110MM02

國立臺北科技大學 110 學年度碩士班招生考試

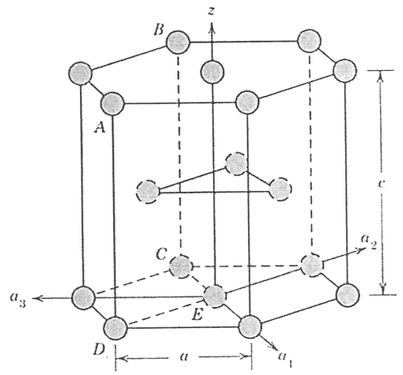
系所組別：3301 材料科學與工程研究所

第二節　材料科學與工程導論　試題（選考）

注意事項：

1. 本試題共九題，共 100 分。
2. 不必抄題，作答時請將試題題號及答案依照順序寫在答案卷上。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

1. Consider the following hexagonal closed-packed unit cell.
   (a) Determine the three-axis Miller index and four-axis Miller-Bravais index for the plane ABCD. (4%)
   (b) Determine the three-axis Miller index and four-axis Miller-Bravais index for the direction $\overrightarrow{AE}$. (4%)
   (c) Determine the planar packing fraction for the CDE plane. (4%)



2. (a) Why the critical resolved shear stress in a BCC (body-centered cubic) metal is higher than that in a FCC (face-centered cubic) metal? (3%)
   (b) A single crystal of a BCC metal is oriented such that the [120] direction is parallel to an applied tensile stress. If slip occurs on a (112) plane, and the critical resolved shear stress is 48 MPa, Compute the yield strength of the single crystal. (6%)
   (c) Is the (111) plane a possible slip plane in a BCC metals? Explain why. (3%)

3. (a) During the solidification of pure metal, what are the two energies involved in the transformation? (4%)
   (b) Write the equation for the total free-energy change involved in the solidification of liquid to produce a strain-free solid nucleus with a radius of R by homogeneous nucleation. (4%)
   (c) Describe and explain the change of the two energies during solidification transformation. (4%)

4. Consider the impurity diffusion of phosphorus into a silicon wafer. If phosphorus is diffused into a thick silicon wafer with no previous phosphorus in it at a temperature of 1100°C. If the surface concentration of the phosphorus is 1×10^{17} atoms/cm^3 and its concentration at a distance of 1.2 μm below the surface is 1×10^{15} atoms/cm^3, how long must be required for the impurity diffusion? The diffusion coefficient for phosphorus diffusing in silicon at 1100°C is 3.0×10^{-13} cm^2/s. (10%)

$$J = -D\frac{dC}{dx}$$

$$\frac{C_x - C_0}{C_s - C_0} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right)$$

z	$erf(z)$	z	$erf(z)$	z	$erf(z)$
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999

注意：背面尚有試題

5. For a copper alloy, the engineering yield strength is 170 MPa, the modulus of elasticity is 110 GPa, the engineering ultimate tensile strength is 280 MPa where the corresponding engineering strain 0.18, and the reduction in area just before fracture is measured to be 32%.
   (a) Estimate the engineering strain just before yield. (3%)
   (b) What is the corresponding true strain just before yield? (3%)
   (c) Determine the true stress corresponding to the engineering ultimate tensile strength. (3%)
   (d) Determine the true strain just before fracture. (3%)

6. How are the following factors that affect the recrystallization process in metals?
   (a) the degree of deformation (3%)
   (b) the initial grain size (3%)
   (c) the purity of the metal (3%)

7. (a) Describe the austempering process for a plain-carbon steel. (4%)
   (b) Draw an isothermal transformation diagram with a cooling curve for an austempered austenitized eutectoid plain-carbon steel. (4%)
   (c) What is the microstructure produced after austempering a eutectoid plain-carbon steel? (2%)

8. (a) Draw the unit cell of a CsCl crystal structure. (3%)
   (b) Calculate the density in grams per cubic centimeter of CsBr, which has the CsCl structure. (8%)
   Ionic radii are $Cs^+ = 0.165$ nm and $Br^- = 0.196$ nm, atomic weights are Cs = 132.9 g/mol and Br = 79.9 g/mol, Avogadro's number = 6.022×10^{23} atom/mol.

9. (a) Draw and describe the structure of a planar *npn* bipolar transistor. (6%)
   (b) Describe the flow of charge carriers when an *npn* bipolar junction transistor during the normal operation. (6%)