# SOME PROPERTIES OF LEAD TELLURIDE WIRE CRYSTALS IN GLASS ISOLATION

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Wire crystals (WC) based on lead telluride due to large free path lengths and large de Broglie wavelengths are convenient objects for observation and investigation of classical and quantum size effects. The paper describes investigation of a number of physical-chemical properties of PbTe wire crystals in a glass isolation grown by the method of filling of vacuumed closed-end quartz capillaries with PbTe melt followed by its directed crystallization [1]. Filling of capillaries having the inner diameter 10-150 μm and the length 150 mm is carried out by the excess pressure of inert gas in the process of the melt crystallization inside the capillaries and it is directed towards their open ends with the velocity less than 10 cm/hour.

Roentgenographical study of WC has shown availability of cubic modification characteristic of PbTe in the form of both thin films and bulk samples with the unit cell parameter a=6,452. The obtained WC are single crystals with the advantageous direction of growth [100].

Metallographical and electron-microscopic studies have shown that along WC micropores of the size less than 3μm are observed. Perfection of WC structure (decrease of defect quantity) increases with their diameter lessening, this being confirmed by determination of density of dislocations on longitudinal and transverse cuts of samples of different thickness.

It is found that the density of dislocations in the region adjacent to the boundary material-quartz (the sample surface layer) is about $10^6$-$10^7$ $cm^{-2}$, and in its central part it is in the limits of $10^3$-$10^4$ $cm^{-2}$. This nonuniform distribution of dislocations differs from the distribution for WC of other semiconductor materials, where it is uniform all over the crystal cross-section [2]. Probably it is connected to appearance of mechanical stresses on the boundary material-quartz in the process of growth.

Influence of compressing efforts from the isolation side on WC is also confirmed by measurement of the electric resistance of WC in the process of dissolution of quartz isolation and by the method of microhardness measuring.

While the isolation dissolves the resistivity ΔR/R sharply grows at the beginning, and then it achieves saturation. The increase of ΔR/R is explained by the fact that as the isolation wall thickness decreases the value of compressing efforts influencing the crystal from the isolation side decreases as well. The curve saturation region is explained by absence of influence of external forces on the single crystal after quartz etching. The microhardness in the regions adjacent to the isolation is by 1,2-1,4 times higher than that in the central part of the sample.

Thus, the above given investigations show that the WC side walls closely adjoin the quartz isolation and undergo compression stress.

Comparison of microhardness values in WC of different diameters shows that when the diameter decreases the microhardness increases, and manifestation of the microhardness size effect begins at diameters less than 50 μm. These results together with those mentioned above, also confirm improvement in perfection of structure of thin wires in comparison with the thick ones.

At the liquid nitrogen temperature the WC microhardness of both n- and p-types of conductivity increases almost twice. Measurements of microhardness of WC of n- and p-types of conductivity have revealed that the microhardness of WC of p-type is higher that its values for crystals of n-type, after isothermal annealing the microhardness of n-type crystals decreases, and of p-type increases (Table 1).

Table 1

Microhardness of lead telluride WC before and after isothermal annealing, T=293 K, P=5gs

| Conductivity type | d, μm | H kgs/mm$^2$ | |
|---|---|---|---|
| | | before annealing | after annealing |
| p | 15,4 | 56,6±1,2 | 60,3±2,4 |
| p | 62,2 | 38,8±2,1 | 44,6±1,6 |
| n | 16,6 | 50,2±1,2 | 44,5±1,8 |
| n | 37,0 | 40,0±1,5 | 36,0±1,2 |

This behavior of crystals of n- and p-types is explained by peculiarities of phase diagram of point defect state in the process of isothermal annealing. As it is known, p-PbTe contains precipitates of tellurium with sizes of about 3 μm, and in the process of annealing dissociation of these precipitates takes place. During this, dissociated atoms of tellurium dissolve in the crystal, i.e. they heal lead vacancies. Since the sizes of tellurium atoms are smaller than the sizes of lead atoms, healing of the vacancies leads to the lattice parameter decrease, and accordingly to the microhardness increase.

In n-PbTe interstitial lead atoms in the annealing process may heal both lead vacancies and tellurium vacancies. This healing leads in its turn to the inner stress removal and to the microhardness decrease. It should be noted that the effect of the lattice inner state change is most brightly shown in wire crystals due to small sizes and cylindrical symmetry.

It was also found that tensosensitivity coefficient values for WC of p-type lead telluride are considerably higher (from 70 to 150 for different diameters) than for WC of n-type conductivity (from 30 to 60 for different diameters).

Tensosensitivity coefficient K of the crystals was determined as $K=\Delta R/R_0\varepsilon$, where $R_0$ is the initial resistance of the sample, $\Delta R$ is the resistance increase under pure bending deformation. The tensosensitivity coefficient of WC of both n- and p-types of conductivity is positive (i.e. when the deformation increases the sample resistance grows). In the studied region of elastic deformations for the crystals of p-type the ratio $\Delta R/R_0$ depends linearly on deformation. For the crystals of n-type certain deviation from the linear dependence is observed [3].

Let us also note that increase of the inert gas pressure in the process of obtaining of PbTe WC leads to improvement of structure perfection and microhardness increase in the limits 0,9-2,3 for both n- and p-type of conductivity.

Comparison with the results on measuring of electrophysical properties of PbTe WC is given and possibility of their application as discrete detectors and injector lasers for the spectrum region 3-5 μm is shown.

## REFERENCES

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