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INVESTIGATION OF THE DIFFERENTIAL RESISTANCE OF HETEROSTRUCTURES BASED ON *p-c-Si* and *i-p-a-Si: H*

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Annotation: *This article investigates the heterojunction resistanse arising between layers of arose layers of amorphous and crysstaline silicon in multilayer photoconverters based on amorphous hydrogenated silicon (a-Si:H) and crystalline silicon (c-Si). From the obtained expressed, it possible to optimize the efficien of photoconverters by choosing the parameters of these layer.*

Keywords: amorphous hydrogenated silicon, crystalline silicon, potential barrier, hetero jurstion, steddy state, multilayer solar cells.

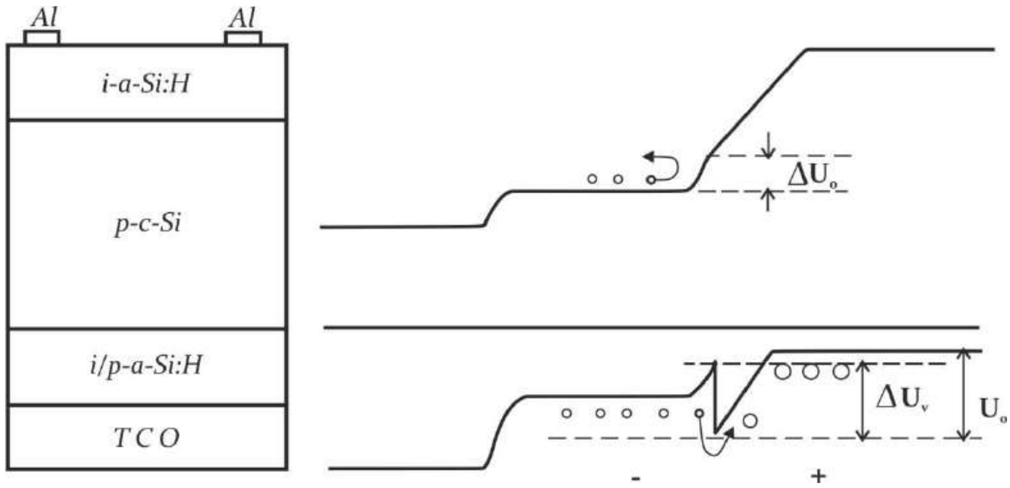
Thin-film multilayer hetero junction converters are promising candidates for use in photovoltaics [1, 2]. This is due to the fact that the use of wide-gap semiconductors such as a-Si: H, µk-Si: H grown over crystalline silicon to some extent, due to surface recombination, allows minimizing the loss of free charge. This allows the efficiency of solar cells to drop. Certain successes have been achieved in the technology of obtaining thin-film amorphous and semicrystalline silicon and the creation of highly efficient solar cells based on them [3,4]. In these works, the process of photo-conversion of solar radiation in heterojunctions between amorphous (a-Si: H) and crystalline (c-Si) silicon was studied, and solar cells with an efficiency of 18-20% were obtained.

Despite the good results obtained, there are some problems that need to be addressed. In order for the photocells to work as efficiently as possible, it is necessary to determine what the main output characteristics of the solar cell depend on and to find the optimal parameters that can be achieved in the manufacture of heterostructures.

Studies of these factors are described in some theoretical works devoted to the simulation of photocells [5]. Works devoted to the modification of heterojunction solar cells based on a-Si: H / c-Si, in particular, are based on the use of computer modulation, but in most cases they do not consider heterojunction solar cells as a whole, but consider only some of its parts [6 , 7].

The purpose of our work is to study the electrical and photoelectric characteristics of heterojunction multilayer solar cells based on a-Si: H / c-Si and obtain an analytical expression for some parameters of the heterojunctions.

To improve the efficiency of the solar cell, it is necessary to increase the output power, that is, P = IkzUxx. Isc - short circuit current, Uxx - open circuit voltage. To increase Isc, the resistance must be low, but in this case Uxx will decrease. Therefore, we are required to find such resistance in order to obtain the greatest power. In multilayer heterojunction SCs, resistance arises in the region of contacts. Therefore, the parameters of the heterojunctions must be such that the required resistance can be obtained. Let us consider the following structures of a multilayer heterojunction SC, (Fig. 1) its band diagram looks as follows (Fig. 2).



Thus, a three-layer solar cell includes barriers that impede current carriers and create resistance. In the same structure, the main role is played by the heterojunction between the i / p-c-Si and p-a-Si: H layers, because it itself creates a great obstacle for electrons. But for holes, the height of the potential barrier is small. Therefore, holes are the main current carriers. Suppose there is a transfer of holes from the p-c-Si layer to p + -a-Si: H, in this case we have

$$j = ep\mu_p E - eD\frac{dp}{dx}$$

$$\frac{\partial \Delta p}{\partial t} - divj = G - \frac{\Delta p}{\tau}$$

Stationary $\frac{\partial \Delta p}{\partial t} = 0$ and the number of generated carriers is equal to the number of recombined carriers, therefore $divj_p = 0$,that is $\frac{\partial j_p}{\partial x} = 0$ *j=const* .Then from equation (1) we obtain $\frac{j_p}{e\mu E} = p - \frac{D}{\mu E}p'$ We got a first order differential equation. If the distribution of holes obeys an exponential law, that is $p(x) = A\exp\left(\frac{eE}{kT}x\right) + C)$,then the solution (3) of the equation is expressed as follows:

$$p(x) = \frac{j_p}{eE\mu_p} + \left(p(0) - \frac{j_p}{eE\mu_p}\right)\exp\left(\frac{eE}{kT}x\right)$$

Here $E = E_v + \Delta E$

In the absence of an external field $j_p = 0$ then we have

$$p(d_1) = p(0)\exp\left(\frac{eU_0}{kT}\right)$$

When a reverse voltage is applied, the concentration in the i / pi a-Si: H region decreases exponentially, then for the current density we have

$$j_p = e\frac{U_0 + U}{d_1}\mu_p p(0)\left[1 - \exp\left(-\frac{eU}{kT}\right)\right]$$

The hole concentration between the p-c-Si / i-a-Si: H layers at x = 0 depends on the concentration of NA donors in the p-c-Si layer and the height of the heterojunction barrier. The height of this barrier is determined as follows, then we have $\Delta U = \Delta U_v - \Delta U_F$

$$p(0) = N_A\exp\left(-\frac{e(\Delta U_v - \Delta U_F)}{kT}\right)$$

Taking this into account for the current density, we finally obtain the following expressions

$$j = e\frac{U_0 + U}{d_1}\mu N_A \exp\left(-\frac{e(\Delta U_v - \Delta U_F)}{kT}\right)\left(1 - \exp\left(-\frac{eU}{kT}\right)\right)$$

From the latter, we can determine the resistance of the heterojunction at *U=0*

$$R = \left(\frac{dj}{dv}\right)^{-1}_{U=0} = \left(\frac{e^2(U_0)}{kTd_1}\mu N_A \exp\left(-\frac{e(\Delta U_v - \Delta U_F)}{kT}\right)\right)^{-1}$$

$$R = \frac{kTd_1}{e^2 U_0 \mu N_A}\exp\left(\frac{e(\Delta U_v - \Delta U_F)}{kT}\right)$$

With the help of this formula, we can calculate the resistance of the heterojunction between the c-Si and a-Si: H layers. By choosing the parameters of the a-Si: H and c-Si layers, we can optimize the efficiency of the photoconverters. This is included in our next study.

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