MT 250 Metallurgical Concepts

Physical Metallurgy

Examination (31.10.03)

Answer all the questions in 90 minutes. Each question carries 4 points.

1. In the Ag-Cu phase diagram (from T.E. Reed-Hill and R. Abbaschian: Physical Metallurgy Principles, Third Edition, p.342)
   (a) Identify the points/lines in this diagram where the number of degrees of freedom (in the modified Gibbs phase rule for condensed systems) is zero.
   (b) At 800 C, identify the phases in an equilibrated alloy with 15 weight % Cu. Also, estimate the amount of each phase in this alloy.
   (c) At 600and 800 C, identify the phases in an equilibrated alloy with 70 weight % Cu.

2. Consider a fine-grained metal, in which the average grain diameter is about one micron. Assuming a grain boundary energy of the metal is 0.5 Jm^{-2}, estimate the energy stored (in 1 mole of the metal) in the form of grain boundaries. Assume a molar volume of 10^{-3} m^3 mol^{-1}.

3. Calculate ρ_a, the number of atoms per unit area, for the (100) and (111) planes in an *fcc* metal; assume a lattice parameter of 0.4 nm.

   Calculate d, the interplanar spacing, for these two planes.

   Show that the total number of atoms per unit volume ($\rho_v = \rho_a/d$) is the same in both cases.

4. A piece of aluminium is deformed at room temperature to a plastic strain of more than 50 %. On annealing at 400 K , it undergoes complete recrystallization in about an hour. Draw a schematic plot of fraction of recrystallized grains as a function of time. In the same figure, plot the curve for an annealing experiment carried out at 500 K.

   Draw a schematic plot of hardness as a function of annealing time for two different annealing temperatures, 400 K and 500 K.

5. The equilibrium vacancy concentration in copper is about 10^{-3} at 1350 (just six degrees below its melting point). Calculate the temperature at which the equilibrium vacancy concentration drops to:
   (a) 10^{-6}
   (b) 10^{-9}