Dielectric Constant of Cr_2O_3 Crystals

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The dielectric constants of Cr_2O_3 were measured at 25.5°C by a two-terminal substitution method on specimens cut from single crystal. The average dielectric constants thus obtained are: at 1 kc/sec parallel *a* axis 13.3, parallel *c* axis 11.9; at 2 Mc/sec parallel *a* axis 13.0, parallel *c* axis 11.8. The dielectric constant for either orientation increased approximately 10^{-3} per 1°C in the temperature interval 298 to 325°K. A small anomaly was observed in the neighborhood of the Néel temperature.

CHROMIUM sesquioxide, Cr_2O_3, has a hexagonal structure similar to corundum[1] and is antiferromagnetic with a Néel temperature of 307°K.[2] Analysis of the recently discovered magnetoelectric effect[3–5] requires a knowledge of the magnetic susceptibility and the dielectric constant. The magnetic susceptibility has been measured in detail.[2] For the dielectric constant, only average values[6,7] obtained on powders are known to us.

A single crystal of Cr_2O_3 grown by the Verneuil technique was used for dielectric measurements. Spectrochemical analysis of the sample showed the impurities Al and Si to be present in amounts less than 0.01%, and Cu Ca, Fe, Mg, and Mn in amounts less than 0.001%. The original crystal was a boule about 7 mm in diameter and 5 cm long, with the axis of the boule approximately 30° from the *c* axis of the crystal. Two *c* plates and two *a* plates were cut into disks approximately 6 mm in diameter and 0.5 mm thick. The surfaces were polished and gold electrodes were applied by evaporation.

The capacitance measurements were made with the sample held between the plates of a parallel plate capacitor. The two-terminal capacitance of the sample was measured by a substitution method. The measurements were made with General Radio 716-C and 716-CSI capacitance bridges and a 722-DQ precision variable capacitor. The experimental procedure is described by von Hippel.[8] All measurements were made at room temperature (25.5°C) in air. The dielectric constants obtained at 1 kc/sec and 2 Mc/sec for the samples are as follows:

	1 kc/sec		2 Mc/sec	
	Run 1	Run 2	Run 1	Run 2
Parallel *a* axis sample 1	13.06	13.16	12.83	12.85
sample 2	13.42	13.32	13.18	13.20
Parallel *c* axis sample 3	11.82	11.78	11.60	11.72
sample 4	11.94	11.92	11.92	11.78

The average dielectric constants obtained from the above data are:

	1 kc/sec	2 Mc/sec
Parallel *a* axis	13.3	13.0
Parallel *c* axis	11.9	11.8

The errors between replicate measurements of the same specimen are considerably smaller than the difference between two specimens of the same orientation. The latter difference would be affected by the accuracy of the measurements of the geometrical dimensions of the crystals. The loss index ($\epsilon' \tan\delta$) in all measurements was of the order of 10^{-3} or less.

It is interesting to compare these data with those of Al_2O_3. At 1 kc/sec and 25°C, the dielectric constants of Al_2O_3 are[9]:

parallel *a* orientation, 9.22;

parallel *c* orientation, 11.25.

The dielectric constants of Cr_2O_3 are greater than those of Al_2O_3, and the orientation which has the larger dielectric constant is opposite in these two materials.

Since the antiferromagnetic Néel temperature of Cr_2O_3 is at 307°K, and the x-ray data indicate a slight nonlinear change of the lattice parameters in this temperature region,[1] we have measured the dielectric constant as a function of the temperature between 298 and 327°K. We observed a very small increase of the dielectric constant with increasing temperature in the order of 10^{-3} per 1°C, and a slight anomaly was observed in the Néel temperature region. This anomaly seems to be of a high order (i.e., not λ type), a similar observation was reported by Samakhvalov.[7]

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