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INVESTIGATION OF THE CURRENT-VOLTAGE CHARACTERISTICS OF THE N-CDS/P-CU(IN, GA)SE2 HETEROSTRUCTURE

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ABSTRACT: - In this work, current transfer mechanism in the n-CdS/p-Cu(In, Ga)Se2 heterostructure in the forward and reverse current directions at T=300 K is investigated. It has been established that the dark current-voltage characteristics of heterostructures built on a double logarithmic scale are described by power-law dependences type of the I=Vα. In the forward direction of the current, sections of the current-voltage characteristic were observed: α1=1 (ohmic) and α2=2 (quadratic), and for the reverse section of the current-voltage characteristic: α1=1 (ohmic), α2=0.25. From the quadratic section of the forward branch, the value μn·τn=4.5·10-10 cm2/V for the CIGS active layer was determined, which is explained by the processes of recombination of charge carriers through simple local centers.

KEYWORDS: Heterostructure, current–voltage characteristic, CIGS, transfer mechanism, ohmic region, quadratic region, recombination.

INTRODUCTION

Analysis of the dark current-voltage characteristic (CVC) of a solar cell based on the n-CdS/p-Cu(In, Ga)Se2 heterostructure makes it possible to determine the patterns of current flow in it and the parameters of recombination constants, which is necessary to optimize the technology for obtaining the most advanced solar cells, operating extreme conditions, as well as evaluate the quality of the p-n-junction and set the parameters of the photoactive region of the structure.

To carry out research, photosensitive structures n-CdS/p-Cu(In, Ga)Se2 were fabricated using the technology described in [1]. The dark CVC of fabricated n-CdS/p-Cu(In, Ga)Se2 heterostructures were studied for forward and reverse current directions at T=300 K. The upper ohmic contact to the n-CdS/p-Cu(In, Ga)Se2 heterostructure, made of silver (Ag) was created by vacuum evaporation.

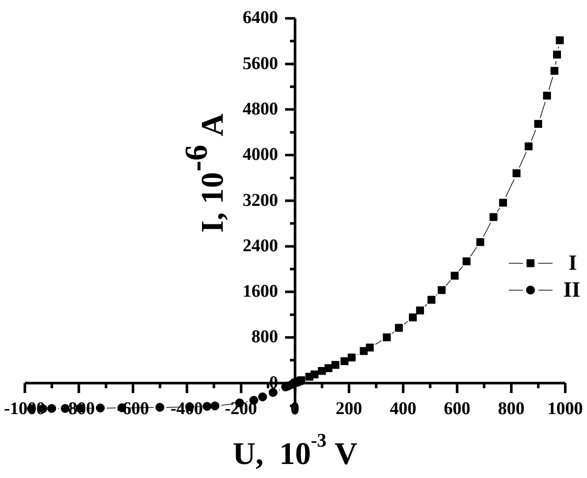

Fig. 1. Dark current-voltage characteristic of the n-CdS/p-Cu(In, Ga)Se_2 heterostructure at room temperature. I - direct branch, II - reverse branch.

The forward direction of the current in the structure was considered when a negative potential was applied to the Ag contact, and the positive applied potential corresponded to the reverse direction. An analysis of the CVCs shows that the structure has rectifying properties and their rectification coefficients, defined as the ratio of forward (I) and reverse (II) current at a fixed voltage $K=I_{forw}/I_{rev}$ (V=1 V) (Fig. 1), is more than one order. The obtained relatively small values of K are apparently related to the imperfection of the transition region of the heterojunction.

The dark CVC of the n-CdS/p-Cu(In, Ga)Se_2 heterostructures built on a log-log scale, both in the forward and backward directions, are described by power-law dependences of the type $I=V^{\alpha}$ (Fig. 2 a, b). The results show that the CVC can be divided into two sections with different values of α [2, 3]. For the direct section of the CVC: $\alpha_1=1$ (ohmic) and $\alpha_2=2$ (quadratic). For the reverse section of the CVC: $\alpha_1=1$ (ohmic), $\alpha_2=0.25$. From the linear section of the direct branch of the CVC [2, 3], at the values $\rho=1.2\cdot10^4$ ohm·cm and $\mu_p\approx20$ cm^2/Vs [4], the concentration of equilibrium holes was estimated $p=2.6\cdot10^{13}$ cm^{-3}. From the quadratic section of the forward branch ($J\sim V^2$) of the CVC [5], the parameters of the CIGS active layer were determined, $\mu_n\cdot\tau_n=4.5\cdot10^{-10}$ cm^2/V. According to [6], at $\mu_p\cdot\tau_p=4.5\cdot10^{-10}$ cm^2/V, recombination processes proceed through simple local centers.

In the first section of the reverse branch of the CVC, an ohmic section is observed up to a bias voltage V = 0.185 V, as well as for the direct branch. After the linear section, the $J\sim V^{0.25}$ section is observed. Such a dependence of current on voltage is observed when the width of the space charge region increases with an increase in the reverse voltage.

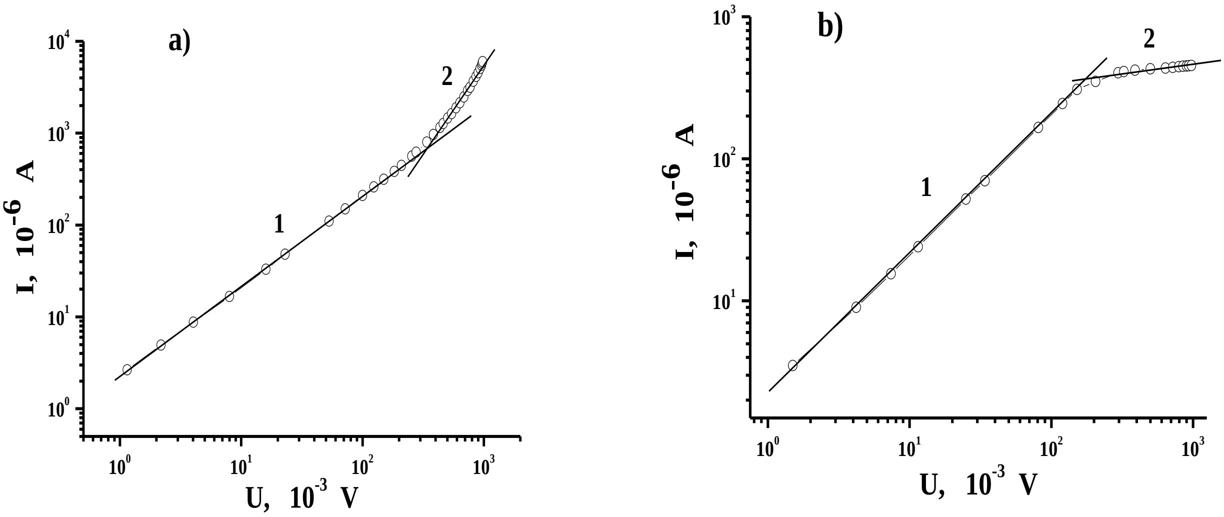

Fig. 2. Direct (a) and reverse (b) branches of the CVC of the n-CdS/p-Cu(In, Ga)Se2 heterostructure on a log-log scale at T=300 K. Direct branch: 1 – J~V, 2 – J~ V2, reverse branch: 1 - J~V, 2 - J~V0.25.

An analysis of the CVCs showed that the Ag-n-CdS/p-Cu(In, Ga)Se2-Mo heterostructure created has a rather ideal design. In the forward direction of the CVC, no current-limiting effects are observed. In the reverse direction of the CVC, with an increase in the applied voltage, the width of the space charge region increases, which proves the absence of back-to-back barriers.
On fig. 3 shows the experimental results of the spectral dependence of the photosensitivity (S, at arb. unit) of the SnO2-CdS/Cu(InGa)Se2-Ag heterostructure determined at room temperature.

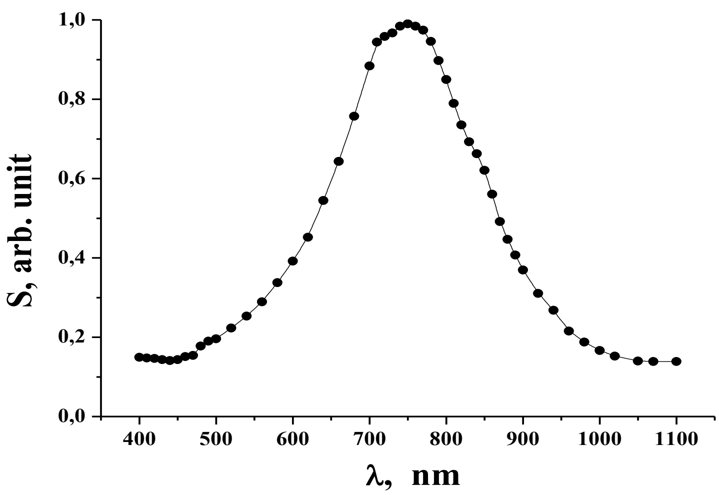

Fig. 3. Experimental results of the spectral dependence of the photosensitivity of the SnO2-CdS/Cu(InGa)Se2-Ag heterostructure (T=300 K).

From fig. 3 shows that the spectral dependence of photosensitivity is in the range from 400 nm to 1100 nm of the emission spectrum. An analysis of the photosensitivity spectrum carried out using the photoresponse method [7] showed that the photocurrents generated in this spectral range are associated with the absorption of photons by semiconductor materials, in which the band gap has the following values: $Eg1 \approx 1.25 \pm 0.02$ eV and $Eg2 \approx 1.33 \pm 0.02$ eV.

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