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DIELECTRIC PROPERTIES OF BARIUM TETRATINATE AND OTHER DIELECTRICS OF THE SYSTEM TiO_2-BaO

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(Russian text and English translation)

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Unclas

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A study of the dielectric constant and X-ray diagrams of the polycrystalline system TiO_2-BaO in relation to the amount of the components showed that these materials can be broken down into the following groups.

The first group are dielectrics close to the already studied $BaTiO_3$, the abnormal properties of which were discovered by Vogel and Goldman(1), or those made up of $BaTiO_3$ in considerable quantity. The dielectric constant of these materials at room temperature and at low voltage lies in the range 130-2000 and is greatly dependent on temperature. If the amount of BaO is increased the curve T vs. ε changes from flat for the compositions near $BaTiO_3$ to a suddenly high value and then gradually flattens out (Fig. 2).

An increase in the amount of TiO_2 over that in the metatitanate $BaTiO_3$ for materials in this group shifts the temperature for maximum ε to the high temperature side and smoothes it out. An increase in BaO shifts the temperature for maximum ε to the low temperature side and also smoothes it. The crystal structure of all dielectrics in this group as shown by X-ray pictures approximates more or less that of Perovskite.

In the second group are dielectrics, near the composition $BaO \cdot 4TiO_2$ that is to barium tetratitanate; the dielectric constant of these materials lies in the range from 29 to 50 and is only slightly dependent on T. The temperature co-efficient of the dielectric constant $(TK\varepsilon)\frac{1}{\varepsilon}\cdot\frac{d\varepsilon}{dT}$ goes through zero for ε near 37; barium tetratitanate has a very small positive (TKε) temperature co-efficient (approx. $+10 \cdot 10^{-6}$ 1/°C) and ε near 33. X-ray analysis shows that the crystal structure of barium tetratitanate differs both from Perovskite and also from Rutile, that is, barium tetratitanate is a special chemical compound even in its crystal structure.

In the third group are dielectrics with low BaO content. The dielectric constant is highly dependent on frequency. At low frequencies (50-10000 cycles) it is

large (up to 1000 - compare Curve G, Fig. 2), at high frequency (1-10 megacycles) it is much less (about 100). ε vs. T falls off with temperature at high frequencies, at low frequencies it increases sharply. The mechanism of the dielectric polarization in these materials is principally of a new character and apparently is similar to a relaxation. X-rays show that the structure of this dielectric group is similar to the structure of Rutile.

The fourth group are dielectrics with high content of BaO and are chemically unstable and decompose on standing. The dielectric constant of these lies in the range 10 to 30.

These basic aspects first established in 1945, (2) made it possible to carry out work in various directions. A study of the dielectric loss in barium tetratitanate and the corresponding technical manufacture of these dielectrics lead to the creation of new ceramic condenser materials (tetrabarium) with very low TKε (from +10 to +30 · 10^{-6}), increased dielectric constant (ε = 28), with low loss angle at high frequency, slightly dependent on T, up to high T (Fig. 3), independent of frequency for a sufficiently wide frequency range, (Fig. 4) and also with high volume resistance (10^{15}ohm cm).

Since completing our work, there has been published in the U.S.A. a paper (3) in which analogous properties of barium tetratitanate are described.

Literature Quoted (References)

(1) B.M.Vool and E.M.Goldman - Report Acad. of Science (Russian) 46 #4 (1945).

(2) G.A.Skanavi - Dissertation Physical Institute Acad. Science SSSR 1945.

(3) E.M.Bunting, G.R.Sheldon and A.S.Creamer, Amer. Cer. Soc. Jl. 30 #4 (1947).

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Fig. 1 - Dependence of dielectric constant of the system TiO_2-BaO on account of $BaCO_3$ in the mixture at 20°C ;1 - f = 50 cycles E = 30 V/mm
;2 - f = 3 megacycles E ≈2V/mm.

Fig. 2 - Dependence of ε on temperature for the system TiO_2-BaO at f = 50 cycles and E = 30 V/mm

Heated Mass	Molecular Ratio BaO/TiO_2
A	1.06
B	1.01
C	1.22
D	1.20
E	1.30
F	1.62
G	0.04

Fig. 3 - Dependence of tan δ on T for various frequencies for "tetrabarium" 1 - f = 116 KC
2 - f = 265 KC
3 - f = 595 KC
4 - f = 1.20 Megacycles
5 - f = 3.59 Megacycles

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