

contrast with the dull appearance of surfaces exposed when transformed tin is broken. The internal structure of single crystals has also been investigated by means of x-rays. Figure 5 is a reflection Laue pattern of a crystal in the $[100]$ orientation.

When a crystal is cut to prepare samples, internal imperfections in the form of small pockets of occluded mercury are exposed. The number of these is not so great but that they can be eliminated through proper cutting. If this is done the specimens show a remarkable freedom from mercury contamination as is evidenced by residual resistance measurements made on samples transformed to the metallic phase. Attributing the entire residual resistance to the presence of mercury, the indicated mercury content of one of the early crystals was found to be 0.001 atomic percent. This was a *p*-type crystal. More recently, through better control of growing conditions and purification of the mercury, *n*-type crystals of higher purity have been grown.

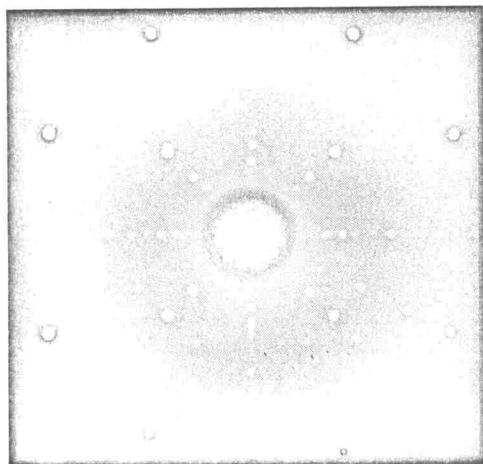


FIG. 5. Reflection Laue pattern of a gray tin crystal in the 100 orientation.

Mercury-free specimens cut from grown crystals and maintained at room temperature usually transform to the metallic phase within a few hours. However a few specimens have remained in the gray phase at this temperature for several weeks. The stability of the crystals at temperatures above 0°C is greatly reduced by contact with mercury. Mercury adhering to the crystal surfaces suddenly goes into solid solution as the temperature reaches about 1°C . At the same time the color changes from gray to white and the crystals become soft as in the normal phase transformation. If only a limited quantity of mercury is present, the crystals are only partially transformed. Specifically if a droplet of mercury is placed on a clean crystal surface a volume of the crystal comparable to that of the droplet is converted. The boundaries of the transformed portion coincide with principal planes of the gray tin lattice delineating an area having the symmetry of the crystal facet on which it occurs as shown in Fig. 6.

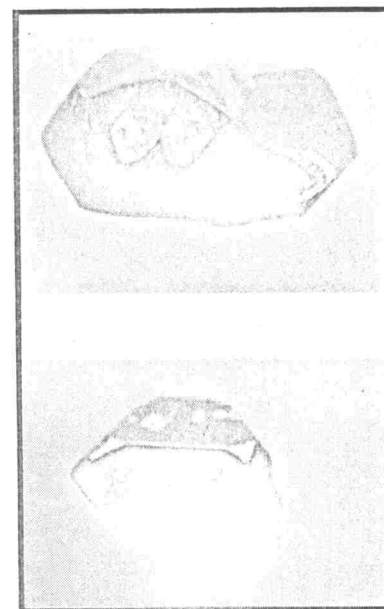


FIG. 6. Partially transformed crystals. The transformation was accompanied by diffusion of mercury into the crystal. Plane boundaries of the transformed regions indicate that the transformation occurs without diffusion of tin atoms.

Plane boundaries such as these generally characterize a diffusionless transformation. In the present case one may conclude that the transformation of pure gray tin to tin amalgam takes place without diffusion of tin atoms.

One of the characteristic features of a diffusionless transformation, namely a stepwise motion of the interface separating the two phases, has been noted in the transformation of pure gray tin to pure white tin. This observation was made on a cleaved surface entirely free of mercury. Under the microscope ($150\times$ magnification) one observes the transformation of distinct domains each of which is bounded by the original interface and an arc-shaped curve on the advancing side of the interface. The transformation of an individual domain is completed in a time that is short in comparison with the time interval between domain transformations. The availability of gray tin single crystals should greatly facilitate further investigations of the gray-to-white transformation which, in the past, has been studied much less extensively than the reverse transformation.⁹

An investigation of the semiconducting properties of these crystals is now in progress. Preliminary results on an *n*-type crystal yield an energy gap of 0.08 eV in agreement with the value for transformed tin. At liquid nitrogen temperature both the conductivity and Hall coefficient of this crystal are greater than the values for pure transformed tin indicating a higher electron mobility. This is confirmed by the value of the magnetoresistance coefficient which is also greater for the single crystal.

⁹ A study of the gray-to-white transformation of granules has recently been reported by Burgers and Groen, *Discussions Faraday Soc.* 23, 183 (1957). See also E. Cohn and A. K. W. A. van Lieshout, *Z. physik. Chem. (Leipzig)* A173, 1 (1935) which also contains references to earlier work.