A Method of determining the Direction of the Axis of a Fibrous Arrangement of Micro-Crystals

By

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Abstract

A Method of determining the direction of the axis of a fibrous arrangement of micro-crystals, by treating the Laue-photograph of the specimen with the "crystallographic globe," is described in this paper.

When the direction of the axis of a fibrous arrangement of micro-crystals of known lattice form is recognized in reference to the specimen, a Laue-photograph can be taken by setting the direction of the axis of the fibre perpendicularly to the incident X-ray beam; and the crystallographic direction of the axis of the fibre is easily determined by treating the Laue-photograph thus taken with "the globe and the spherical scale," as has been shown by Prof. U. Yoshida.[1] But even if the direction of the axis of the fibre is not inferable in reference to the specimen, it can be also determined in reference both to the specimen and the crystallographic axes with the aid of "the globe and the spherical scale." Since the paper referred to was written, Prof. U. Yoshida's "globe and spherical scale" has been improved by him. The spherical scale consisting of the latitude and the longitude is graduated on a metalic globe as shown in Fig. 1 of Plate I; and the directions of the normals to prominent atomic planes of the crystal of known lattice form are represented by the points marked with their indices on a semi-spherical cap of celluloid which can be just fitted to the globe. The apparatus thus improved is called by him as "the crystallographic globe."

1 U. Yoshida; Japanese J. Phys., **4**, 133 (1927)

Now suppose that a Laue-photograph is taken in such a way that the fixed direction OA in a specimen and the photographic plate are both placed perpendicularly to the incident X-ray beam XO, as shown in Fig. 1. If the axis of the fibrous arrangement is assumed to be in the direction OF, then the normals to the atomic planes of the micro-crystals of given indices envelope a circular cone with OF as its axis. Some of these atomic planes will reflect the incident X-rays and will produce a radiating band on the photographic plate. Let ON be the direction of the normal to an atomic plane giving rise to the point N′ in the radiating band, and O′A′ be a line drawn on the photograph parallel to OA. Then the angle A′O′N′ can be measured; let it be denoted by α. Thus the angle φ between OA and ON will be given by the relation :—

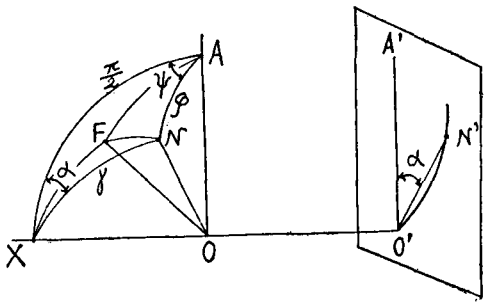

Fig. 1

$$\cos\varphi = \sin\gamma\cos\alpha,$$

where γ is the angle of incidence of the X-ray to the atomic plane under consideration, and is calculated from the distances OO′ and O′N′. Further, the angle between the planes AOX and AON, which is represented by ψ in Fig. 1, is also determined by the equation :—

$$\cos\gamma = \sin\varphi\cos\psi.$$

Thus the values of φ and ψ for several different points in the radiating band can be calculated in the same way as above.

Now, consider the specimen is so oriented at the center of the crystallographic globe that the two directions OA and OX are directed to the pole and the position of the azimuth zero on the equator respectively. Next mark on the surface of the globe the positions of the points representing the directions of the normals to the reflecting atomic planes, with the values of the co-latitude φ and the longitude ψ, which are already obtained for various points on the radiating band under consideration. The curve passing through these positions on the surface of the globe is nothing but one part of the intersection of the surface

of the globe and the circular cone enveloped by the normals to the reflecting atomic planes of the micro-crystals arranged in a fibrous manner. Thus if we draw several such curves on the surface of the globe, which correspond to various radiating bands appearing in the photograph, the direction of the axis of the fibre in reference to the specimen will be obtained immediately by finding the mean position of the centers of curvature of such curves on the surface of the globe.

Next, if the spectra of the characteristic radiation of the target appear on the respective radiating bands, then the indices of the atomic planes corresponding to the respective radiating bands can be determined respectively. Take the semi-spherical celluloid cap, which is already furnished with the points representing the normals to the prominent atomic planes, and put it on the globe. Search for such position of the cap that the points furnished with respective indices on it may elapse respectively along the circular curves on the surface of the globe which have the corresponding indices, by letting various points on the cap coincide successively with the point representing the direction of the axis of the fibre on the surface of the globe, and by rotating the cap around this point. When such position of the celluloid cap on the surface of the globe is found, then this center of rotation of the cap will be the direction of the axis of the fibrous arrangement of the micro-crystals with respect to the crystallographic axes.

In order to verify the method above described actually, a Laue-photograph was taken with a wire of aluminium, which was prepared by drawing it through dies successively. The direction of a horizontal incident X-ray beam and the vertical direction were taken as the reference directions, and the axis of the wire was made to incline equally to the two reference directions at an angle of 60°. The photographic plate was set perpendicular to the horizontal incident X-ray beam and was placed 2.5 cm. from the wire. The photograph obtained is reproduced in Fig. 2 of Plate I. From the photograph it was determined in the manner stated above that the axis of the fibrous arrangement of the micro-crystals in the wire was nearly parallel to the axis of the wire and its crystallographic direction was [111]. The result is entirely the same as that already obtained by T. Fujiwara[1] and others.

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1 T. Fujiwara; These Memoirs, **8**, 299 (1927)

In conclusion, the writer wishes to express his sincere thanks to Prof. U. Yoshida for his kind guidance in the reseach.

Plate I

Fig. 1

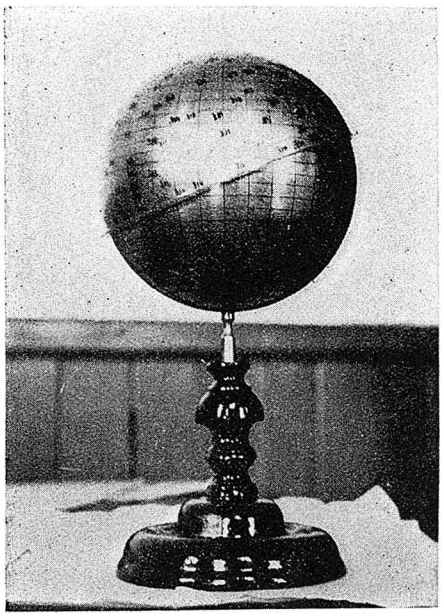

Fig. 2

Vertical direction