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Development and Study of a New Model of Photothermogenerator of a Selective Radiation with a Removable Slit

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ABSTRACT: A photo thermoelectric method of converting light energy is proposed in the article on the basis of theoretical analyzes of diffraction phenomena, radiation dispersion and the characteristics of a black body. A new design of a highly efficient selective photothermogenerator's radiation is presented. The design of a combined device with a removable slot trench is recommended.

KEY WORDS: radiation, diffraction, spectrum, absolutely black body, photothermogenerator, selected radiation, prism, slit trench.

I.INTRODUCTION

The development of science and technology, in turn, leads to an increasing in demand for electricity. Based on this, one of the most actual issue is the creation and use of cost-effective, practically inexhaustible energy sources that will ensure no-break supply of electricity to current and future generation.

In connection with this issue, high hopes in the world are placed on so-called alternative energy sources, such as solar radiation. But its widespread introduction is constrained by the high cost of solar installations and the low efficiency of solar generators.
Despite the active research and improvement of technologies and structures, the results in this branch have not yet been crowned with significant success. The efficiency of laboratory samples is still in the range of 25-26% (heterostructural solar cells), and in practice, elements with an efficiency (efficiency) of 12-15% are used.

Therefore, the problem of finding ways of the most optimal, cost-effective way to convert the energy of sunlight into electrical energy based on semiconductor photoelectric converters is becoming increasingly important.

II. RELATED WORK

A number of studies by the authors [1] on the development (Figure 1) and optimization of high-performance structures led to the creation of a new design, so-called "photothermogenerator" [2].

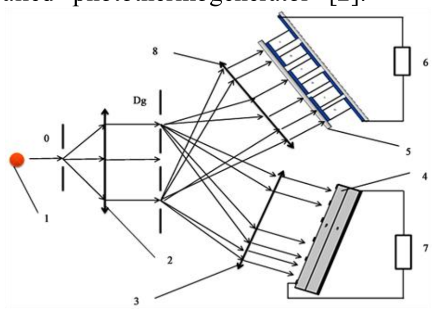

Fig.1. Diagram of the distribution of light radiation on the surface of photovoltaic and thermoelectric converters. 1-light source, 2, 3, 8-set of optical lenses, 4-photovoltage transducer, 5-front surface of the thermal transducer, 6-load thermal transducer, 7-load photo-transducer, 0-entrance slit trench, Dg-diffraction lattice.

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In the construction of the photothermogenerator, the light emission is divided in such a way that the main, mainly component of the shortwave and visible regions of the spectrum, part of the radiation creating electron-hole pairs, falls on the front surface of the photoelectric converter. And the longer wavelength part of the radiation, acting on the upper hot switching plates, is additionally converted into an electrical one. This design differs from the others in that in this case the heating of photoelectric converters disappears and the practically unchangeable value of the efficiency disappears, even at high light intensities. This fact is explained by the authors of the design by the following formula [1]:

$$\eta_{p.e.c.} = \frac{W_{full}^{m.p.v.}}{W'_{fall}} \quad (1)$$

In formula (1), the expression in the denominator, unlike traditional calculations, has a value equal to $W'_{fall} = (1-k)W_{fall}$,, where $W_{full}^{m.p.v.}$ is the useful maximum electrical power released by the load of the photothermometer, W_{fall} is the integrated light power directed from the light source to the photothermal converter, k is the coefficient of reflection of light from the front surface of the photoconverter. Respectively efficiency thermal converter is calculated by the following formula [1]:

$$\eta_{t.e.c.} = \frac{W_{full}^{m.t.v.}}{(1-k)W_{fall} - W'_{fall}} = \frac{W_{full}^{m.t.v.}}{Q_{t.e.c.}}, \quad (2)$$

where W is the net electrical power generated at the load of the thermal converter, $Q_{t.e.c.}$ is the light capacity falling on the ceramic plate and on the surface of the thermal converter.

The fact that this design is cheap and effective. And the authors of the work have already proved this fact both theoretically and empirically. But nevertheless, this design can be upgraded or modernized. Currently, the authors of the article are working on this and as an experimental version, the following construction of the separation of light waves by spectra has been proposed (Figure 2).

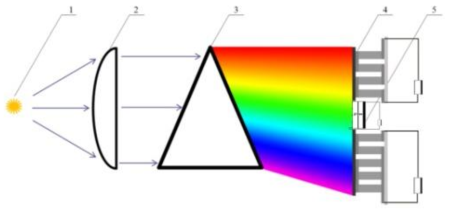

Fig. 2. Photothermogenerator with a removable slot trench. 1-radiation source, 2-set of lenses to create parallel beams of rays, 3-prism, 4-thermoconverter, 5-photoconverter.

III. METHODOLOGY

In new construction it is proposed not to divide the spectrum, but to place the photoconverter in the place where the required part of the spectrum falls. Since a certain part of the spectrum falls on the phototransducer, its efficiency is suddenly improved and at the same time the photocell almost does not heat up. Since in the construction of photocells are in the open air close to the thermoelement, an increase in air temperature and thermoelement affects the efficiency of the photocell, worsening it. Under natural conditions, non-active radiation from the environment enters the photocell. In addition, due to the smooth change of the spectrum, it is impossible to optimally place the photocell. For small sizes, it is impossible to cover the entire necessary part of the spectrum, and for large sizes, unnecessary parts of the spectrum will fall on the photocell. To ensure more efficient operation of the structure, it is necessary to add an additional block (in the form of an absolutely black body) in which photo cells protected from side effects and a secondary monochromatization system are placed to improve spectrum selection (Figure 3).

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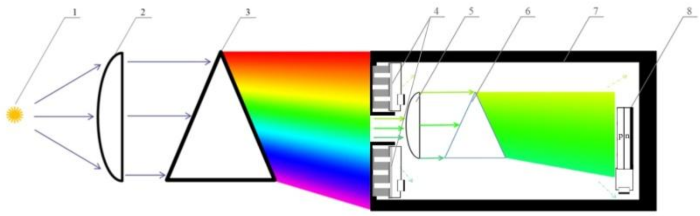

Fig. 3. Photothermogenerator with a removable slot trench. 1-radiation source, 2,5-set of lenses for creating parallel beams of rays, 3,6-prism, 4-secondary radiation source, 7-thermoconverter, 8-photoconverter.

This construction differs from the first one in that the photoactive part of the obtained spectrum does not fall directly into the photocell, but passing through the slot trenches creates a secondary source of radiation. After entering, the secondary wave of the beam will hit the collimator, and after that it will again be divided into spectra. But this time the spectrum will consist of more selective parts of the beam, and unnecessary radiation on the photocell can be avoided as much as possible. All unnecessary part of the spectrum and the radiation of the environment is absorbed by the thermal converter. To maintain a stable temperature inside the unit, you can add a heat insulation layer or an internal cooling system (this issue is still being studied).

The slit trenches can for passing ray be transferred in two directions using an automated displacement system that works based on static data of voltage or power calculations. This ability allows the regulation of ray selection with a desired wavelength.

IV. EXPERIMENTAL RESULTS

Research on finding the optimal range of sensitivity to the spectrum using an exemplary version of the design led to the following results.
1. Silicon-based photoconverter is more sensitive to the spectrum in the range of 800-900 nm.
2. The temperature of silicon photovoltaic converter is lower in the range of 850-900 nm.
3. In the range of 830-870 nm, the radiation intensity affects the efficiency, and the temperature remains almost unchanged.
In the study, a type monochromator and a polycrystalline silicon Hinergyphotoconverter from Chinese manufacturers with an efficiency of 17-19% were used. The diagram below (Fig. 4) shows the change in the sensitivity and temperature values in a single measurement.

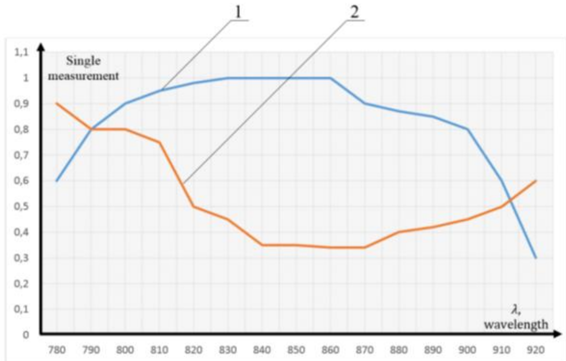

Fig. 4. Graph of changes in the sensitivity values (1) and temperature (2) of the photocell versus wavelength.

V.CONCLUSION

Thus, in the proposed construction of a photothermogenerator with a removable slit trench, it is possible to move the slit trench for transmitting photoactive radiation depending on the positions of the emission spectrum and the photovoltage transducer along the frontal plane in two directions. This allows the use solar cells with any photoactive spectral sensitivity.

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