MAE 212: Spring 2001

HW 7

Due Thursday, March 15

1. Several tensile specimens of an FCC metal in single crystal form are machined with the tensile axis in the following directions:

Specimen	Tensile Axis
1	[100]
2	[110]
3	[211]

   (a) Determine the Schmid factors for <u>all</u> 12 slip systems for each specimen.

   (b) Which specimen will have the largest macroscopic yield strength?

   (c) The material is copper with internal resistance force $f = 0.012$ N/m. Calculate the macroscopic yield strength for specimen 3? (Hint: get the magnitude of Burgers vector from Problem 5 of HW 6).

2. It is found that the prevalent slip systems in HCP materials are $(0001)[11\bar{2}0]$ referred to as basal slip or $(10\bar{1}0)[1\bar{2}10]$ called prismatic slip or $(\bar{1}011)[11\bar{2}3]$ referred to as pyramidal slip. (a) Show the orientations of the slip planes and directions (b) Verify that the given slip directions lie within the given slip planes.

3. The critical shear stress τ_c for the $< \bar{1}10 > \{111\}$ slip system of pure copper was found to be 1 MPa (145 psi). (a) What stress σ must be applied in the [001] direction to produce slip in the [101] direction on the $(\bar{1}11)$ plane? (b) In the [110] direction on the $(\bar{1}11)$ plane?

4. Both $[01\bar{1}]$ and $[11\bar{2}]$ lie in the (111) plane of FCC aluminum. Therefore, both $[01\bar{1}](111)$ and $[11\bar{2}](111)$ slip are conceivable. (a) Make a sketch of the (111) plane and show the $[01\bar{1}]$ and $[11\bar{2}]$ unit slip vectors (b) Compare the energies of the dislocation lines that have these two displacement vectors.

5. Calculate the resolved shear stress on the $(111)[0\bar{1}1]$ slip system of a unit cell in an FCC nickel crystal if a stress of 13.7 MPa is applied in the [001] direction of a unit cell.

6. If a crystal with a dislocation density of 10^9 cm/cm^3 is deformed at a shear strain rate of 10^{-3} per second, (a) what is the average dislocation velocity and (b) At what strain rate will the dislocation velocity approach the velocity of sound ($= 10^5$ cm/sec), the upper limit of the dislocation velocity? It is given that $|b| = 2\ 10^{-8}$ cm.

7. Describe the difference between slip and twinning (read about twinning in your textbook!).

8. (a) Derive an expression for the shear stress τ needed to bow a dislocation line into a semicircle between small hard articles a distance L apart.
(b) A polycrystalline aluminum alloy contains a dispersion of hard particles of diameter 10^{-8} m and average center-to-center spacing of 6×10^{-8} m measured in the slip planes. Estimate their contribution to the tensile yield strength Y of the alloy.
(c) The alloy is used for the compressor blades of a small turbine. Adiabatic heating raises the blade temperature to 150^o C, and causes the particles to coarsen slowly. After 1000 hrs they have grown to a diameter of 3×10^{-8} m and are spaced 18×10^{-8} m apart. Estimate the drop in yield strength (the shear modulus of Aluminum is 26 GN m^{-2} and $b = 0.286$ nm).