SOLAR CELLS ON THE BASE OF $CD_{1-X}ZN_XS/CDSE_{1-X}TE_X$ HETEROJUNCTIONS

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ABSTRACT

In this paper some properties of film photocells prepared on the basis of $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunctions are resulted. Heterojunctions were prepared by a method of deposition from a solution in a uniform work cycle.

Under AM1.5 illumination the $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ photo cells generated open-circuit voltages of about 500 ÷ 600 mV and short circuit-current density of about 10mA/cm^2 also had efficiency up to 8 %. With Zn increase in a base material the open-circuit voltage U_{oc} increases and the short circuit current decreases. Use as a base material of $Cd_{1-x}Zn_xS$ firm solutions causes increase in a potential barrier.

Keywords: solar, film photocell, heterojunctions, compounds, potential barrier.

I. INTRODUCTION

Have been renewed intensive researches of the heterojunctions on the base of A^2B^6 compounds last years, in connection with an opportunity of creation on its basis the most economic and relatively effective photoreceivers [1-3]. Electrooptical properties of these heterojunctions have found practical application in phototransistors and in solar elements. However, the physics and technology of heterojunctions have also other prominent aspect - creation, research and practical application of nonideal heterojunctions. Polycrystalline semiconductors with incoincident constants of crystal lattices form such structures, frequently and various lattice symmetries. Have been observed the big set of various effects and phenomena in nonideal heterojunctions connected to various properties of semiconductors on both border sides, and also in accordance with the appearance of plenty electrically active defects on the heteroborder, participating in currentcarrying, absorption and radiation of light quantums. Perspectivity of practical application of the nonideal heterojunctions is connected first of all to more economic technology of creation polycrystalline heterostructure in comparison with the monocrystal. One of directions in studying of the nonideal heterojunctions is the opportunity of application solar cells on the basis of $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunction.

The $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ system represents a nonideal unizotype heterojunction at which difference of constant crystal lattices of contacting $Cd_{0.4}Zn_{0.6}S$ and $CdSe_{0.5}Te_{0.5}$ semiconductors makes 4%. Such significant difference of the lattices periods at heterojunction formation creates the high density of discrepancy dislocations on an interface. Torn off connections in dislocations result in occurrence of power levels in the band gap, responsible for capture of the carriers or for them recombination and render essential influence on charge carrying through the impoverished area.

II. RESULTS AND DISCUSSIONS

In this work some properties of film photocells prepared on the basis of $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunctions are resulted. Heterojunctions were prepared by a method of deposition from a solution in a uniform work cycle.

Under AM1.5 illumination the $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ photo cells generated open-circuit voltages of about 500 ÷ 600 mV and short circuit-current density of about 10mA/cm^2 also had efficiency up to 8 %. With Zn increase in a base material the open-circuit voltage U_{oc} increases and the short circuit current decreases. Use as a base material of $Cd_{1-x}Zn_xS$ firm solutions causes increase in a potential barrier. On the other hand, discrepancy of constant lattices of contacting materials results in reduction of concentration of states in interface region of the heterojunctions, and also speeds up the degradation process.

Consecutive resistance limits the short circuit-current, and its dependence on illumination intensity is superlinear. The dependence of an open-circuit voltage on illumination intensity differs from logarithmic. Therefore, with increase in intensity of illumination efficiency of the $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunctions increases [4].

Have been observed peaks on the photosensitivity spectrum of the $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunctions at 0.48-0.49µm and 0.72-0.75µm. The photoanswer in long-wave area of a spectrum explains by presence of a high-resistance layer at the border of near-surface areas of the $CdSe_{0.5}Te_{0.5}$ films (fig 1). Peaks on the photosensitivity spectrum at 0.5µm and 0.9µm correspond to border of own absorption. Have been investigated the dependence of the spectral distribution nature of a photocurrent on a mode of reception of the $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunctions and features of spectral distribution of a current in them depending on a thickness of the $CdSe_{0.5}Te_{0.5}$ films. With increase a thickness of the $CdSe_{0.5}Te_{0.5}$ films increasing of a photocurrent in long-wave area of spectral sensitivity is observed (fig 1, curves 2 and 3). Researches show that essential changes occur in $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunctions at heat treatment. The nature of a change of electric and photo-electric properties of heterojunctions depending on the heat treatment shows, that due to presence acceptor levels in near-surface $Cd_{0.4}Zn_{0.6}S$ layer there is an expansion of a layer of a volumetric charge (fig 2). Therefore the capacity of p-n heterojunctions decreases.

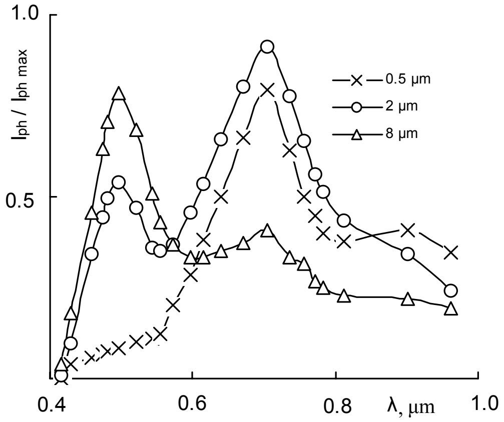

Fig 1. Photoconductivity spectrum of heterojunctions, at various thicknesses of n-$CdSe_{1-x}Te_x$ films.

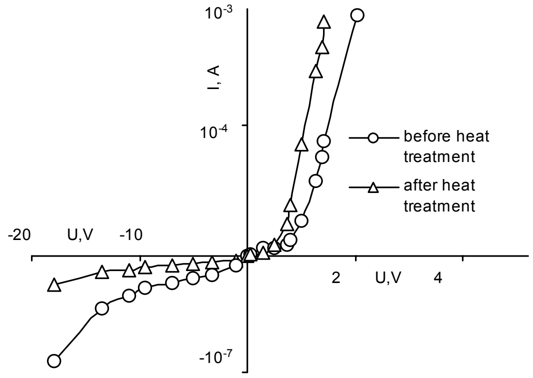

Fig 2. Current-voltage characteristic of the izotype $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunctions at T = 450K.

Increase of the photoanswer on all spectrums specifies that fact, that due to compensation of donor type natural defects by acceptor levels is formed a high-resistance layer in a near-surface layer and increases the rectification factor. Absorption of light becomes more effective due to a high-resistance layer, i.e. the usefulness of an absorbed beam and accumulating of carriers by the p-n heterojunctions raises [5].

At a chemical way of obtaining $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunctions tunnel currents prevail even at temperatures of 240 K in them (fig 3). Changing technology of heterojunction obtaining it is possible to reduce a tunnel current considerably, first, due to increase in a potential barrier, through which tunnel electrons and second, due to reduction of centers' concentration at interface. Electrons tunnel from the conductivity zone of wide-band material on narrow-band at the tunnel mechanism [6].

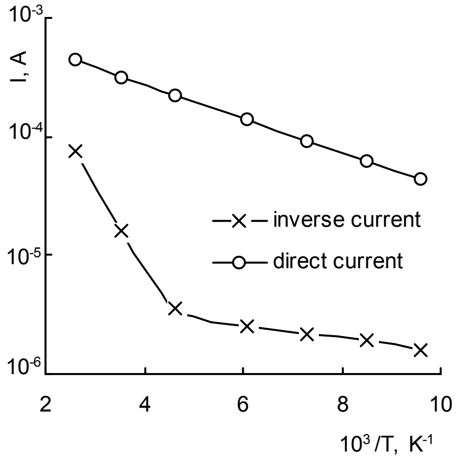

Fig 3. The temperature dependence of current in the izotype $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunctions.

Appear nonequilibrium electrons and holes at photoexcitation by quantums from area of own absorption of $Cd_{0.4}Zn_{0.6}S$. A barrier field in the base area volume removes electrons, and holes are captured near interface on traps and the recombination centers. Presence of such compensating centers with the big concentration actually is one of the basic properties of the considered heterojunction. The barrier field promotes electron accumulation in the spatial charge area; therefore, distribution of a positive charge in $Cd_{0.4}Zn_{0.6}S$ considerably changes even at an insignificant level of photoexcitation, which results in growth of the transition capacity. Herewith sharply increases the intensity of the electric field at interface of the heterojunction [7].

The short circuit current is in direct dependence on spatial distribution of electric potential, and this distribution is directly related to electron's concentration located on traps.

At displaying on a sample of any image, its points are illuminated differently that results in various electron concentration, captured on traps and accordingly to a various bend of power zones in the spatial charge area. If displaying to stop, distinction in the electron concentration is kept enough long time that allows using this heterojunction as the device remembering the optical information. Reading of this information is possible at scanning a sample by infrared light. By the use of infrared illuminations also is possible to make deleting the image, herewith a sample to be illuminated with pulses of the long duration with high frequency of following. Then the sample is suitable for repeated storing other image.

Processes of record and reading can be considerably carried in time, however long storage is accompanied by a thermal devastation of traps that results in gradual loss of the optical information.

Reading the information is possible during several days at storage of a sample at the temperature about 80K. Rise in temperature of storage results in faster thermal hole liberation to a valent zone. The $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunction can be in two various conditions. One of them - equilibrium - possesses low sensitivity to the infra-red light and allows to receive low value of short-circuit current. Other condition - nonequilibrium - is high sensitive to infrared light and gives considerably high short-circuit current value. Transition from an equilibrium condition to nonequilibrium is carried out under illumination of short-wave light due to the effect of capture described above and the accumulation of nonequilibrium holes on traps in the spatial charge aera of $Cd_{0.4}Zn_{0.6}S$. Time of preservation of the nonequilibrium condition by structure is determined by the recombination barrier size and the process of hole emission from the traps, going alongside with accumulation. The emission starts to play a main role in currentcarrying after cancellation of short-wave illumination so releasing of the captured charge causes inverse changes of parameters of a barrier and transition of structure from a nonequilibrium condition to equilibrium. Intensity of emission determines rate and speed of this change of barrier parameters, so and short-circuits current. Therefore it is obviously important to know, how emission influences on barrier parameters after the termination of photoexcitation by short-wave light and how quick they change since time.

Let's consider possibility of such system to use to registrations of the optical image of the different spectral composition. The maximal effect is achieved at 520 nanometers. More short-wave light is strongly absorbed in a base layer. Therefore the thickness of $Cd_{0.4}Zn_{0.6}S$ layer and the diffusion length of charge carriers in this material determine the photoexcited hole concentration in vicinities of the spatial charge area. The spatial charge area is reached not all photogenerated electrons, which result in reduction of the short-wave stimulation rate. Sharp recession of sensitivity of a sample in the short-wave area of a spectrum is caused by that the generated charge carriers are recombinated in volume of $Cd_{0.4}Zn_{0.6}S$ layer, not being in time to reach to the spatial charge area, i.e. there is absorption of light in a superficial layer of $Cd_{0.4}Zn_{0.6}S$. The wane of sensitivity in long-wave area speaks about reduction of gathering factor of $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ and about presence of the impurity centers in $Cd_{0.4}Zn_{0.6}S$, participating in generations of current carriers. For increase of sensitivity it is necessary or to reduce thickness of a base layer, or to create the optical image on the part of thin $CdSe_{0.5}Te_{0.5}$ layer.

III. CONCLUSION

Thus, the device can operate in all area of the visible spectrum with different sensitivity. As in the given device reading of the image is made by infrared light but not by an electronic beam, and it does not need the vacuum and the high voltage, used for formation of an electronic beam. Spectral distribution of a short circuit current allows characterizing the shaper of image signals as green sensitive on a basis of the $Cd_{0.4}Zn_{0.6}S/CdSe_{0.5}Te_{0.5}$ heterojunction, on the standard classification for photographic layers. Hence, record of the optical information is most effective at wavelengths of about 520 nanometers.

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