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Figure 1

Figure 1: Figure 1

Abstract

Full Text

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ANOMALIES OF ELASTICITY AND INTERNAL FRICTION IN THE VICINITY OF THE ANTIFERROELECTRIC CURIE POINT IN $PbMg_{1/2}W_{1/2}O_3$

(Presented by Academician A. V. Shubnikov, 12 V 1962)

Anomalies of many physical properties (dielectric permittivity, dielectric losses, the coefficient of linear expansion, specific heat, etc.) in the region of the phase transition from the paraelectric to the antiferroelectric phase (in the vicinity of the antiferroelectric Curie point) have been experimentally found in a number of dielectrics (see, for example, ([1])). However, until now neither theoretically nor experimentally has the existence, in the region of the antiferroelectric Curie point, of anomalies of the elastic constants and internal friction been shown, although their presence could have been expected on the basis of various considerations.

To detect the indicated anomalies we investigated the new antiferroelectric $PbMg_{1/2}W_{1/2}O_3$, first obtained and studied by G. A. Smolenskii and co-workers ([2–4]). He also placed at our disposal specimens for measurements in the form of polycrystalline ceramic rectangular bars with approximate dimensions $25 \times 5 \times 1.8$ mm.

Fig. 1. Temperature dependences of the elastic compliance s_{11} (1) and of the logarithmic decrement of damping δ (2) for $PbMg_{1/2}W_{1/2}O_3$

Measurements of the elastic compliance s_{11} and of the corresponding logarithmic decrement of damping δ were carried out by the method of a composite (double) resonator, with quartz as the exciter. During the measurements the composite resonator was thermostated with an accuracy of 0.1°. An estimate of the influence of the finite transverse dimensions of the specimens and of the change of their length with temperature showed that the correction to the value of s_{11} due to this lies beyond the limits of the measurement accuracy. Therefore the influence of these factors was not taken into account.

The density of the specimens, which had practically zero open porosity, was, according to measurements, 7.52 g/cm^3 (at 20°).

Fig. 2. Temperature dependence of the dielectric permittivity for $PbMg_{1/2}W_{1/2}O_3$, measured at a frequency of 1000 Hz with a UM-3 bridge.

Figure 2: Fig. 2. Temperature dependence of the dielectric permittivity for $PbMg_{1/2}W_{1/2}O_3$, measured at a frequency of 1000 Hz with a UM-3 bridge.

From the typical experimental dependences (for one of the specimens) shown in Fig. 1, it is seen that the curves $s_{11}(t)$ and $\delta(t)$ exhibit clearly pronounced anomalies in the region of 33-38°: a jump in s_{11} and a maximum of δ. The temperatures of the maximum of δ and of the inflection point on the curve $s_{11}(t)$ coincide with one another and, as comparison with the data shown in Fig. 2 indicates,

lie slightly to the left (by ~2°) of the temperature of the maximum of ε (the antiferroelectric Curie point). A small temperature hysteresis (~1-1.5°) was found in the curves.

A noticeably larger value of the internal friction near the phase-transition point in the antiferroelectric phase, compared with the value of the internal friction in the paraelectric phase, is apparently due to an additional contribution to the internal friction in the antiferroelectric phase from losses at "domain" (twin) boundaries. Let us note that the theoretically possible character of the domain structure in $PbMg_{1/2}W_{1/2}O_3$ permits displacement of domain boundaries under the action of mechanical stresses. The increase in elastic compliance in the antiferroelectric phase of $PbMg_{1/2}W_{1/2}O_3$, compared with the compliance in the paraelectric phase, can be explained by the same cause, as well as by a decrease in the "stiffness" of the crystal lattice (the latter agrees with the positive volume spontaneous strain of $PbMg_{1/2}W_{1/2}O_3$ found in ([4])).

Fig. 2. Temperature dependence of the dielectric permittivity for $PbMg_{1/2}W_{1/2}O_3$, measured at a frequency of 1000 Hz with a UM-3 bridge.

Directly near the phase-transition point, apparently, the greatest role is played by the influence of dynamic stresses on the process of establishment of dipole antipolarization, which also leads to the presence of a maximum on the $\delta(t)$ curve and a jump on the $s_{11}(t)$ curve; in a single crystal these will probably occur over an even narrower temperature interval.

It may be assumed that in other antiferroelectrics as well, among the anomalies of various physical properties in the vicinity of the antiferroelectric Curie point, anomalies of elasticity and internal friction will occur.

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Note: Figure translations are in progress. See original paper for figures.