SOLAR CELLS EFFICIENCY ON THE BASIS OF n-ZnS/*p*-CdTe HETEROJUNCTIONS WITH OPTICAL LOSSES CONSIDERATION

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Thin solar cells (SC) on the basis of *n*-ZnS/*p*-CdTe heterojunction (HJ) are considered as an alternative to traditional *n*-CdS/*p*-CdTe photovoltaic devices. From the theoretical point of view replacement of CdS (E_g=2.45 eB) optical window material by more wide band ZnS (E_g=3.68 eB) must lead to the increase of SC photosensivity in the ultra-violet spectrum zone and to the increase of their efficiency [1]. But the experimental solar cells efficiency value on the basis of *n*-ZnS/*p*-CdTe HJ, obtained today, don't increase 4 %, though according to the theoretical evaluations the devices' efficiency with CdTe absorbing layer can be (28-30) %. This is caused by energy losses connected with reflection and absorption of the light in window, buffer and additional layers of photovoltaic devices, by recombination of generated charge carrier at extensional and interface recombination centers.

The aim of this work is to define the maximal theoretical SC efficiency value, that have the construction of glass/*n*-ZnO/*n*-ZnS/*p*-CdTe with the optical losses consideration on the interfaces of contacting materials depending on the thickness of these layers.

The value of the maximal SC efficiency without the regard of optical losses in the window and buffer layers was held with the help of SCAPS-3200 software environment for the modeling of SC basic characteristics. The modeling was made in the range of thickness changes of absorbing CdTe (0.03-5.0) μm and ZnS (0.01-0.5) μm window layer. The optical losses in the photovoltaic device were defined with the consideration of ZnO and ZnS transmission layer index with the use of ratio:

$$T(\lambda) = (1-R_{12})(1-R_{23})(1-R_{34})(1-R_{45})(e^{-\alpha_1 d_1})(e^{-\alpha_2 d_2}), \quad (1)$$

where R_{12}, R_{23}, R_{34}, R_{45} – the reflection coefficients on the interfaces of contacting materials, α_1, α_2, d_1, d_2 – absorbing coefficients and thickness of SC buffer and window layers correspondingly.

The corresponding transmission coefficient was defined for the range of wave length from 300 to 900 nm. Finally it was established that the maximal SC efficiency on the basis of *n*-ZnS/*p*-CdTe HJ is 26.46 % (J_{sc}=28.91 mA/cm^2, U_{oc}=1.04 V, *FF*=87.61 %) with the optical thickness of window (d_{ZnS} = 0.05-0.1 μm) and absorbing (d_{CdTe} = 3-4 μm) layers. The influence of ZnO and ZnS layers thickness on the SC optical losses was defined. The calculations showed that with the increase of ZnS window layer thickness the transmission coefficient is reducing to 7 – 74 % with dependence on the wave length. It leads to the reduction of SC maximal efficiency. The modeling of SC basic characteristics with optical losses consideration gave the possibility to choose the SC optimal construction.

[1] D.I. Kurbatov, V.V. Kosyak, M.M. Kolesnyk, A.S. Opanasyuk, S.N. Danilchenko, Yu.P. Gnatenko, Materials Chemistry and Physics, 138, 731 (2013).

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