PHYSICAL PROPERTIES OF LITHIUM TETRABORATE SINGLE CRYSTALS AT HYDROSTATIC PRESSURE

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The lithium tetraborate $Li_2B_4O_7$ single crystals were produced using the Czochralsci method by means of an HX-620 setup. The dielectric and dilatometric studies of the $Li_2B_4O_7$ single crystals were carried out within the 80-400 K temperature range under the high hydrostatic pressure (up to 600 MPa) conditions. The anomalies (at 100 KHz frequency) were observed at T_t=248 K being, probably, related to the lithium sublattice disordering. The increase of the hydrostatic pressure results in a linear shift of anomalies in the dependences ε(T) and tgδ towards the lower temperature region with –58±2 K/GPa coefficient. For the $Li_2B_4O_7$ single crystals the values of the linear compressability $\chi_{[100]}$ and $\chi_{[001]}$ and their temperature behaviour were determined.

Lithium tetraborate $Li_2B_4O_7$ *(LBO)* belongs to the 4mm tetragonal symmetry with a polar axis along the crystallographyc c axis and is a promising piezoelectric material due to its elastic properties and high coefficient of electromechanical coupling. Besides, in these crystals in the temperature range of 248 K a phase transition to the superionic state is observed, associated with the disordering of lithium sublattice [1].

LBO crystals for our studies were obtained in platinum crucible at ambient air by Czochralsci technique using a HX-620 setup with automatic diameter control.The crystal pulling rate was by 3 mm/day with the rotation of 5 rpm, the axial gradient above the melt being 2-3 K/mm. The crystal was grown in [001] direction from the composition with the excess of 0,5 mol.% B_2O_3. The crystals were annealed for 24 h at 1130 K, the cooling rate was 15 K/h.

Dielectric and dilatometric studies of *LBO* single crystals in the temperature range from 80 to 400 K were measured under high hydrostatic pressure up to 600 Mpa. ε and tgδ measurements were performed using a conventional technique at 50 Khz using high hydrostatic pressure cell. The pressure in the cell was measured by a manganine manometer within ±2MPa. Dilatometric studies were carried out in a three-window optical high-pressure cell, the pressure being transferred by aviation petrol .The *LBO* compressibility was measured by the interference technique. With the continuos variation of the pressure in the cell the changes in the laser light interference, passing through a Fabri-Perot interferometer. Between the interferometer mirrors, three pyramids cut of the crystal under investigation, were located, their size determining the distance between the mirrors. In order to eliminate the contribution of the pressure agent refractive index variation into the changes in the interference pattern, the measurements were carried out simulteneously for the sample and for the standard item , made of *KBr*, whose compressibility has been studied well. The relative error in the determination of *LBO* compressibility was 5%.

In fig.1,2 temperature dependencies of ε and tgδ of *LBO* crystal, measured along [001] crystallographic axis, are shown.

In the range of temperatures near T_t=248 K an anomaly in the dielectric permeability ε is observed as a slight maximum as well as a rapid increase of the dielectric loss. No such anomalies of ε and tgδ were observed in [100] crystallographic direction. Such behaviour of ε and tgδ is, probably, related to the lithium sublattice disordering. The increase of the hydrostatic pressure linearly shifts the anomalies in ε(T) and tgδ plots towards lower temperatures with the coefficient of -58±2 K/GPa, at $T>T_t$ ε and tgδ increase being observed.

In fig.3 pressure dependencies of linear compressibility for *LBO* crystal, measured along [100] and [001] crystallographic axis.

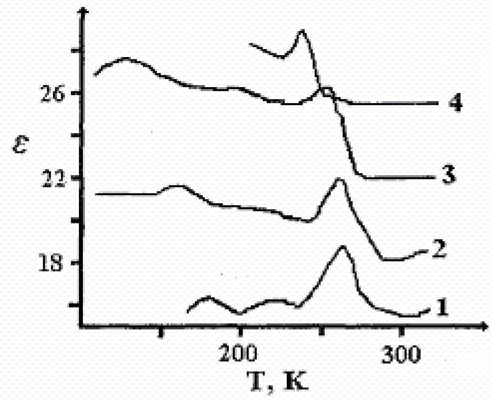

Fig.1 .Temperature dependences of dielectric permiability for *LBO* crystal at different meaning of hydrostatic pressure P, GPa: 1 - 0,05; 2 - 0,27; 3 - 0,33; 4 - 0.53

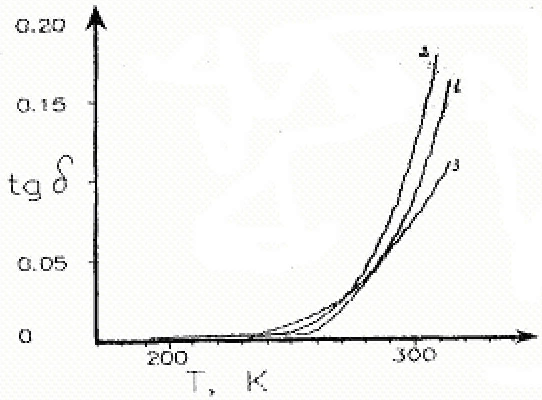

Fig 2. Temperature dependences of dielectric loss tangent for *LBO* crystal at different meaning of hydrostatic pressure P, GPa: 1 - 0,08; 2 - 0,33; 3 - 0,53

Linear isothermal compressibility at zero pressure $\chi_{[100]}$=0,51*10^{-11} Pa^{-1}, $\chi_{[001]}$=1,15*10^{-11} Pa^{-1}. The hydrostatic pressure increase

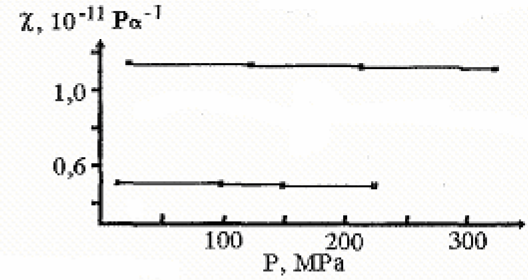

Fig.3. Pressure dependence of linear compressibility of *LBO* crystal along the crystallographic axis: 1 - $_{[001]}$, 2 - $_{[100]}$.

results in the decrease of this values by 1% Kbar^{-1}. *LBO* is seen to reveal a strong anisotropy of its elastic properties indicating the interatomic foreskin this crystal along the fourth-order axis to be much weaker than in the plane perpendicular to this axis. The linear thermal expansion coefficient α in *LBO* along [100] and [001] directions equals to 19,8*10^{-6}, K and 1,62*10^{-6} K respectively [2]. The specific feature of lithium tetraborate is the absence of correlation between α and χ in various directions, since usually in crystals high χ values are observed along the directions with high χ values. The measured linear compressibility values are in good agreement with those determined from the elastic compliance modules: $\chi_{[100]} = S_{11} + S_{12} + S_{13}$ = 0,53*10^{-11} Pa^{-1} and $\chi_{[001]} = S_{33} + 2S_{13}$ = 1,32*10^{-11} Pa^{-1} [2].

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Фізичні властивості монокристалу тетраборатa літія в умовах гідростатичного тиску.

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Проведені діелектричні та ділактометричні дослідження кристалів $Li_2B_4O_7$, отриманих методом Чохральського, в широкому інтервалі температур та тисків (до 600 MPa). Виявлено аномалії діелектричної проникності ε(T) та tgδ в точці T=248K, які пов'язуються з розупорядкуванням підгратки літію. Зростання гідростатичного тиску приводить до лінійного зсуву аномалії ε(T) та tgδ в низькі температури з коефіцієнтом −58±2 K/Gpa. Для монокристалів $Li_2B_4O_7$ отримані значення лінійної стисливості $\chi_{[100]}$ і $\chi_{[001]}$.