Extent of Strain of Primary Glide Planes in Extended Single Crystalline Alpha Brass

by R. Maddin

IN analyzing the relation between the orientation of new grains and that of the deformed matrix of axially extended and recrystallized single crystals of face-centered cubic metals, a two-stage rotation process¹⁻⁴ is generally used where the first rotation is made in order to account for an "adjustment of orientation to the environment of strain."¹ It has been argued that in spite of the difference of orientation, which may amount to as much as 12° (in α brass),¹ between the octahedral plane as observed in the parent lattice and in the recrystallized grain, it is believed to be a common plane in the sense that it constituted the nucleus in the parent strained crystal from which the new grain grew.¹

A possible source of the deviation in orientations of a common pole in the new grain and that of the deformed single crystal matrix from which it has grown may be found in the distribution of strain resulting from the plastic deformation. It might be expected in view of the incongruent nature of shear⁵ that the perfection of the octahedral plane along which glide has occurred is disrupted and that this disruption constitutes the strain from which nuclei of new grains can grow during recrystallization. Evidence for the existence of strain along glide planes was first detected by Taylor⁶ in 1927 and substantiated by Collins and Mathewson² in 1940. In their investigations, however, the deformed single crystalline specimens (aluminum) were cut mechanically along the glide planes followed by mechanical polishing. X-ray exposures (glancing angle) of only 8 min with filtered radiation were used. It was later shown⁷ that this type of surface preparation did not remove with all certainty the mechanically disturbed surface. It was felt that a re-investigation of this phenomenon using more refined techniques might reveal a more correct extent of the strain resulting from the deformation which might correlate the deviation of the common pole of the recrystallized grain with the acting slip plane of the matrix crystal.

In accordance with these thoughts, a single crystal of α brass (70/30 nominal composition) $\frac{1}{2}$ in. in diam x 5 in. long, tapered as in previous experiments,¹ was extended and carefully documented with respect to elongation and shear. Disks about $\frac{3}{8}$ in. thick parallel to the primary slip planes were cut from the specimen by means of an etch cutter.⁸ These disks represented volumes of the specimen which had been extended 0, 5, 10, 15, and 20 pct. Copper $K\alpha$ monochromatic radiation was obtained by reflecting 35,000 v copper radiation from the c-cleavage face of a pentaerythritol crystal. The monochromatic radiation was collimated and led on to the disk set at the proper θ angle for reflection from the primary (111) planes. The monochromatic beam was aligned in a plane containing the active slip direction. Following a 10 hr exposure at the theoretical Bragg angle, the disk was reset at $\theta + 1^\circ$,

Table I. Extent of Strain in Disks Investigated

Elongation, Pct	Stress Axis Rotation, Degrees	Shear "Abgleitung"	Variation in θ Angle	
			Parallel to Slip Direction, Degrees	Perpendicular to Slip Direction, Degrees
0	0	0	2	2
5	1.5	0.098	6	7
10	2.6	0.240	11	8
15	4.6	0.311	13	13
20	5.6	0.407	25	20

$\theta - 1^\circ$, $\theta + 2^\circ$, $\theta - 2^\circ$, etc., until no Bragg reflection was obtained. The disk was then rotated 90° about its polar axis, and the same X-ray procedure was used. The results are shown in Table I.

It may be seen from the results in Table I that the plastic deformation (20 pct elongation) produces fragments of the glide plane which are rotated or tilted as much as 25° from the normal position on a purely block slip model. In addition to the large variation in θ angle in the slip direction, there is a variation in θ as much as 20° in the direction at right angles to the direction of slip, i.e., $\langle 110 \rangle$.

In view of the results shown, it may now be argued that the strain distribution finds its origin in the incongruent nature of the slip process.⁵ The use of the two-stage rotation process seems valid in attempting to explain the relation between the orientation of recrystallized grains and the matrix from which they have grown.

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