Department of Materials Science and Engineering
Massachusetts Institute of Technology
3.14 Physical Metallurgy – Fall 2003

Problem Set #8

Due Wednesday, November 26, 2003

8.1 Problem 21.2

The next four questions deal with the determination of the theoretical fracture stress for cleavage on the (100) plane in both iron and tungsten. An interatomic potential for each is given below, as well as other information that may be necessary in determining the theoretical fracture stress.

8.2 The first step is to determine the energy-separation curve for Fe.
a. Plot the interatomic potential for Fe.
b. Identify the mean interatomic distance across the fracture plane (100) at zero stress (in class we called this r_o, your book calls it d).

8.3 The next step is to determine the properties of the cleavage plane.
a. Calculate the bond density in the fracture plane.
b. Calculate the surface energy for the (100) plane ($= \gamma$). Hint: This is the energy of all of the bonds that must be broken to create this surface.

8.4 Finally, calculate the theoretical fracture stress for cleavage for two different scenarios:
a. With no flaws present
b. With a 5 μm long Griffith crack (Figure 22.3). This is about the smallest size crack that you could detect with an optical microscope. The microscope will not tell you the radius of curvature at the tip, so you will need to make a reasonable assumption for it.

8.5 Repeat the calculations (interatomic distance, surface energy, and theoretical fracture stresses) for tungsten. Compare your results to those for Fe and explain the reason for any differences you find.

Interatomic potentials

The form of the potential is:

$$E = D\left[e^{-2\alpha(r_j - r')} - 2e^{-\alpha(r_j - r')}\right]$$

where r_j is the separation between atoms, and E is the energy that results from this separation.

The values of the other variables are given below:

Metal	α (Å^{-1})	r' (Å)	D (eV)
Fe	1.3885	2.845	0.4174
W	1.4116	3.032	0.9906

Useful information

E_{100} of Fe = 125 GPa

E_{100} of W = 385 GPa