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Abstract

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ON THE QUESTION OF THE DIELECTRIC PROPERTIES OF THE POLYCRYSTALLINE SOLID SOLUTION $Ba(Ti, Sn)O_3$ AT HIGH PRESSURES

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Dielectric properties of solid solutions based on barium titanate have been studied in detail in the works of G. A. Smolenskii and other authors ([1]-[6]). These studies made it possible to investigate the influence of various ions on the ferroelectric properties of crystals. There are also works ([7], [8]) devoted to the study of the influence of hydrostatic pressure on the ferroelectric properties of some solid solutions based on barium titanate.

The present work is devoted to investigating the influence of hydrostatic pressure on the dielectric properties of a substance of composition $Ba(Ti_{0.9}, Sn_{0.1})O_3$, which is formed in the barium titanate—barium stannate system. As is known, in this system a continuous series of solid solutions is formed with a perovskite-type structure, possessing ferroelectric properties.

The specimen studied was in a polycrystalline state, with a thickness of 0.52 mm and a diameter of 4.6 mm. The electrodes were applied by thermal evaporation of silver in vacuum. The capacitance of the specimen under study was measured at a frequency of 800 Hz.

In the work, the temperature dependence of the dielectric permittivity of $Ba(Ti, Sn)O_3$ was measured in the region of the phase transition at various values of hydrostatic pressure: 1000, 2000, 3050, and 4200 kg/cm^2. Throughout the entire experiment the pressure remained strictly constant. The temperature of the high-pressure vessel and of the specimen placed in it was raised from 20 to 60°. Each point on the curves was recorded only after the temperature had reached the prescribed value and had been maintained constant for 1 hour.

The temperature part of the apparatus made it possible to maintain the constancy of the temperature with an accuracy of 0.02° in the above-mentioned temperature range. The temperature of the bomb was measured by a potentiometric circuit using a calibrated copper-constantan thermocouple.

Fig. 1. Dependence of the dielectric permittivity of the polycrystalline solid solution $Ba(Ti, Sn)O_3$ on temperature at different pressures.
1 $-P = 0$; 2 −1000 kg/cm^2; 3 −2000 kg/cm^2; 4 −3050 kg/cm^2; 5 −4200 kg/cm^2.

The experimental data obtained are presented in Fig. 1. As is seen from Fig. 1, $Ba(Ti, Sn)O_3$ at pressure $P = 0$ possesses a very high

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Figure 1: Fig. 1. Dependence of the dielectric permittivity of the polycrystalline solid solution Ba(Ti,Sn)O_3 on temperature at different pressures. 1 –P = 0; 2 –1000 kg/cm^2; 3 –2000 kg/cm^2; 4 –3050 kg/cm^2; 5 –4200 kg/cm^2

Fig. 2. Dependence of the Curie temperature of $\mathrm{Ba(Ti,Sn)O_3}$ on pressure

Figure 2: Fig. 2. Dependence of the Curie temperature of $\mathrm{Ba(Ti,Sn)O_3}$ on pressure

the value of the dielectric permittivity in the region of the Curie point. In works (^{2,5}) it was shown that the high value of the dielectric permittivity in the region of the Curie point in a weak field for $\mathrm{Ba(Ti,Sn)O_3}$ is explained by considerable orientational polarization, caused by a change in the domain structure, i.e., by a change in certain regions of the direction of spontaneous polarization under the action of an electric field. Under high-pressure conditions the processes of domain reorientation are hindered, which leads to a decrease in orientational polarization. At the same time the value of the dielectric permittivity of the crystal should also decrease. This assumption is in good agreement with the results of the investigation carried out in the present work.

Fig. 2. Dependence of the Curie temperature of $\mathrm{Ba(Ti,Sn)O_3}$ on pressure

As can be seen from Fig. 1, with increasing pressure applied to the specimen the value of the dielectric permittivity of the polycrystalline $\mathrm{Ba(Ti,Sn)O_3}$ specimen during the phase transition decreases considerably. Thus, at a pressure of 4200 kg/cm^2 the value of the dielectric permittivity at the Curie point decreases by more than a factor of two. At the same time, in the region of the phase transition at high pressures for $\mathrm{Ba(Ti,Sn)O_3}$, a sharp maximum of dielectric permittivity is not observed. Under high-pressure conditions the dielectric permittivity during the ferroelectric phase transition passes smoothly through a maximum at the Curie point.

As the point of the phase transition, the point on the curve for which $d\varepsilon/dP = 0$, corresponding to the maximum of the dielectric permittivity, was taken. However, the phase transition at high pressures occurs within a certain temperature range, and it is necessary to speak of a region of the phase transition. From the obtained data on the maxima of ε, the dependence of the temperature of the ferroelectric phase transition for $\mathrm{Ba(Ti,Sn)O_3}$ on pressure was constructed. The dependence of the Curie-point temperature on hydrostatic pressure for a polycrystalline $\mathrm{Ba(Ti,Sn)O_3}$ specimen is shown in Fig. 2. A linear dependence was obtained between the Curie-point temperature and hydrostatic pressure up to 4200 kg/cm^2. The Curie temperature decreases with increasing pressure with a coefficient of $-3 \cdot 10^{-3}$ deg/atm.

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