國立台灣科技大學九十六學年度碩士班招生試題

系所組別：　高分子工程系碩士班丁組

科　　目：　材料科學

共 9 大題，總分 100 分；請於答案卷內依序作答。

1. An x-ray diffractometer recorder chart for an element that has either the BCC or FCC crystal structure showed diffraction peaks at the following 2θ angles: 40.663°, 47.314°, 69.144° and 83.448°. (The wavelength λ of the incoming radiation was 0.15405 nm.)

(a) Determine the crystal structure of the element. 4%)

(b) Determine the lattice constant of the element. (4%)

(c) Identify the element. (2%)

2. A silicon wafer is doped with 7.0×1021 phosphorus atoms/m^3. Calculate

(a) The electron and hole concentrations after doping. (5%)

(b) The resultant electrical resistivity at 300 K. [Assume $ni = 1.5 \times 1016/\mathrm{m}^3$ and $\mu n = 0.1350\ \mathrm{m}^2/(\mathrm{V} \cdot \mathrm{s})$] (5%)

3. A polymeric material has a relaxation time of 100 days at 27°C when a stress of 6.0 MPa is applied.

(a) How many days will be required to decrease the stress to 4.2 MPa? (5%)

(b) What is the relaxation time at 40°C if the activation energy for this process is 25 kJ/mol? (5%)

4. For BCC iron, compute (a) the interplanar spacing and (b) the diffraction angle for the (220) set of planes. The lattice parameter for Fe is 0.2866 nm. Also, assume that monochromatic radiation having a wavelength of 0.1790 nm is used, and the order of reflection is 1. (20%)

5. Consider a parallel-plate capacitor having an area of $6.45 \times 10^{-4}\ \mathrm{m}^2$ (1 in^2) and a plate separation of 2×10^{-3} m (0.08 in.) across which a potential of 10 V is applied. If a material having a dielectric constant of 6.0 is positioned within the region between the plates, compute

(a) The capacitance.

(b) The magnitude of the charge stored on each plate.

(c) The dielectric displacement D.

(d) The polarization.

(20%)

Hint：The permittivity of a vacuum is 8.85×10^{-12} F/m

6. (7%) Many phase transformations involve nucleation and diffusion, in which the growth is thermally activated. Therefore, the overall growth rate is determined by activation free energy for homogeneous nucleation, as well as activation energy for diffusion.

(a) Deduce and point out two variables of materials, affecting the activation free energy for nucleation. (Hint: Start from the total free energy change due to phase change in bulk and the creation of an interface between two phases. And the nucleation occurs spontaneously as the total free energy change reaches the minimal.)

(b) How does the temperature influence the activation free energy for nucleation? [Hint: (free energy driving-force) = (equilibrium enthalpy change) – (temperature) x (equilibrium entropy change)]

(c) Give a real example of diffusionless (i.e., activation energy of diffusion= 0 = activation free energy for nucleation) phase transformation.

7. (8%) Silicon (Si) crystal has the diamond cubic structure, where each atom is coordinated by four other atoms. A unit cell is composed of two FCC lattices displaced from each other by 1/4 of a body diagonal. Lattice constant= 5.431 Angstroms. Atomic weight= 28.09.

(a) Find the total number of atoms per unit cell.

(b) Find the mass density.

(d) Find the least diffraction angle for (111) crystal plane bombarded by X rays with wavelength= 0.154 nm.

8. (8%) The energy gap for intrinsic semiconductor Si is 1.21 eV, and the electrical conductivity at room temperature 4.3 X 10^{-4} (ohm-m)$^{-1}$. 1 eV= 1.6 X 10^{-19} J. Boltzmann constant= 1.381 X 10^{-23} J/K. charge of electron= 1.602 x 10^{-19} C

(a) Explain the meaning of energy gap.

(b) Predict the electrical conductivity at 350 K.

(c) Given mobility of electron and hole is 0.135 and 0.048 $m^2/(V\text{-}s)$, respectively. Find the electron density (i.e., number of electrons per unit volume).

國立台灣科技大學九十六學年度碩士班招生試題

系所組別：高分子工程系碩士班丁組

科　　目：材料科學

9. (7%) An aluminum crystal has a shear modulus G and dislocates with a Burgers displacement vector b.

(a) Explain the meanings of edge and screw dislocations, two types of line defects in crystalline solids.

(b) Show graphically the Burgers vector in atomic arrangement in screw dislocation.

(c) How does the elastic strain energy due to screw dislocation vary with G and b? (Suppose the ratio of distortion for all single crystals is constant.)