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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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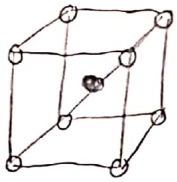
JANUARY 2012

① KCl

a) verify cesium chloride structure

$$\frac{r(Cl^-)}{r(K^+)} = \frac{0.181}{0.133} = 1.36 \quad 0.732 \rightarrow CsCl \text{ structure}$$

b) packing factor



○ Cl^-
● K^+

$$\text{packing factor} = \frac{V_{atoms}}{V_{cell}}$$

cube diagonal $\sqrt{3}a$ $\quad 2r(Cl^-) + 2r(K^+) = \sqrt{3}a$

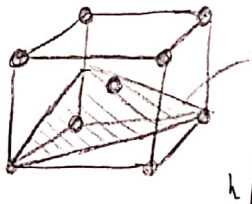
$n(Cl^-) = 8 \cdot \frac{1}{8} = 1$

$n(K^+) = 1$

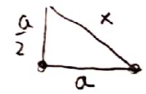
$$a = \frac{2 \cdot 0.181 + 2 \cdot 0.133}{\sqrt{3}} = 0.36\,nm$$

$$\text{packing factor} = \frac{\frac{4}{3}\pi r(Cl^-)^3 + \frac{4}{3}\pi r(K^+)^3}{a^3} = \frac{\frac{4}{3}\pi(0.181^3 + 0.133^3)}{0.36^3} = \underline{\underline{0.74}}$$

② BCC iron $\quad \rho_{(112)} = 9.94 \times 10^{14}\ atoms/cm^2$







$$x^2 = a^2 + \frac{a^2}{4}$$

$$x^2 = \frac{5a^2}{4} \rightarrow x = \frac{\sqrt{5}}{2}a$$



$$h^2 = \frac{5}{4}a^2 - \frac{2}{4}a^2 = \frac{3}{4}a^2$$

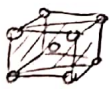
$$h = \frac{\sqrt{3}}{2}a$$

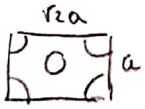
$$A_{(112)} = \frac{B \cdot h}{2} = \frac{\sqrt{2}a \cdot \frac{\sqrt{3}}{2}a}{2} = \frac{\sqrt{6}}{4}a^2$$

$$n^\circ atoms_{(112)} = 2 \times \frac{1}{6}$$

$$\rho_{(112)} = \frac{n^\circ atoms_{(112)}}{A_{(112)}} \rightarrow a$$

a) $\rho_{(110)}$?





$$\rho_{(110)} = \frac{4 \cdot \frac{1}{4} + 1}{\sqrt{2}a \cdot a} =$$

b) $(112) \rightarrow d_{112} = \frac{a}{\sqrt{1^2+1^2+2^2}} = \frac{a}{\sqrt{6}}$

$(110) \rightarrow d_{110} = \frac{a}{\sqrt{1^2+1^2}} = \frac{a}{\sqrt{2}}$

Slip easyly (?)

where ↓ 161 (?)

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https://amzn.to/2Lg6wRM

③

a) Maximum solubility of Pt in Al: 0.1% Pt at 657°C

Maximum solubility of Al in Pt: 88% Pt → 12% Al at 1507°C

b)

(1) At room T: $Al + Pt_5Al_{21}$ Adv: lower Tm, cheaper Disadv: has an intermetallic phase which usually brittle

(2) At room T: Pt — easier to process because it is pure

adv: "

disadv: high Tm, high cost

c)

(1) Pt_5Al_{21}: stoichiometric compound

β: non-stoichiometric compound

d) Congruent melting: Pt_2Al_3, $PtAl$, Pt_5Al_3

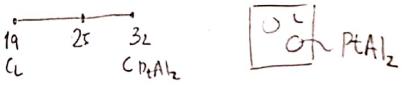
Incongruent melting: Pt_5Al_{21}, Pt_8Al_{21}, $PtAl_2$

e) 25% Pt

1400°C: $C_L = 25\%$ Pt [L] $W_L = 1$

1130°C: $C_L = 19\%$ Pt $W_L = \frac{32-25}{32-19} = 0.54$

$C_{PtAl_2} = 32\%$ Pt $W_{PtAl_2} = \frac{25-19}{32-19} \sim 0.46$



1000°C: phases: Liquid and Pt_5Al_{21}

$C_L = 11\%$ Pt $W_L = \frac{27-25}{27-11} = 0.125$

$C_{Pt_5Al_{21}} = 27\%$ Pt $W_{Pt_5Al_{21}} = 0.875$

810°C phases: Liquid and Pt_5Al_{21}

$C_L = 4\%$ Pt $W_L = \frac{27-25}{27-4} = 0.09$

$C_{Pt_5Al_{21}} = 27\%$ Pt $W_{Pt_5Al_{21}} = 0.91$

600°C. Phases: Pt_5Al_{21} and Pt_5Al_{21}

$C_{Pt_5Al_{21}} = 20\%$ Pt $W_{Pt_5Al_{21}} = \frac{27-25}{27-20} = 0.3$

$C_{Pt_5Al_{21}} = 27\%$ Pt $W_{Pt_5Al_{21}} = 0.7$

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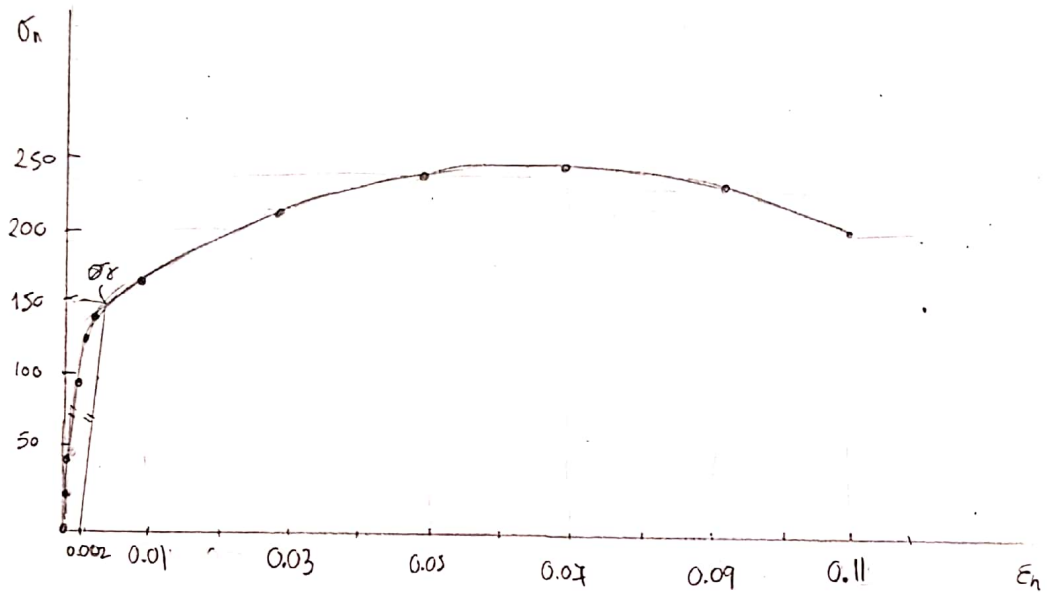
g) Difference in concentration and weight. As the temperature drops, there is more Pt_8Al_{21} and less liquid

g) 1127°C?
↳ Peritectic reaction: $L + PtAl_2 \rightarrow Pt_8Al_{21}$

h) 1397°C? for $C_0 = 25\%$ Pt nothing but for $54\%\,Pt \leq C_0 \leq 61\%\,Pt$ →
→ Eutectic reaction $L \rightarrow \beta + Pt_5Al_3$

④

a)



b) $\sigma_n = E\,\varepsilon_n \rightarrow \boxed{E = \frac{121.5\ MPa}{0.003} \triangleq 40000\ MPa = \underline{40\ GPa}}$

c) $\boxed{\sigma_y = 150\ MPa}$

d) ultimate tensile strength → $\boxed{\sigma_{max} = 134\ MPa}$

e) $\boxed{U_r = \frac{1}{2}\frac{(\sigma_y)^2}{E} = \frac{1}{2}\,\frac{150^2}{40000} = \underline{0.28\ MPa}}$

⑤ $v_f = 0.4$

Glass fiber: $E_c = 0.4 \cdot 72 + 0.6 \cdot 3.1 = 30.66\,GPa = 3.06 \cdot 10^4\ MPa < 5.5 \cdot 10^4\ MPa$ required ×

$\sigma_c = 0.4 \cdot 2000 + 0.6 \cdot 69 = 841.4\ MPa < 1200\ MPa$ required ×

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C fiber: $E_c = 0.4 \cdot 350 + 0.6 \cdot 3.1 = 141.86\,GPa = 14.2 \cdot 10^4\,MPa > 5.5 \cdot 10^4\,MPa$ required ✓

$\sigma_c = 0.4 \cdot 3500 + 0.6 \cdot 69 = 1441.4\,MPa > 1200\,MPa$ required ✓

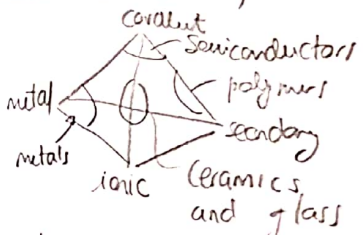
Aramid fiber: $E_c = 0.4 \cdot 124 + 0.6 \cdot 3.1 = 51.46\,GPa = 5.146 \cdot 10^4\,MPa < 5.5 \cdot 10^4\,MPa$ required ✗

$\sigma_c = 0.4 \cdot 3500 + 0.6 \cdot 69 = 1441.4\,MPa > 1200\,MPa$ required ✓

The best candidate is **C fiber**

⑥

- Metals: high electric conductivity since they are make up by metallic bonds (electron cloud → free e^- → high conductivity)
- Ceramics: limited electrical conductivity (absence of electronic cloud)
- Polymers: no electric conductivity (electric insulators)



⑦

- Néel temperature: temperature at which an antiferromagnetic material becomes paramagnetic - that is, the thermal energy becomes large enough to destroy the macroscopic magnetic ordering within the material.
- Curie temperature: temperature at which feromagnetic and ferimagnetic materials become paramagnetic. (it loses its magnetism - Wikipedia)

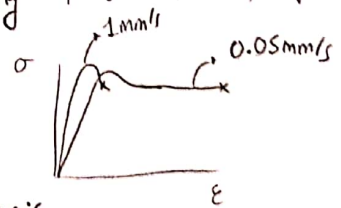
⑧

Ceramics have both an ionic and a covalent character. The percentage of ionic and covalent character of the bond determines the crystalline structure. However, glasses are an amorphous inorganic solid with the structure of a liquid, with no distinct melting or freezing point

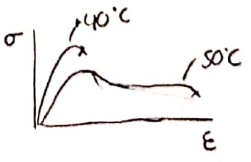
Ceramic processing methods have several steps: powder manufacturing, powder conditioning, forming - shaping, drying and sintering (or Simultaneous ...) and finishing operations. While glass processing consists on two steps: melting and shaping (specific process) - from liquid → wide processes - from powder

⑨

If strain rate ↑ { ↑ Brittleness; ↓ % deformation to fracture (ductility); ↑ difficulty of uncrossing



If T ↑ { ↓ Young's modulus; ↓ Tensile strength (σ_{max}); ↑ % deformation to fracture (ductility)



ppt page 37

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