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THE INVESTIGATION OF SOLID SOLUTIONS THIN INTERLAYERS IN CdS/CdTe FILM HETEROSYSTEMS

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The photo-response spectral dependence's of ITO/CdTe/Au/Cu and ITO/CdS/CdTe/Au/Cu film heterosystems were investigated. At illuminations ITO/CdS/CdTe/Au/Cu heterosystems on ITO side a photo-response maximum was observed for photon absorption with a wavelength of 0.87 μm that is stipulated by formation of CdS_xTe_{1-x} solid solutions interlayer with band gap width less than in CdTe layer. By use optical measurement transmittance spectra was selected a spectral photosensitivity interval appropriate to the contribution of non-equilibrium charge carriers generated in solid solutions interlayer by photon absorption with energy less than CdTe film band gap.

1. INTRODUCTION

The pCdTe/nCdS heterojunction represents interest for creation of the thin film solar cells for terrestrial applications. Fanrenbruch et. al. [1] theoretically estimated the solar conversion efficiency for CdS/CdTe heterojunction and obtained a value 27%. The some distinction of crystalline lattice parameters of the CdS and CdTe is one of the main negative factors at preparation of the high efficiency solar cells [2].

The literary data analysis [3,4] has shown, that now for development of CdS/CdTe film solar cells the steadfast attention is given to a problem of possible availability on CdS-CdTe interface boundary of CdS_xTe_{1-x} solid solutions. Such solid solutions have other band gap width then CdS and CdTe layers [5]. One of the most express methods for study of band gap width of the semiconducting materials is the analysis of photo-response and transmission spectral dependencies.

The CdS/CdTe film heterosystems were investigated by photoelectrical and optical methods for identification of the solid solutions thin interlayer.

2. EXPERIMENT

The ITO films with sheet resistance 10 Ω/□ coated soda lime glass substrates are used to fabricated heterosystem on CdTe base. For preparation ITO/CdS/CdTe heterosystems the CdS layers are grown in an ultra vacuum evaporation chamber with substrate temperature of 150 °C and subsequently annealed at 450°C for recrystallization. Then without breaking the vacuum CdTe film are deposited at a substrate temperature of 300°C. For preparations CdTe/ITO heterosystems CdTe film are deposited at a substrate temperature of 300°C.

Before evaporation, the fluxes of CdS and CdTe are controlled by an UHV ionization gauge (Balzers IMG-U2), and after evaporation, thickness is measured with a profilemeter (dektat 3030). In a standard deposition CdS thickness is about 0.5 μm and CdTe 4 μm.

For the $CdCl_2$ treatment, vacuum evaporation is used for the deposition of $CdCl_2$ layers on CdTe. The stacks are annealed at 430°C for 30 minutes in air.

For back contacts the CdTe surface is etched using a Br-Methanol solution followed by the deposited of Cu/Au stacks and a short annealing at 300°C.

For optical measured the ITO/CdTe and ITO/CdS/CdTe heterosystems the CdTe layers is etched using a Br-Methanol solution more long time, that to decrease think of CdTe layers to 0.8 μm.

The spectral responses of short-circuit current $I_{sc}(\lambda)$ of the heterosystem on CdTe base were studied in the wavelength range of 0.4-1.2 μm by means of a doublemonochromator DMP-4 providing the monochromatization accuracy 0.005 μm. The error of Isc measurement called by voltage oscillations in a net of light source did not exceed 1 %.

The transmission though the heterosystems (T) were measured in the of wavelengths range of 0.3-0.9 μm using two-channel method by means of spectrophotometer.

3. RESULT

The photo-response spectral dependences of the ITO/CdTe/Au/Cu and ITO/CdS/CdTe/Au/Cu heterosystems were investigated for determination of the energy structure features. The illumination was on the ITO side and on the CdTe side (Fig. 1).

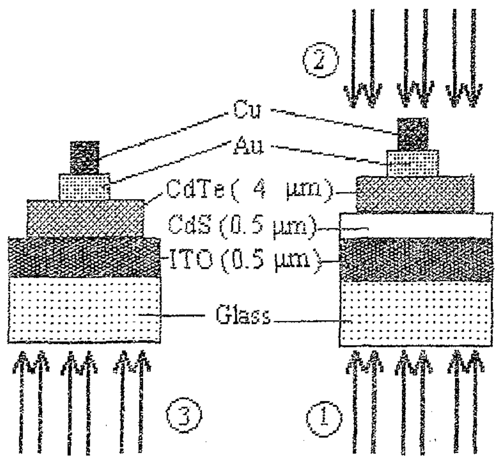

Fig. 1. Samples for the photoelectrical investigations

At illumination ITO/CdTe/Au/Cu heterosystems on the ITO side the photo-response maxim was observed for photons absorption with a wavelength of 0.81 μm (Fig. 2, curve 1), that correspond to photon energy with 1.49 eV. The photosensitivity spectral interval consists [0.45-0.91] μm. At illuminations ITO/CdS/CdTe/Au/Cu hetero-systems on the CdTe side photo-response maximum was observed for photon absorption with a wavelength of 0.82 μm (Fig. 2, curve 2), that correspond to photon energy 1.48 eV. The photosensitivity spectral interval consists [0.47-0.95] μm. The photosensitivity spectral dependence are similar to spectral dependence ITO/CdTe//Au/Cu heterosystems at illuminations on the ITO side. At illuminations ITO/CdS/CdTe/Au/Cu heterosystems on the ITO side the photo-response maximum was observed for photon absorption with a wavelength of 0.87 μm (Fig. 2, curve 3), that correspond to photon energy 1.42 eV. The photosensitivity spectral interval consists [0.47-1.00] μm.

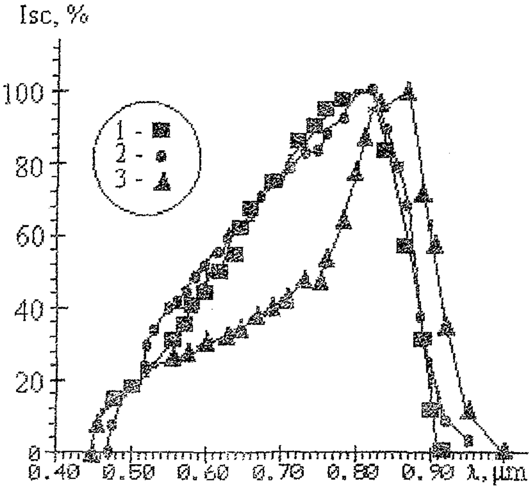

Fig. 2. Photo-response spectral dependences of heterosystems on CdTe base

The literary data shown [4], that usually photo-response maxim of the CdS/CdTe heterosystems are formed for photon absorption with energy more than CdTe band gap width (E_g) (E_g=1.45eV for CdTe films [4]). The generation of non-equilibrium charge carriers at photon absorption with energy smaller than CdTe band gap width cannot give the main contribution to creation of the photo-response, as the absorption of light in CdTe happens by means of direct interzonal transitions and the probability of two-photon generation of non-equilibrium charge carriers is insignificant. It is necessary to mark, that in general case there is a possibility of the exchanging of CdTe photosensitivity spectral dependence in long wavelength area of spectrum at photon absorption of doping levels. In heterosystem investigations the main source of doping impurities is $CdCl_2$ layers. So $CdCl_2$ is putted on the CdTe surface, first of all the availability of doping impurities must to influence on spectral dependence of ITO/CdTe/Au/Cu and ITO/CdS/CdTe/Au/Cu heterosystems at illumination from the CdTe side, that experimentally is not observed.

According to the condition diagram of CdS-CdTe system [6] in this system is possible formation of CdS_xTe_{1-x} (x<0.2) and $CdTe_yS_{1-y}$ (y<0.1) solid solutions. The band gap width of CdS_xTe_{1-x} (0<x<0.2) monocrystals are in an energy interval of 1.35 to1.5eV, the band gap width of $CdTe_yS_{1-y}$ monocrystals with y<0.1 are in an energy interval of 2.10 to 2.40eV [5]. Apparently, the non-equilibrium carriers of a charge generated under an operation of photons with energy lower that CdTe films band gap in the CdSxTe1-x (x<0.2) solid solutions interlayer form maxim of photo- response ITO/CdS/CdTe/ Au/Cu heterosystems at illumination on ITO side. At illumination ITO/CdS/CdTe/Au/Cu heterosistems on CdTe side the main generation of non-equilibrium charge carriers happens in CdTe base layer and contribution in photoresponse of non-equilibrium carriers generated is little. Therefore at illumination on CdTe side the photoresponse maxim is formed for photon energy more than CdTe band gap.

There is a possibility to select a photosensitivity spectral interval appropriate to the contribution of non-equilibrium charge carriers generated in solid solutions interlayer by photon absorption with energy less than CdTe film band gap. For this purpose it is necessary to investigate transmittance spectra of ITO/CdS/CdTe heterosystems by two channel method. For identification interface interaction in the comparison channel was inserted glass/ITO/CdS and CdTe/ITO/glass heterosystems (Fig. 3). In the analysable channel was inserted glass/ITO/CdS/CdTe and ITO/glass heterosystems (Fig.3). Thus difference between samples in the channels could be connected only with CdS/CdTe interface interaction.

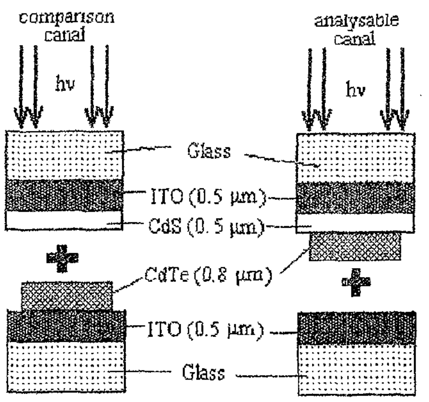

Fig. 3. Samples for optical investigation

The result of the optical researches are indicated on Fig. 4. The analysis shows, that in wavelengths range of 810-850 μm in CdS/CdTe heterosystems is present additional absorption of light, that correspondence absorption of light in CdS_xTe_{1-x} solid solutions interlayer (x< 0.2).

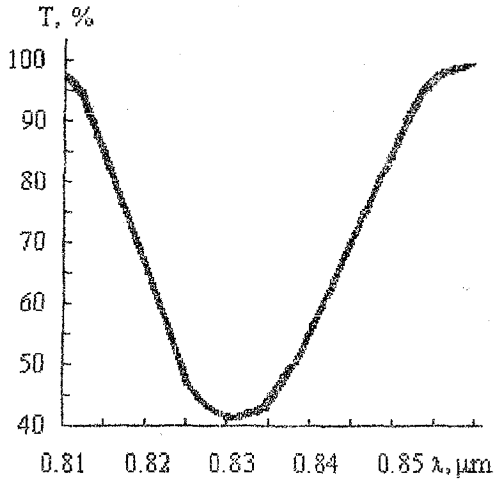

Fig. 4. Spectral dependence of absorption of CdS_xTe_{1-x} layers

It is possibility to define a thickness this solid solutions interlayer (t) :

$$t = -\ln T / \alpha,$$

where:

T - transmission coefficient of solid solutions interlayer;

α - absorption coefficient of solid solutions interlayer.

4. CONCLUSIONS

Is shown that the research of photo-response spectral dependencies of the at illumination various directions allows to identify availability in CdS/CdTe heterosystems of CdS_xTe_{1-x} solid solutions interlayer. The optical researches of transmission spectra of CdS/CdTe heterosystems allow to determine a thickness such interlayers, that is the actual problem for optimisation physic-technological conditions obtaining highly efficiency CdS/CdTe solar cells.

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