Title

FOIL THICKNESS DETERMINATION FROM SINGLE CRYSTAL DIFFRACTION PATTERNS

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Publication Date

1969-08-01

Submitted to 27th Annual EMSA Meeting,
St. Paul, Minneosta, August 26-29, 1969

UCRL-18865
Preprint
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August 1969

AEC Contract No. W-7405-eng-48

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Foil thickness measurements are necessary for determining crystal volumes, which in turn are needed to calculate defect densities for dislocations or point defect clusters or for determining interparticle spacings. The most generally applied technique for obtaining the foil thickness is the trace method (1, 2, 3) wherein the trace of a known plane (slip trace, stacking fault, grain boundary, etc.) must be determined, its projected width on a micrograph measured, the precise crystal orientation calculated from a diffraction pattern and the thickness calculated from simple trigonometric relationships. If no traces are obtainable on an image, an alternate method uses extinction contours (2): a perfect wedge-shaped crystal is set at the Bragg angle, and the number of white fringes from the edge of the foil in a bright-field micrograph (or dark fringes in a dark-field micrograph) counted and multiplied by the extinction distance (which must be accurately known)for the particluar reflection involved. If the foil is uniformly bent such that, over a small region, bend contours from both plus and minus diffraction planes are available, the value of the macroscopic deviation parameter can be calibrated linearly between the bend contours. The dynamical theory can then be used to determine the foil thickness from the positions of the intensity minima and their corresponding deviation parameters in the same manner as described below where the deviation parameters are obtained from the diffraction pattern. Also, stereomicroscopy techniques can be used when there are defects intersecting the foil surfaces or identifiable material on these surfaces.

The trace method and stereomicroscopy utilize electron images for which the magnification must be accurately known if correct thicknesses and volumes are to be obtained. The bent foil method is free from magnification dependence but is not widely applicable because uniformly bent regions are not always present in the region where a thickness determination is desired. Methods using the diffraction pattern are usually specialized, involving extremely thin foils or magnetic materials. However, a method described by Amelinckx (3), for use with layer structures not conducive to the trace method, is found to be generally applicable for calculating crystal thicknesses. Amelinckx's equation for the foil thickness is

$$t = \sqrt{2}[s_1^2 - 2s_2^2 + s_3^2]^{-1/2} \qquad (1)$$

where s_1, s_2, and s_3 are the deviation parameters of three successive dark field intensity minima in the dynamical distribution of diffracted intensity. This paper deals with the methods of obtaining diffraction patterns from which measurements can be made of the deviation parameters

(Submitted to 27th Annual EMSA Meeting, St. Paul, Minnesota, August 26-29, 1969) UCRL - 18865

an electron microscope. A recent application to ultra-high-voltage electron microscopy has been found in which this method can be used to determine the "disappearance" voltage for a second order reflection. Details will be presented in future publications.

Acknowledgements

We wish to thank the United States Atomic Energy Commission for continued financial support of the research.

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2. Hirsch, P. B., Howie, A., Nicholson, R. B., Pashley, D. W., and Whelan, M. J., Electron Microscopy of Thin Crystals, (Butterworths, London, 1965), p. 416.

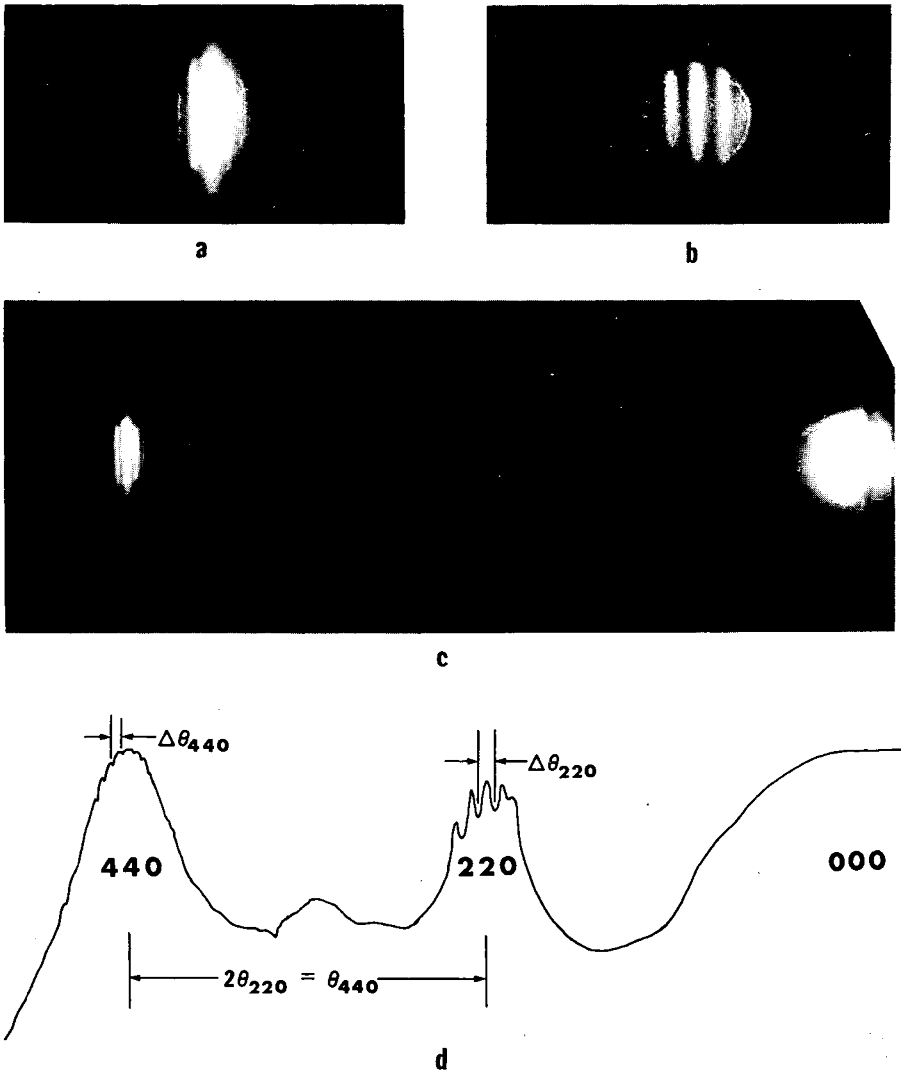
3. Amelinckx, S., The Direct Observation of Dislocations, (Academic Press, New York, 1964), p. 193.

Figure Caption

Figure 1: a) and b). Enlargements of the 440 and 220 diffraction "spots" shown in c).

c). Divergent beam, selected area diffraction pattern of the 440, 220, and 000 "spots" in silicon.

d). Microphotometer trace of c) illustrating the necessary measurements for thickness determinations.



XBB 695-3382

Fig. 1

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