LETTERS TO THE EDITORS

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Optical Properties of Barium Titanate

A PAPER by Kay in the *Acta Crystallographica* for November 1948 has just appeared which traverses ground so close to that which we have been exploring during the past two years that it seems desirable to announce at once a few points which seem to be both new and interesting in our work.

In 1946 one of us (R. W.) observed that 'Barkhausen clicks' occurred when a commercial ceramic titanate condenser (Dubilier) was electrically connected in a suitable circuit. We then, in pursuit of the problem, prepared single barium titanate crystals and examined them in polarized sodium light under various conditions of temperature (−5° to 140° C.) and in electric fields up to about 30,000 volts/cm. The well-known twinning (101 and 011 types) was immediately apparent in our small crystals, and in Fig. 1 is shown a scale model of just one example built up on an actual photograph (× 500). This photograph with its legend is self-explanatory.

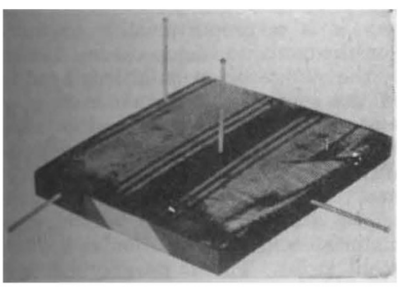

Fig. 1. Scale model of a typical crystal with pins indicating the direction of the optic axis in the twin components

The application, at room temperature, of an electric field of sufficient strength causes the *c*-axis to turn into the field direction throughout the crystal, a change usually achieved by the growth of small wedge-shaped needles lancing out at 45° from a crystal edge, which, when long enough to extend right across, begin to expand at right angles to their length, finally devouring the whole crystal. This movement may be quite slow, lasting minutes, and is often accompanied by light and dark lines which appear transiently, parallel to the *c*-axis, when viewed between crossed Nicols near the extinction position. At a twin boundary, these transient lines turn abruptly through 90°, as shown in Fig. 2, which, for reasons we cannot here elaborate, was taken in an alternating field at room temperature. It is thought that this phenomenon may be connected with a change of spontaneous polarization through 180°, these two directions being optically indistinguishable in the steady state.

Fig. 2. Crystal observed near the extinction position in an alternating field of 20 kV./cm. (× 750)

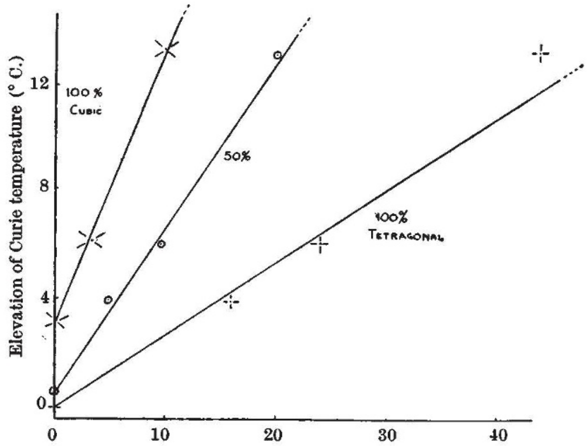

Fig. 3

We have specially examined the behaviour of these small crystals in the neighbourhood of the Curie temperature, the highest value of which was found to be about 121° C. At this temperature the structure changes from tetragonal to cubic; but this transition is inhibited by the application of an electric field, so that with fields approaching breakdown the transition does not occur until as high a temperature as 130° C. is reached. This effect, which has its counterpart in ferromagnetics, is approximately summarized in Fig. 3.

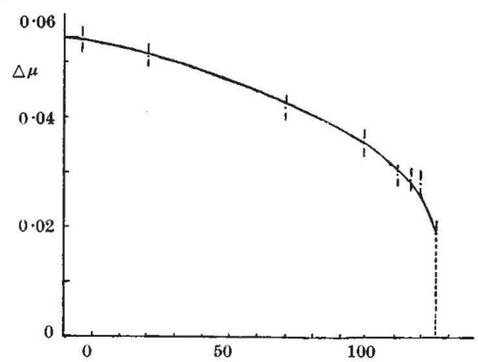

Fig. 4

We have also measured, by examination of the interference fringes shown in Fig. 1, the birefringence ($\Delta\mu$) over a range of crystal temperature. The results are shown in Fig. 4, and are in general agreement with the c/a curves published by Megaw[1]. We find that approximately $\Delta\mu = 5{\cdot}5\ (c/a - 1)$.

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[1] Megaw, H. D., *Proc. Roy. Soc.*, A, **189**, 261 (1947).