

a)
b) Same as January 2013

c) $C_0 = 4.1\%C$

T = 1300 °C

phases = micro . Liquid

$C_L = 4.1\%C$ $W_L = 1$

T = 1000 °C

• phases: γ and Fe_3C

$C_\gamma = 1.6\%C$ $W_\gamma = \frac{6.7 - 4.1}{6.7 - 1.6} = 0.51$

$C_{Fe_3C} = 6.7\%C$ $W_{Fe_3C} = 0.49$

• micro: γ' and ledeburite (γ + Fe_3C)

Marina: $C_{\gamma'} = 1.7\%$ $W_{\gamma'} = \frac{4.3 - 4.1}{4.3 - 2.14} = 0.09$

$C_{Fe_3C+\gamma} = 4.3\%C$ $W_{\gamma+Fe_3C} = 0.91$

L → L + γ → γ' + lede →

→ pearlite + Fe_3C'

T = 730 °C

• phases: γ and Fe_3C

$C_\gamma = 0.76\%C$ $W_\gamma = \frac{6.7 - 4.1}{6.7 - 0.76} = 0.44$

$C_{Fe_3C} = 6.7\%C$ $W_{Fe_3C} = 0.56$

• micro: γ' and ledeburite (γ + Fe_3C)

$C_{\gamma'} = 0.76\%C$ $W_{\gamma'} = 0.09$

$C_{Fe_3C+\gamma} = 4.3\%C$ $W_{\gamma+Fe_3C} = 0.91$ → $W_{\gamma, lede} = W_{\gamma_{TOT}} - W_{\gamma'} = 0.44 - 0.09 = 0.35$

T = 400 °C

• phases: α and Fe_3C

$C_\alpha = 0.01\%C$ $W_\alpha = \frac{6.7 - 4.1}{6.7 - 0.01} = 0.4$

$C_{Fe_3C} = 6.7\%C$ $W_{Fe_3C} = 0.6$

• micro: perlite (α + Fe_3C), (α + Fe_3C + Fe_3C) transformed ledeburite (γ', α')

Marina: phase micro: pearlite + Fe_3C'

$C_{Fe_3C'} = 6.7\%$

$C_{perl} = 0.76\%$

↑ crystallinity ↓ elongation (ductility)

• curing with chemical rxn

• curing without chem rxn

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d)

$m_{\gamma 1} = 100 \cdot W_{\gamma 1} = 100 \cdot 0.09 = 9g$

$m_{\gamma,t} = 100 \cdot W_{\gamma,t} = 100 \cdot 0.35 = 35g$

c) Cr favours α (stabilizes α phase) : displace eutectoid $\uparrow T, \downarrow \%C$

⑥

a) Surface preparation is important to remove surface contaminants and to achieve an appropriate surface roughness that will improve adherence
Good surface contact → creation of adhesion

Primers: a low viscosity adhesive that is applied before making the adhesive joint in order to improve adherence. It prevents capillary absorption of adhesive solution in porous adherent. It optimizes interaction between substrate and adhesive (increase wetting, reactivity)

↓

objectives:

- Protect substrate surface
- optimize interaction between substrate and adhesive (increase wetting, reactivity)
- increase strength of union
- improve stress transfer
- facilitates processing flexibility
- protect against UV radiation

b) Superconductivity: for a few materials, the resistivity, at a very low temperature, abruptly plunges from a finite value to one that is virtually zero and remains there upon further cooling

The electrical resistivity of a superconductor becomes zero below some critical temperature (T_c). At temperatures below T_c, the superconducting state will stop upon application of a sufficiently large magnetic field or current density, which depends on temperature and decreases with increasing temperature

The Meissner effect is an expulsion of a magnetic field from a superconductor during its transition to the superconducting state.

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