

MECH 6301/MSEN 6310 Homework Assignments

1. Homework I: Chapter 1: 1.1, 1.3, 1.4, 1.7 (Due Sept. 1, 2010)
2. Homework II: Chapter 2: 2.2 [Plus two attached supplemental Problems 2 and 3] (Due Sept. 13, 2010)
3. Homework III: Chapter 2, 3: 2.8 [Plus attached supplemental Problem 2], 3.11, 3.14 (Due Sept. 22, 2010)
4. Homework IV: Chapter 4: 4.4, 4.8, 4.10, 4.14, 4.20, 4.37 (Due Oct. 4, 2010)
5. Homework V: Chapter 5: 5.4, 5.5, 5.24, 5.25, 5.41 (Due Oct. 18, 2010)
6. Homework VI: Chapter 6: 6.1, 6.9, 6.16, 6.33, 6.47, 6.51 (Due Oct. 27, 2010)
7. Homework VII: Chapter 7: 7.1, 7.5, 7.7, 7.14, 7.22 (Due Nov. 3, 2010)
8. Homework VIII: Chapter 8: 8.1, 8.6, 8.8, 8.12, 8.20, 8.27 (Due Nov. 22, 2010)
9. Homework IX: Chapter 9, 15: 9.4 (Just approximate values for σ'_f and b for 9.4 (b)), 9.21, 9.22, 9.40, 15.12 (Use MAR-M200 with a larger grain size and Eqn: 15.5 for 15.12 (c)), 15.13, 15.17 (Due Dec. 6, 2010)

Supplemental Problems

Homework II

Problem 2:

The net potential energy between two adjacent ions, E_N , may be represented by the equation

$$E_N = -\frac{A}{r} + \frac{B}{r^n} \quad \text{Eqn. 1}$$

where the first term on the right $-A/r$ represents the attractive energy and the second term on the right B/r^n represents the repulsive energy. The force can be derived from this equation by differentiating E_N with respect to r .

- A) Differentiate E_N with respect to r to determine an expression for the force.
- B) Solve for the equilibrium spacing r_o in terms of A , B , and n where the force would equal zero.
- C) Calculate the equilibrium bonding energy E_o by substituting r_o into Eqn. 1.
- D) Calculate r_o for a $\text{Na}^+\text{-Cl}^-$ ion pair by taking $A = 1.436 \text{ eV}\cdot\text{nm}$, $B = 7.32 \times 10^{-6} \text{ eV}\cdot\text{nm}^8$, and $n = 8$ where eV is an energy term represented by the energy required to raise one electronic charge (1.6×10^{-19} coul) one volt equal to 1.6×10^{-19} joules.
- E) Finally, calculate the equilibrium bonding energy E_o .
- F) Plot up E_N versus r using axes given in eV and nm and compare the r_o and E_o approximated from this plot to the calculated results.

Problem 3:

The yield strength versus the grain size varies by the Hall-Petch equation for many different materials according to the relation

$$\sigma_o = A + Bd^{1/2}$$

where the yield stress is shown to increase with decreasing grain size. In effect, the grain boundaries act as a barrier to dislocation movement across the material causing an increase in yield strength. These parameters for 70 Cu-30 Zn cartridge brass are $A = 25 \text{ MPa}$ and $B = 12.5 \text{ MPa}(\text{mm})^{1/2}$.

- A) Plot up yield stress versus grain size. Plot grain size as $d^{-1/2}$ ($\text{mm}^{-1/2}$) from $1.0 \times 10^{-3} \text{ mm}$ to 1 mm with actual grain size plotted on the opposite axis to $d^{-1/2}$ to better visualize the results.
- B) Determine the yield stress for this alloy when the average grain size equals $2.0 \times 10^{-3} \text{ mm}$.

Homework III

Problem 2:

The elastic modulus can be determined from the relation

$$E = \frac{x_e}{A} \cdot \left. \frac{dP}{dx} \right|_{x=x_e} \quad \text{Eqn. 2.2}$$

where x_e is the equilibrium spacing, A the area of the bond, and $\frac{dP}{dx}$ the slope of the interatomic force with distance. Using the equation for the net potential energy given in Eqn 1 in Homework II Problem 2 with the parameters defined for NaCl in Part D, calculate the elastic modulus for NaCl. Use the equilibrium spacing r_o calculated in Part D of that problem for x_e and determine the bond area by using the area πr_o^2 . Note that the coordination number in the NaCl rock salt structure is six so the resultant value from this calculation must be divided by six to give the elastic modulus. Compare to the average elastic modulus for polycrystalline NaCl of 39.96 GPa.