MAE 212
Spring 2001

HW 4

Due Thursday, February 21

1. Draw the plane $(\bar{2}111)$ and direction $[10\bar{1}0]$ in a hexagonal lattice. What is the plane normal to the direction $[10\bar{1}0]$ and why?

2. (a) Derive the relation between the lattice parameter a and the atomic radius r for fcc, bcc and hcp metal structures. (b) The atomic diameter of an atom of nickel is 0.2492 nm. Calculate the lattice constant a of fcc nickel. (c) The atomic diameter of an atom of iron is 0.2482 nm. Calculate the lattice constant a of bcc iron.

3. (a) Show that the c/a ratio (height of unit cell divided by its edge length) is 1.633 for the ideal hcp structure. (b) Comment on the fact that real hcp metals display c/a ratios varying from 1.58 (for Be) to 1.89 (for Cd) (Problem 3.11 from the Text).

4. Calculate the atomic packing factor of 0.68 for the bcc metal structure, 0.74 for the fcc metal structure and 0.74 for the hcp metal structure (Problems 3.8, 3.9 and 3.10 from the Text – and also in the lecture notes!).

5. The atomic weight of nickel is 58.71 $Kg\ Kmol^{-1}$. Calculate the density of nickel (calculate first the mass per atom, and the number of atoms in a unit cell).

6. The atomic weight of iron is 55.85 $Kg\ Kmol^{-1}$. Calculate the density of iron.

7. Calculate the planar density of atoms in the (111) plane of (a) bcc iron and (b) fcc nickel.

8. Show that the true strain, defined as $\epsilon = ln(\frac{l}{l_o})$ for uniform deformation, may also be expressed by any of the following:

$$\epsilon = ln(\frac{l}{l_o}) = ln(\frac{A_o}{A}) = 2ln(\frac{D_o}{D}) = ln(\frac{1}{1-r}) \tag{1}$$

   where l_o, A_o, and D_o are initial values of length, area, and diameter; l, A and D are instantaneous values; and r is the reduction of area defined as

$$r = \frac{A_o - A}{A_o} \tag{2}$$

9. Show that in a tensile test $\epsilon = ln(1 + e)$ and $\sigma = S(1 + e)$. Discuss the practical limitations of these relationships.

10. During a tensile test with a metal that obeys $\sigma = K\epsilon^n$, the tensile strength (recall that tensile strength is the (ultimate) maximum engineering stress) is found to be 340 MPa. Reaching the maximum load required an elongation of 30%. From this limited information, find K and n.

11. A tensile specimen is machined to a gage diameter of 0.357-in and is marked with a starting gage length of 2-in. When subjected to a test, the following results were found:

    - yield load = 2,000 lbf
    - fracture diameter = 0.27-in
    - diameter at ultimate load = 0.31-in
    - elastic modulus = 25×10^6 psi

    After completing this test, you are informed that the tensile specimen had been cold-worked some amount before it was machined and tested, and that in the annealed state $\sigma = K\epsilon^n$ with n=0.5.

    - What is the yield strength Y for this specimen?
    - How much strain was induced by the unknown amount of cold work?
    - What maximum load (i.e. F_u) was reached during the test?

    p.s. This problem was given in all three MAE212 exams in 2000!

12. An annealed brass specimen of 0.505-in starting diameter supports a maximum tensile load of 120,000-lbf at which point the initial area is reduced by 40%. If a second identical specimen were loaded until the induced strain was half the magnitude of n, what load would be needed to reach this condition?