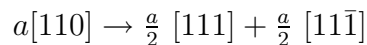


MAE 212: Spring 2001

HW 6

Due Thursday, March 8

1. Consider the gas carburizing of a gear of 1020 steel at  $927^\circ\text{C}$  ( $1700^\circ\text{F}$ ). 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  $D_{927^\circ\text{C}} = 1.28 \cdot 10^{-11} \text{ m}^2/\text{s}$ .
2. Consider the gas carburizing of a gear of 1020 steel ( $1700^\circ\text{F}$ ) 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  $1.0 \cdot 10^{-17} \text{ m}^2/\text{s}$  at  $500^\circ\text{C}$  and  $7.0 \cdot 10^{-13} \text{ m}^2/\text{s}$  at  $1000^\circ\text{C}$ . Calculate the activation energy (joules per mole) for the diffusion of Ag in Ag in the temperature range 500 to  $1000^\circ\text{C}$ .
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  $1100^\circ\text{C}$  for 3 hrs, what is the depth below the surface at which the concentration is  $10^{22} \text{ atoms/m}^3$  if the surface concentration is  $10^{24} \text{ atoms/m}^3$ ? For gallium diffusing into silicon at  $1100^\circ\text{C}$ , the diffusion coefficient is given as  $D_{1100^\circ\text{C}} = 7.0 \cdot 10^{-17} \text{ m}^2/\text{s}$ .
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  $a = 0.1278 \text{ nm}$ ) 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:



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