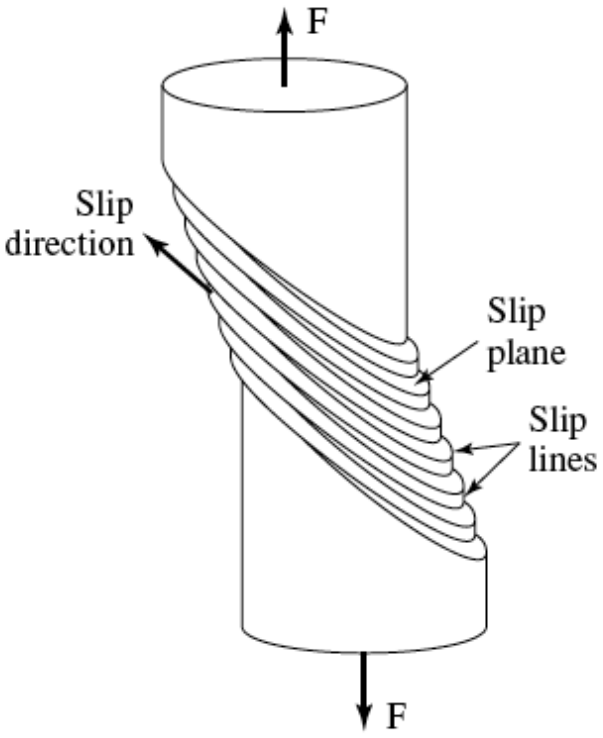
CME 300 Properties of Materials

Homework 2 September 28, 2011

1) Explain why metals are ductile and ceramics are brittle. Why are FCC metals ductile, HCP metals brittle and BCC metals tough.

2) Why does slip occur along approximately a 45° angle in the following picture?



3) The symbol for a Burgers vector is an upside down T. Explain the meaning of this symbol using an edge dislocation.

4) Explain strain hardening in an FCC metal like copper.

5) Why does twinning mostly occur in HCP metals like zinc?

6) BCC metals display a thermal dependence for the critical resolved shear stress shown in figure 3.23 below. Write an equation for this behavior ($\tau_0 = f(T)$) and explain the terms including a definition of τ_0. Why do BCC metals differ from FCC and HCP metals in terms of this thermal dependence?

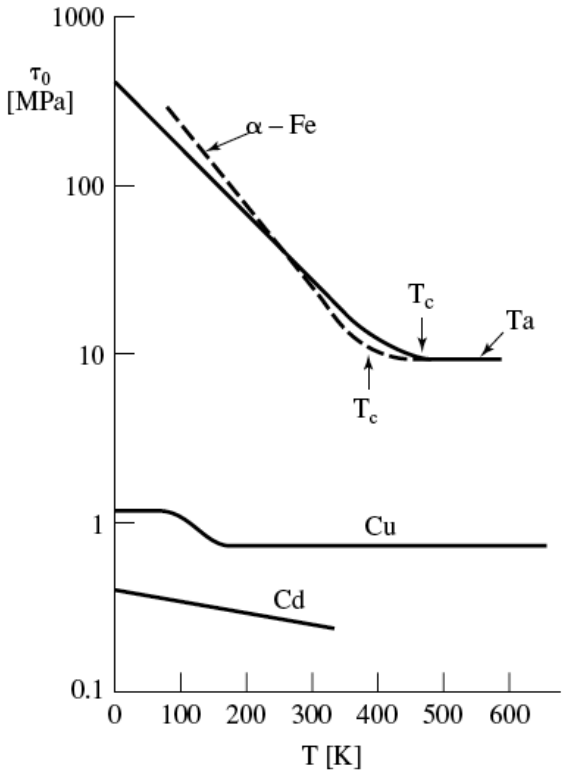


FIGURE 3.23. Schematic representation of the temperature-dependence of the critical resolved shear stress, τ_0, for Ta (BCC), α-Fe (BCC), Cu (FCC), and Cd (HCP) single crystals. Since τ_0 depends strongly on the crystal orientation, an *average orientation* has been chosen. Specifically, the tensile direction has about the same angle to the [100], [110], and [111] crystal axes. Note the logarithmic scale on the *y* axis.

7) Synthetic polymers in the melt are described as random coils, meaning that there is little regular organization of the chain structure. In order for crystallization to occur in these chain molecules what sequence of steps must be followed?

8) Describe a dilute solution polymer crystal. Why do polymers not crystallize in cubic lattices like metals?

9) Explain the following plot:

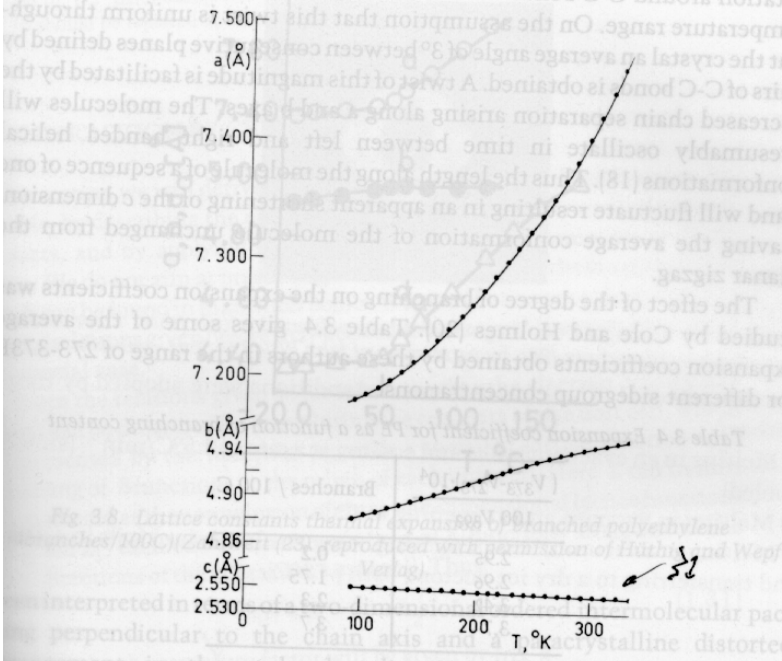


Fig. 3.7. Lattice constants thermal expansion for linear polyethylene (Davis et al.,24)

10) Derive the Gibbs-Thompson equation for a cubic crystal such as NaCl. In solution nanoparticles can be made by a chemical reaction that results in a rapid rise in a crystallizing species followed by rapid depletion of the species. Explain this in terms of the Gibbs-Thompson equation.

11) A sheet of aluminum is shown below. Explain how the striations in the image are formed and how they relate to the FCC crystal structures we discussed in class.

12) Guess at the origin of the Hall-Petch relationship based on your understanding of yielding in metals. First explain why yielding occurs, then how grains could impact yielding in a polycrystalline sample compared to a single crystal, then indicate a possible origin for the particular functionality in the Hall-Petch relationship, 1/(normalized yield stress).