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The unit cell and space group of gallium iron oxide, a piezoelectric ferromagnetic crystal.

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A new crystal with the composition $Ga_{2-x}Fe_xO_3$ (with x close to 1) has been made by J. P. Remeika and shown by him to be both ferromagnetic and piezoelectric (Remeika, 1959). These properties have not previously been found together in one substance.

As grown by Remeika (1959), the crystals are commonly acicular, dark brown in color, with the habit shown in Fig. 1. Between crossed polarizers these needles show parallel extinction. In cross-section, their four major faces form a parallelogram with angles approximately 94° and 86°. Such a section, in crossed polarized light, shows extinction directions bisecting these angles, which, with the parallel extinction above, indicates that the crystal is orthorhombic.

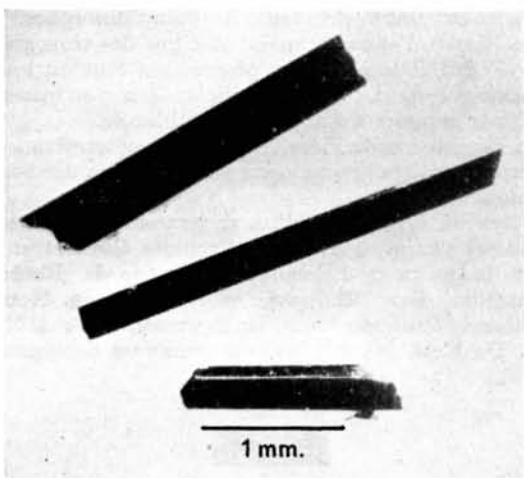

Fig. 1. Single crystals of gallium iron oxide.

Precession, Weissenberg and rotation diffraction patterns of several crystals have been taken with Cr radiation ($K\alpha_1$, $\lambda = 2{\cdot}2897$), Mo radiation ($K\alpha_1$, $\lambda = 0{\cdot}7093$ Å) and with Cu radiation ($K\alpha_1$, $\lambda = 1{\cdot}5405$). These patterns show the crystal to be orthorhombic with

$$a = 8{\cdot}75 \pm 0{\cdot}03,\ b = 9{\cdot}40 \pm 0{\cdot}03,\ c = 5{\cdot}07 \pm 0{\cdot}03 \text{ Å}.$$

Since arctan $9{\cdot}40/8{\cdot}75 = 47°$, the major faces of the needles are thus shown to be {110} faces. Twinning on {101} is common. Since arctan $a/c = 59°\ 55'$ the c axes of the two individuals of such a twin make an angle of approximately 120° with each other. When this twinning is repeated, pseudohexagonal plates are formed like that shown in Fig. 2. The major surfaces of such plates are thus parallel to {010}.

There are no systematic absences of hkl reflections. $hk0$ reflections are present only for $h + k = 2n$. $0kl$ reflections are present only for $l = 2n$. There are no additional systematic absences of $h0l$ reflections. Since the crystal lacks a center of symmetry, the most probable space group is C_{2v}^9. For the axes as assigned above, conforming to the convention $c < a < b$, the Hermann–Mauguin symbol is $Pc2_1n$ (setting bca). For the standard setting, the symbol

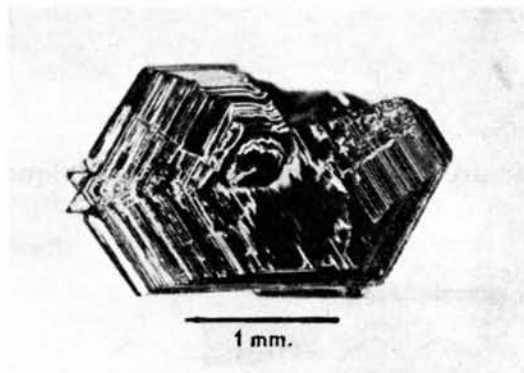

Fig. 2. A twinned crystal of gallium iron oxide.

is $Pna2_1$. The cell volume is 417 Å^3 and the formula weight is 173·57. The density calculated on the basis of eight formula weights per unit cell is 5·53. The density of a dense polycrystalline specimen measured by L. G. Van Uitert was 5·2. This specimen was prepared by Van Uitert by pressing and sintering the powdered oxides.

Since the ratio of gallium to iron in this crystal can be varied over a range of about $Ga_{0.6}Fe_{1.4}$ to $Ga_{1.3}Fe_{0.7}$, one might anticipate the possibility of ordered and disordered occupation of metal sites.

A full investigation of the structure is now being carried out.

The preferred direction of magnetization is the c direction (Bozorth, 1959). R. M. Bozorth has measured the magnetic moment and the magnetic Curie temperature as a function of iron concentration (Remeika, 1959).

D. L. White has caused the crystal to oscillate piezoelectrically and has picked up a resonant response magnetically. He has performed the reverse experiment with positive results also (White, 1959).

A. G. Chynoweth, using a sensitive technique devised by him for the detection of pyroelectricity (Chynoweth, 1957), did not detect pyroelectricity in a crystal with silver-paste electrodes from which Remeika had observed a very strong piezoelectric signal with the Giebe–Scheibe tester. Chynoweth concludes that if the crystal is pyroelectric, the effect must be very weak (Chynoweth, 1959).

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