CHARACTERISTIC PECULIARITIES OF p-PbTe/n-$Pb_{0,99}Tm_{0,01}Te$ p-n TRANSITIONS

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On the basis of $Pb_{0,99}Tm_{0,01}Te$ single crystals and PbTe epitaxial layers the photoreceivers which are sensitive at 5-12 μm wavelength band have been fabricated. Spectral, volt-ampere and volt-farad characteristics have been studied on multielement scales of photosensitive structures. It was established that at 77 K product of differential resistivity at null dislocation and active area. R_0A is equal to 10 ohm·cm^2 (R_0A=10 ohm·cm^2). It has also determined that a main mechanism of current traverse is generation - recombination of charge carriers. The concentration gradient of electroactivity centers in field of volumetric charge band is about ~ $0{,}54\cdot10^{21}$ cm^{-4}, and therefore the generated p-n transitions are abrupt.

1. Introduction.

PbTe and solid solutions on its basis have wide application in semiconducting optoelectronics for creation of photoreceivers and injection layers operating at 3-5 μm and 8-14 μm wavelength band. Possibility of fabrication of devices operating at such a spectra of range is conditioned by alteration of the size of prohibited zone width, by way of regulating the stechiometric compound, which affaires simple to implement within the limit of homogeneity surfaces. Consequently, solid solutions of $Pb_{1-x}Tm_xTe$ can be exceedingly suitable for creation of photosensitive structures with practically valuable parameters. The present information contains results of investigations of some photoelectrical, volt-ampere and volt-farad characteristics of infrared emission receivers created by way of epitaxial build up of -PbTe thin layers into n-$Pb_{1-x}Tm_xTe$ single crystals.

2. Experimental.

Single crystals of *n*-$Pb_{1-x}Tm_xTe$ solid solutions have been grown by directed crystallization method and were used as a substrate for preparation of photosensitive structures. Mechanical processing was initially carried out, and after cutting of single crystals in a (100) plane direction aimed to removal of disturbed layers, their surfaces were treated with chemical etching in 6 % Br_2 solution in HBr. Then Electro-chemical polishing of the surface was provided in Norman etching (H_2O:KOH:glyserine and ethyl spirt=15ml:20g 35ml:20 g), with further removal of etching residues by deep flushing in dionized water flow. With the help of a "hot wall" method by using of two-phase lead and tellurium mixture (in stechiometri ratio), PbTe films were grown on these backings. To decrease concentration of self defects (eigen defects) in condensed films and to enable the courtral over charge carriers concentration in PbTe films, an additional source of tellurium vapor was used [1] in the process of growth. Thickness of grown pate epitaxial layer was within the margin of 5 to 10 μm. Scales of photosensitive elements were formed with the help of photolithography`, but prior to laying it onto the surface of films, metallic contact indium layer was applied by thermal evaporation in vacuum of prepared meza-structures formed 0,2 mm^2 and that of bonding pad was 0,05 mm^2. Gold wires of diameter. ~30 μm were joined to bonding pads by using of low-temperature solder ($T_{\pi A}$≈333K) consisting of 50% Br+25%Pb+12,5%Sn+12,5%Cd.

Volt-ampere and spectral characteristics of prepared p-n transitions in temperature interval of 77-300 K were studied as in [2]. Prepared structures were observed to have rectifying characteristics even at ~300 K.

3. Results and Discussion.

Fig.1 demonstrates volt-ampere characteristics (VACh) of p-PbTe/n-$Pb_{1-x}Tm_xTe$ diode structures at 77K. VACh forward-bias region is qualitatively described by a function $I=I_s exp(eV/\beta kT)$. Based on temperature dependence calculations β coefficient of which is equal to 2. It testifies to predominance of recombination constituent of electric current. Substantial distinction of $I\sim f$ (U) dependence is existence at U>150 mV in reverse-bias region of a section corresponding to tunnel break-through of *p-n* transition. Mentioned section gradually disappears by increasing the temperature. It is well known that in *p-n* transitions at 300 K is diffusional. It is well known that in *p-n* transitions of materials close in their contents to the materials preferred with the help of a device described in present work, considerable number of electroactive centers are refereed to exist, and increase of their concentration gradients affects on decrease of width of volumetric charge bend, and the concentration value of charge carriers on the boundary of volumetric charge carriers on the boundary of volumetric charge band may also increase in this case [3].

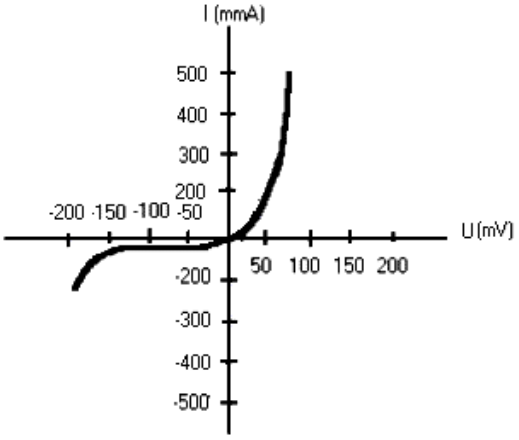

Fig.1. Volt-ampere characteristics of p-n structures p-PbTe/n-$Pb_{0,99}Tm_{0,01}Te$ pieced at 77 K.

In produced solid state structures of *p*-PbTe/*n*-$Pb_{1-x}Tm_xTe$ the growth of R_0A value against the degrease of temperature is bound up with diffusional constituent of the current, thus testifying to existence of above mentioned mechanism in them. At zero bias, the produced structures had $R_0=7,5\ k\Omega$ (at 300K) and $R_0=5k\Omega$ (at 77K). Determination the concentration gradient of electroactivity centers in field of volumetric charge band (a) was provided with the help of [4]

$$a = \frac{p+n}{W} \quad (cm^{-4}).$$

Where *p* and *n* are concentrations of charge carriers in *p* and *n* bands of p-n transitions and *W* is the width of volumetric charge band. According to voltage-capacitance characteristics of created structure *W*=0,003cm, and $n=0{,}43\cdot10^{18}cm^{-3}$ [5].

Hall finding [5] have established that $p=1{,}2\cdot10^{18}cm^{-3}$ in $Pb_{0,99}Tm_{0,01}Te$ single crystal. Consequently, $a=0{,}54\cdot10^{21}cm^{-4}$ derived value of volumetric charge concentration evidences to the formed p-n transition to be sharp.

Fig.2. shows the spectral characteristic of produced IR photoreceivers. Maximum of spectral characteristic is in agreement with wave length equal to 5,7 μm. Volt-watt sensitivity value of S_ζ was calculated with $S_\zeta=V(\lambda)/P(\lambda)$, (*V/W*) formulae, where $V(\zeta)$ is a photo-electromotive force (e.m.f.) on ж wave length for separate meza-structures $V(\zeta)=(70\text{-}94)\ \mu V$, $P(\zeta)$ is a power of radiation with χ wave length, incident on specimen, at 77K, the value of S_ζ for separate meza-structures amounted from 121 to 162 *V/W*. Photocurrent was defined as per measured value of photo-e.d.f (V_s) and the value of meza-structure resistance at zero shift of (R_0) :

$$I_{photo}=V_s(\zeta)/R_0\ .$$

At 300K the value of $I_{photo}=12{,}5\mu A$, and at 77K the value of $I_{photo}=18{,}8\ nA$.

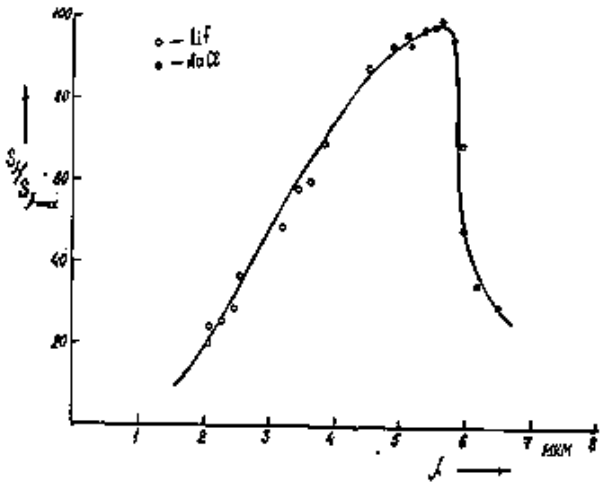

Fig.2. Spectral characteristic of photoreceiver on *p*-PbTe/*n*-$Pb_{0,99}Tm_{0,01}Te$ structure basis (○-prism from LiF; •-prism from NaCl).

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p-PbTe/*n*-$Pb_{0,99}Tm_{0,01}Te$ *p-n* KEÇİDLƏRİNİN XARAKTERİSTİKALARININ XÜSUSİYYƏTLƏRİ

$Pb_{0,99}Tm_{0,01}Te$ monokristalları və PbTe epitaksial təbəqələri əsasında 5-12mkm dalğa uzunluqlarında həssas olan fotoqəbuledicilər hazırlanmışdır. Çoxsaylı elementlərin düzülüşündən ibarət olan fotohəssas quruluşlarda voltamper, spektral və voltfarad xarakteristikaları tədqiq edilmişdir. Müəyyən olunmuşdur ki, 77K temperaturunda tarazlıq halında differensial müqavimətin aktiv sahəyə hasili R_0A=10 Om·sm^2. Cərəyanın axma mexanizmi yükdaşıyıcıların generasiya-rekombinasiyası ilə aydınlaşır. Həcmi yüklər oblastında elektroaktiv mərkəzlərin konsentrasiya qradiyenti ~$0{,}54\cdot10^{21}$ sm^{-4} olduğundan, yaradılan p-n keçid kəskindir.

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ОСОБЕННОСТИ ХАРАКТЕРИСТИК *p-n* ПЕРЕХОДОВ *p*-PbTe/*n*-$Pb_{0,99}Tm_{0,01}Te$

Изготовлены фотоприемники на основе монокристаллов $Pb_{0.99}Tm_{0.01}Te$ и эпитаксиальных слоев PbTe, чувствительных в диапазоне длин волн 5-12 мкм. На многоэлементных линейках фоточувствительных структур исследованы спектральные, вольтамперные и вольтфарадные характеристики. Установлено, что при 77 К произведение дифференциального сопротивления при нулевом смещении на активную площадь R_0A=10 Ом·см^2. Определено, что основным механизмом протекания тока является генерация-рекомбинация носителей заряда. Градиент концентрации электрически активных центров в области объемного заряда порядка ~$0{,}54\cdot10^{21}$ см$^{-4}$ и поэтому сформированные p-n переходы являются резкими.

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