

MECHANISM OF CURRENT TRANSFER IN $n\text{CdS-pCdTe}$ SOLAR CELLS HETEROSTRUCTURES

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ABSTRACT

The material, fabrication and operation parameters for cadmium telluride CdTe солнечных элементов require high sensitivity, small pixel size, low defect density, long-term thermal-cycling reliability and large area substrates. The focus of this work is on the epitaxial growth of CdTe thin films on Si(111) for the purpose of using the resulting material as a substrate for the solar cell. In contrast, polycrystalline CdTe grown for solar cell applications, results in CdTe grown predominately in the (111) orientation. A photosensitive $n\text{Si/pCdTe}$ heterojunction based on single-crystalline silicon has been obtained and studied. As substrates, we used n-type silicon single-crystal wafers $\text{Si}\langle 111 \rangle$, with a thickness $d=300\div 350$ μm , on the surface of which thin layers of p-type CdTe with conductivity $d=50\div 70$ μm were deposited in a vacuum quasi-closed volume. The resulting CdTe films had a cubic structure. The study of the $n\text{Si/pCdTe}$ heterostructure by energy-dispersive X-ray diffraction analysis showed that the composition of the CdTe layer depends on its thickness on the silicon surface. The spectral characteristics of the formed heterostructure were also obtained, where the decline of the maximum located in the long-wavelength region of the spectrum corresponds to silicon, and the decline of the maximum located in the short-wavelength region corresponds to cadmium telluride and covers a wide region - from the visible region of the spectrum to the infrared region (300 \div 1400 nm).

Keywords: Heterojunction, Si, CdS, CdTe, photosensitivity, structure, spectrum, crystalline structure, to belt, layer.

INTRODUCTION

Results of research of the mechanism of carrying over of a current in $n\text{CdS-pCdTe}$ - heterostructures with an intermediate layer of a firm solution with a thickness $d \approx 1\mu\text{m}$ and a parity $d/L \approx 2\div 3$ (L - diffusion length of no basic carriers of a current) are results $d \approx \mu \approx \div$. It is shown, that volumetric characteristic (VAC) such structure is described by two sub linear sites. These sites, on which the current with growth of pressure falls a little, are connected by a site of sharper decrease of a current. Such sub linear VAC speaks presence of the big number of

the centers of the sticking leading to independence of speed ambipolars of drift from concentration of free carriers. It is shown; that VAC on a site of sharp decrease of a current it is caused recombination no equilibrium carriers of a current through difficult complexes in which

the grasped carriers of a current are late. The photoelectric method defines structures of firm solutions and their width of forbidden zone $E_g(x)$ and constants of a crystal lattice $a_0(x)$. The capacitor method defines a thickness of firm solutions of various structures, which correspond to the data, received on microscope MIM-8 by measurement on the cut.

INTRODUCTION

Last year's various semi-conductor structures on the basis of polycrystalline CdTe, first of all n-n/n-n - heterostructures [1,2] are intensively investigated. Very often heterostructures n-CdS / p-CdTe are used as solar elements. Therefore, the big attention is given to processing methods of creation of heterostructures (HS) n-CdS/p-CdTe and to studying of electronic processes in such structures. By authors of works [3, 4] it has been shown, that semiconductor binary connections CdS and CdTe, co-operating among themselves, form a solid solution (SS) $CdTe_{1-x}S_x$ with continuous change of maintenance CdS

($0 < x < 1$). After an establishment of possibility of formation, FS $CdTe_{1-x}S_x$ $CdTe_{1-x}S_x$ on border of section of heterostructures n-CdS/p-CdTe [5] intensive research of properties of this layer has begun. In works [6,7] it has been shown, that FS $CdTe_{1-x}S_x$ on heteroborder it is formed strongly non-uniform, and in [8-10] it has been established, that the firm solution is also non-uniform and on structure. Efficiency of

Solar elements on a basis n-CdS/p-CdTe is in many respects defined by perfection of structure, and the geometrical sizes and fazes FS [11]. For achievement of the best efficiency solar element -SE the firm solution should possess continuous structure at thickness $d < 1\mu m$ and change from CdS to CdTe. It is the difficult technological problem connected with application of a heat. Use of high-temperature technology at formation n-CdS/p-CdTe heterostructures leads to increase in the maintenance of uncontrollable impurity on all structure, including in film CdTe. Therefore an actual problem is reception n-CdS/p-CdTe - heterostructures with small concentration of uncontrollable impurity and small thickness FS. For this purpose it is necessary to investigate n-n/n-n-heterostructures with the small geometrical sizes FS, received at various technological and temperature modes.

In the given work results of researches on role revealing highly - omens layer SS $CdTe_{1-x}S_x \approx 1 \mu m$ in the mechanism of carrying over of a current in n-CdS/p-CdTe to heterostructures are resulted by thickness.

Experiment

For carrying out of researches have been made n-CdS/p-CdTe heterotransition on the technology described in [12]. The top contact from which party illumination is carried out, has been made from In, raised dust in vacuum $\sim 10^{-5}$ torr in a kind «II». Back contact was produced from molybdenum. As a base material for heterostructures films p-CdTe which specific resistance was equal $\rho \approx 10^2 \div 10^3 \text{ Om} \cdot \text{cm}$ served, and the thickness made $\approx 70 \mu m$. Films consist of blocks of microcrystal with column structure of the grains focused in a direction of growth

and time focused on an azimuth. The sizes of grains are in limits from 100 to 150 μm so grains cover all the thickness long films.

Volt-amperes characteristics were registered in direct and return directions over a wide range of current and pressure change at a room temperature. C-V characteristics were registered at frequency $f \approx 1$ MHz at a room temperature, as they under the form are identical to that in the field of frequencies

100 kHz – 5 MHz.

Time of a life of no basic carriers of a current (τ_p) on a relaxation of an electric signal in a mode of pressure of idling - V_{cc} [13,14] was measured at various constant displacement ($V_{cm} \approx 2 \div 15V$) on the sample. At measurement τ_p from the generator of calibrated impulses G5-53 moved «Π»-shaped impulses with amplitude 60-80 mV and duration 100÷200 μs. The steepness of such impulses made no more $2 \cdot 10^{-8}s$, and area For not less $5 \cdot 10^{-4}s$.

The phase structure of a transitive layer of a firm solution is investigated by means of a photoelectric method by measurement of spectral distribution of photosensitivity in without pressure a mode as in work [10]. Spectral dependence of photosensitivity was measured on monochromator ZMR-3 at a room temperature. As a radiation source the lamp of type DKSHS-1000 working in a mode of is minimum admissible capacity, which provided a light stream served xenon 53000 Lm, and brightness to 120 Mkd/m² with the central light stain.

RESULTS AND DISCUSSION

On Fig. 1 the characteristic (VAC) of this structure is resulted volt-ampere at a direct direction of a current. Following sites are brightly allocated for VAC:

1. $J = J_{01} \exp\left(\frac{qV}{c_1 kT}\right)$, $c_1 = 2, 2$, $I_{01} = 1, 7 \cdot 10^{-8} A/cm^2$.

2. $J = J_{02} \exp\left(\frac{qV}{c_2 kT}\right)$, $c_2 = 16, 4$, $J_{02} = 3,2 \cdot 10^{-5} A/cm^2$.

3. The first sub linear a site,

$$V = V_0 \exp(d/aJL^2) \quad V_0 = 0,12V,$$

$$\alpha = 2,51 \cdot 10^7 \text{ A}^{-1} \text{ cm}.$$

4. Exponential a falling site of type

$$J = J_{03} \exp\left(-\frac{qV}{c_3 kT}\right),$$

5. The second sub linear a site, $V = V_0 \exp(d/aJL^2) \quad V_0 = 5,55V, \alpha = 8 \cdot 10^7 \text{ A}^{-1} \text{ cm}.$

The first and second sites VAC have been investigated by us in [15]. It has been thus shown, that on the first site VAC is shown the law inherent in thermionic issue (see e.g. [16]), and on the second site the current is well described V.I.Stafeeva's received at the account of a power failure on kvazi the neutral to base [17] by known formula. From the second site VAC by means of formulas [15]:

$$J = J_0 \exp\left(\frac{qV}{ckT}\right), \quad c = 2 \frac{(1+bChd/L)}{1+b}$$

$$J_0 = \left(\frac{kT}{q} \frac{bch \frac{d}{L}}{L(b+1)tg \frac{d}{2L}} \right) \quad (1)$$

Values of the relation of a thickness of base d (FS $\text{CdTe}_{1-x}\text{S}_x$) to diffusions to length of no basic carriers (holes) L have been estimated: $d/L \approx 2.9$; length of diffusion of holes $L_p = 3,4 \cdot 10^{-5} \text{cm}$; product $\mu_p \tau_p \approx 4 \cdot 10^{-8} \text{cm}^2/\text{V}$; time of a life of holes $\tau_p \approx 7 \cdot 10^{-8} \text{s}$ and specific resistance of base $\rho \approx 1.5 \cdot 10^7 \text{ Ohm}\cdot\text{cm}$. At an estimation was accepted, that $d = 1 \mu\text{m}$ and $b = \mu_n/\mu_p \approx 10$ [18]. The thickness of base d was measured from an end face of the sample by means of electronic microscope MIM-8 as in [15]. On this site VAC at pressure $V_{\text{cm}} = 2\text{V}$ the relaxation of no equilibrium carriers of a current also was investigated. Relation the curve is described by two of exponents dependences $\ln \Delta n \approx \ln \Delta n_0 - \frac{t}{\tau_1}$ and $\ln \Delta n \approx \ln n_0 - \frac{t}{\tau_2}$ from which the time constants equal $\tau_1 \approx 9,1 \cdot 10^{-8} \text{s}$ and $\tau_2 \approx 1,5 \cdot 10^{-6} \text{s}$ have been defined $\tau \cdot \tau$. The first of them will not bad be co-ordinate with lifetime τ_p , defined of the second site VAC. The second value of time of a life of no basic no equilibrium carriers of a current $\tau_p \approx 1,5 \cdot 10^{-6} \text{s}$, shows, that recombination processes proceed simultaneously through two independent groups recombination's the centers or other layer of a firm solution is responsible for this time ($\text{CdTe}_{1-x}\text{S}_x$) with other structure.

Further, to VAC there are two sub linear sites, which are divided by a site of sharp recession of a current (Fig. 1). It is represented to us what to explain unusual enough kind of this VAC it is possible, involving the model described in [19]. In the long diode ($d/L > 1$) in the presence of the big number of the centers of sticking the conditions leading to independence of speed ambipolars of drift from concentration of free carriers can be realized. As a result of it, the basic equation of a problem describing distribution of concentration of free carriers in base becomes [19]:

$$\frac{d^2 p}{dx^2} - aJ \frac{dp}{dx} - \frac{p}{L_p^2} = 0 \tag{2}$$

Where -

$$a = \frac{1}{2qD_n N_t} \tag{3}$$

The parameter depending on concentration of the deep centers of sticking N_t , $L_p = \sqrt{D_p \tau_p}$ - diffusion length of free carriers.

If in $p-i-n$ structure counter directions ambipolars diffusion and drift the mode of "injection pauperization" takes place, for the first time theoretically predicted in [20] and observed on many materials (see e.g. [21,22]) are realized. VAC in this case looks like:

$$V \approx V_0 \exp(aJd) \tag{4}$$

It is necessary to notice, that on this site the current slowly grows with pressure. Such VAC it was observed by us on $\text{CdS} - \text{CdTe}$ -structures with enough to stretch the intermediate layer of a firm solution playing a role i -of-base. It was in detail analyzed in [23].

On both sub linear sites presented on Fig. 1, the current slowly decreases with pressure growth. In [19] it was noticed, that in case of conterminous directions ambipolars diffusion and drift of free carriers probably occurrence to VAC a sub linear site of a kind:

$$V = V_0 \exp(d/aJL^2) \tag{5}$$

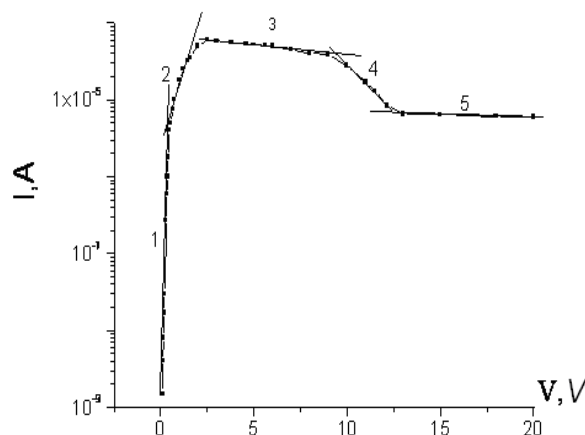


Fig. 1. Volt-ampere the characteristic n-CdS/p-CdTe – heterostructures with a thickness bazes 1µm at a room temperature.

On which the current, unlike type (4) site, decreases with pressure. Parameter *a*, found from experimental data under the formula:

$$a = \frac{d}{L^2} \frac{(1/J_2 - 1/J_1)}{\ln(V_2/V_1)} \tag{6}$$

(Here J_2 and, J_1 V_2 and - V_1 density of a current and pressure on two points experimental VAC) allows to define concentration of the deep centre on the first and second sub linear sites which have appeared equal $N_i \approx 8,5 \cdot 10^{13} \text{cm}^{-3}$ и $N_i \approx 3 \cdot 10^{12} \text{cm}^{-3}$, accordingly.

Now we will analyze the falling site which is between subs linear sites VAC. Recession VAC leading to nonlinearity N - type, can be caused various mechanisms. In particular, tunnel diodes and the superconducting metal films divided by a dielectric backlash have such characteristic. Volt-ampere the n-type characteristic is observed also at effect Hannah. On a falling site (Fig. 1) intensity of electric field makes VAC $8 \cdot 10^4 - 1,2 \cdot 10^5 \text{V/cm}$, that it is quite enough for a transfer electron from the bottom valley in the top valley of a zone of conductivity SS CdTe_{1-x}S_x and, possibly, can lead to nonlinearity of N-type. However, as zone structure SS CdTe_{1-x}S_x is poorly studied, we cannot unequivocally assert, that the site of sharp recession of a current is caused by effect Hannah. At the same time at an explanation of the reasons leading to strengthening of decrease of a current with pressure after the first sub linear site VAC, apparently, it is necessary to consider, that in our material are present at a considerable quantity not only simple local recombination the centers, but also various impurity and defects (in particular vacancies Cd and Te), and also defect- impurity and an impurity- impurity complexes of the most various nature. It forces to assume, that at high enough level of excitation in recombination can start to play an essential role processes of an intracomplex exchange by carriers. In this case expression for speed recombination looks like [24]:

$$U = N_R \frac{c_n c_p (pn - n_i^2)}{c_n (n + n_1) + c_p (p + p_1) + \alpha \tau_i np} \tag{7}$$

Where α - the factor defined by the concrete nature of a complex, τ_i - time of an exchange of carriers inside recombination a complex (irrespective of its nature). As soon as the processes

of an intra complex exchange described by last member in a denominator (7), start to play though any notable role, speed recombination can be approximately presented in a kind:

$$U \approx N_R \frac{c_n c_p}{c_n + c_p} p - N_R \frac{c_n c_p \alpha \tau_i}{(c_n + c_p)^2} p^2 \quad (8)$$

It means, that time of a life of free carriers $\tau = p/U$ will not be now a constant, and will grow with growth of concentration of free carriers:

$$\tau \approx \frac{c_n + c_p}{N_R c_n c_p} + \frac{\alpha \tau_i p}{N_R c_n c_p} \quad (9)$$

Hence, diffusion the length of free carriers will grow also with growth of level of excitation and as in expression for VAC (5) L^2 costs in a denominator of indicator exhibitors, it unequivocally means, that decrease of a current with pressure will amplify. Occurrence of the second sub linear site of type (5) means, that other, less high-resistance layer of a firm solution starts to work. For the statement of correctness of the offered mechanism time of a life of no basic no equilibrium carriers of a current (τ) on 3, 4, 5 sites VAC (Fig. 1 see) to which there correspond following values of constant displacement $V_{sm} = 5v$ has been measured: τ ; 10V 15V.

Have been thus received: $\tau_1 \approx 3 \cdot 10^{-6}s$, $\tau_2 \approx 8,5 \cdot 10^{-6}s$, $\tau_3 \approx 5,6 \cdot 10^{-5}s$ ($V_{tr}=5V$) on 3 site VAC; $\tau_1 \approx 1,5 \cdot 10^{-5}s$, $\tau_2 \approx 3,2 \cdot 10^{-4}s$, ($V_{tr}=10V$) on 4 site VAC; $\tau_1 \approx 6,5 \cdot 10^{-5}s$, $\tau_2 \approx 2,8 \cdot 10^{-4}s$, $\tau_3 \approx 7,8 \cdot 10^{-4}s$ ($V_{tr}=15V$) on 5 site VAC.

The received results show, that to growth of the enclosed constant pressure really there is an increase in time of a life of no basic no equilibrium carriers a current (τ) that occurrence of a falling site after a sub linear site VAC where the current slowly decreases with pressure growth From this follows, most likely, occurs because of increase of length of diffusion (L_p) no equilibrium no basic carriers of a current.

Occurrence at same constant pressure $-V_{tr}$ sometime constants on a curve relaxation specifies, that in recombination processes some types of complexes which can be in layer SS of one structure or in layers of a firm solution of various structure simultaneously participate.

In structure, SS It is easy to fly component atoms of cadmium are. Therefore in under a lattice It is easy to fly atoms of cadmium are easily formed one under a lattice It is easy to fly and two under a lattice It is easy to fly vacancies of atoms of cadmium, V_{cd}^- and V_{cd}^{-2} between communication atom Cd_i . Two vacancies of atoms of cadmium in most cases V_{cd}^{-2} form complexes with positively charged impurity of type $(V_{cd}^{-2} D^+)^{-1}$ and with neutral between a small knot atoms of tellurium of types $(V_{cd}^{-2} Te_i^+)^{-2}$ [25]. These complexes are deep acceptor the centers.

In structure SS are available as donor Cl, In, Al, and acceptor impurity P, Li, Ag, Au, Cu. Atoms of silver (Ag), copper (Cu), gold (Au) give deep acceptor the centers. It is obvious, that in structure SS also there are vacancies of atoms of sulphur (V_s) and tellurium (V_{Te}) which have donor the nature while between a small knot Te_i and Si_i have acceptor the nature. Possibly, these defects and impurity can form defect - impurity type complexes «negatively charged acceptor + positively charged ion of introduction» or «positively charged donor + negatively charged vacancy» through which occurs recombination no equilibrium carriers of a current to a delay which play a defining role in recombination processes in layers of a solid solution (SS) $CdTe_{1-x}S_x$ $nCdTe-pCdTe$ heterostructures.

It is known, that in polycrystalline semiconductors kinetic parameters, including times of a life of no basic carriers of a charge, basically, are defined by defects on a surface (concentration N_{ss}) from which a leading role play between grain superficial conditions. Electronic conditions of defects, impurity in between grain conditions (in to stretch defects), basically, define kinetic, and process degradations and mechanisms of course of a current. Therefore, for the purpose of definition of electronic conditions of defects in between grain borders and for finding-out of a role of defects (complexes) in conductivity modulation dielectric - SS the C-V-characteristic has been investigated. The investigated heterostructures works as p-p-p - structure [12] where a p-layer is CdTe, as an i-layer - $CdTe_{1-x}S_x$, a n-layer - CdS. It can, prove as MDS-structure as CdS - the layer practically is the semimetal alloyed In $\sim 10^{18} \text{sm}^{-3}$. Experimental C-V-curve removed on frequency $f = 1 \text{ MHz}$ at a room temperature shows the MDS-structure characteristic (Fig.2a). Concentration of equilibrium carriers of the current (holes), defined from on size of flat zones and on an inclination volt - farad characteristics it has appeared a C-curve equal $\sim 4 \cdot 10^{14} \text{cm}^{-3}$ [26], and on size of the minimum capacity $\sim 7 \cdot 10^{13} \text{cm}^{-3}$. Concentration $p_0 \sim 4 \cdot 10^{14} \text{cm}^{-3}$ on the size is very close to equilibrium concentration of holes of a base film p-CdTe, therefore it is used for construction of the settlement C-V-characteristic. Settlement volt-farad the characteristic is constructed as in [26] (Fig. 2b see,2). The experimental C-V-characteristic lays to the right of the settlement C-V-characteristic. It means that the base of investigated MDS- structure has conductivity p-type. Besides, in a mode of accumulation the capacity has three areas of a constancy of capacity from the enclosed negative pressure of displacement (V_{tr}). It shows that in MDS- structure there are three types dielectric, which differ on geometrical capacity.

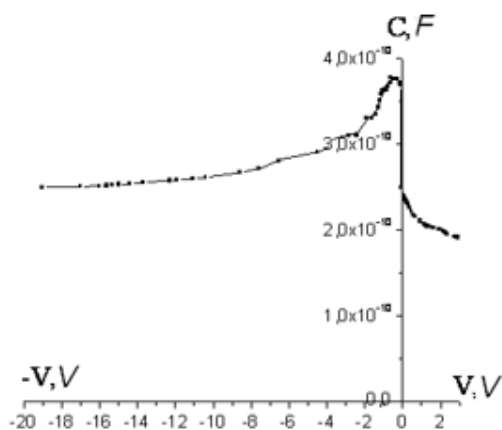


Fig. 2a. The experimental C-V-characteristic
Which has been removed on frequency $f = 1 \text{ MHz}$
At a room temperature when on the top metal
electrode negative displacement (V_{tr}) is submitted.

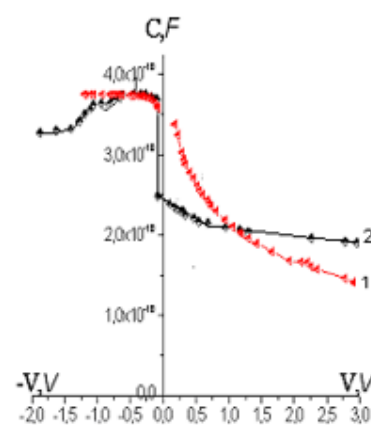


Fig. 2b. Of the characteristic of
experimental (1) and settlement (2) volt-
farads.

In n-n/n-n-structure, the role dielectric plays SS $CdTe_{1-x}S_x$, formed on border of section of layers CdS and CdTe. The photoelectric method [10] had been investigated structure SS for the investigated sample. In spectral distribution of photosensitivity (Fig. 3) between edges of

own absorption CdS and CdTe obvious peaks $\lambda_{1max} = 670$ nanometers, $\lambda_{2max} = 690$ nanometers, $\lambda_{3max} = 740$ nanometers, $\lambda_{4max} = 796$ nanometers, and also weak peak are observed at $\lambda_{5max} = 850$ nanometers which amplitude on two order is less than at the peaks which have been found out in visible area of a spectrum. For the found out peaks in spectral dependence of photosensitivity edges of fundamental absorption $\lambda_{e, fa}$, width of forbidden zone $E_g(x)$, a constant of a crystal lattice $a(x)$ which values are resulted in tab. 1 are defined. Given table. 1. Show that SS consists of four layers, which differ among themselves dielectric on structure and on conductivity. As FS in investigated heterostructures play a role (oxide), their capacities correspond to value of capacity on a plateau of C-V-characteristics. Thickness SS, the C-V-characteristics estimated from this area have appeared accordingly equal (Fig.2a): $d_1 \approx 2,4 \cdot 10^{-5} \text{cm}$; $d_2 \approx 2,6 \cdot 10^{-5} \text{cm}$; $d_3 \approx 2,9 \cdot 10^{-5} \text{cm}$. The total thickness FS, estimated on a plateau of C-V-characteristics, has appeared $\sim 0,8 \mu\text{m}$. Here the thickness SS with $x = 0,21$ is not considered, as this firm solution is not shown on the C-V-characteristic, possibly, it too thin.

Table 1. Dependence of a constant lattice $a_0(x)$, average width of forbidden zone E_g, qV , and edges of fundamental absorption $\lambda_{efa, \text{nm}}$ for firm solution $\text{CdTe}_{1-x}\text{S}_x$.

| $\lambda_{i \text{ max, nm}}$ | $\lambda_{efa, \text{nm}}$ | E_g, qV | $a_0(x), \text{A}^\circ$ |
|-------------------------------|----------------------------|------------------|--------------------------|
| 670 | 674 | 1,84 | 0,5942 |
| 690 | 704 | 1,76 | 0,5972 |
| 740 | 760 | 1,63 | 0,6030 |
| 796 | 810 | 1,53 | 0,6477 |
| 850 | 880 | 1,4 | 0,6346 |

The estimation was spent under the formula $d = (\epsilon S/C)$, where ϵ -dielectric permeability dielectric (SS), S - the area of the top metal electrode. At an estimation was considered $\epsilon = 9,3$ as at sulphide and telluride of cadmium it is equal 9 and 9,6 accordingly [27]. The thickness FS, estimated on capacitor measurements, will be co-ordinate with the thickness received on microscope MIM-8 by measurement on the cut. Except above specified feature of the experimental C-V characteristic, it is necessary to note following features still. It is crossed from a settlement C-V-curve at two values of the enclosed pressure: $V=1,1\text{V}$ ($\psi_s=0,324\text{qV}$) and at $V=-0,15\text{V}$ ($\psi_s=-0,02\text{qV}$). Possibly, at these values of superficial potential superficial conditions are completely compensated, i.e. $N_{SA}=N_{SD}$. Besides it, the capacity at value $V=-0,1\text{V}$ ($\psi_s=-0,01\text{qV}$) practically in steps changes from value $C=250\text{pF}$ to $C=360\text{pF}$ which is close enough to value of capacity of the first layer dielectric (SS).

This phenomenon specifies that the volume charge of free holes on section border p-CdTe-dielectric (SS) sharply increase because of filling negatively charged acceptor superficial conditions. Thus, dependence of effective density of superficial conditions (N_{ss}) from superficial potential (ψ_s) changes under the difficult law (Fig. 3) Values N_{ss} and ψ_s were defined as follows. On shift of the experimental C-V-characteristic on an axis of pressure concerning the settlement the full grasped charge (Q_{ss}) by superficial conditions (N_{ss}) and value of superficial potential (ψ_s), corresponding to the set displacement on the top metal electrode is found. Real position of superficial potential is defined from value ψ_s from ideal volt – farad characteristics at the same value experimental and settlement C-V curves. Found such by dependence N_{ss}

from ψ_s is resulted on Fig. 3. From the analysis of dependence $N_{ss}(\psi_s)$ follows, that the effective density of superficial conditions is strongly compensated also its maximum value does not exceed $\sim (2-3) \cdot 10^{10} \text{cm}^{-2}$. Thus effective density N_{ss} in a mode of flat zones ($\psi_s=0$) has acceptor the nature and is characterized by size $N_{SA}=1,8 \cdot 10^8 \text{cm}^{-2}$ (Fig. 3 see2). Besides, it is very sensitive to the pressure enclosed to structure. For example, at values of pressure $V=-0,1 \text{V}$ ($\psi_s=-0,01 \text{qV}$) and $V=1,1 \text{V}$ ($\psi_s=0,324 \text{qV}$), $N_{SS}=N_{SA}-N_{SD}=0$, that about full indemnification. And after extreme point $V=1,1 \text{V}$ ($\psi_s=0,324 \text{qV}$) effective density N_{SS} passes with acceptor type N_{SA} on donor (N_{SD}) which quickly grows with the further increase ψ_s , and then practically leaves on a plateau. However, effective density N_{SA} and N_{SD} in the field of saturation $N_{SA}(\psi_s)$ and $N_{SD}(\psi_s)$ have almost identical values.

In general, the considered dependence of density of superficial conditions N_{SS} on superficial potential ψ_s characterizes MDS-structure, which is insignificant, is rejected from thermodynamic balance. Thus the negative displacement enclosed on the top metal electrode, does not exceed $0,2 \text{V}$ ($\psi_s=-0,02 \text{qV}$), and in the opposite direction a current, displacement it is no more, than $\approx 1,5 \text{V}$ ($\psi_s=0,37 \text{eV}$). In both cases through structures small currents $10^{-8} \div 10^{-7} \text{A}$. For Fig. 1. Fig. 2. Fig. 2a. Fig. 3. Fig. 4. us interestingly condition of structure when it is considerably rejected from thermodynamic balance i.e. when through structure big enough currents of an order $10^{-5} \div 10^{-4}$ proceed and (Fig. 1, 3-5 sites VAC see).

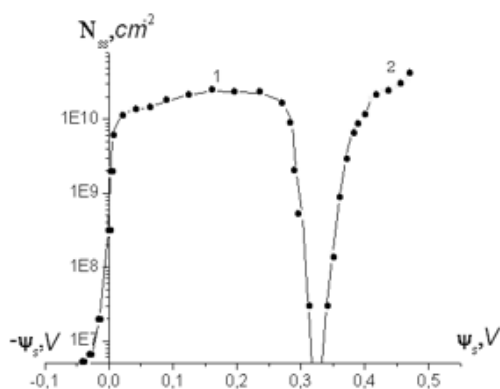


Fig. 3. Dependence of effective density of superficial conditions on superficial potential with non section border dielectric ($\text{CdTe}_{1-x}\text{S}_x$) – the semiconductor (pCdTe):

- 1. - Acceptor superficial conditions (N_{SA}),
- 2. - donor superficial conditions (N_{SD}).

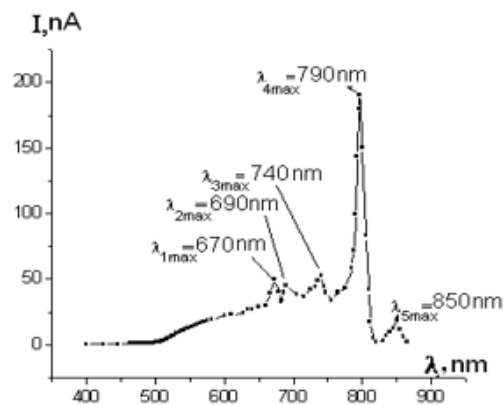


Fig 4. Spectral distribution of photosensitivity n-n/n-n - heterostructures thickness based $\sim 1 \mu\text{m}$ a room temperature.

On these sites VAC values of the negative displacement enclosed on top metal the electrode, change in limits $\sim 2, 5 \div 8, 8 \text{V}$ (3), $\sim 9 \div 13 \text{V}$ (4) and $\sim 9 \div 20 \text{V}$ (5). At these values, V_{tr} the capacity decreases (Fig. 2b). In addition, on the third site VAC the capacity decreases from 310pF to 265pF , and on (4) and (5) sites the capacity decreases from 265pF to 255pF , and from 255pF to 249pF accordingly. From these data follows, that the capacity volume a charge of free carriers of a charge (holes) on border of section $\text{SS CdTe}_{1-x}\text{S}_x - \text{p-CdTe}$ decreases. In addition, it decreases differently in the specified areas of pressure. For example, in the field of pressure-

2, $5V \div 8,8V$ the structure capacity decreases on 45 pF, and in areas of pressure $-9V \div 13V$ and $13V \div 20V$ it decreases on 10 pF and 6 pF accordingly. It means, that on the third site VAC where the current with pressure growth slowly falls, concentration of the accumulated holes decreases much faster, than on 4 and 5 sites VAC. Concentration of free holes on section border p-CdTe-SS can decrease at the expense of capture of holes by defects in firm solutions and at the expense of current course through structures because of reduction of a potential barrier between CdS-SS and SS - p - CdTe.

All these phenomena leads to change of charging conditions of defects, impurity in firm solutions and, basically, charging conditions of defects in between grain borders (in to stretch defects) as components n-CdS/p-CdTe - structures are polycrystalline materials. Here, possibly, capture of no equilibrium carriers of a current and them recombination is carried out by difficult defects which form among themselves type complexes «negatively charged acceptor + positively charged ion of introduction» or «positively charged donor + negatively charged vacancy» in which the grasped carriers of a charge are late to what the measured values of times of a life of no basic no equilibrium carriers of a charge $\tau_p \approx 10^{-5} \div 10^{-3} s$ testify τ .

CONCLUSION

It is established, that in process formation of heterostructures n-CdS/p-CdTe, the intermediate layer of a firm solution $CdTe_{1-x}S_x$ with thick $\sim 1\mu m$, located between layers CdS and CdTe, containing enough of defects is synthesized. As a part of defects along with dot defects on the visible there are difficult complexes of type «negatively charged acceptor + positively charged ion of introduction» or «positively charged donor + negatively charged vacancy». By researches volt-ampere, volt-farads of characteristics and measurements of times of a life of no equilibrium carriers of a current at various density of a current it is shown, that in kinetic processes and the mechanism of carrying over of a current in n-n/n-n - structures at the big density of a current ($10^{-3} - 10^{-2} A \cdot sm^{-2}$) the basic role is played by the difficult complexes which are in these firm solutions. An exchange of free carriers in which occur inertial. The photoelectric method defines structures of firm solutions and their width of forbidden zone $E_g(x)$ and constants of a crystal lattice $a_0(x)$. The capacitor method defines a thickness of firm solutions of various structures, which correspond to the data, received on microscope MIM-8 by measurement on the cut.

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