A Method of obtaining a Single Crystal of Aluminium of Any Desired Crystallographic Orientation

By

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Abstract

An easy method of obtaining a metallic single crystal with any desired crystallographic orientation is described in this report. Experiments have been performed, for the present, with aluminium. It was also confirmed that, when a piece of aluminium was brought into contact with another piece of the same metal, the single crystal did not develop across the boundary between the two pieces, so long as the heating was in the air and at temperatures lower than the melting point of the metal.

Single aluminium crystals of comparatively large dimensions were obtained as in the cases of Zn[1], Sn[2] etc. whose melting points are much lower than that of Al, by cooling molten aluminium very slowly, say by taking several hours per degree at the melting point. In these experiments, if the aluminium specimens in the form of bars or plates were placed in a furnace so as to come into contact with each other, and the temperature was raised to the melting point or slightly higher than that for half an hour or so, the writer often found that a single-crystal of aluminium developed from bar to bar or from plate to plate when two adjacent pieces were melted together at some point. By etching slightly the specimens thus obtained with e. g. a dilute aqueous solution of hydrochloric acid, the writer could obtain single-crystals with a peculiar metallic lustre, which were easily separable from each

1. J. Czochralski, Zeitschr. f. phys. Chem., **92**, 219 (1918);
   E. G. Linder, Phys. Rev., **29**, 554 (1927)
2. K. Tanaka, These Memoirs, **12**, 375 (1929)

other. By taking Laue photographs with such crystals the writer was able to confirm that the orientation of the crystallographic axes was entirely the same in both specimens. This shows that the crystal of aluminium had grown from one piece to the other across the point where the two pieces were melted together. We can in this way easily obtain separate single-crystals with identical crystallographic orientation.

Next an alminium single-crystal, whose crystallographic orientation had been already determined, was put into a furnace with a heterogeneous temperature distribution so that only a part of the crystal was melted, by proper regulation of the temperature of the furnace. Then the temperature of the furnace was made to diminish very slowly so that the alminium crystal might grow fully in the resolidified part of the specimen. The orientation of the single crystal thus produced in the resolidified part was compared with that of the original one. Several experiments showed that if the regulation of the temperature was perfect, a crystal of the original orientation again developed in the once melted and then resolidified portion of the specimen. This was not, however, always the case, and in some cases crystals of some other orientations than the original one were seen to have grown in the resolidified part.

Judging from the facts stated above, it is easy to obtain a single-crystal of aluminium of any desired orientation. Using a furnace with a heterogeneous temperature distribution, we have to melt the polycrystalline piece of aluminium, then to bring one end of a single crystal of the same metal into contact with the molten metal at a certain proper orientation by keeping the greater part of the single-crystal unmelted, and finally to lower the temperature of the furnace very slowly. This method is entirely the same as that adopted by Sh. Ito[1] in the case of zinc crystals.

The problem of whether the crystal in one solid piece can grow and develop, merely by annealing, into another solid piece of the same metal which is brought into close contact with the former, was also studied in the present experiment, but without any success. According to the present experiment done in the air, when the temperature is lower than the melting point of aluminium, a crystal of a certain orientation does not develop from one piece to the other across the

1. Sh. Ito, These Memoirs, **12**, 97 (1929)

boundary between the two pieces which are placed closely in contact with each other, even though individual pieces become almost completely single crystals on annealing. In some cases, the two pieces were found to be of nearly equal crystallographic orientation. But such cases are so rare that they can be looked upon as a mere accidental coincidence. We can say generally that a crystal of aluminium in one piece cannot develop, by mere annealing, into another piece across the boundary between the two pieces which are placed in close contact with each other, if the annealing is carried out in the air and the annealing temperature is not very close to the melting point of aluminium. As the annealing was carried out in the air in the above experiment, the surfaces of the metallic specimens were of course subjected to strong oxidation. Thus even though the two pieces are placed in very close contact with each other, it may be possible that the metal parts of the two pieces do not actually touch each other, owing to their being separated by the oxide films. A closer examination of this point will be made in the near future.

In the present experiment the crystallographic orientation of the single-crystal was determined by treating the Laue-photograph taken with the crystal, with the crystallographic globe devised by Prof. U. Yoshida.[1]

In conclusion, the writer wishes to express his sincere thanks to Professor U. Yoshida for his kind guidance in this research.

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