Impact Factor: 9.9 ISSN-L: 2544-980X

Energy Band Diagrams of the Heterojunction Cu $_{2-X}$ S-Cds

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Annotation: This article studies the processes of photofatigue and current-voltage characteristics of solar cells based on Cu 2-x S-CdS. Analysis of current-voltage characteristics of the load of real photoconverters showed that the shape of the curves differs significantly from rectangular and is determined by the value of the fill factor.

Key words: photoconverter , volt-ampere characteristic, photofatigue processes, photosensitivity distribution , spectral characteristic, photodetector.

Introduction . At present, heterojunctions based on CdTe have been obtained that effectively operate as solar cells [1] and photodetectors in the visible and IR spectral ranges [2]. Solar photoconverters based on $^{A2B6\ compounds}$ (especially CdS) are of interest for the creation of solar batteries for terrestrial applications due to economic considerations. However, the currently achieved efficiency of converting solar energy into electrical energy is limited to 9.15% [4] based on the $Cu_{2-x}S$ - CdS heterojunction and is much lower than the efficiency of known silicon photoconverters. Although the theoretical value of the efficiency of these devices is 15% [5], the actually achievable value is determined by energy losses and failure to improve the heterojunction design. The authors of [3], using the technique of transient processes of contact photoconductivity in CdTe films , determined the surface recombination rate, which is equal. These studies also identified a dominant deep level with a photoionization energy of 1.23 eV, which leads to a reduction in the impact of surface recombination.

METHODS OF ANALYSIS

To explain many electrical and photoelectric properties of solar photoconverters based on the Cu $_{2-x}$ S-CdS heterostructure , it is necessary to know the type of the band diagram. This issue has been discussed in the literature for a long time. According to their qualitative appearance, the band diagrams presented by many researchers can be divided into two groups. In the first, the discontinuity of the conduction band Δ Ec prevents the separation of minority carriers-electrons generated in Cu $_{2-x}$ S, i.e. the conduction band of CdS at the interface is located higher than the conduction band of Cu $_{2-x}$ S and has a peak equal to ΔEc . Other authors believe that the peak at the interface is absent [7]. These disagreements are explained by a number of reasons : the lack of unambiguous data on the energy of electron affinity of Cu $_{2-x}$ S, a large spread in the value of the width of the forbidden band of Cu $_{2-x}$ S; in addition, as indicated in the work, with copper doping the value of the electron affinity of CdS changes . The paper presents a measurement technique and a current-voltage characteristic of solar cells based on Cu $_{2-x}$ S-CdS film heterojunctions. For a given intensity of incident radiation, the power generated by the photoconverter depends on the load resistance. For a certain value of the load, called optimal Qопт , the optimal power Rопт is released on it , which in the ideal case (Rn = 0, R→∞) is determined by the maximum area of the rectangle inscribed in the load characteristic. The point Rопт corresponds to the value of Iопт and Допт . The shape of the load characteristic is determined by the value of the fill factor (FF) K, the value of which is calculated using the expression [6] The greater the FF, the greater the power delivered to the load, and the greater the efficiency of the photoconverter.

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RESULTS AND DISCUSSION

Figure 1 shows a band diagram that has a peak at the interface. When illuminated, the traps located at the interface are emptied, and therefore the peak width decreases. At a hole concentration of ~ 10^{20} $cm^{-3,}$ the form level is 0.05 eV below the valence band edge. For sensitivity, heterojunctions are due to the absorption of light in Cu_{2-x} S and separation of photocarriers by the space charge field. Before heat treatment, the peak width is such that tunneling is possible . After heat treatment, copper diffuses into CdS , expanding the combined CdS layer and, consequently, the peak. In this case, tunneling of electrons is significantly hampered. This explains the decrease in the long-wave sensitivity of Cu_{2-x} S-CdS after heat treatment. However, within the framework of this model, the experimentally observed increase in the value of I sc after heat treatment remains unexplained .

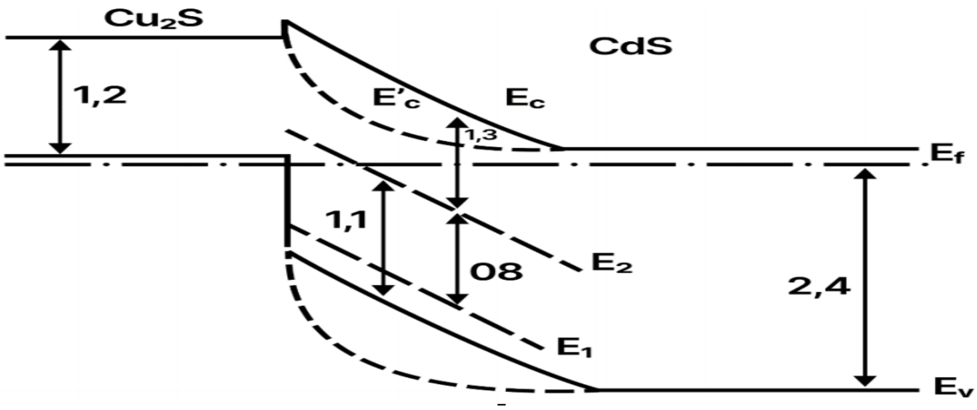

Fig. 1. The band diagram of the Cu_{2-x} S- CdS solar cell (energy is expressed in electron volts): solid lines – in the dark; dashed lines – under illumination (the peak width decreases)

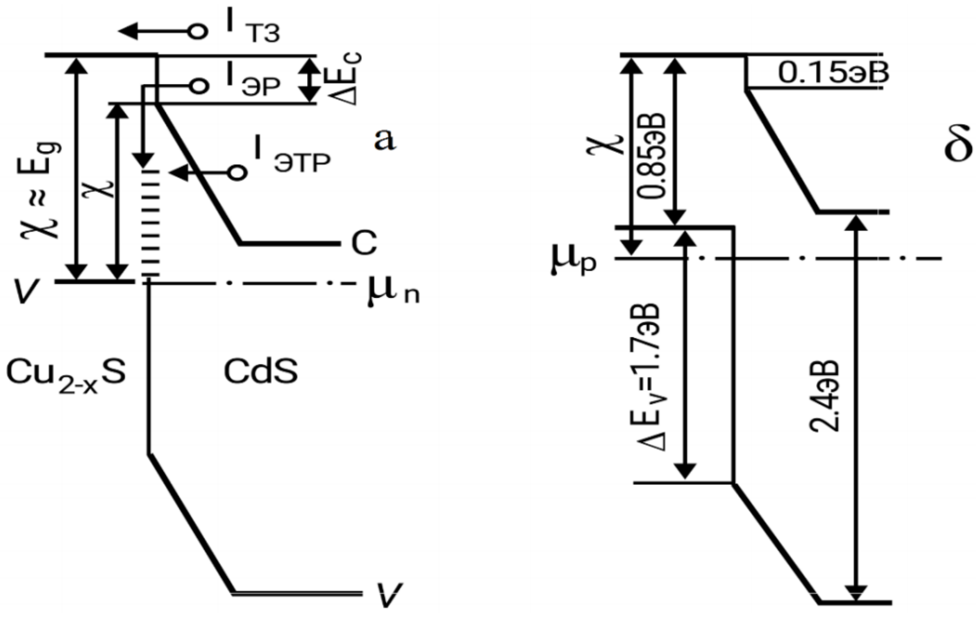

Fig. 2. Qualitative (a) and quantitative (b) energy band diagrams of the Cu_{2-x} S-CdS heterojunction.

SUMMARY

Current: Iтэ – thermionic, Iетр – emission-tunneling-recombination

Therefore, when producing solar cells, it is better to use thermal vacuum condensation, since they produce heterojunctions with more stable characteristics.

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