PROBLEMS

17.1 With the aid of Appendix B and Appendix E, make a sketch similar to that in Fig. 17.13 for $\{10\bar{1}2\}$ twinning in cadmium.

17.2 Now make an equivalent sketch for $\{10\bar{1}1\}$ twinning in titanium.

17.3 Compute the twinning shears associated with $\{10\bar{1}2\}$ twinning in cadmium and $\{10\bar{1}1\}$ twinning in titanium.

17.4 **(a)** Consider the $\{10\bar{1}1\}$ and $\{10\bar{1}3\}$ twinning systems that have been observed in magnesium. These are called *reciprocal twins*. Examine Appendix E and determine the significance of this designation for the two twinning systems.

(b) Determine the twinning shear for these two types of twins in magnesium.

17.5 Considering both the $\{10\bar{1}1\}$ and $\{10\bar{1}3\}$ twinning systems in magnesium, would you expect them to form under either a tensile or a compressive stress applied to a magnesium crysal along the direction of its basal plane pole? Explain.

17.6 Appendix E lists the twinning elements for body-centered cubic metals such as iron, as K_1 $\{112\}$, $\eta_1\langle 11\bar{1}\rangle$, K_2 $\{11\bar{2}\}$, and $\eta_2\langle 111\rangle$.

(a) How many different $\{112\}$ twinning planes are there in a body-centered cubic crystal?

(b) Make a list showing the (specific) twinning elements for each of the bcc $\{112\}$ twinning modes.

17.7 In fcc metals the twinning plane is $\{111\}$.

(a) On how many planes of an fcc crystal can twins form?

(b) How many twinning systems are there in an fcc crystal?

(c) List the (specific) twinning elements for each of the fcc $\{111\}$ twins.

17.8 In the case of badly deformed fcc and bcc crystals, what is the maximum number of different twin traces that one should expect to find?

17.9 Plot the $\{111\}$ poles on a standard (100) stereographic projection of a cubic crystal. Assume that twinning occurs with (111) as K_1 and with $(11\bar{1})$ as K_2, and draw on the diagram the great circle corresponding to the twinning plane. Next, plot on the stereographic projection the directions corresponding to η_1 and η_2. Label all the plotted data with the proper Miller indices.

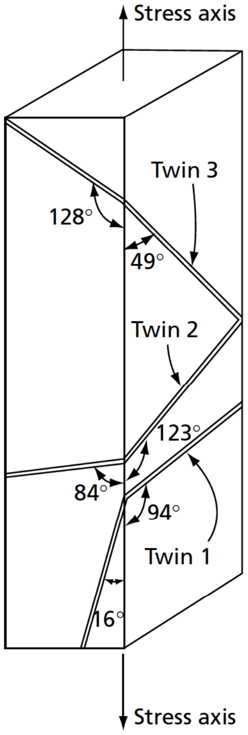
(a) On the assumption that the twin forms as a twin of the first kind, rotate the data plotted in the stereographic projection into the orientations that they will assume in the twin.

17.10 Repeat Prob. 17.9 assuming that the twin forms as a twin of the second kind.

17.11 **(a)** Determine the magnitude of the shear associated with a twin in a face-centered cubic crystal.

(b) Compare this twinning shear with that of the $\{10\bar{1}2\}$ twins in the hcp metals. Which type of twin would be the easiest to nucleate? Explain.

17.12



This diagram represents a face-centered cubic crystal with a rectangular cross-section. The crystal has twinned on three planes and the twin traces have been measured with respect to a vertical edge, or the stress axis of the crystal. The angles thus obtained are shown in the figure. Orient this crystal by the two-surface technique following the steps listed below.

(a) Lay out a stereographic projection on a sheet of tracing paper with the front face of the crystal as the basic circle and the top of this circle the stress axis.

(b) Around the basic circle, plot the twin trace orientations corresponding to the front face.

(c) Draw in the great circle corresponding to the side of the crystal and plot on the circle the corresponding twin trace orientations.

(d) Draw in the three great circles representing the three twinning planes. Plot the poles of these three planes.

(e) From the geometry of the fcc crystal structure, determine the orientation of a cube pole; that is, {100}. Plot this on the figure.

(f) Rotate the stereographic projection thus obtained into a standard {100} projection, making sure that the stress axis is also rotated. In order to simplify the result, this last step is best performed on a second sheet of tracing paper.

(g) Draw in the boundaries of the standard stereographic triangle that surrounds the stress axis, thus defining the stress axis orientation.

17.13 Make a rough sketch of the stress-strain curve corresponding to the data in Fig. 17.21.

17.14 **(a)** Some martensite transformations are completely reversible; however, there may be a large difference in the size of the hysteresis loop that couples a complete temperature-induced cycle. Explain why in some cases the size of the hysteresis is large and in others it is small.

(b) The martensite transformation in steels is normally not reversible. Rationalize this fact.

17.15 **(a)** What is pseudoelasticity?

(b) What is the shape-memory effect?

(c) What is the meaning of the term *stress-induced martensite*?

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