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HIGH VOLTAGE MICROSCOPY OBSERVATIONS OF DISLOCATIONS IN COBALT FERRITES

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March 1970

As part of a study of phase transformations in cobalt ferrites (to be discussed elsewhere), the nature of dislocations in cobalt ferrite spinels is reported.

The dislocation dissociation for the spinel structure has been analyzed in detail by Hornstra[1]. He extended the considerations made by Kronberg for conrundum[2], and advanced arguments for a fourfold dissociation of a perfect dislocation in the spinels. Fig. 1 shows his predicted configuration. The two outer pairs of partials are bounding a stacking fault in the oxygen sublattice, in which at the same time the cations would have moved to their favored crystal coordination. This process is called synchro-shear by Kronberg. The two inner partials bound a fault in the cation stacking only. His arguments are based on the requirement of local electro-neutrality, and on the observations of twinning on {111} planes.

In the system under investigation here no dissociation has been resolved, as is shown in fig. 2(a). It is, however, necessary to determine the magnitude of the Burgers vector before a definite conclusion can be drawn. For this purpose, in fig. 2b, a densitometer tracing of a dislocation is compared with the calculated image profiles for a few possible values of $\vec{g}.\vec{b}$. The observations were made at 650 kV in a Hitachi electron microscope. The calculations were based on the incremental solution, worked out by Bell and Thomas[4], for a 12 beam case at this voltage. In the calculations $\vec{g}$ must be equal to the first order

reflections, i.e., g = 220. The good agreement between the observed and the calculated image profile for $\vec{g}.\vec{b} = 2$, and the absence of fringe contrast from possible faults between the dislocations indicate that $b = \pm a/2[110]$. Hence, the dislocations are not dissociated, although for these spinels $b \cong 6\text{Å}$. It must be concluded that in the ferrites of the examined compositions (from $Co_{0.8}Fe_{2.2}$ to $Co_{1.5}O_4$) the stacking fault energies for both the oxygen and the cation sublattices are too high to permit any appreciable dissociation.

The present observations do not, of course, rule out that for spinels of either high Fe or Co content dissociated dislocations can indeed exist, or that the dislocations do dissociate somewhat under the stress necessary to move them through the crystal lattice. It is believed, however, that it can be taken as a general rule that the oxygen stacking fault energies are high in oxide ceramics with high bonding energies [see also $MgAl_2O_4$[4]; UO_2[5]; MgO[6]; NiO[7]; Al_2O_3[8]].

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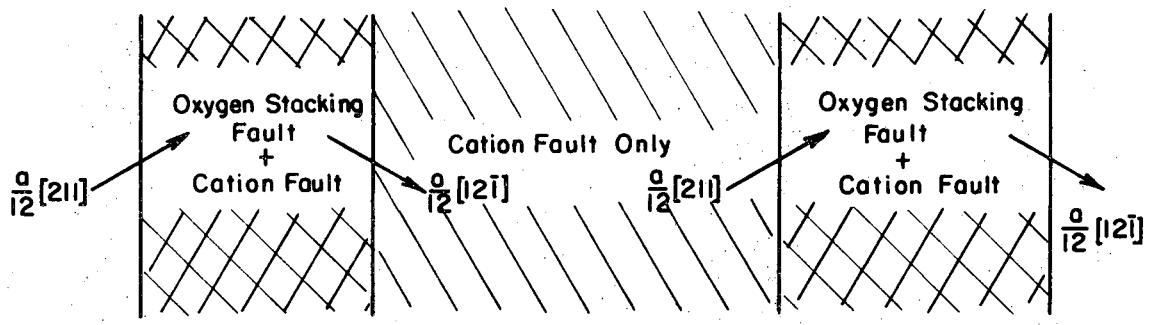
FIGURE CAPTIONS

Figure 1. Proposed model for dislocation dissociation in the spinel structure[1].

Figure 2. (a) Dislocations observed in cobalt ferrite at 650 kV.

(b) Comparison of observed and calculated image profiles.



$$\frac{a}{2}[110] \rightarrow \frac{a}{4}[110] + \frac{a}{4}[110]$$

$$\frac{a}{4}[110] \rightarrow \frac{a}{12}[211] + \frac{a}{12}[12\bar{1}]$$

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Figure 1

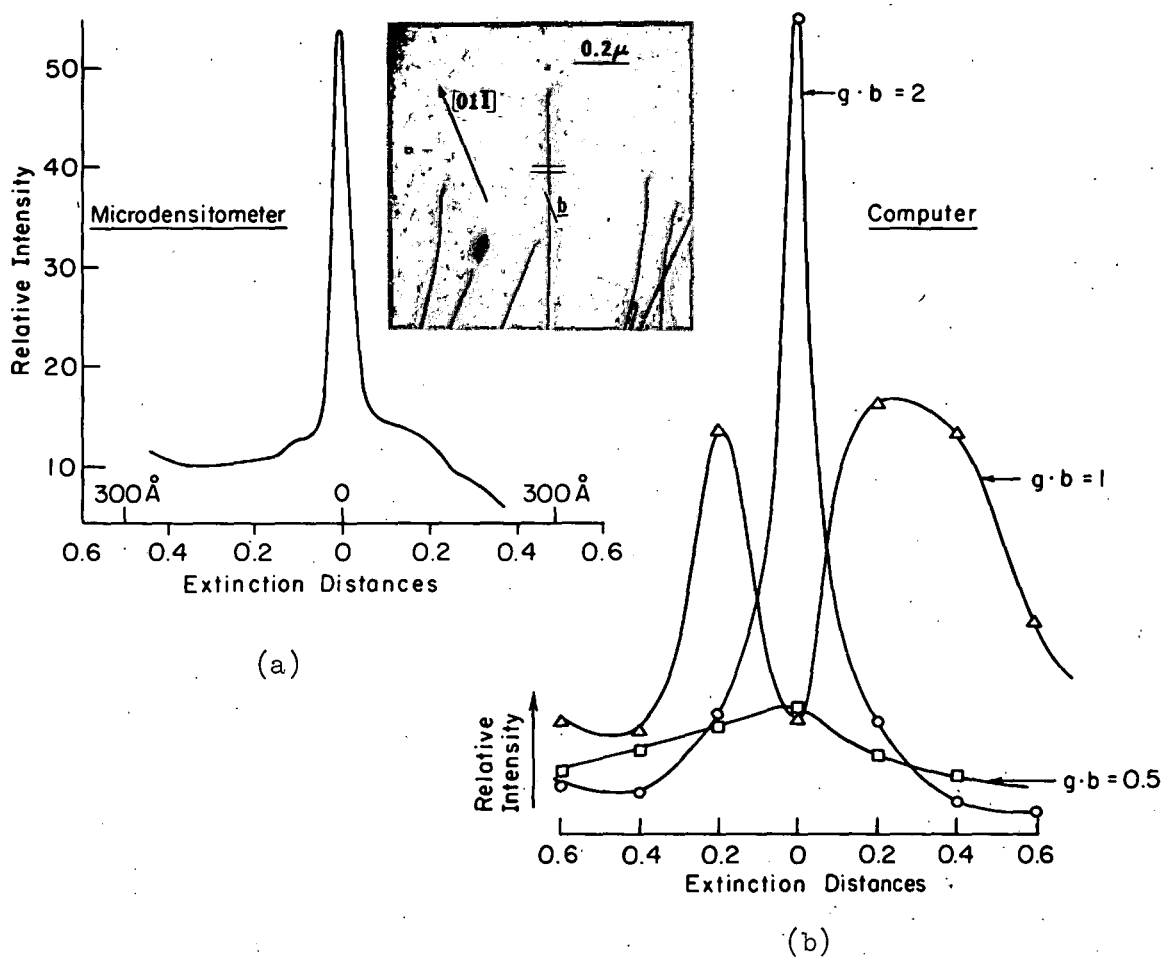

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Figure 2

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