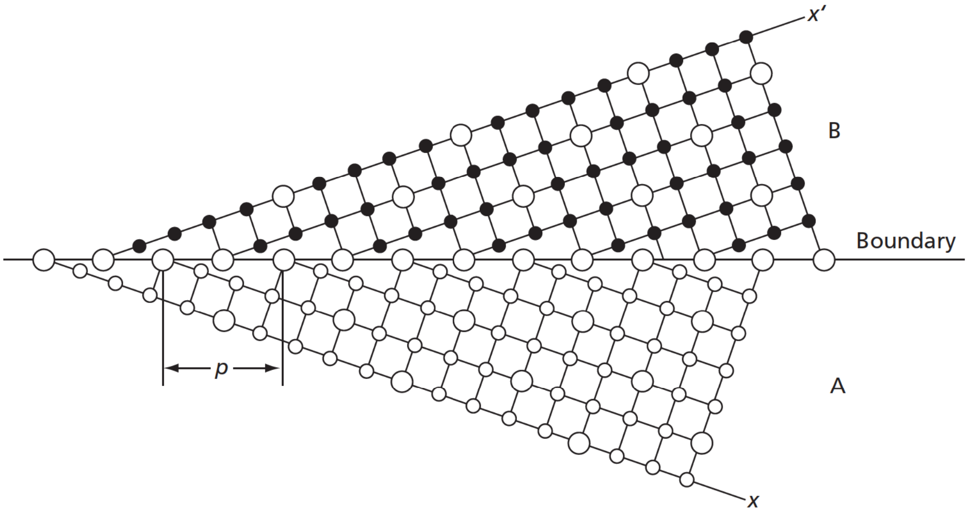

FIG. 6.34 As suggested by Aust,[18] the overlapping of the atoms at the boundary could be relieved by a relative translation of the lattices above and below the boundary

PROBLEMS

6.1 (a) Given a small-angle tilt boundary whose angle of tilt is 0.1°, find the spacing between the dislocations in the boundary if the Burgers vector of the dislocations is 0.33 nm.

(b) On the assumption that the dislocations conform to the conditions involved in Eq. 4.20, that $r' = d/2$, $\mu = 8.6 \times 10^{10}$ MPa and $\nu = 0.3$, determine an approximate value for the surface energy of the tilt boundary. Give your answer in both J/m^2 and ergs/cm^2.

6.2 According to quantitative metallography, N_l, the average number of grain-boundary intercepts per unit length of a line laid over a microstructure is directly related to S_v, the surface area per unit volume, by the relation

$$S_v = 2N_l$$

(a) Determine the value of N_l for the microstructure in Fig. 6.1 if the magnification of the photograph is 350×.

(b) Assuming that the grain–boundary energy of zirconium is about 1 J/m^2, what would be the grain-boundary energy per unit volume in J/m^3 of the zirconium in the specimen?

6.3 A very fine-grained metal may have a mean grain intercept of the order of 1 micron or 10^{-6} m. Assuming the grain-boundary energy of the metal is 0.8 J/m^2, what would be the approximate value of its grain-boundary energy per unit volume? Give your answer in both J/m^3 and calories per cm^3.

6.4 (a) Consider Fig. 6.8. If the grain-boundary energy of a boundary between two iron crystals is 0.78 J/m^2, while that between iron and a second phase particle is 0.40 J/m^2, what angle θ should occur at the junction?

(b) If the surface energy between the iron and the second phase particle were to be 0.35, what would the angle be?

6.5 The following data are taken from Jones, R. L. and Conrad, H., *TMS-AIME*, **245** 779 (1969) and give the flow stress σ, at 4 percent strain, as a function of the grain size of a very high purity titanium metal. Make a plot of σ versus $d^{-1/2}$, and from this determine the Hall-Petch parameters k and σ_0. Express k in $N/m^{3/2}$.

6.6 Plot the data of the preceding problem showing σ as a function of d^{-1}, as well as of $d^{-1/3}$. Do these plots

Grain Size in Micron, μ	Stress, σ in MPa
1.1	321
2.0	279
3.3	255
28.0	193

indicate that there is some justification for Baldwin's comments on the Hall-Petch relationship (see Sec. 6.11)?

6.7 (a) With regard to the coincident site twist boundary on a {111} fcc metal plane shown in Fig. 6.25, show using the Ranganathan relationships (Eqs. 6.21, 6.22, and 6.23) that a choice of $x = 2$ and $y = 1$ will also give this $\Sigma = 7$ boundary.

(b) To what angle of twist does $x = 2$ and $y = 1$ correspond?

(c) Is the fact that $x = 2$ and $y = 1$ are able to produce an equivalent coincident site boundary to that in Fig. 6.25 related to the symmetry of the atomic arrangement on the {111} plane? Explain.

6.8 This problem concerns a coincidence site boundary on a {210} plane of a cubic lattice. Note that the determination does not depend on whether the lattice is simple, face-centered, or body-centered cubic. It holds for all three cases. The basic cell in this plane has $x = a$ and $y = \sqrt{5}a$. A coincidence site lattice can be formed with $x = 2$ and $y = 1$. Assuming a twist boundary, determine:

(a) The twist angle θ for the coincidence structure.

(b) Σ, the reciprocal of the density of coincidence sites.

(c) Check your answer for θ and Σ using two drawings of the atomic structure as revealed on a {210} plane. Note that this involves an array of rectangular cells in which $x = a$ and $y = \sqrt{5}a$, where a is the lattice constant of the crystal. In this operation, note that one drawing of the structure should be made on tracing paper so that it can be placed on and rotated over the other so as to reveal the coincidence sites.

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