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ЧИСЛЕННОЕ МОДЕЛИРОВАНИЕ ЭФФЕКТИВНОСТИ СОЛНЕЧНОГОЭЛЕМЕНТА НА ОСНОВЕ СТРУКТУРЫ A-SI: H / C-SI

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Аннотация

В данной работе представлена зависимость эффективности однопереходного солнечного элемента на основе структуры a-Si: H/ c-Si от толщины и степени легирования фронтального слоя, а также была представлена зависимость КПД солнечного элемента от температуры.Моделирование проводилось в программе AFORS-HETv2.5, которая предназначена для моделирования фотоэлектрических преобразователей. Было установлено, что с повышением толщины и степени легирования слоя a-Si: H происходит снижение КПД устройства. Повышение температуры от 300 Кдо 380 К, также способствует снижению КПД солнечного элемента.

Ключевые слова: солнечный элемент, толщина, температура, КПД, степень легирования.

NUMERICAL MODELING OF EFFICIENCY OF THE SOLAR CELL BASEDON STRUCTURE A-SI: H / C-SI

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Abstract

In this paper, the dependence of the efficiency of a unijunctioned solar cell on the basis of the structure of a-Si: H / c-Si on the thickness and degree of doping of the frontal layer is presented, and the dependence of the efficiency of the solar cell on temperature was presented. Modeling was carried out in the program AFORS-HET v2.5, which is designed for modeling photoelectric converters. It was found that with an increase in the thickness and degree of doping of the a-Si: H layer, the efficiency of the device decreases. Increasing the temperature from 300 K to 380 K, also contributes to a decrease in the efficiency of the solar cell.

Key words: solar cell, thickness, temperature, efficiency, degree of doping.

At present, solar cells are attractive sources of renewable energy. Using the same technology of manufacturing thin-film solar cells allows to reduce production costs and to obtain sufficient efficiency. Hydrogenated amorphous silicon (a-Si: H) is today an important material in the manufacture of thin-film solar cells because of its lower cost compared to crystalline silicon and the possibility of using it on cheaper substrates (the deposition temperature of a-Si: H is much lower than for c-Si). In this paper, the dependence of the efficiency of a unijunction solar cell on the basis of the structure of a-Si: H / c-Si on the thickness and doping level of the frontal layer is presented, and the dependence of the efficiency of the solar cell on temperature was given [1]. Modeling was carried out in the program AFORS-HET v2.5, which is designed for modeling photoelectric converters. Figure 1 shows the structure of the simulated solar cell.

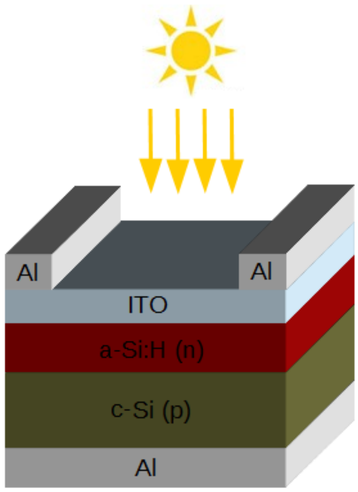

Figure 1. Structure of a solar cell based on a-Si: H / c-Si

Hydrogenated amorphous silicon (a-Si: H) has a band gap of 1.72 eV, and c-Si has a band gap of 1.12 eV.

The simulation was carried out at a constant thickness of the c-Si layer 13 μm and a constant degree of its doping $N_A = 9 \cdot 10^{16}$ cm^{-3}. In the simulation, the thickness of a-Si: H was set at 10 nm, 100 nm and 200 nm in Fig. 2 (modeling of the dependence of the efficiency on the thickness of the a-Si: H layer was carried out at a constant degree of doping of the a-Si layer: H $N_A = 9 \cdot 10^{16}$ cm^{-3}). So, with the thickness of the layer a-Si: H 10 nm, the efficiency of the device was 13.38%, figure 2 (a), with a-Si: H 100 nm thickness, the efficiency of the solar cell decreased to 12.11% Figure 2 (b) thickness of the a-Si layer: H 200 nm, its efficiency already amounted to 11.3% Figure 2 (c). From the results obtained, it follows that with increasing thickness of the a-Si: H layer, the efficiency of the device decreases, which is related to the depth of the p-n junction and the diffusion length of the charge carriers. The smaller the distance to the next layer, the higher the efficiency of the device [2].

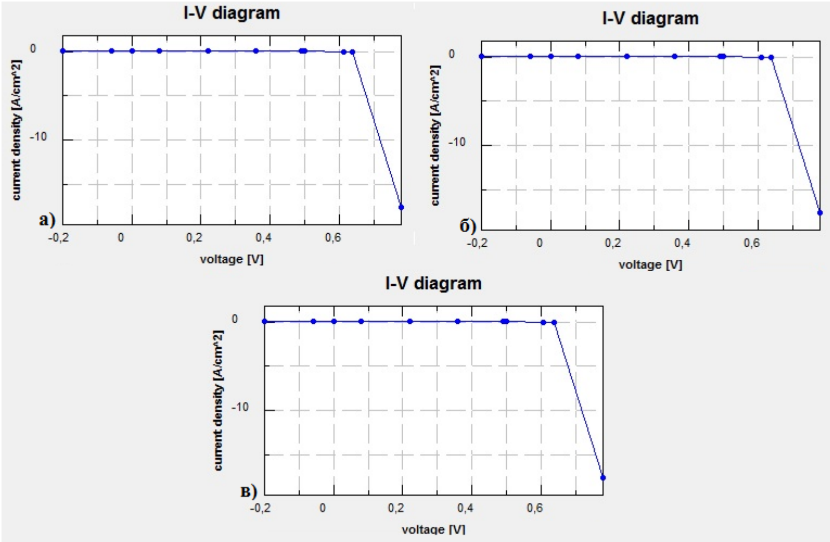

Figure 2. Dependence of the efficiency and current-voltage characteristics of a solar cell on the thickness of a-Si: H a) at the thickness a-Si: H layer 10 nm efficiency is 13.38% b) for thickness of a-Si layer: H 100 nm efficiency is 12.11 % c) of the a-Si: H layer 200 nm efficiency is 11.3%

Further, the dependence of the efficiency on the degree of doping of the a-Si: H layer was calculated. Figure 3 shows the dependence of the change in efficiency on the degree of doping of the frontal layer. So, with the $N_D = 1 \cdot 10^{19}$ cm^{-3} doping level, the efficiency is 13.38% Figure 3 (b), and for the $N_D = 1 \cdot 10^{17}$ cm^{-3} alloying rate, the efficiency is 13.69%. This slight change in the efficiency of the solar cell is associated with a change in the magnitude of the potential barrier due to its doping.

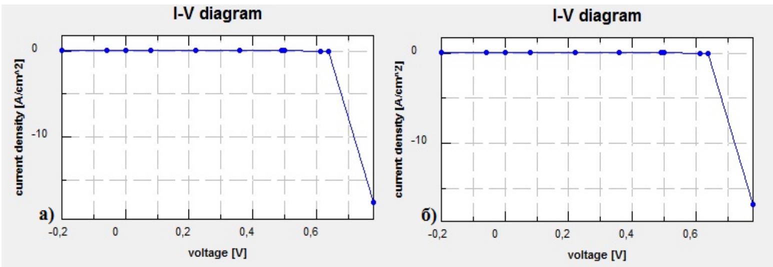

Figure 3. Dependence of the efficiency and I-V on the degree of doping a) atthickness a-Si: H 10 nm and doping level $N_D = 1 \cdot 10^{19}$ cm^{-3}efficiency is 13, 38% b) atthickness a-Si: H 10 nm and degree of doping $N_D = 1 \cdot 10^{17}$ cm^{-3}efficiency is 13.69%

Further, the dependence of the efficiency on the temperature at which this solar cell operates was shown in Fig. 4 (the previous dependences were obtained at a temperature of 300 K). It was found that with an increase in temperature from 300 K to 380 K, the efficiency of the solar cell decreases from 13.69% to 9.594% [2,3].

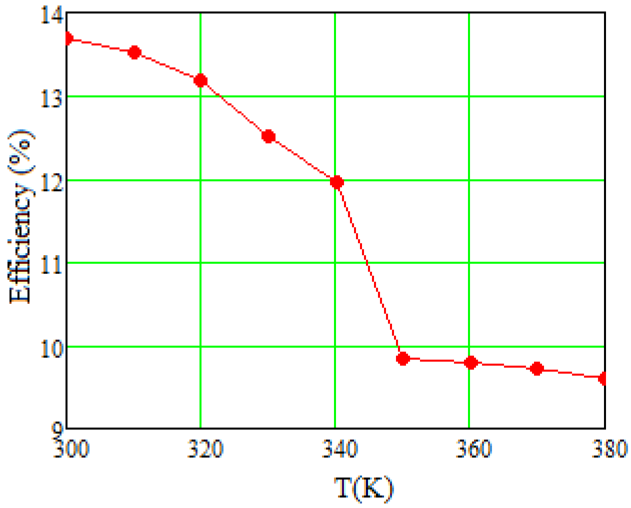

Figure 4. Dependence of the efficiency of a solar cell based on a-Si / c-Si on the temperature change

Based on the results of the simulation, the dependence of the efficiency and I-V on the thickness of the frontal layer and on the degree of its doping was established, and the dependence of the efficiency on temperature was evaluated. The obtained simulation results can be useful at the stage of technological production.

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