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PHOTO-THERMOELECTRIC CONVERSION OF SOLAR ENERGY USING A PHOTOTHERMOGENERATOR

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Abstract. This article analyzes a number of factors affecting the efficiency of converting solar radiation into electrical energy, describes the principle of operation of a new model of a solar installation - a photothermogenerator, presents the results of experiments performed by concentrating selective radiation before sending it to a solar cell made of polycrystalline silicon.

Keywords: *Photons, heating, electron-hole pair, photothermogenerator, selective radiation, protective block, photocell coordinate, movable slit, automated system.*

Introduction. There are several ways to convert solar energy into electricity: photoelectric, thermoelectric, thermo and photoemission. However, only photoelectric conversion is performed by direct conversion, and in all other cases, the process occurs with conversion to heat [1].

Due to the fact that the magnitude of the energy transitions in semiconductors is discrete, photons with a lower energy than the transition energies do not participate in the formation of electron-hole pairs, and part of the energy of photons with higher energy is uselessly spent on thermal heating of the semiconductor. For this reason, and taking into account a number of additional factors, such as the recombination of charge carriers, the temperature of the solar cell, the reflection of radiation from the surface of the converter [2-5], etc., the efficiency of semiconductor photocells is theoretically limited to certain values (for silicon photocells this indicator has theoretical border of the order of 22-26%). The real value of the efficiency of silicon photoconverters usually lies in the range of 10–16% [6–10].

Although the above factors serve to reduce productivity, even if there were no influence of negative factors on the conversion, the electric power would not reach the expected values. Because only 20-25% of the radiation emitted by the sun reaches the surface of the solar cell. The rest is lost by reflecting (30-35%), absorbing the atmosphere (15-18%), scattering to the earth from the sky (10-11%) and clouds (14-15%) [11, 12].

The focus of all researchers, scientists, innovators and inventors who are currently exploring the problems of converting solar radiation into electricity is the problem of eliminating various losses. They are trying to solve these problems by improving solar technologies, developing new technologies, searching for and using new materials, introducing various impurities into the composition of the most common materials, etc. New types of solar installations - photothermogenerators [13,1 4] with concentrators have an obvious advantage over non-concentrating systems, since they can significantly reduce the number of required photovoltaic cells [15], which often cost more than other parts of the system. The main tasks in creating a source concentrator are to ensure reliable cooling of devices for solar batteries [16]. The most common way to increase efficiency Photovoltaic solar cells — the use of cascade photoconverters with several p – n junctions — can also be used to increase the efficiency of solar TFE generators [17]. But, among all the ways to increase the efficiency of solar cells, the use of selective thermal radiation generators with concentrators and a solar tracking system is the most economical and efficient [18].

Despite active research, the obtained performance indicators of existing devices do not meet the expectations of scientists. All known models have several disadvantages:

- high possibility of overheating of solar panels due to the presence of non-photoactive rays;
- decrease in efficiency (COP) with increasing radiation density;
- the need to use photovoltaic batteries from a certain type of material, etc.

Photothermogenerator selective radiation. The results of our studies on the creation of highly efficient devices have led to the creation of a more perfect sample [13,14,18] of a photothermogenerator of selective radiation that can solve the above problems: increasing and stabilizing the efficiency value, eliminating temperature factors that negatively affect the electrophysical parameters of semiconductor materials.

The proposed model of a photothermogenerator is more efficient than existing analogues, due to the fact that the direction of selective radiation eliminates overheating of solar cells, and therefore ensures the stability of the conversion of photovoltaic energy. This design differs from previous ones in that it uses a protective unit in which photocells are protected that are protected from side effects using an automated system for determining the optimal coordinates of the photocell and there is a movable slit. The concentration of solar radiation reduces the area of solar panels. In addition, additional heat is converted using a thermoelectric converter, which leads to an increase in the overall efficiency system.

It is known that the value of the electrophysical parameters of semiconductor solar cells is relatively stable at a certain temperature. Considering that the temperature varies depending on the light intensity, it can be concluded that the direction of concentrated sunlight at one point in order to get more energy usually only leads to a sharp increase in temperature in this area. Therefore, when the temperature of the solar cell exceeds the relative limit, its efficiency is sharply reduced n times.

The results of the experiments. To avoid this problem, in our experiment, concentrated light was divided into spectra before being sent to a polycrystalline silicon photocell. As a result, with an increase in the radiation density, the voltmeter indicators connected as a load also increased.

For the reliability of the results, the experiments were carried out using a standard solar module - MSM 12-700. The module was located in a protective box to protect it from the environment, and the radiation was directed through standard glass with a conductivity of 100%, 72% and 32%. When lightening with intensities of 783, 559 and 403 lux (52.2 Vt / m^2, 39.9 Vt / m^2 and 26.9 Vt / m^2), the value of the free-wheel voltage and short-circuit current was U_{fw} = 3.91 V, U_{fw} = 4.75 V, U_{fw} = 5.19 V and $I_{sh.c.}$ = 1.25 mA, $I_{sh.c.}$ = 2.62 mA, $I_{sh.c.}$ = 4.8 mA, respectively.

According to the obtained data, the efficiency coefficients were η (52.2) = 4.0%, η (39.9) = 3.3%, and η (26.9) = 2.2%, respectively.

Based on the above results, it was found that the efficiency of the photocell does not change accordingly when lighting with different intensities using a light source with the same spectral content. Although the intensity in the first and third cases is three times different, the difference in the efficiency coefficients was only 2%. Similar results were obtained in experiments with samples with a higher coefficient (15–18%).

At the second stage, the efficiency of the solar cell was studied with a maximum efficiency of 6-7% at an average temperature of + 30 ° C. The maximum current was Wmax (13.4) = 1.3 W when illuminated with monochromatic radiation (800-900 μm) and an intensity of 201 lux. And the utility value of the photoelectric coefficient was estimated at 9.7-10%. This figure increased to 15-16% with increasing intensity.

Conclusions. The smallest and maximum efficiency coefficients of a single-crystal silicon solar cell of a production sample (with a productivity of 6% and 13%, respectively) using a photothermogenerator were 15 and 16%, respectively. Although the conversion efficiency of solar cells should be higher when using selective radiation, in real conditions these indicators do not correspond to the expected results. This is due to the problem associated with the detection of an ideal photoactive spectrum and its perpendicular direction to the photocell.

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ФОТО-ТЕРМОЕЛЕКТРИЧНА КОНВЕРСІЯ СОНЯЧНОЇ ЕНЕРГІЇ З ВИКОРИСТАННЯМ ФОТОТЕРМОГЕНЕРАТОРА

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РЕСПУБЛІКА УЗБЕКИСТАН

Анотація. У цій статті проаналізовано низку факторів, що впливають на ефективність перетворення сонячного випромінювання в електричну енергію, описано принцип роботи нової моделі сонячної установки - фототермогенератора, представлені результати експериментів, проведених шляхом концентрування селективного випромінювання перед відправленням його на сонячну батарею з полікристалічного кремнію.

Ключові слова: *фотони, нагрівання, електронно-лункова пара, фототермогенератор, селективне випромінювання, захисний блок, координата фотоелементів, рухома щілина, автоматизована система.*

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