3.091 Fall Term 2004

Homework Quiz #8A

solution outline

(a) Metals yield at stresses much lower than those calculated on the basis of bond strength alone. This is explained by the presence of defects. Name the principal defect responsible and explain how it acts to lower the stress needed for plastic deformation.

Dislocations are principally responsible.

In the case of shear, for example, the presence of dislocations obviates the need to break all bonds along the shear face and instead facilitates the transfer of stress via sequential bonding breaking.

(b) A specimen of nickel powder is studied by x-ray diffractometry. The sample is irradiated with Cr K_α radiation, which has a wavelength, λ, of 2.29 Å. Only three diffraction peaks are observed in total: (111), (200), and (220). Explain why reflections from planes of higher Miller index are not observed. The lattice constant, a, for nickel is 3.53 Å.

Ni is FCC, so the next plane in the sequence of reflections is (311)

let's use Bragg's Law, $\lambda = 2\, d_{hkl} \sin\theta$ to determine the angle of reflection for (311)

$$d_{311} = \frac{a}{\sqrt{3^2 + 1^2 + 1^2}} = \frac{3.53}{\sqrt{11}} = 1.06 \text{ Å}$$

$$\lambda = 2\, d_{hkl} \sin\theta$$

$$\therefore \quad \theta = \sin^{-1}\left(\frac{\lambda}{2 \times d_{hkl}}\right) = \sin^{-1}\left(\frac{2.29}{2 \times 1.06}\right) = \sin^{-1}(1.08) = \textit{undefined}$$

Thus, the only way to measure reflections from planes of higher Miller index than (220) is to change the target in the x-ray generator to a heavier element in order to decrease the wavelength of the radiation. In this way, it is possible to satisfy Bragg's Law.