Euroasian Journal of Semiconductors Science and Engineering

Volume 1
Issue 6 *Issue 6*

Article 3

12-15-2019

# DEVELOPMENT OF PHOTOTHERMOELECTRIC CONVERTERS AND RESEARCH OF THEIR DESIGN AND OPERATIONAL FEATURES

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**ПОЛУПРОВОДНИКОВАЯ МИКРОЭЛЕКТРОНИКА**

**SEMICONDUCTOR MICROELECTRONICS**

**UDK 621.315.592**

# DEVELOPMENT OF PHOTOTHERMOELECTRIC CONVERTERS AND RESEARCH OF THEIR DESIGN AND OPERATIONAL FEATURES

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***Annotation.*** *The paper considers the physical basis of operation and varieties of existing designs of photo thermoelectric energy converters, analyzes the principles of operation and design features of existing one-and two-stage photo thermoelectric converters, and describes the scheme of an experimental installation.*

***Keywords****: thermocouple, sensor, selenium, tellurium, stebium, quartz, efficiency, extremum, electron.*

# РАЗРАБОТКА ФОТОТЕРМОЭЛЕКТРИЧЕСКИХ ПРЕОБРАЗОВАТЕЛЕЙ И ИССЛЕДОВАНИЕ ИХ КОНСТРУКТИВНЫХ И ЭКСПЛУАТАЦИОННЫХ ОСОБЕННОСТЕЙ

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***Аннотация.*** *В работе рассматриваются физические основы работы и разновидности существующих конструкций фототермоэлектрических преобразователей энергии, проводится анализ принципов работ и конструктивные особенности существующих одно и двухкаскадных фототермоэлектрических преобразователей.*

***Ключевые слова:*** *термоэлемент, датчик, селен, теллур, стибиум, кварц, эффективность, экстремум, электрон.*

## 1. Introduction

The photovoltaic method of direct conversion of solar energy into electrical energy based on semiconductor photovoltaic converters (PVC) is of particular interest due to the endless source of solar energy.

In ground-based photovoltaics, due to the high cost of the most important components of solar photovoltaic installations (SPVI), in particular solar batteries, the attention of researchers was drawn to solving the problem of reducing the cost of "Solar electricity" and, as a result, the direction associated with methods and means of concentrating solar radiation. The result of developments in this area was the creation of solar cells based on silicon and gallium arsenide, allowing operation on concentrated radiation (CR). Moreover, providing in these conditions an increased conversion coefficient compared to natural irradiation. Another achievement in this area is the theoretical substantiation, development and creation of a wide range of concentrating systems (CS), ranging from the simplest flat mirror systems, giving one and a half or double increase in the irradiation intensity with a photoelectric generator, to complex parabolic systems, including those with double reflection, providing CSI at the level of 500 ÷ 2500 times [1,2,3].

**2. Experimental technique**

Analysis and accounting of the loss of light energy show [4, 5] that during the formation of electron-hole pairs due to the generation process, the amount of light energy is converted into electrical energy. The rest of the energy, that is, approximately 80%, disappears in the form of energy losses.

There are two types of photothermoelements [6, 8, 10]. In converters of the first type, the role of the thermoelement branches is played by the quasineutral regions of the photocell. In this case, a total current flows through the photocell and the thermoelement, therefore, such a photothermocouple is called a photothermoelement with a total current. A photothermoelement of another type consists of photo and thermoelements separated by an electrical insulating gasket having a high thermal conductivity. In this case, there are different loads in the circuit of each element. The photothermoelectric converter is called the split-load photothermoelement.

The energy of the radiation incident on the converter is partially converted into an electrical signal, and the rest of the radiation, turning into heat, heats the photoconverter and the hot end of the thermoelement. The cold junction of the thermoelement is either specially cooled or in direct contact with the environment.

The use of converters with common currents is complicated by the following circumstances:
-nonoptimality of the total current simultaneously flowing through the photo and thermoelements;
- violation of Ohm's law when current flows through the photoconverting device;
- difference in temperature dependences of currents of photo and thermoelements [5].

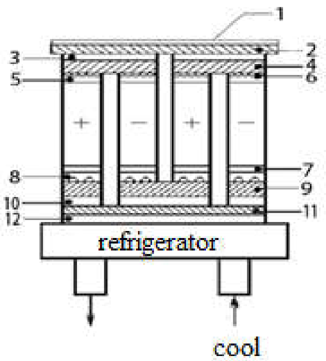


***Fig. 1. TEG in the "photo-thermo" system mounted on the refrigerator (side section). 1-CdSn solder ($T_{TM}$ = 176 ºC); 2-top ceramic (BeO); 3-solder Sn ($T_{TM}$ = 2320C); 4-top connection plate (Fe); 5-solder BiSb; 6-solder SnTeSb ($T_{TM}$ = 5770 C); 7-solder BiSb; 8-solder BiSnSb ($T_{TM}$ = 1400 C); 9-lower connection plate (Ni); 10-Sn solder; 11-bottom ceramic BeO; 12-alloy "Newton" ($T_{TM}$ = 1030C).***

For the photothermoelectric conversion device, we have chosen a device with a separate load. The advantages of split-load devices include:
- the possibility of designing photo and thermoelements without taking into account the parameters of the combined element;

- when using concentrated solar radiation, the TEG can act as a cooling agent for the photoconverting part;
- the possibility of creating devices in which the converting cascades operate in independent modes.

### 3. Results and discussion

Photothermoelectric converters are manufactured in stages. The first stage includes the fabrication of the thermopile (cutting the substance, etching, fabrication of patch plates, soldering and assembly).

The creation of high-current thermoelements increases the requirements for their geometric dimensions, since with a decrease in the length of the leg, the power increases due to the inversely proportional dependence of the power on the length of the thermoelement for a given weight of the working substance.

The connecting plates for the cold ends of the half-cells are made of nickel and have the same geometric characteristics as the iron plates. To ensure satisfactory contact between the base of the half-cell and the nickel plate, the plate is cleaned with a cord brush and tinned; uses $ZnCl_2$ flux for tinning. In addition, the nickel plate is bulged so that the BiSnSb solder, which makes contact with the half-cell, is not completely squeezed out of the space between them [11,12].

The assembly of the separated parts of the thermoelement must be carried out without violating the specified geometric configuration of the half-elements. For this, special mandrels made of heavy alloys, such as brass, are used.

The TEG assembly is completed by connecting the assembled structure to the refrigerator. The free surface of the lower ceramic plate is bonded to the cooler using Newton's alloy. A schematic view of the assembled TEG is shown in fig. 1.

Performance studies were carried out for a thermopile consisting of 8 thermoelements connected in series. Thermoelements had the following geometrical parameters: height 14 mm, sectional area - 2 · 0.16 mm2. The substances from which the thermoelements were made (before they were assembled into a single thermopile) had the following thermoelectric parameters (at 300 K): for p - type α = 160 μV / K, σ = 1500 Ohm -1 cm -1, æ = 15 mW / K cm; for n - type α = 180 μV / K, σ = 1000 Ohm -1 cm -1, æ = 16 mW / K cm.

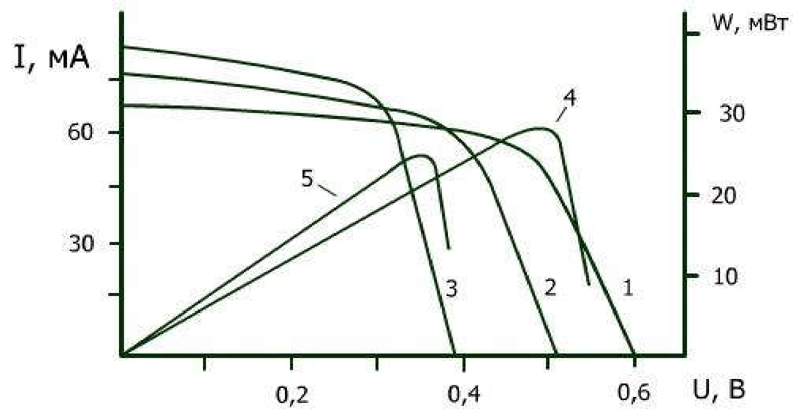


***Fig. 2. Load current-voltage characteristics (1,2,3) and output power (4,5) of a photocell based on amorphous silicon at T, K: 300 (1.4); 350 (2); 400 (3.5).***

The article presents from our experiments, in order to maximize the approximation of field tests to natural conditions, the light intensity sensor and the cold junction of thermoelements were cooled with water.

During the tests, the cold junctions of the thermopile were maintained at a temperature of 17-18 ºC, cooling was carried out by passing running water through the refrigerator. The temperature of the hot junction was changed to temperatures of 105-115 ºC (A) and 125-135 ºC (B) by adjusting the power of concentrated radiation incident on the thermoelement.

To study the operational characteristics of solar cells, we used elements from ready-made prototypes of solar cells based on α - Si: H with the maximum efficiency. 9-12%. The measurements were carried out according to the standard techniques used to study photogenerating structures [7, 9].

## 4. Conclusion

The developed design of AFS-thermopiles is acceptable for solving metrological problems, as well as convenient for automatic control of the gas content (or the content of chemicals in the air) of the environment with the provision of energy to signaling devices. Thus, since there is a need and possibility of using concentrating systems of solar radiation, the advantage of using a photothermoelectric converter in such conditions becomes obvious.

Here, an important advantage of FTEPs operating on various loads is the ability to generate electricity of significant value in comparison with TPEs operating separately. The benefits also depend on concentrated radiation.

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