Conductivity Effects in Bi_2TeO_5 Single Crystals

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The tellurites of metals have attracted the attention as useful materials for acousto-optical devices. The physical properties of the compositions $Bi_{1-x}TeO_{(3+x)/2}$, where $0{,}33 \le x \le 0{,}50$, were studied and improper ferroelectric behavior of these compositions were revealed [1,2]. Bismuth tellurite (Bi_2TeO_5) is one of the most stable forms among the numerous compositions identified in the phase diagram of the Bi_2O_3 – TeO_2 system. Bi_2TeO_5 crystallizes in an orthorhombic structure with space group Abm2 and have layer type structure along c-axis. The nonlinear crystal of bismuth tellurite became an interesting material when its photorefractive properties were discovered [3].

In this report, we present the results of investigations of the electrical conductivity and dielectric parameters for the Bi_2TeO_5 single crystals over wide range of temperatures (20 – 400 °C) and frequencies ($2\cdot10^2$ – $5\cdot10^7$ Hz). The dielectric parameters and ac–conductivity of Bi_2TeO_5 have been measured along three crystallographic directions corresponding to the rhombic lattice axes. dc-conductivity ($\sigma_=$) has been measured along c-axis only.

The features of the dielectric parameters as a function of the temperature and frequency are discussed. It was found that the frequency dependence of $\sigma_\sim$ can be described by relation of $\sigma_\sim \sim w^s$, where s depends from frequency and changes from 0,4 to 2. There are relaxation maxima of the $\sigma_\sim$ in temperature dependence.

The dc–conductivity increases with the temperature increase up to 150 °C with activation energy $\Delta E \approx 0{,}2$ eV and $\sigma_=$ increases exponentially at higher temperature with $\Delta E \approx 1{,}0$ – 1,1 eV.

Voltage-current curves of the Bi_2TeO_5 single crystals are typical for the space charge limited currents [4]. From these characteristics, the effective mobility of carriers and concentration of the equilibrium-trapped charge at different temperatures have been determined. Low values of the mobility (10^{-7} $cm^2/V\cdot s$ at 100 °C) obtained for the carriers and its exponential increase with temperature are characteristics for hopping conductivity model.

The conductivity stimulation effect was observed in Bi_2TeO_5 single crystals at the fields corresponding to nonlinear ranges of voltage-current curves. If it is assumed the hopping conductivity model for Bi_2TeO_5 single crystals then the conductivity stimulation can be explained by increase of carrier mobility due to the shift of the Fermi level to range with higher density of states. The latter is the result of the occupation of the state levels by injected carriers.

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