THE OBTAINING AND INVESTIGATION OF PHOTOELECTRIC PROPERTIES OF THE *InP – CdS* STRUCTURES BASED HETEROJUNCTIONS

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ABSTRACT

The task of the widening of spectral range of the useable sources and radiation-measuring instrument appears during the development of the semiconductor electronics. As the semiconductor compounds $A^{III}B^{V}$ and the solid solutions on their base can't satisfy the demands of science and technique, so the creation of the "hybrid" heterojunctions, where the layer of $A^{III}B^{V}$ compound is used in the capacity of the one of the components, and the layer of the $A^{II}B^{VI}$ compound is used in the capacity of the another one, is the one of the ways of the task solving.

Keywords: film, structures, photoelectric, semiconductor, heterojunctions.

I. INTRODUCTION

The heterojunctions InP-CdS' present the special interest between many different variants, as the compounds, used in the given case, have the small disparity of lattice parameters $\frac{\Delta a}{a} = 0.3\%$ at 25°C, which practically doesn't change with the temperature increase.

Thus, the paper is dedicated to the treatment of the technology of epitaxial growth of the layers of CdS on the substrate of InP with the transversal layer p^{+}InP, to the investigation of the electrical, photoelectrical properties of the obtained heterojunctions and also it will study the influence of the technological factors on pInP – nCdS heterostructure properties [1].

II. RESULTS AND DISCUSSION

The growth from the gas phase with the help of the transport reactions is the main method of the obtaining of the monocrystallic films of CdS nowadays. We prefer the open lubricating system in the equipment design, as the more technological one in the comparison with the soldered ampoule. The open system allows to rule more effectively by the growth and doping processes of the film, and also to carry out several consistent operations in the one installation.

Her main knots are:

1) The systems of purification, stabilization and measurement of helium flow;

2) gas-distribution system with the source of three-chlore phosphate;

3) quartz reactor with the volume Cd or S;

4) four-band resistance furnace with the system of the regulation and temperature measurement.

The plates by the size $5\times10\times0.5 mm^3$, cut from InP monocrystal on the plane (I I I) with the exactness lower than1°, were used in the capacity of the substrates.

As it is known, the state of the surface of the semiconductor substrate defines significantly the quality of the produced devices, their longevity and durability. That's why the obtaining of the high-qualitive surfaces of the semiconductor substrates, maximally perfect by the structure, geometry, homogeneous by the chemical nature and purity, is the especially important condition at the production semiconductor heterostructures.

The roentgen-structural analysis showed, that films have cubical structure and pInP – nCdS heterojunctions, prepared by the correspondence of the lattice parameters are close to the "ideal" ones.

The microroentgen-spectral, roentgen-difractional analysis and usual metallographical methods, which show, that the obtaining of pInP – nCdS structure has the strong heteroborder and mutual diffusion of the constituents is small in the chosen technological mode, are used with the aim of the study of the interface of the prepared heterojunctions, the definition of the composition and character of the distribution of main components in the epitaxial layers [2].

The typical volt-ampere characteristics of pInP – nCdS heterojunction with the transversal layer in the dynamic mode /T=300K/ is given on the fig.1. As it is seen from the fig.1 the investigated structure has the strongly expressed straightening: the rectification factor achieves the value 10^2 at U=1V.

From the analysis of the tempo volt-ampere characteristics of pInP – p^{+}InP - nCdS structures with the transversal layer, investigated in the wide interval of densities of the current and temperatures (150-300K) is followed, that the current passing through in the temperature range 150-190K is explained by the method

of the intraband tunneling of the termically excited carriers.

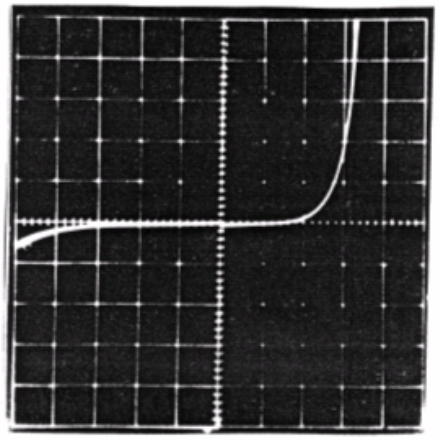

Fig.1. VAC of InP - CdS heterojunctions at T=300°K, on the point J=2mA; U=0.5V.

The mechanism of current passing through connects with the generation-recombination processes in the region of the volume charge in the temperature interval 240-300K and forward voltage $\frac{3KT}{q} < U < 0.5V$. The current passing through at the more high voltages (U>0.5V) is defined by Zener tunneling of the electrons from the valent zone of the narrow-band material InP in the conduction band of wide-band CdS [3].

The volt-ampere characteristics of pInP – nCdS heterojunction at the different intensities of the lightening is shown on the fig.2.

Fig.2. The volt-ampere characteristics of pInP - nCdS heterojunction with transversal layer at the different powers of the fallen light: 1-10MVt/cm^2; 2 - 25MVt/cm^2; 3-70MVt/cm^2.

The dependences of the open-circuit voltage $U_{xx}(I)$ and short-circuit photocurrent density $J_{s.c.}$ (2) on the power of the fallen white light on the sample are shown on the fig.3.

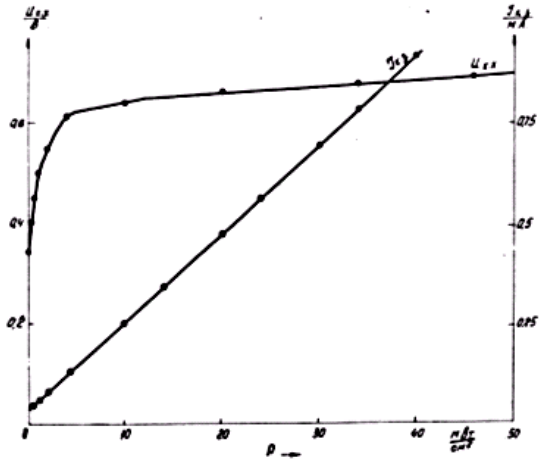

Fig.3. The dependence of open-circuit voltage U_{xx} and short-circuit photocurrent I_{sc} on the lightening.

It is shown, that short-circuit photocurrent density linearly increase and the open-circuit voltage achieves the saturation with the increase of the power of the fallen light.

The investigation of the open-circuit voltage dependence (U_{xx}) on the temperature showed, that the voltage (U_{xx}) in the range 77÷300K linearly decreases with the increase of the temperature coefficient $2 \cdot 10^{-3}$V/grad.

The open-circuit voltage and short-circuit photocurrent density for the best samples are U=750÷780mV and $J_{s.c.}$=30÷32mA/cm at the lightening of heterojunctions with the transversal layer by the white light of the power 90mV/cm^2.

The value of the open-circuit voltage and short-circuit photocurrent density are correspondingly equal to 740÷770mV and 15-17mA/cm^2 for pInP – nCdS heterojunction without transversal layer at the lightening by the light of the power 70mV/cm^2.

It is shown, that the strongly slump of the quantum output value in the short-wave region of the spectrum (λ<0.55mkm) is caused by the light absorption in the "thick" layer of CdS (5 mkm), the slow slump is observed at the decrease of the photon energy of recombination losses and at the increase of the scattering from the generation place of electron-hole till interface.

The photoelectric properties of n – Cd - pInP – nInP heterohomojunctions have also investigated.

The accumulation of the photocurrent sign and the appearance of the strongly negative maximum at the photon energy, which is equal to 1.35eV is characteristic for the samples with nInP – pInP - nCdS heterohomojunction.

Moreover, the positive short-wave maximum saves (fig.4). As it is seen, the strong junction from maximal positive value till minimal negative value on the narrow region of the spectrum is observed in spectral characteristics, and the region of the sign change of short-

circuit photocurrent is linear in the dependence on the wave length of fallen radiation.

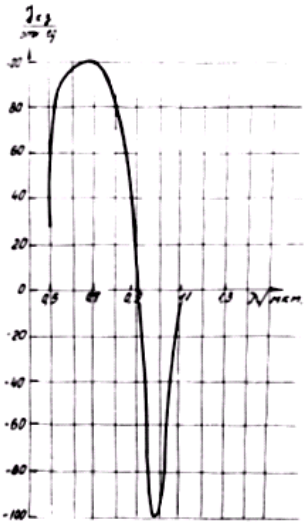

Fig.4. The spectral distribution of I_{sc} nInP – pInP - CdS heterohomojunction.

The analogical results have obtained for the spectral dependence of the photo electromotive force also. The negative and positive maximums at photon energy 1,4eV are caused by two different competitive mechanisms. Whereas the negative maximum connects only with the separation of electron-hole couples on pInP - nInP homojunction, the positive maximum is caused by the accumulation in the conditional nCdS - pInP heterojunction. For the provement of the above mentionedthe experiment, in which the spectral distribution of photocurrent of the sample with p-n-homojunction after co-polishing of CdS of main pInP - nCdS heterojunction was carried out. Moreover, the positive short-wave maximum disappears and negative maximum at 1,4 eV saves and doesn't change the sign. The analogical co-poloishing on the samples without p-n homojunction has led to the total disappearance of the sensitivity.

The energetic band diagram of pInP - nCdS prepared heterojunctions with transversal layer on the interface and without it has constructed on the base of the experimental data. It is shown, that they describe Andersen midship, in which breaches of conduction band ΔE_c and valent band $\Delta E_ϑ$ are equal to ΔE_c =-0.12eV; $\Delta E_ϑ$ =1.26eV for the structure with transversal layer and ΔE_c =-0.06eV and $\Delta E_ϑ$ -1.20eV for the structure without transversal layer and energetic "beam" is absent in the conduction band.

III. CONCLUSION

The main electrical and photoelectrical parameters (non-ideality coefficient of VAC, short-circuit photocurrent density, saturation current, surface recombination velocity, quantum efficiency, transformation efficiency of solar energy in electrical one) in pInP – p^+InP - nCdS heterostructures with transversal layer are better on 15-50% than in pInP – nCdS heterostructures without transversal layer.

It is shown, that the improvement of the parameters of heterojunction with transversal layer is caused by the decrease of the density of the recombination (defect) centers on the interface of pInP - nCdS structure, and also by the increase of contact electric field strength.

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