MAE 212: Spring 2001

HW 6

Due Thursday, March 8

1. Consider the gas carburizing of a gear of 1020 steel at 927^o C (1700^o F). Calculate the time in minutes necessary to increase the carbon content to 0.40% at 0.50 mm below the surface. Assume that the carbon content at the surface is 0.90% and that the steel has a nominal carbon content of 0.2%. The diffusivity (diffusion coefficient) is given as $D_{927^oC} = 1.28\ 10^{-11}\ \ \mathrm{m^2/s}$.

2. Consider the gas carburizing of a gear of 1020 steel (1700^o F) as in the earlier problem. Only in this problem calculate the carbon content at 0.50 mm beneath the surface of the gear after 5 hrs carburizing time. Assume that the carbon content of the surface of the gear is 0.9% and that the steel has a nominal carbon content of 0.20%.

3. The diffusivity of silver atoms in solid silver is $1.0\ 10^{-17}\ \ \mathrm{m^2/s}$ at 500^o C and $7.0\ 10^{-13}$ $\mathrm{m^2/s}$ at 1000^o C. Calculate the activation energy (joules per mole) for the diffusion of Ag in Ag in the temperature range 500 to 1000^o C.

4. Consider the impurity diffusion of gallium into a silicon wafer. If gallium is diffused into a silicon wafer with no previous gallium in it at a temperature of 1100^o C for 3 hrs, what is the depth below the surface at which the concentration is 10^{22} atoms/m^3 if the surface concentration is 10^{24} atoms/m^3? For gallium diffusing into silicon at 1100^o C , the diffusion coefficient is given as $D_{1100^oC} = 7.0\ 10^{-17}\ \ \mathrm{m^2/s}$.

5. Derive expressions for the Burger's vectors in terms of the lattice parameter, a, for FCC and BCC materials. For copper (an FCC material with $a = 0.1278$ nm) calculate the magnitude and direction of the Burger's vector.

6. A molybdenum (Mo) crystal has a Burger's vector of length 0.272 nm. If the lattice parameter, a, of Mo is 0.314 nm, determine its crystal structure (i.e. FCC, BCC or HCP ?).

7. The energy necessary to generate a dislocation is proportional to the square of the length of the Burgers vector, $|b|^2$. This means that the most stable (lowest energy) dislocations have the minimum length, $|b|$. For the BCC metal structure, calculate (relative to $E_{b=[111]}$) the dislocation energies for (a) $E_{b=[110]}$ and (b) $E_{b=[100]}$ (problem 4.21 from the text).

8. Show that a dislocation in a BCC structure with a Burgers vector equal to $a < 110 >$ is energetically unstable and will split into two $\frac{a}{2} < 111 >$ dislocations by the following reaction:

$$a[110] \rightarrow \frac{a}{2}\ [111] + \frac{a}{2}\ [11\bar{1}]$$

9. You are designing a turbine engine part made of an FCC single crystal. By using the Schmid law, determine the τ_c necessary for the part to have a uniaxial yield strength of 200 MPa in the [331] crystallographic direction?