Mechanical Twins in White Tin and Zinc

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By

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Abstract

A simple method of using Laue-photograph to determine the orientation of twin bands referred to the mother crystal was applied to the case of mechanical twins in white tin and zinc single-crystals and the twinning planes were found to be (331) and $(10\bar{1}2)$ respectively.

It is well known that crystals of metals such as zinc, cadmium, bismuth and white tin exhibit twinning when they were subjected to a mecanical stress, and also that the native metal crystals such as gold, silver and copper exhibit banded structures. In the present investigation such circumstances with white tin and zinc were examined by treating the Laue-photograph with the crystallographic globe.[1]

When a Laue-photograph of a crystal containing a twin band is taken, there appear two sets of Laue-spots which belong to the respective parts of the twin. In some cases it is easy to distinguish the Laue-spots belonging to the two parts of the crystal and to determine the relation between their orientation by the size and shape of the spots or, when they are treated by the crystallographic globe, by their mode of arrangement belonging to the same zone of the crystal. In the case of mechanical twins, if we take the Laue-photographs of the crystal before and after the formation of the twin band by the stress, we can easily pick out the Laue-spots due to the twin band.

1. U. Yoshida, Jap. Journ. Phys., **4**, 133 (1927); S. Takeyama, These Memoirs, **12**, 257 (1929)

Fig. 1, Plate I shows the mechanical twin bands caused by stretching single-crystal plates of white tin, which belongs to the tetragonal lattice type.[1] The initial crystallographic orientations are given in Fig. 1, where the pole of the stereographic projection corresponds to the direction of the normal to the surface of the plate and the vertical direction to the lengthwise direction of it or to that of the stretching. In Fig. 1, Plate I there appear two sets of parallel twin bands in each specimen. Figs. 2 and 3, Plate I are Laue-photographs of two different portions of specimen II each containing

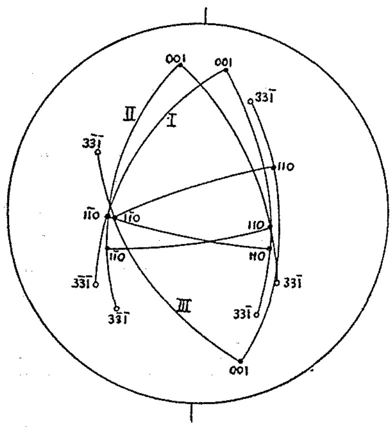

Fig. 1

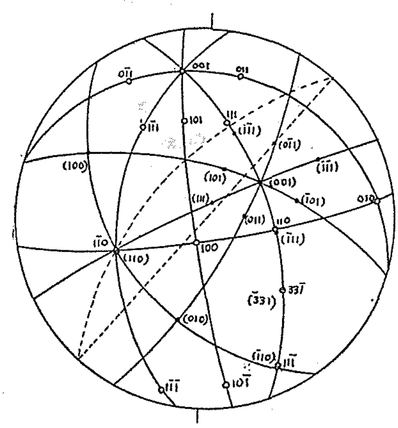

Fig. 2

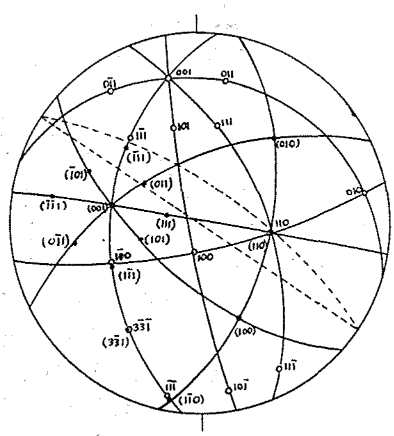

Fig. 3

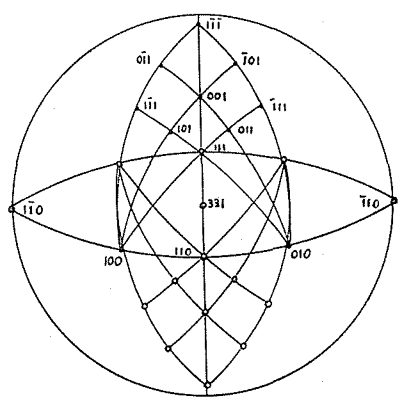

Fig. 4

1. A. E. van Arkel, Proc. Roy. Acad. Amsterdam, **27**, 97 (1924)

a twin band of two different kinds. Both these photographs contain two sets of Laue-spots caused by either of the twin bands and by the mother crystal. The spots that appear in the same positions in both photographs are those due to the mother crystal and the others are those of the twin bands. By treating these two sets of Laue-spots with the crystallographic globe we get the results shown in Figs. 2 and 3, corresponding to Figs. 2 and 3 in Plate I respectively. In these figures the orientation of the crystallographic axes of the mother crystal is shown by small circles and that of twin band by dots whose indices are given in brackets. It is clear from each of these figures that the two components of the twin crystal have a common (331) plane, and with respect to this common plane one component is the mirror image of the other. The orientations of two parallel twin bands on the surface of specimen II are shown by the dotted straight lines respectively in Figs. 2 and 3. These dotted straight lines coincide respectively with the twin planes shown by dotted arcs in the same figures.

The relation between the crystallographic orientations of the component crystals of such twin are shown diagrammatically in Fig. 4 by taking the direction of the twinning axis as the pole. In this figure the position of the crystallographic axes of one component is shown by the dots, and that of the other component is shown by the small circles. The symmetrical distribution of the dots and the small circles in reference to the horizontal diameter of the figure shows that the (331) plane is the twin plane. Other two specimens were also examined in the same way and the same result was obtained. In Fig. 1 the orientations of the crystallographic axes including those of the twin axes are given for the three specimens examined. Of these specimens, the crystallographic orientations are nearly the same and they are roughly symmetrical with respect to the lengthwise direction of the specimen. Crystals having very different orientations from the three above mentioned were also examined, but no twin band was observed to be formed before they were fractured by stretching.

The mechanical twin bands formed in a hexagonal zinc crystal caused by stretching have already been investigated in various ways by many authers,[1] and the twin plane was found to be the $(10\bar{1}2)$ plane. This result was also confirmed by the writers by applying the

1. C. H. Mathewson and A. J. Phillips, Proc. Inst. Met. Div. A. I. M. E., E. Schmid and G. Wasserman, Z. S. f. Phys., **48**, 370 (1928)

method described above. Two Laue-photographs taken with two different twin bands in the same specimen are shown in Figs. 4 and 5, Plate I. In these two photographs the spots marked by small circles are those which are caused by the twin planes of the respective twin bands, and it can be seen that each of them belongs in common to the two sets of Laue-spots of the component crystals. By determining the orientation of the crystals from these photographs it was ascertained that the marked spot was caused by one of the $(10\bar{1}2)$ planes which is common to both components whose orientations are so related that they are mirror images to each other with respect to this plane.

Many specimens composed of large single-crystals of different orientations were tested. Some of the specimens were fractured without showing any twin band, and others showed two or four sets of parallel twin bands on stretching. The results of the examination of such specimens are summarized in Figs. 5, 6 and 7, in which the orientations of the crystals tested are shown by indicating the direction of the normal to the basal plane of the hexagonal zinc crystal by a small circle and the directions of the three normals to the prismatic planes $(10\bar{1}0)$ by dots. The direction of the twin axis or that of the normal to the twin plane $(10\bar{1}2)$ is marked by a small circle with a dot in it, and the direction of the stretching applied to the specimen is taken to be vertical in the figures.

The zinc crystals having the orientations shown in Fig. 5 showed no twin band till they were easily fractured along the basal plane. In the case of Fig. 6 each crystal showed two sets of parallel twin

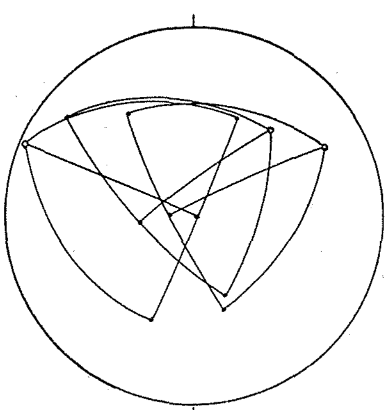

Fig. 5

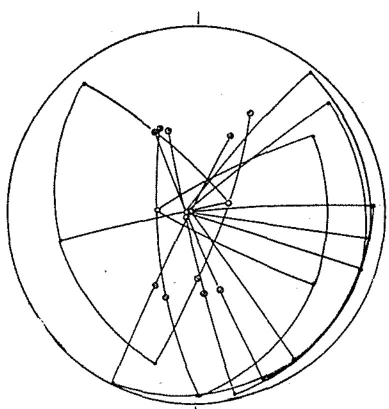

Fig. 6

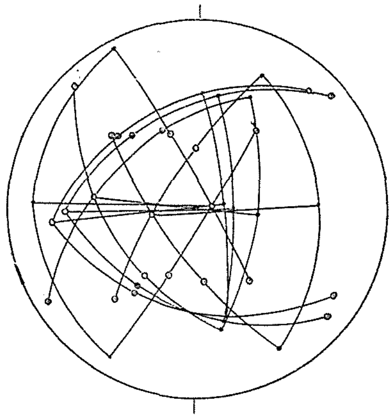

Fig. 7

bands on stretching, and then the crystals were fractured along one of the prismatic (10$\bar{1}$0) planes belonging to the same zone as the two twin planes and the basal plane. The axis of this zone makes the smallest angle with the plane perpendicular to the direction of stretching, among the similar zones. Fig. 7 shows the orientations of the crystals which formed four sets of parallel twin bands on stretching, and then they were fractured along a prismatic (10$\bar{1}$0) plane whose normal makes the smallest angle with the direction of stretching or along some irregular zig-zag planes. As may be seen from the figure, these orientations are nearly symmetrical about the lengthwise direction of the specimen and the basal planes make small angles with the direction of stretching.

In conclusion, the writers wish to express their sincere thanks to Prof. U. Yoshida for the interest he has taken in the present research.

Plate I

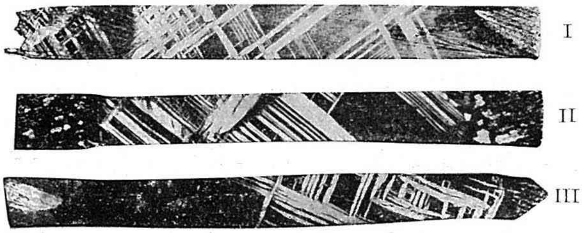

Fig. 1

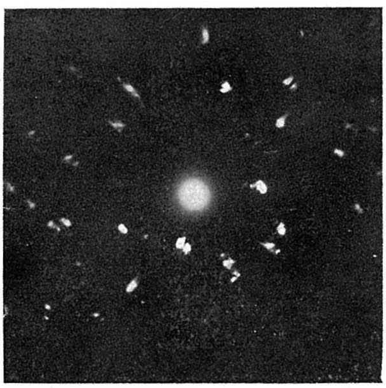

Fig. 2

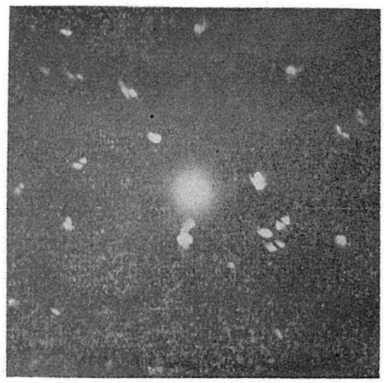

Fig. 3

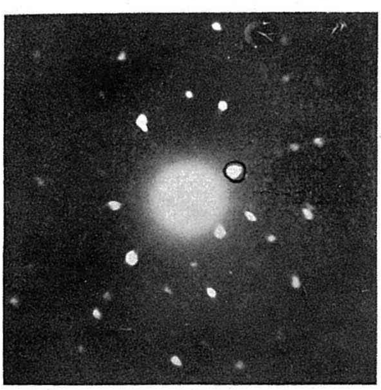

Fig. 4

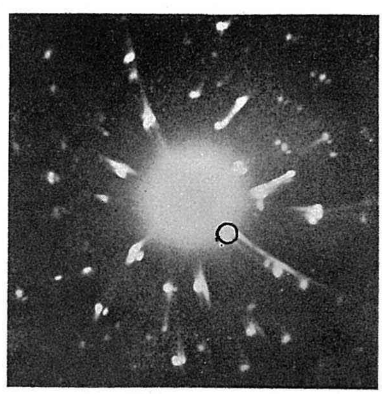

Fig. 5