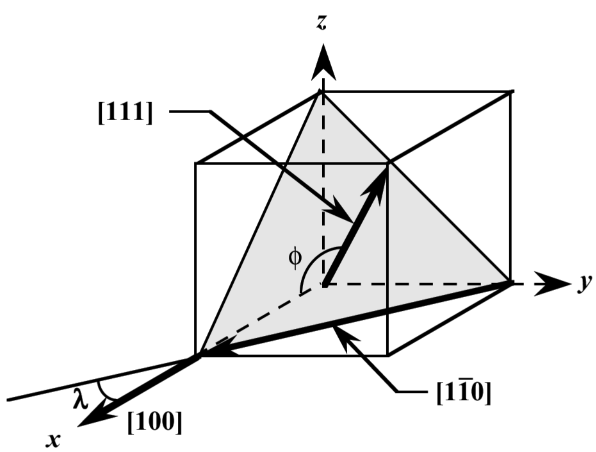
7.11 *Sometimes cos ϕ cos λ in Equation 7.2 is termed the Schmid factor. Determine the magnitude of the Schmid factor for an FCC single crystal oriented with its* [*100*] *direction parallel to the loading axis.*

Solution

We are asked to compute the *Schmid factor* for an FCC crystal oriented with its [100] direction parallel to the loading axis. With this scheme, slip may occur on the (111) plane and in the $[1\bar{1}0]$ direction as noted in the figure below.



The angle between the [100] and $[1\bar{1}0]$ directions, λ, may be determined using Equation 7.6

$$\lambda = \cos^{-1}\left[\frac{u_1u_2 + v_1v_2 + w_1w_2}{\sqrt{\left(u_1^2 + v_1^2 + w_1^2\right)\left(u_2^2 + v_2^2 + w_2^2\right)}}\right]$$

where (for [100]) $u_1 = 1$, $v_1 = 0$, $w_1 = 0$, and (for $[1\bar{1}0]$) $u_2 = 1$, $v_2 = -1$, $w_2 = 0$. Therefore, λ is equal to

$$\lambda = \cos^{-1}\left[\frac{(1)(1) + (0)(-1) + (0)(0)}{\sqrt{\left[(1)^2 + (0)^2 + (0)^2\right]\left[(1)^2 + (-1)^2 + (0)^2\right]}}\right]$$

$$= \cos^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45°$$

Now, the angle ϕ is equal to the angle between the normal to the (111) plane (which is the [111] direction), and the [100] direction. Again from Equation 7.6, and for $u_1 = 1$, $v_1 = 1$, $w_1 = 1$, and $u_2 = 1$, $v_2 = 0$, and $w_2 = 0$, we have

$$\phi = \cos^{-1}\left[\frac{(1)(1) + (1)(0) + (1)(0)}{\sqrt{\left[(1)^2 + (1)^2 + (1)^2\right]\left[(1)^2 + (0)^2 + (0)^2\right]}}\right]$$

$$= \cos^{-1}\left(\frac{1}{\sqrt{3}}\right) = 54.7°$$

Therefore, the Schmid factor is equal to

$$\cos\lambda \cos\phi = \cos(45°)\cos(54.7°) = \left(\frac{1}{\sqrt{2}}\right)\left(\frac{1}{\sqrt{3}}\right) = 0.408$$

7.13 *A single crystal of aluminum is oriented for a tensile test such that its slip plane normal makes an angle of 28.1° with the tensile axis. Three possible slip directions make angles of 62.4°, 72.0°, and 81.1° with the same tensile axis.*

(a) Which of these three slip directions is most favored?

(b) If plastic deformation begins at a tensile stress of 1.95 MPa (280 psi), determine the critical resolved shear stress for aluminum.

Solution

We are asked to compute the critical resolved shear stress for Al. As stipulated in the problem, ϕ = 28.1°, while possible values for λ are 62.4°, 72.0°, and 81.1°.

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

$$\cos(62.4°) = 0.46$$

$$\cos(72.0°) = 0.31$$

$$\cos(81.1°) = 0.15$$

Thus, the slip direction is at an angle of 62.4° with the tensile axis.

(b) From Equation 7.4, the critical resolved shear stress is just

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

$$= (1.95\text{ MPa})\left[\cos(28.1°) \cos(62.4°)\right] = 0.80\text{ MPa} \quad (114\text{ psi})$$