On the Favourable Direction of Growth of Some Metal-Crystals

By

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Abstract

The favourable crystallographic direction of growth of various metal-crystals is examined in the present experiment. Most of the aluminium and lead crystals grow in the direction nearly parallel to the [100] axis of the face-centred cubic crystals of these metals. The majority of the zinc, cadmium and bismuth crystals grow in the direction nearly perpendicular to the principal axis of the hexagonal crystals of these metals.

It is already known from the experiments of P. W. Bridgman[1] and K. Tanaka[2] that when the crystallisation of a molten metal is made to proceed in one direction by cooling it from one end, the direction of growth of the metal crystal assumes a certain definite crystallographic direction. In the present experiment the writer examined the same problem with five different metals. The metal crystals were prepared by Czochralski's method[3]. Thus the direction of growth of the metal crystal is supposed to coincide with the lengthwise direction of the long specimen of the crystal in the present case. The speed at which the wire was hung up from its molten state was limited to about 2—4 cms. per minute. The orientation of the crystallographic axes of the crystal thus obtained was determined by treating the Laue-spots taken with the specimen with the globe and the spherical scale devised by Prof. U. Yoshida.[4]

1 Nature, **117**, 569 (1929).
2 These Memoirs, **11**, 361 (1928).
3 Z. S. Phys. Chem., **92**, 219 (1917).
4 Japanese J. Phys., **4**, 133 (1927).

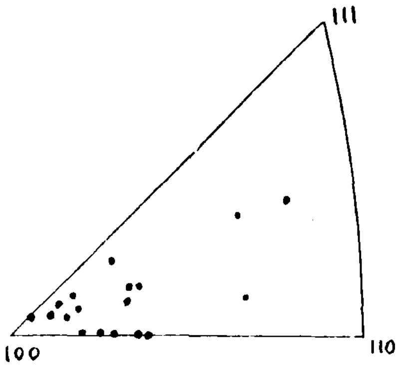

Fig. 1

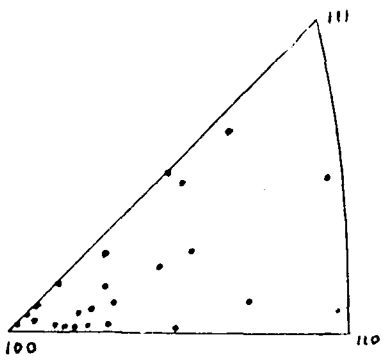

Fig. 2

In Figs. 1 and 2 the dots represent the direction of growth of the aluminium crystals obtained by hanging up aluminium wire solidified from its molten state at the end of polycrystalline wires of copper and iron respectively, where the [100], [110] and [111] axes of the cubic crystal of aluminium are taken as the reference axes of the stereographic projection. It will be seen from these figures that the direction of growth is more favourable in the direction parallel to the [100] axis than in the others, independently of the material of the hanging wires. However when a single crystal of aluminium is used as the hanging wire, the orientation of the crystallographic axes of the crystal newly obtained is found to be the same as that of the hanging crystal.

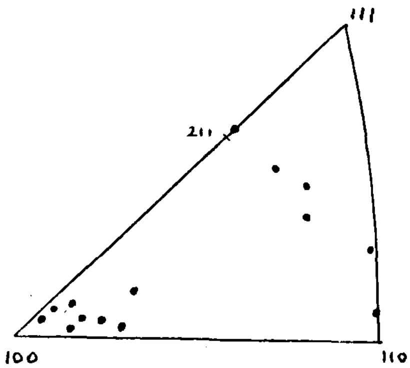

Fig. 3

A similar result is also obtained with the lead crystals. The direction of growth of the lead crystal is represented in Fig. 3, as in the case of the aluminium crystal. However, there were

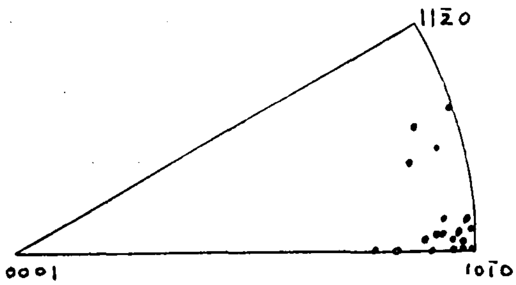

Fig. 4

several crystals, in this case, which grew in the direction nearly perpendicular to the [1 1 1] axis of the cubic crystal. The six dots lying between the [2 1 1] and the [1 1 0] axes in Fig. 3, represent the direction of growth of such crystals.

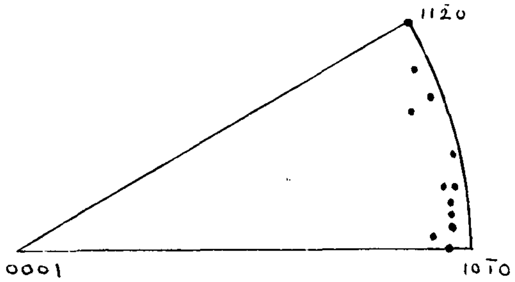

Fig. 5

The dots in Fig. 4 represent the direction of growth of the hexagonal crystal of zinc which is obtained by hanging up the wire of zinc solidified from its molten state at the end of a polycrystalline wire of copper, in reference to the crystallographic axes. Next a single crystal of zinc is used as the hanging wire, and it is found that, if the (0001) plane of the hanging crystal does not incline too much to the direction of growth of the new crystal, a crystal having the same crystallographic orientation as that of the hanging crystal is obtained; and that, if the inclination of the (0001) plane of the hanging crystal to the direction of growth of the new crystal is greater than about 40°, a crystal which grows in the direction nearly parallel to the [10$\bar{1}$0] axis is obtained. Taking these points into consideration, we find that the crystal of zinc seems to grow more easily in the direction parallel to the [10$\bar{1}$0] axis of the hexagonal crystal.

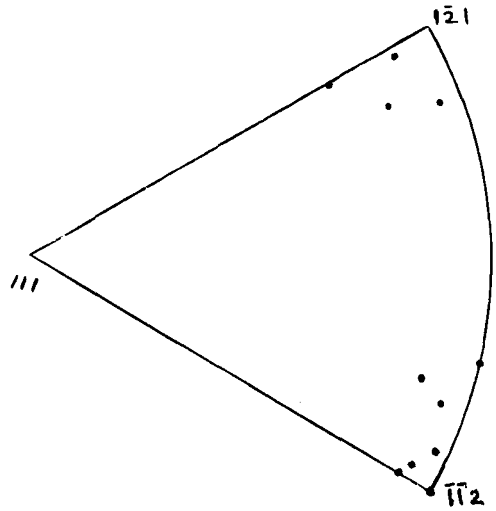

Fig. 6

A similar experiment with cadmium crystals indicates that the hexagonal crystal of cadmium grow evenly in all directions parallel to the basal plane of the hexagonal crystal, because the distribution of the dots in Fig. 5 which represent the direction of growth of the cadmium crystals in stereographic projection, is wholly at random in the (0001) plane.

The rhombohedral hexagonal crystal of bismuth also grows more easily in the direction nearly perpendicular to the principal axis [111], as in the case of zinc and cadmium. The direction of growth of the crystals of this metal is shown in Fig. 6.

Thus it may be said, from the results stated above, that the favourable direction of growth of the crystal of a metal is definite for each metal, and that this favourable direction is intimately connected with the lattice form of the crystal of a metal.

In conclusion, the writer wishes to express his sincere thanks to Professor U. Yoshida of Kyoto Imperial University for his kind guidance during the research.

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