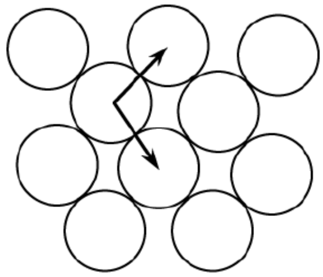
Homework #10

Due Nov 13

8.7 Below is shown the atomic packing for a BCC {110} type plane. The arrows indicate two different <111> type directions.



8.11 We are asked to compute the critical resolved shear stress for Zn. As stipulated in the problem, ϕ = 65°, while possible values for λ are 30°, 48°, and 78°.

(a) Slip will occur along that direction for which ($\cos\phi\cos\lambda$) is a maximum, or, in this case, for the largest $\cos\lambda$. The cosines for the possible λ values are given below.

$$\cos(30°) = 0.87$$
$$\cos(48°) = 0.67$$
$$\cos(78°) = 0.21$$

Thus, the slip direction is at an angle of 30° with the tensile axis.

(b) From Equation 8.3, the critical resolved shear stress is just

$$\tau_{crss} = \sigma_y (\cos\phi\cos\lambda)_{max}$$

$$= (2.5\text{ MPa})\left[\cos(65°)\cos(30°)\right] = 0.90\text{ MPa} \quad (130\text{ psi})$$

8.18 Small-angle grain boundaries are not as effective in interfering with the slip process as are high-angle grain boundaries because there is not as much crystallographic misalignment in the grain boundary region for small-angle, and therefore not as much change in slip direction.

8.20 These three strengthening mechanisms are described in Sections 8.9, 8.10, and 8.11.

8.21 (a) Perhaps the easiest way to solve for σ_0 and k_y in Equation 8.6 is to pick two values each of σ_y and $d^{-1/2}$ from Figure 8.15, and then solve two simultaneous equations, which may be set up. For example

$d^{-1/2}$ (mm) $^{-1/2}$	σ_y (MPa)
4	75
12	175

The two equations are thus

$$75 = \sigma_0 + 4k_y$$

$$175 = \sigma_0 + 12k_y$$

These yield the values of

$$k_y = 12.5 \text{ MPa}(\text{mm})^{1/2} \quad \left[1810 \text{ psi}(\text{mm})^{1/2}\right]$$

$$\sigma_0 = 25 \text{ MPa} \quad (3630 \text{ psi})$$

(b) When $d = 1.0 \times 10^{-3}$ mm, $d^{-1/2} = 31.6 \text{ mm}^{-1/2}$, and, using Equation 8.6,

$$\sigma_y = \sigma_0 + k_y d^{-1/2}$$

$$= (25 \text{ MPa}) + \left[12.5 \text{ MPa}(\text{mm})^{1/2}\right]\left(31.6 \text{ mm}^{-1/2}\right) = 420 \text{ MPa} \quad (61,000 \text{ psi})$$

8.26 In order for these two cylindrical specimens to have the same deformed hardness, they must be deformed to the same percent cold work. For the first specimen

$$\%\text{CW} = \frac{A_0 - A_d}{A_0} \times 100 = \frac{\pi r_0^2 - \pi r_d^2}{\pi r_0^2} \times 100$$

$$= \frac{\pi(15 \text{ mm})^2 - \pi(12 \text{ mm})^2}{\pi(15 \text{ mm})^2} \times 100 = 36\%\text{CW}$$

For the second specimen, the deformed radius is computed using the above equation and solving for r_d as

$$r_d = r_0\sqrt{1 - \frac{\%\text{CW}}{100}}$$

$$= (11 \text{ mm})\sqrt{1 - \frac{36\%CW}{100}} = 8.80 \text{ mm}$$

8.31 For recovery, there is some relief of internal strain energy by dislocation motion; however, there are virtually no changes in either the grain structure or mechanical characteristics. During recrystallization, on the other hand, a new set of strain-free grains forms, and the material becomes softer and more ductile.

8.34 (a) The driving force for recrystallization is the difference in internal energy between the strained and unstrained material.

(b) The driving force for grain growth is the reduction in grain boundary energy as the total grain boundary area decreases.

8.37 Yes, it is possible to reduce the average grain diameter of an undeformed alloy specimen from 0.050 mm to 0.020 mm. In order to do this, plastically deform the material at room temperature (i.e., cold work it), and then anneal at an elevated temperature in order to allow recrystallization and some grain growth to occur until the average grain diameter is 0.020 mm.

8.41 (a) and (b) The mechanisms by which semicrystalline polymers elastically and plastically deform are described in Section 8.17.

(c) The explanation of the mechanism by which elastomers elastically deform is provided in Section 8.19.

8.43 (a) The tensile strength of a semicrystalline polymer increases with increasing molecular weight. This effect is explained by increased chain entanglements at higher molecular weights.

(b) Increasing the degree of crystallinity of a semicrystalline polymer leads to an enhancement of the tensile strength. Again, this is due to enhanced interchain bonding and forces; in response to applied stresses, interchain motions are thus inhibited.

(c) Deformation by drawing increases the tensile strength of a semicrystalline polymer. This effect is due to the highly oriented chain structure that is produced by drawing, which gives rise to higher interchain secondary bonding forces.

(d) Annealing an undeformed semicrystalline polymer produces an increase in its tensile strength.