The Fibrous Arrangement of the Micro-Crystals of Silver Chloride

By

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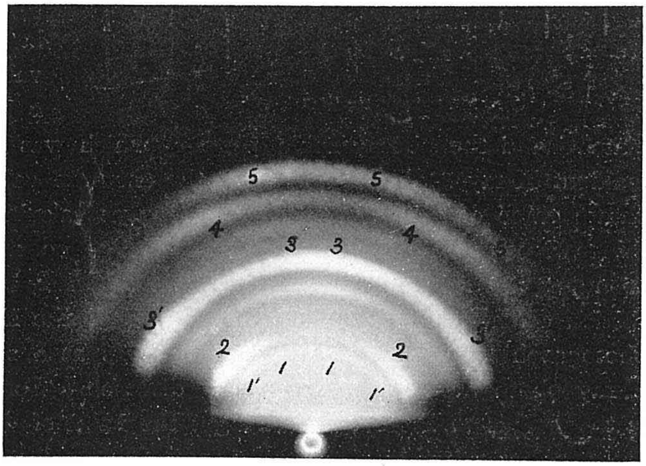
Abstract

A diffraction pattern showing a fibrous arrangement of the micro-crystals of silver chloride was obtained by sending the characteristic X-rays of copper obliquely to the surface of a silver plate which had been dipped for a long time in chlorine water. The writer found that the fiber axis was parallel to the [331] axis of the crystal of silver chloride and was perpendicular to the surface of the silver plate.

The fibrous X-ray photograph shown in Fig. 1 was obtained by sending the K radiation of copper obliquely to the surface of a silver plate which had been dipped in chlorine water for more than fifty hours. So long as the inclination of the X-ray beam to the surface of the silver plate is constant, the same X-ray patterns are always obtained, even if the plate is placed at different orientations. This fact indicates that the fiber axis is perpendicular to the surface of the silver plate. Also, the same pattern was obtained with both annealed and rolled silver plate, and hence it appears that the manner of the arrangement of the micro-crystals of silver chloride is independent of the grain size and the arrangement of the micro-crystals of silver in silver plate.

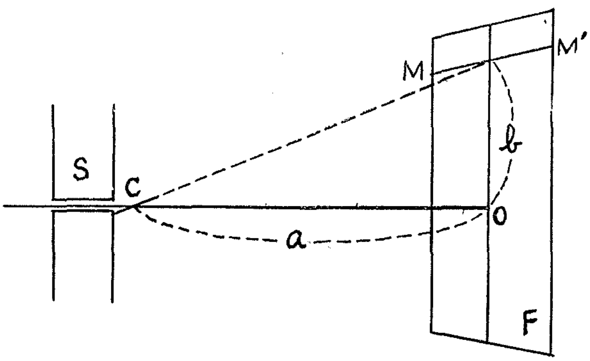
Fig. 1



The photograph reproduced in Fig. 1 was obtained as follows. In Fig. 2 the X-ray beam through the slit S illuminates the silver plate C which is placed just behind S obliquely for the X-ray beam. In order to obtain on the same photographic plate the image of the central spot where the X-ray beam strikes the photographic plate directly, the silver plate was removed and a short second exposure was made on the same photographic plate which had already received the long exposure while the silver plate was in position.

The angle δ of the inclination of the X-ray beam for the surface of the silver plate was found of the following way: As the crystal structure of silver chloride is known, the indices and consequently the lattice constants of the atomic planes corresponding to the circular arcs on the photograph were obtained from the radii of the circular arcs and the rough value of the distance a between the silver plate C and the photographic plate F which was set normal to the incident X-rays. In order to get the accurate value of δ, more accurate value of a is required; and this was calculated reversely from the radii of the circular arcs and the lattice constants of the corresponding atomic planes obtained as above. Next, let the line of intersection of the plane including the surface of the silver plate and the photographic plate be MM′, which appears as a shadow line on the X-ray photograph; then when the distance b from the central spot O to MM′ is measured, we can get the value of δ from the relation

Fig. 2



$$\tan\delta = b/a.$$

The value of δ thus determined was 15° in the case of Fig. 1.

Now, as the value of δ is found, we can determine roughly the direction of the fiber axis by using the crystallographic globe.[1] The writer found roughly that the fiber axis was perpendicular to the sur-

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

face of the silver plate and was parallel to the axis [110] or [331] of the crystal of silver chloride.

In Fig. 3 AC is the direction of the incident X-rays, CN the normal to an atomic plane, the plane POD the photographic plate which is normal to the incident beam, P the position of the image of the reflected rays on the photographic plate, CB the direction of the fiber axis and OD is the line of intersection of the plane ABC and the photographic plate. If the angles α, β, γ and ε are taken as shown in Fig. 3, then we get the relation

$$\cos\beta = \cos\gamma\cos\varepsilon + \sin\gamma\sin\varepsilon\cos\alpha. \qquad (1)$$

As $\varepsilon = \frac{\pi}{2} - \delta$, we can get the value of $\cos\beta$ for each atomic plane from the above formula.

Next, take the three edges of a unit cell of the cubic crystal as the rectangular coordinate axes; and let the direction cosines of the fiber axis be l, m, n and those of the normal to an atomic plane be l', m', n' as shown in Fig. 4, then we get the following relation

$$\cos\beta = ll' + mm' + nn'. \qquad (2)$$

If the direction of the normals to three different atomic planes is given, then we can get the values of l, m and n. In the present case the writer found the values of $\cos\beta$ for the most intense spots in the circular arcs 1, 2 and 3 in Fig. 1. As these circular arcs belong respectively to the atomic planes (111), (200) and (220) of the cubic crystal of silver chloride, the values of l', m' and n'

Fig. 3

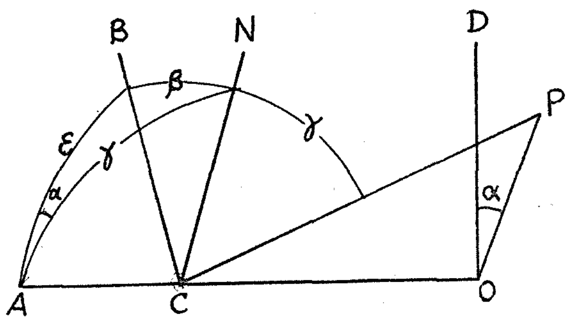
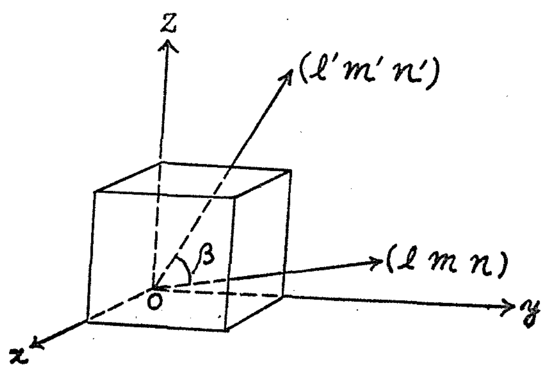


Fig. 4



for these atomic planes are readily calculated. By inserting the values of l', m', n' and $\cos\beta$ thus obtained in the equation (2), we obtain three linear equations containing l, m and n; and by solving these equations the writer obtained the following values for l, m and n

$$l=0.702, \qquad m=0.683, \qquad n=0.203.$$

On the other hand, the direction cosines of the [110] axis are

$$l=m=0.708, \qquad n=0,$$

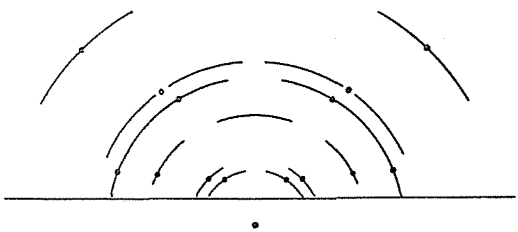
and those of the [331] axis are

$$l=m=0.689, \qquad n=0.229.$$

Then it seems better to take the [331] axis as the fiber axis than the [110] in the present case.

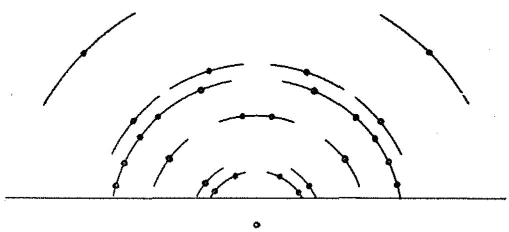
The values of the angle γ for an atomic plane is calculated easily for a given wave length of the X-rays. As the values of the angles ε and β are also obtained for a given fiver axis, the angle α is calculated readily with equation (1). In such a manner we can draw a diffraction pattern for a given fiber axis. Figs. 5 and 6 are the fibrous patterns thus drawn respectively by taking the [110] and the [331] axes as the fiber axes and by taking $\delta=15^\circ$ as was actually observed. In these figures dots are the calculated positions of the spots when the micro-crystals arrange themselves in the fibrous manner perfectly and the circular arcs indicate the diffraction patterns obtained actually on the photographic plate. In Fig. 5 where [110] was taken as the fiber axis there are no spots corresponding to the arcs 3 and 5 in Fig. 1. Whereas in Fig. 6 where [331] was taken as the fiber axis the dots are present favourably in positions corresponding accurately to all the prominent arcs. Here it must be mentioned that the arc 4 is to be considered as composed of

Fig. 5



[110]

Fig. 6



[331]

many arcs and thus it appeared as a long continuous arc on the photograph. From these facts it seems almost certain that the fiber axis of the micro-crystals of silver chloride is parallel to the [331] axis and perpendicular to the surface of the silver plate.

The writer obtained an identical fiber photograph with a silver plate which was exposed to the chlorine gas. This seems to support the view that the fibrous arrangement of the micro-crystals of silver chloride as is stated above is mainly due to the nature of the micro-crystals themselves and not the mode of depositting the micro-crystals on the silver plate.

In conclusion, the writer wishes to express his sincere gratitude to Prof. U. Yoshida for his kind guidance during the course of this experiment.
