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Features of Structural Inhomogeneities in Doped Cadmium Antimonide Crystals

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The paper presents the results of research to identify inhomogeneities in tellurium doped CdSb crystals. The work aims to investigate the influence of structural inhomogeneities and establish the presence of periodicity in the distribution of data inhomogeneities. It was found with two-probe compensation method, optical topography method, scanning electron microscopy and EDX-analysis the presence layered structure with several layers of types, characterized by different periods.

Keywords: anisotropy, crystal, impurity, resistivity, inhomogeneities, layered structure.

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Introduction

It's well known that the crystals grown by Czochralski method or zone melting method, are the layered structure (layers or strips of growth) [1-3]. Layered structure is a periodic change in the concentration of impurities and defects along the growth axis of the crystal. This causes periodic changes in resistivity and other parameters crystals affect the properties of devices yield of integrated circuits, features position-sensitive detectors and long-range particles detectors for which the maximum geometric size is chosen along the axis of crystal growth [1].

I. Analysis of recent research and publications

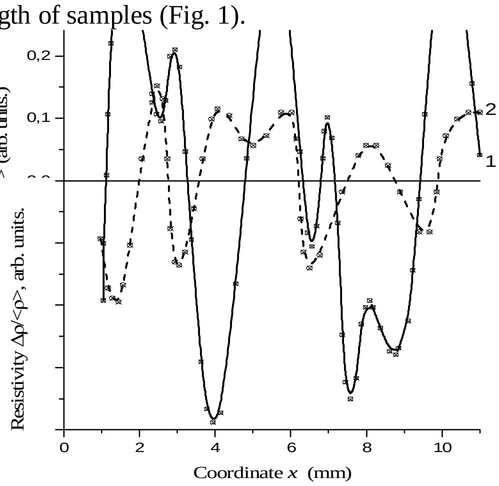
In the works of many authors, in particular [2, 4], draws attention to the fact, that period is different layered inhomogeneity in the range of tens of microns to millimeters and growing proportion temperature gradient in the crystallization front. It is believed that the impurity band formed by temperature fluctuations during crystal growth, arising from the rotation or as a result of convection currents in the melt. This leads to fluctuations in the rate of growth that cause non-uniform distribution of impurity segregation coefficient which is different from the unit. The formation of bands of high and low impurity concentration dependence of this ratio is due to growth rate and the speed of rotation of the crystal. Along with the fact there is another point of view, according to which the layered structure is the result of convection currents caused by temperature gradients. As a result of growing concentration hypothermia front quickly moving forward to the disappearance of unstable temperature gradient when the growth rate again takes a normal value. A periodic repetition of the process of changing the rate of growth in crystal form transverse layers with different content of impurities.

Analysis of many methods used to study inhomogeneities in semiconductors, showed that in the case of multivalley semiconductors necessary requirements can satisfy quantitative control two-probe compensation (TPC) method with the greatest possible resolution. Accuracy TPC-method was practically depends on the resistivity of the material, because the current through the measuring probes when full compensation is not and they are potential [5].

The goal of the article is to identify structural inhomogeneities in tellurium doped cadmium antimonide crystals, and to establish the presence of periodicity in the distribution of these inhomogeneities.

II. Materials and research results

Samples CdSb(Te) for research TPC-method were cut parallel and perpendicular to the axis of crystal growth. A sample was passed stabilized constant current that could change, both in magnitude and direction. Voltage drop between the probes measured compensation method using potentiometer setting. Measurement of resistivity conducted along the length of the sample ($\vec{j}$ [001], $\vec{j}$ [010]) with a resolution 0,5 mm. As a result of the measurement curves constructed experimental resistivity distribution along the length of samples (Fig. 1).



Coordinate *x*, mm

Fig. 1. Relative resistivity deviation from the mean for samples CdSb(Te), cut out to the axis of crystal growth: 1 – parallel; 2 – perpendicular.

In the obtained dependences $\Delta\rho/\langle\rho\rangle = f(x)$ revealed a much higher resistivity deviation from the mean $<\rho>$ in samples cut along the axis of crystal growth $\vec{j}$ [001] than cut perpendicular to this axis $\vec{j}$ [010]. Sudden changes in gradient resistivity $\Delta\rho$ in the direction of crystal growth due to the existence in this field gradients significant carrier concentration Δn. Therefore, we can speak of crystal growth in the direction of impurity concentration inhomogeneities, with a periodicity should be noted (a few millimeters) in their distribution along the length of the samples.

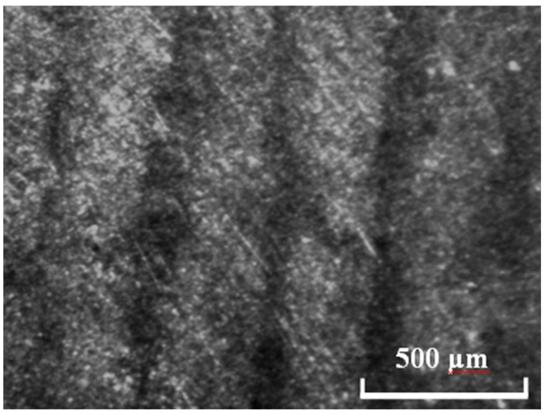


Fig. 2 – Topograms longitudinal section doped Te CdSb crystal.

We also studied the data of crystals by optical topography and revealed the presence in their layered structure with a period of about 300 microns (Fig. 2).

Analysis of results obtained both the TPC-method and by the optical topography shows layered structure with several layers another type, characterized by different periods. In order to test this assumption studied the structure on scanning electron microscope (Fig. 3).

Fig. 3. The structure of CdSb(Te) crystals.

In the course of these studies revealed a layered structure with a period investigated crystals of the order of 1.5 microns.

Along with those using Energy Dispersive X-ray (EDX) analysis assessment made distribution of chemical elements in the bulk crystal. In the obtained dependence (Fig. 4) also observed inhomogeneous distribution of impurity concentration Te along the length of the samples.

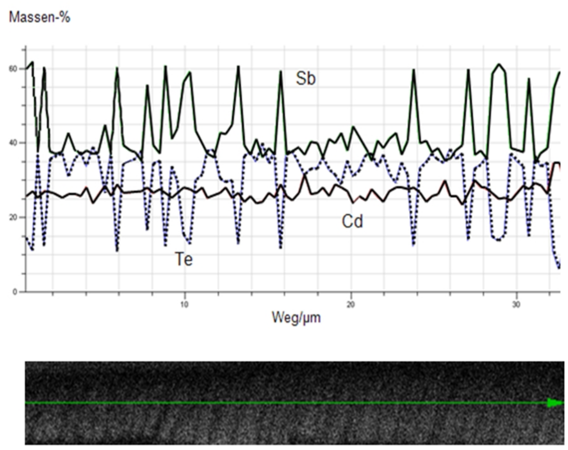


Fig. 4. Distribution of chemical elements in length samples CdSb(Te).

Conclusions

From the researches results TPC-method, optical topography method, scanning electron microscope and EDX-analysis follows, in Te doped CdSb crystals are layers of inhomogeneous distribution of impurities from different periods that must be considered when studying the anisotropy of the physical properties of crystals of data and designing devices with them.

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Особливості структурних неоднорідностей в легованих монокристалах антимоніду кадмію

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У роботі представлені результати досліджень по виявленню неоднорідностей в кристалах CdSb, легованих Te. Робота переслідує мету дослідити структурні неоднорідності та встановити наявність періодичності в розподілі даних неоднорідностей. Виявлено за допомогою двозондового компенсаційного методу, оптичної топографії, растрової електронної мікроскопії та EDX-аналізу наявність шаруватої структури з декількома типами шарів, що характеризуються різними періодами.

Ключові слова: анізотропія, кристал, домішка, опір, неоднорідності, шарувата сструктура.