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In transmission electron microscopy it is generally believed that for the pairs of Kikuchi lines resulting from inelastic scattering, the line nearer the transmitted spot on the diffraction pattern should always be associated with deficiency of electrons while the other should always contain excess electrons. However, Thomas and Bell (1) demonstrated experimentally that in a case where the incident beam occurs at an exact Bragg angle, the intensities of the lines in a pair reversed, depending only on foil thickness. This color reversal of the Kikuchi line pair is associated with the dynamical behavior of the Kikuchi electrons where crystal absorption plays an essential role.

Based on the two-beam dynamical theory for elastic electrons, a corresponding (two-beam) theory on the fine structures of the Kikuchi electron intensity distributions in relation to the various diffraction and absorption parameters has been formulated (2). In this theory, the Kikuchi electrons were taken to be those inelastic electrons generated in an infinitesimal thickness of the specimen which subsequently underwent Bragg diffraction. The initial inelastic electron wave amplitudes generated at any position inside the crystal were obtained phenomenologically by considering the decrease in amplitude of the elastic electrons due to absorption by the crystal. Appropriate scattering factors for the inelastic electrons were also phenomenologically introduced for the proper Bragg diffractions being considered. A scattering matrix similar to that used in dynamical scattering calculations (with absorption included) was used to describe the effects upon these newly generated inelastic electrons as they traveled through the crystal.

It can be shown that the asymmetrical nature in angular distributions of the Kikuchi electron intensities is due to anomalous absorption of the electrons by the crystal. With correctly chosen absorption parameters, specimen thickness, etc., the color reversal experiment of Thomas and Bell (1) can be explained. It is well known that the intensity within the Kikuchi band, i.e. the region bounded by the pair of Kikuchi lines, may change from a deficiency to an excess of electrons when the energy of the incident electrons is increased or the crystal thickness decreased (3,4). This phenomenon can also be explained in terms of the anomalous absorption of electrons.

Finally, and also contrary to general assumption, the angular separation between the two lines of the Kikuchi pair has been shown to be thickness dependent and therefore may be appreciable different from the observed line spacing between the Kikuchi pair and the corresponding diffraction spot pattern (figs. 1 and 2). This phenomenon is also associated with anomalous absorption. Thus, the principal experimental behavior of Kikuchi electrons is quite well explained by the theory.

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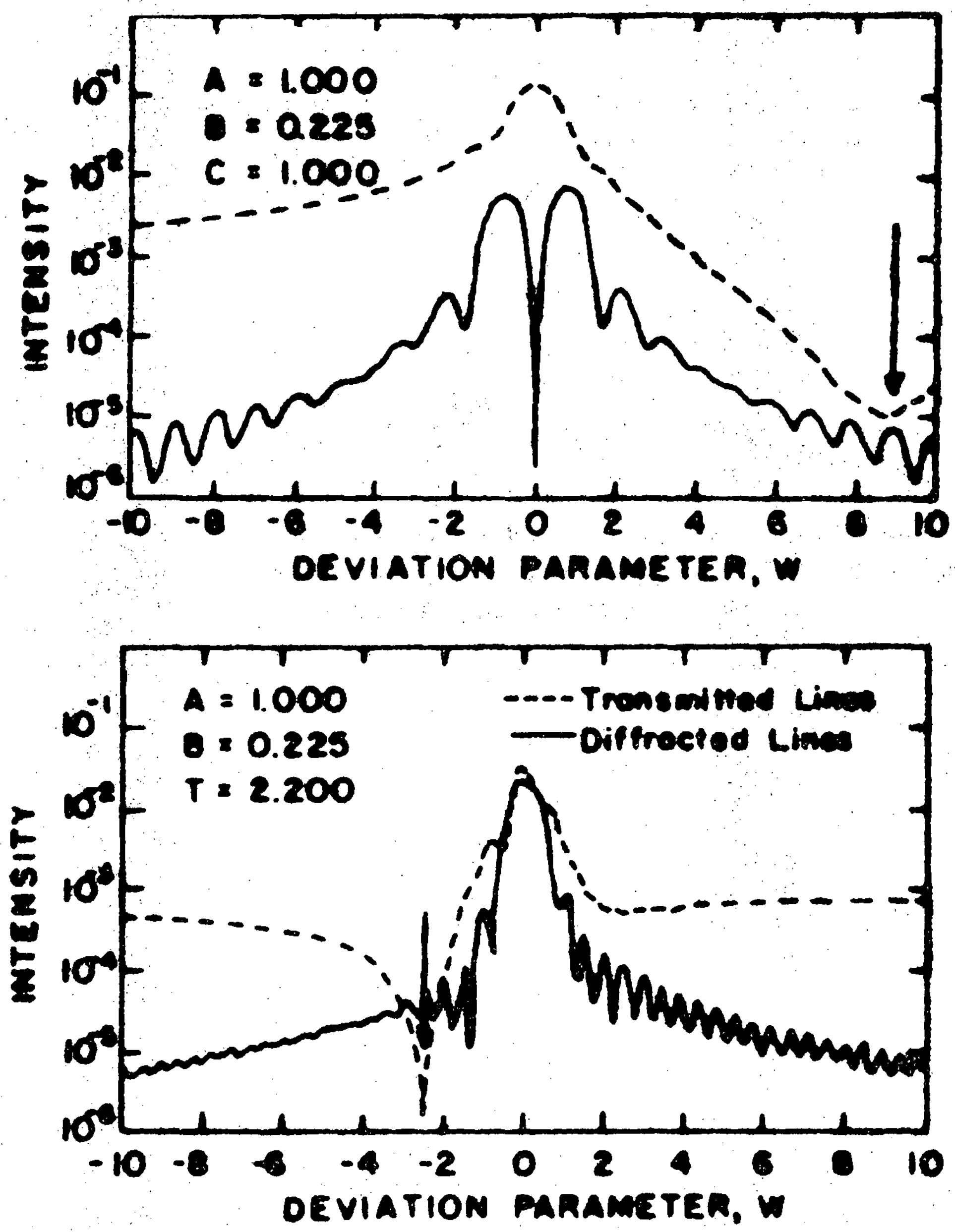
1. G.Thomas and W.L. Bell, European Regional Conference on E.M. 283, 1968,Rome.
2. Complete details of the theory are to be published, see T. Y. Tan, W.L. Bell and G. Thomas, UCRL-19020 (1970).
3. H. Boersch, Phys. Z. 38, 1000, 1937.
4. H. Pfister, Ann. Phys. Lpz. 11, 293, 1953.

Fig. 1. Computed intensity curves showing the possible Kikuchi line spacing as a function of the inelastic electron deviation parameter W for two different foil thickness. The Kikuchi line spacing in (a) is larger than that of $2\theta_B$ and in (b) smaller than that of $2\theta_B$.

Fig. 2. Observed silicon 551 Kikuchi line spacing variation with increasing thickness. The Kikuchi line spacing in (a) is larger than that of $2\theta_B$, in (b) and (c) are equal and smaller than that of $2\theta_B$, respectively.



(a)

(b)

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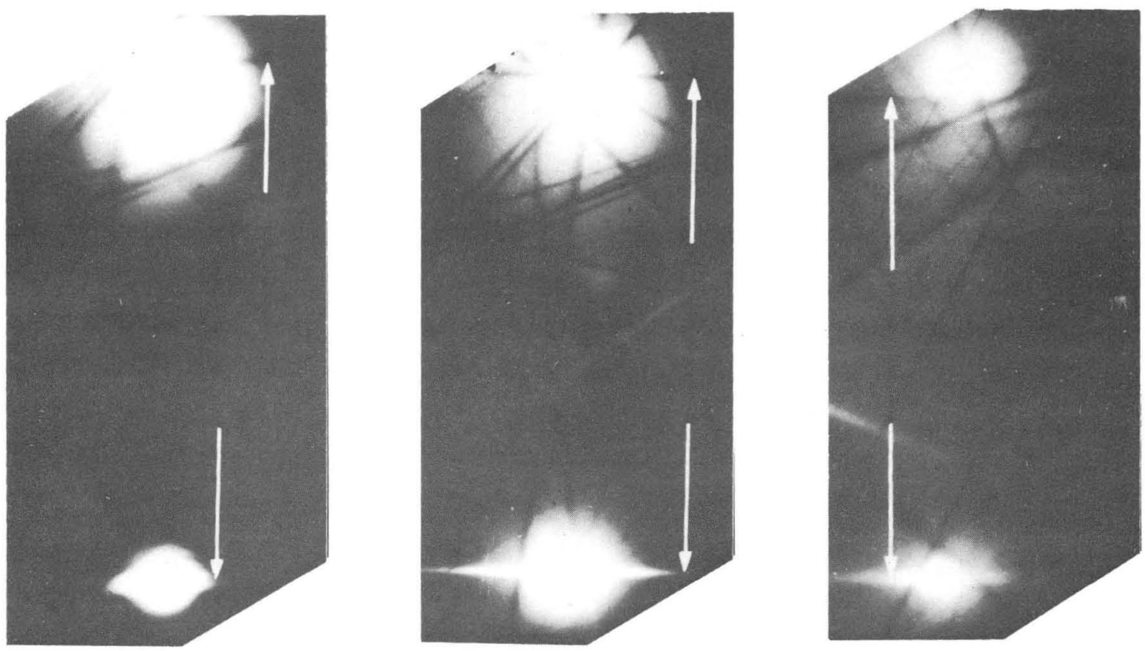
Fig. 1



(a) (b) (c)

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Fig. 2