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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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Universidad Carlos III de Madrid

EXAM

January 2015

Aerospace Materials I (2nd Year)

Surname: Name: Group:

Information:

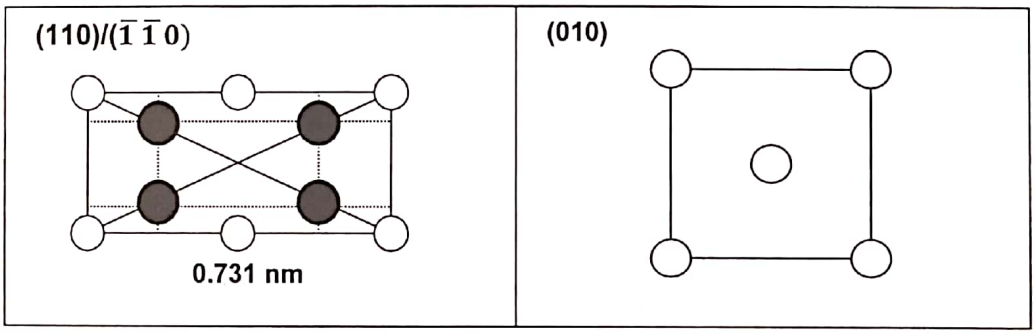
- Read the questions carefully before answering. Use the space given for answering each question.
- You have 2h 30min to complete the exam.
- The marks assigned to each of the questions are given at the beginning of the question.
- To pass the exam you need a minimum mark of 4 over 10.

1. **(2 marks)** In the figure, two crystallographic planes are represented. They correspond to a cubic unit cell of a ceramic material with the following formula A_xB_y that has density of 5.92 gr/cm^3.
   a) Determine and describe the type of structure and indicate its stoichiometry. What is the coordination index (C.I) for the ion A?
   b) Determine the lattice parameter of the unit cell and the molecular weight of ion B
   c) Determine the radius of ion B and calculate the packing factor
   d) Calculate the linear density in the direction [111]

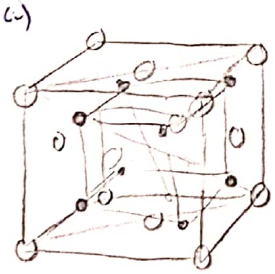
   DATA: r(A^{m+})=0.086 nm; M(A)=91.224 g/mol ; N_A=6.023x10^{23} mol^{-1}

Ion A: ○

Ion B: ●



a)



Fluorite CaF_2 structure → F^- : tetrahedral interstitial
Ca^+ : FCC packing

A_1B_2 ○ A ● B

CI(A) = 8

b)

$a\,r_2 = 0.731\,nm \rightarrow \boxed{a = \frac{0.731}{r_2} = 0.517\,nm}$

$\rho = \frac{\sum n_i M_i}{N_A V_c} = \frac{4 \cdot 91.224 + 8\,M(B)}{6.023 \cdot 10^{23} \cdot (0.517 \cdot 10^{-7}\,cm)^3} = 5.92\,\frac{g}{cm^3} \rightarrow \boxed{M(B) = 15.98\,g/mol}$

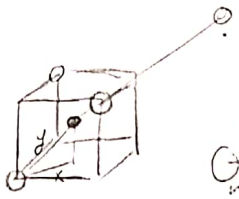
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e)



$y = \frac{\sqrt{3}a}{4}$ (one quarter of the unit diagonal)

$r(A)+r(B)$

$\frac{\sqrt{3}a}{4} = r(A)+r(B)$

$r(B) = \frac{\sqrt{3}}{4}\,0.517 - 0.086 = 0.138\ nm$

$PF = \frac{V_{ions}}{V_{cell}} = \frac{\frac{4}{3}\pi r(A)^3 \times 4 + \frac{4}{3}\pi r(B)^3 \cdot 8}{a^3} = 0.714$

d)



$P_{(111)} = \frac{n^{\circ}at_{(111)}}{L_{(111)}} = \frac{2 + 2\times 1/2}{\sqrt{3}\,a} = 3.35\ \frac{atoms}{nm}$

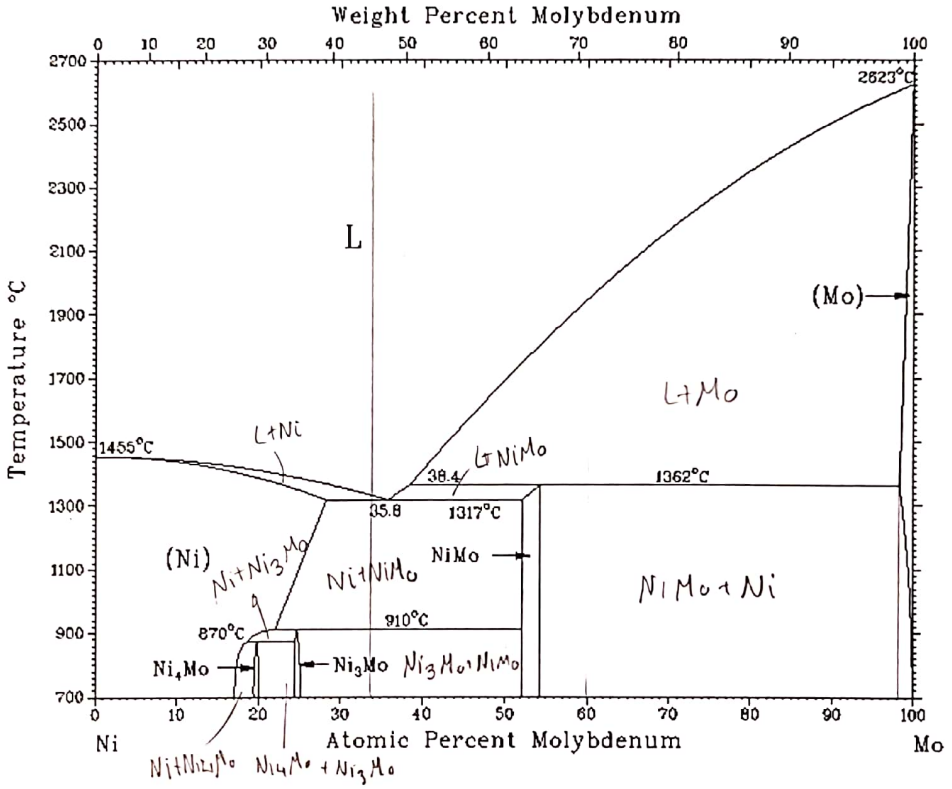
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2. **(2 marks)** Use the following phase diagram to answer the questions.



a) **(0.8 marks)** Mark as true (T) or false (F) the following statements

F	NiMo melts congruently
T	NiMo is an intermetallic compound
F	At 870ºC the reaction of Ni-20at%Mo alloy is ~~eutectoid~~ peritectoid
F	At 1362ºC the reaction of Ni-54at%Mo alloy is ~~eutectic~~ peritectic
T	Maximum solubility of Mo in (Ni) is about 28at%
F	Maximum solubility of Ni in (Mo) is 15at% Ni ? 4% at Mo – 2% at Ni
F	The microconstituents of Ni-60at%Mo alloy at 1300ºC, are pro~~eutectic~~ (Mo), and ~~eutectic~~ ((Mo)+ NiMo) Ni proteutectic peritectic
T	At 910ºC the reaction of Ni-25at%Mo alloy is peritectoid

b) **(0.8 marks)** Determine the quantity and composition of the phases present and the quantity of the microconstituents present for a Ni-34at%Mo alloy at: (i) 1318ºC and (ii) 1316ºC

c) **(0.4 marks)** Draw in the square provided a schematic sketch of the microstructure at a temperature of 1316ºC for a Ni-34at%Mo alloy

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El **mejor proyector**
relación calidad/precio
Los recomendados de amazon y WUOLAH



https://amzn.to/2Lg6wRM



$C_0 = 34\%$ Mo

b) $T = 1318\ ^\circ C$

phases ≡ microconstituents → L and Ni

$C_L = 35.8\%$ Mo $\quad W_L = \frac{34-28}{35.8-28} = 0.77$

$C_{Ni} = 28\%$ Mo $\quad W_{Ni} = 0.23$

$T = 1316\ ^\circ C$

• phases: Ni and NiMo

$C_{Ni} = 28\%$ Mo $\quad W_{Ni} = \frac{52-34}{52-28} = 0.75$ ④

$C_{NiMo} = 52\%$ Mo $\quad W_{NiMo} = 0.25$

• microconstituents: Ni' and eutectic (Ni + NiMo)

$C_{Ni'} = 28\%$ Mo $\quad W_{Ni'} = \frac{35.8-34}{35.8-28} = 0.23$

$C_E = 35.8\%$ Mo $\quad W_E = 0.77$

$W_{Ni,E} = W_{Ni,T} - W_{Ni'} = 0.75 - 0.23 \rightarrow 0.52$ ④

$W_{NiMo,E} = W_{NiMo,T} = 0.25$

$W_{NiMo,E} + W_{Ni,E} = W_E$

$0.25 + 0.52 = 0.77$ ✓

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internal / not sure

3. **a) (0.5 marks)** How does the amount of crystallinity in a thermoplastic affect (i) its density, (ii) its tensile strength and (iii) its melting temperature? Explain briefly.

   b) (0.5 marks) Describe briefly the main differences between thermosetting and thermoplastic polymers with respect to (i) structure and (ii) temperature stability.

a) Crystallinity increases the density since in the same volume there can fit more atoms (more mass) → higher degree of packing

If crystallinity increases, the melting temperature also increases ¿ why?

Crystallinity increases the tensile strength

b)

Structure

Thermoplastic



Van der Waal Forces

Crystaline or semicrystalline

They melt

Stable

Thermosets

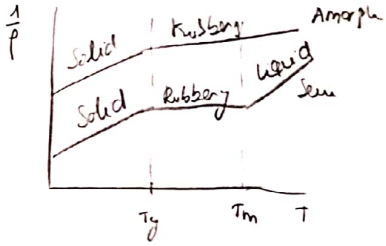


Crosslinking

Amorphous

They don't melt

Enough



4. **(1 mark)** Answer the following questions and explain briefly:
   - **a)** What is GLARE? Describe its components.
   - **b)** In what applications it is used?
   - **c)** What material does it substitute? What are its main advantages?

a) GLARE is a "glass-reinforced" Fibre Metal Laminate (FML), composed of several very thin sheets of metal (usually aluminium) intercalated with layers of "prepeg" fiberglass, all linked together with an epoxy matrix

b) It is applied in the aviation field (fuselages, leading edge of the tail surfaces...)

c) It substitutes aluminium alloys

Main advantages:

- improved damage tolerance
- better corrosion resistance
- better fire resistance
- lower density

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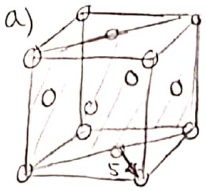
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Un poco invent

Edge

5. **(1 mark)** Two FCC-type crystalline structures are given. Both of them have defects characterized by an extra plane of atoms. In one of these structures, the extra plane of atoms is parallel to plane (110) and in the other one is parallel to plane (100). Determine and justify: The type of defect in each structure, direction of Burger's vector and the magnitude as a function of atomic radius. In which structure is slipping easier? (Consider the same atomic radius for both structures).

a)



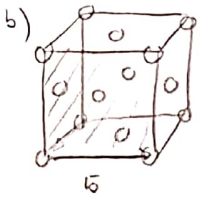
Edge dislocation

$\vec{b}$ direction: [110]

$|\vec{b}| = \frac{\sqrt{2}\,a}{2} = \frac{\sqrt{2}\,4R}{2\sqrt{2}} = 2R$

$4R = \sqrt{2}\,a \rightarrow a = \frac{4R}{\sqrt{2}}$

b)



Screw dislocation

$\vec{b}$ direction = [010]

$|\vec{b}| = a = \frac{4R}{\sqrt{2}}$

$\vec{b}$ direction = [100]

$|\vec{b}| = a$

Slipping is easier a) $|\vec{b}|^2 \begin{cases} |\vec{b}_a|^2 = 4R^2 \\ |\vec{b}_b|^2 = 8R \end{cases}$ → slipping in a) is easier

6. **a) (0.5 marks)** Explain briefly the difference between prepolymerized and polymerizing adhesives and give an example of each. Which of the two types is high resistance adhesive?

Prepolymerized adhesive: solvent is evaporated. They contain a polymer in solution or suspension in a solvent

Polymerized adhesives: adhesives that polymerize at the adhesive joint, Monomers that polymerize at the adhesion. → High resistance adhesives

b) (0.5 marks) What are the main types of charge carriers in the following:

i. Intrinsic semiconductors
ii. p-type extrinsic semiconductors
iii. n-type extrinsic semiconductors

i) 2 types of charge carries: electrons (n) in conduction Band and holes (p) in valence band

ii) Charge carriers are positive holes in the valence band

iii) Charge carriers are negative e- in the conduction band

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7. **(1 mark)** Which factors affect the diffusivity of a material? How?

1) Diffusion mechanism, since it depends on the atom size. Small atoms (C, H, O, N) diffuse interstitially in big atoms, while bigger atoms diffuse by vacancy

2) Type of crystalline structure of the matrix lattice (solvent). Each type of crystalline structure has its own packing factor, smaller packing factor means higher diffusivity

3) type of imperfections or defects in the crystal. Open structures have more holes and, therefore, its diffusivity is higher. $D_{surface} > D_{grain\ boundary} > D_{volume}$

4) Concentration of species that diffuse. When we increase the concentration of solute atoms we modify the diffusivity

5) Temperature. If we increase temperature, we increase diffusivity because within the temperature increament, the amplitude of vibration of atoms increases, causing greater probability of jump → ↑ Diffusivity

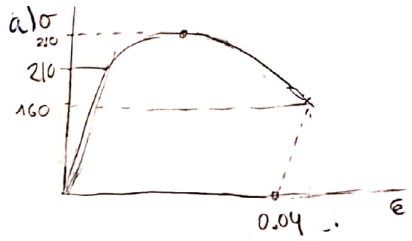
8. Answer the following questions:

a) **(0.3 marks)** Draw the stress-strain curve of an Al alloy with the yield strength σ_Y=210MPa, the ultimative tensile strength of σ_{UTS}=250MPa and a fracture stress of σ_f=160MPa at %EL=4%. ~ $\varepsilon_f = 0.04$

b) **(0.3 marks)** Briefly describe the main difference between elastic and plastic deformation macroscopically and microscopically.

Está bien? → Sí

c) **(0.4 marks)** The Al material given above will be used for a tube-shaped retainer. The inner diameter has to be 10mm. For the application a safety factor of n=2 is given. The static load is F=12000N. Calculate the outer diameter of the retainer.

a) 

b) Elastic deformation:
Macroscopically, when the load is removed, the specimen recovers its original shape
Microscopically, small changes in the interatomic space and the bonds between atoms is stressed / the atoms are displaced from the original positions without reaching other positions).

Plastic deformation:
Macroscopically, permanent deformation → the specimen does not recover its original shape
Microscopically, breaking and formation of new bonds / the atoms are displaced permanently from their initial to new positions)

c) $\sigma_W = \frac{\sigma_Y}{N} \rightarrow F_W = \frac{F_Y}{N} \rightarrow F_Y = F_W \cdot N = 12000 \cdot 2 = 24000\,N$

$\sigma_Y = \frac{F_Y}{A_0} \Rightarrow F_Y = 210 \cdot 10^6\,Pa \cdot \frac{\pi}{4}\left[d_{out}^2 - (10 \cdot 10^{-3})^2\right] = 24000$

$d_{out} = 0.016\,m = 16\,mm$

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