Ministry of Higher Education & Scientific Research
University of Technology
Laser&Optoelectronic Eng. Department
Branch: Optoelectronics Eng.
Class: 3rd Year:
Subject: Solid state Physics &Material science

Final Examination
Time: 3Hrs
Date: 29/5/2016
Examiner: Dr. Kadhim
Code: OPE 3308
Academic Year 2015-2016

Attempt only (Five) Questions

Q1: A diffusion couple for two hypothetical metals A and B. After a 30-h heat treatment at 1000 K (and subsequently cooling to room temperature) the concentration of A in B is 3.2 wt% at the 15.5-mm position within metal B. If another heat treatment is conducted on an identical diffusion couple, only at 800 K for 30 h, at what position will the composition be 3.2 wt% A? Assume that the preexponential and activation energy for the diffusion coefficient are 1.8 x 10^{-5} m2/s and 152,000 J/mol, respectively.

(12 Marks)

Q2: a): Calculate the unit cell edge length for an 85 wt% Fe–15 wt% V alloy. All of the vanadium is in solid solution, and at room temperature the crystal structure for this alloy is BCC. A_{Fe}= 55.85,A_V = 50.94, ρ_{Fe} = 7.87 gm/cm^3, ρ_V = 6.1 gm/cm^3.

b): Cite two reasons why interstitial diffusions normally more rapid than vacancy diffusion

(12 Marks)

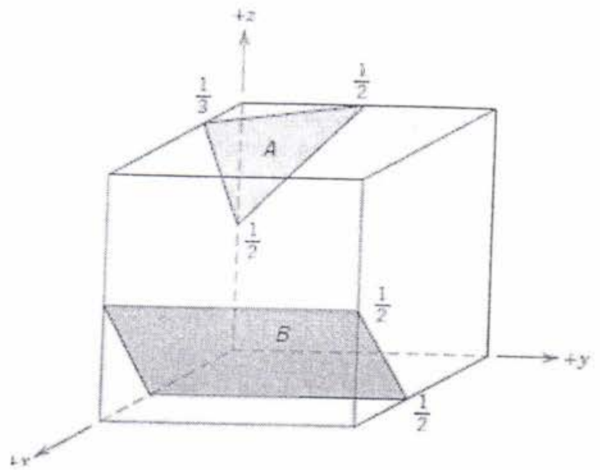
Q3: a): Acylindrical specimen of an alloy 8 mm in diameter is stressed elastically intension. A force of 15.7 KN produces a reduction in specimen diameter of 5 X 10^{-3} mm . Compute Poisson's ratio for this material if its modulus of elasticity is 140 GPa.

(b): Distinguish between materials that are opaque, translucent, and transparent in terms of their appearance and light transmittance

(12 marks)

Q4:a): The transmissivity T of a transparent material 20 mm thick to normally incident light is 0.85. If the index of refraction of this material is 1.6, compute the thickness of material that will yield a transmissivity of 0.75. All reflection losses should be considered.

(b): Determine the Miller indices for the planes shown in the following unit cell:



(12 Marks)

Q5:a). The metal rubidium has a BCC crystal structure.If the angle of diffraction for the (321) set of planes occurs at 27^0 (first-order reflection) when monochromatic x-radiation having a wavelength of 0.0711 nm is used, compute (a) the interplanar spacing for this set of planes and (b) the atomic radius for the rubidium atom.

b). A brass alloy is known to have a yield strength of 275 MPa , a tensile strength of 380 MPa , and an elastic modulus of 103 GPa. a cylindrical specimen of this alloy 12.7 mm . in diameter and 250 mm long is stressed in tension and found to elongate 7.6 mm. On the basis of the information given, is it possible to compute the magnitude of the load that is necessary to produce this change in length? If so, calculate the load. If not, explain why.

(12 Marks)

Q6: a): At room temperature the electrical conductivity and the electron mobility for copper are $6.0 \text{ X } 10^7 \text{ (ohm.m)}^{-1}$ and $0.0030 \text{ m}^2/\text{V.s}$, respectively.(a) Compute the number of free electrons per cubic meter for copper at room temperature. (b)What is the number of free electrons per copper atom? Assume a density of 8.9 g/cm^3. $A_{Cu} = 63.55$ gm/mol.

b). Determine the ASTM grain size number if 8 grains per square inch are measured at a magnification of 600 X.

(12 Marks)

NOTE:

$N_A = 6.022 \times 10^{23}$ atoms/mol , R = 8.31J/mol.K, $\mu_o = 1.257\text{x}10^{-6}$ H/m ,$\epsilon_o = 8.85\text{x}10^{-12}$ F/m

Dr. Kadhim A. Hubeatir

"Good Luck"

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المرحلة الثالثة / هندسة الالكترونيات البصرية. ٢٠١٥/٢٠١٦

Q1):

سؤال
الجواب الأول :

$$\frac{x^2}{D} = const$$

$$\frac{x_{800}^2}{D_{800}} = \frac{x_{1000}^2}{D_{1000}}$$

Now it is necessary to compute values of both D_{800} و D_{1000}

$$D_{800} = 1.8\times10^{-5}\ m^2/s\ \exp\left[-\frac{152000}{8.31\times800K}\right]$$

$$= 2.12\times10^{-15}\ m^2/s$$

$$D_{1000} = (1.8\times10^{-5})\ m^2/s\ \exp\left[-\frac{152000}{8.31\times1000K}\right]$$

$$= 2.05\times10^{-13}\ m^2/s$$

solving the above equation for x_{800} yields

$$x_{800} = x_{1000}\sqrt{\frac{D_{800}}{D_{1000}}}$$

$$= 15.5\sqrt{\frac{2.12\times10^{-15}}{2.05\times10^{-13}}}$$

$$= 1.6\,mm$$

جواب السؤال الثاني
Q2

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فرع a)

$A_{Fe} = 55.85$, $A_V = 50.94$ g/mol

$\rho_{Fe} = 7.87$ g/cm³, $\rho_V = 6.1$ gm/cm³

$$\rho_{ave} = \frac{n A_{ave}}{V_c N_A}$$

The unit cell is cubic, then $V_c = a^3$

$$\rho_{ave} = \frac{n A_{ave}}{a^3 N_A}$$

$$a = \left[\frac{n A_{ave}}{\rho_{ave} N_A}\right]^{1/3}$$

$n = 2$ For BCC

$$a = \left[\frac{n\left(\frac{100}{\frac{C_{Fe}}{A_{Fe}} + \frac{C_V}{A_V}}\right)}{\left(\frac{100}{\frac{C_{Fe}}{\rho_{Fe}} + \frac{C_V}{\rho_V}}\right) N_A}\right]^{1/3}$$

$$a = \left[\frac{2\left(\frac{100}{\frac{0.85}{55.85} + \frac{0.15}{50.94}}\right)}{\left(\frac{100}{\frac{0.85}{7.87} + \frac{0.15}{6.1}}\right) \times 6.022\times10^{23}}\right]^{1/3}$$

$$a = 2.89\times10^{-8}\ \text{cm} = 0.289\ \text{nm}$$

فرع b) Interstitial diffusion is normally more rapid than vacancy diffusion because:
1. interstitial atoms being smaller, are more mobile.
2. The probability of an empty adjacent interstitial site is greater than for a vacancy adjacent to a host atom.

جواب ⊃

Q_3 a جواب (فرع)

$$\epsilon_z = \frac{\sigma}{E} = \frac{F}{A_0 E}$$

$$= \frac{F}{\pi \left(\frac{d_0}{2}\right)^2 E} = \frac{4F}{\pi d_0^2 E}$$

$$\epsilon_x = \frac{\Delta d}{d_0}$$

$$\nu = -\frac{\epsilon_x}{\epsilon_z} = -\frac{\Delta d / d_0}{\left(\frac{4F}{\pi d_0^2 E}\right)} = -\frac{d_0 \Delta d \pi E}{4F}$$

$$= \frac{-(8\times10^{-3}\,m)\times(-5\times10^{-6}\,m)\,\pi\,(140\times10^{9}\,N/m^2)}{4\times 15700}$$

$$= 0.280$$

جواب

b)

opaque materials: are impervious to light transmission, it is not possible to see through them.

Translucent materials: light is transmitted diffusely through it, i.e there is some internal light scattering, objects are not clearly distinguishable when viewed through this type of material.

Transparent materials: Virtually all of the incident light is transmitted through it, and one can see clearly through them.

جواب سؤال
Q4)
فرع a)

$$R = \frac{(n_s-1)^2}{(n_s+1)^2} = \frac{(1.6-1)^2}{(1.6+1)^2} = 5.33\times10^{-2}$$

$$\frac{I_T}{I_0(1-R)^2} = e^{-\beta l}$$

نأخذ ln الطرفين

$$\ln\left(\frac{I_T}{I_0(1-R)^2}\right) = -\beta l$$

$$\beta = -\frac{1}{l}\ln\left(\frac{I_T}{I_0(1-R)^2}\right)$$

$$T = \frac{I_T}{I_0}$$ therefore

$$\beta = -\frac{1}{l}\ln\left(\frac{T}{(1-R)^2}\right)$$

$$\beta = -\frac{1}{20}\ln\left(\frac{0.85}{(1-5.33\times10^{-2})^2}\right)$$

$$= 2.65\times10^{-3}\ \text{mm}^{-1}$$

Now, solving for l when $T = 0.75$

$$l = -\frac{1}{\beta}\ln\left[\frac{T}{(1-R)^2}\right]$$

$$= -\frac{1}{2.65\times10^{-3}}\ln\left[\frac{0.75}{(1-5.33\times10^{-2})^2}\right]$$

$$= 67.3\ \text{mm}$$

جواب
فرع b)
Q4

For plane A

	x	y	z
intercepts	$\frac{a}{3}$	$\frac{b}{2}$	$-\frac{c}{2}$
Intercepts in terms of a, b, c	$\frac{1}{3}$	$\frac{1}{2}$	$-\frac{1}{2}$
Reciprocals of intercept	3	2	-2
Enclosure	$(32\bar{2})$		

For plane B

x	y	z
$-\frac{a}{2}$	∞b	$\frac{c}{2}$
$-\frac{1}{2}$	∞	$\frac{1}{2}$
-2	0	2
Reduction		
-1	0	1

Enclosure $(\bar{1}01)$

جواب السؤال
Q5
فرع a)

$$2\theta = 27^\circ \therefore \theta = \frac{27}{2} = 23.5^\circ \quad , n = 1$$

$$2 d_{321} \sin\theta = n\lambda$$

$$d_{321} = \frac{1 \times 0.0711\,nm}{2 \sin 23.5} = 0.1523\,nm$$

The metal Rb has BCC crystal structure

$$a = d_{321}\sqrt{h^2+k^2+l^2} = 0.1523\sqrt{3^2+2^2+1^2}$$

$$= 0.1523\sqrt{14} = 0.57\,nm$$

$$R = \frac{a\sqrt{3}}{4} = \frac{0.57\sqrt{3}}{4} = 0.2468\,nm$$

جواب فرع b Q5

For elastic behavior when

$$\varepsilon(test) < \varepsilon(yield)$$

The deformation is elastic and the load can be measured

but if the deformation is plastic i.e

$\varepsilon(test) > \varepsilon(yield)$ the computation of the load is not possible.

$$\varepsilon(test) = \frac{\Delta l}{l_0} = \frac{7.6}{250} = 0.03$$

$$\varepsilon(yield) = \frac{\sigma_y}{E} = \frac{275}{103 \times 10^3} = 0.0027$$

Therefore the computation of load is not possible because $\varepsilon(test) > \varepsilon(yield)$.

جواب السؤال Q6 فرع a)

$\rho_{cu} = 8.9\ g/cm^3$ $A_{cu} = 63.55\ gm/mol$

$$n = \frac{\sigma}{|e|\mu_e} = \frac{6 \times 10^7}{1.602 \times 10^{-19} \times 0.003} = 1.25 \times 10^{29}\ m^{-3}$$

No. of free electron per cubic meter for Cu at room temp

$$N_{cu} = \frac{N_A\ \rho'}{A_{cu}}$$

$$N_{cu} = \frac{6.022 \times 10^{23} \times 8.9 \times 10^6}{63.55}$$

$$N_{cu} = 8.43 \times 10^{28}\ m^{-1}$$

No. of free electrons per copper atom.

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(جواب السؤال Q6
فرع b)

$$N_M \left(\frac{M}{100}\right)^2 = 2^{n-1}$$

$$N_M = 8 \quad M = 600$$

$$n = \frac{\log N_M + 2\log\left(\frac{M}{100}\right)}{\log 2} + 1$$

$$= \frac{\log 8 + 2\log\left(\frac{600}{100}\right)}{\log 2} + 1$$

$$= 9.2$$