ELECTRICAL CONDUCTIVITY OF GRANULED SEMICONDUCTOR THERMOELECTRIC MATERIAL

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Anotation: In the article, the bulk polycrystalline semiconductor silicon and other semiconductor materials that have become unusable appear to be granular. Granulated semiconductor thermoelectric materials based on crushed granules that convert cheap and high-quality thermal energy into electricity using sunlight have been proposed. In the production of granulated thermoelectric material, the preparation of a new type of mono and polycrystalline castings using a solar furnace, as well as the processes associated with charge transfer in the new material obtained are shown.

Keywords: Semiconductor, granules, sunlight, thermoelectric materials, solar furnace, electrical conductivity.

1. INTRODUCTION

As a result of the development of modern physics, the field of semiconductors began to be widely studied, along with the growing demand and supply of semiconductor physics and semiconductor materials science. The field of semiconductor physics is wide-ranging, and the role of granulated semiconductors in the rapid development of the industry is of great importance. Granular semiconductor materials play an important role in the development of the energy sector and in the production of electricity, increasing the efficiency of solar cells and the conversion of thermal energy into other types of energy.

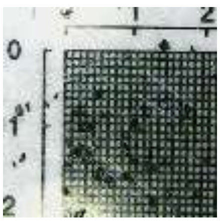
Today, as a result of the integration of semiconductor physics and production, granular materials are widely used in the creation of micro and nanoscale semiconductors, various semiconductor devices, solar cells, thermocouples and integrated circuits [1-2,8,14-18,20].

2. PROPERTIES OF SEMICONDUCTOR GRANULES

In recent years, the physical properties of granulated semiconductors under certain conditions, in particular, the mechanisms of manifestation of the input thermal voltage effects have been widely studied [1,2,19]. According to the studied sources, we can see that the mechanisms of manifestation of the above effects depend on the following. These depend on the size *V* of the granulated semiconductors, the input states on the surface of the semiconductors, and the defects resulting from the input coupling. It has been shown that the formation of electron-cavity pairs in semiconductors as a result of these conditions can increase the efficiency of semiconductors. However, the structure of granulated semiconductor materials and the effect of the processes associated with the charge transfer *q* in the granule have not yet been fully studied [4-7]. Taking into account these conditions, the study discusses the results of experiments on the structure of granulated semiconductor thermoelectric material, current *I*, voltage *U*, resistance *R*, the electrical conductivity (σ) formed in them [11].

3. RESULTS OF THE EXPERIMENT

In the preparation of thermoelectric materials, silicon particles of conductivity *n* and *p* are selected as raw materials, as shown in Pic.1, which has become unusable. The isolated *Si* dioxide particles are granulated for experimentation using a smooth ceramic base and a ceramic hammer, which are resistant to strong deformation at natural room temperature. Using the powder method, the surface of silicon particles is coated with a layer of *Si*-dioxide in nanoscale, forming granules up to 1 micrometer in size. The silicon granules, which appear to be powdered, are sieved and separated using a special sieve.

a) 

б) 

(Pic1. Silicon granules)

The sieved granules were prepared in a mixture of silicon granules using ethyl alcohol in various shakes, and they were heated in a solar oven and attached [3]. When the mixture is heated with sunlight in the range of T-9000^0 S to T-13000^0 S, it partially binds to each other, forming strong tunneling contacts at the two joints of the granules, forming a composite layer on the surface of the granules. Once tunnel contacts are formed between the granules, a heterogeneous environment is created in the thermoelectric material, resulting in tunnel contacts as well as local energy levels. As a result, we obtained a new type of semiconductor thermoelectric material using the above experiment. Another important aspect of the experiment is that when the mixture prepared from silicon dioxide using a solar furnace is slowly heated from T-900^0 C to T-1500^0 C, the granules coalesce and liquefy in the oxide [9-10]. New types of mono and polo crystal silicon wafers were made by geometrically shaped molten silicon granules.

Samples of different sizes and sizes are important. Depending on these, the methods of determining the specific resistance of plates, thin layers, columnar thermoelectric material differ from each other. One probe, two probes and four probes and other methods can be used to determine the specific resistance of a material using its full resistance.

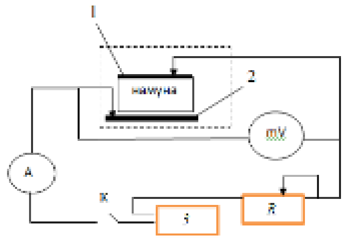
There are contact and non-contact methods for determining the specific resistance of semiconductors, and metal contacts are formed on the surface of the sample as shown in Pic. 3, through which current *I* is passed. In this process, the voltage $U = IR$ between the two contacts of the sample is measured according to the current *I*. In this case, if the current *I*, the voltage U and the geometric dimensions of the sample are known, the specific resistance r is determined. In this case, it is possible to determine the number of semiconductors $\rho=10^{-2} \div 10^{-6}$(Om sm). A closed layer or field is formed between the semiconductor and the metal contact, and the concentration of charge carriers in this area is small relative to the size of the semiconductor. It does not cause a change in the concentration of charge carriers in the semiconductor when current flows through the contacts.

In this case, the relationship between current and voltage between the contacts can be expressed as follows [12-13].

$$\frac{U}{I} = R = \rho\frac{a}{S}$$

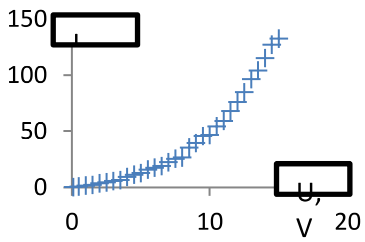
Where R is the total resistance of the sample, a is the length of the sample or the distance between the contacts, and S is the cross-sectional area of the sample.

The experiment is performed using the following electrical circuit.



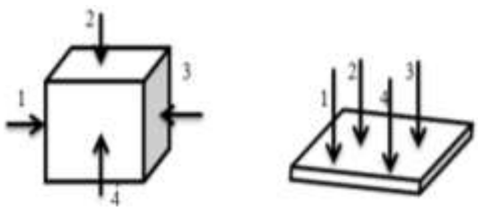
Pic. 3. Simplified scheme of the device

1 and 2 are the upper and lower contacts, respectively. A-ammeter, mV-millivoltmeter, K-switch, 3-power supply, (---) protective cover.



Pic.4. VAX when a constant current is applied to the sample

Using another four-probe method to measure the specific resistance of plate-shaped specimens, the ability to measure specimens of any shape and different sizes is higher than other methods, and this method is very common [12-13]. It is possible to determine the resistance of a semiconductor material in the cast state or in the case of integrity, and to determine the specific resistance of plates that do not have any dimensions. The four probe methods are shown in Pic. 4a,b.



Pic. 4a, b.

An electric current $I_{1,4}$ is passed through the outer probes (1 and 4) placed on the surface of the sample, and $U_{2.3}$ is measured through the inner probes (2 and 3). The distance S between the probes is much smaller than the peripheral area of the sample from the probes. In this case, the applied current passes through the surface on which the probes are placed. An electric field is created as a result of the passage of a current, and we can write that the electric field generated in the radius r_1 of the current passing through the first probe is energized as follows.

$$E_1 = \rho J_1 = \frac{\rho l}{2\pi r_1^2}$$

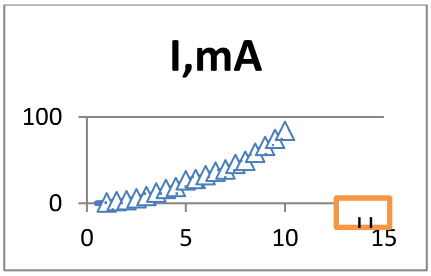
Here, when the current density J_1 is $r_1 \to \infty$, the field potential tends to zero ($\varphi \to 0$). We can write the wash for this point.

$$\varphi_1(r_1) = -\int_{\infty}^{r_1} E_1 \, dr_1 = \frac{\rho l}{2\pi r_1}$$

It is appropriate to write a similar equation for the fourth probe.

$$\varphi_4(r_4) = -\int_{\infty}^{r_4} E_4 \, dr_4 = \frac{\rho l}{2\pi r_4} = \frac{\rho l}{2\pi s}$$

The given expressions correspond to the point charge potential, the point potential of phons 1 and 4 of sizes r_1 and r_4 is $\varphi_1(r_1) + \varphi_2(r_2)$. The potential of probe 2 is $U_2 = \varphi_1(s) + \varphi_1(2s)$, 3- the potential of the probe $U_3 = \varphi_1(2s) + \varphi_4(s)$ is the potential difference between them, $U = U_2 - U_3 = \frac{\rho l}{2\pi s}$ Determining the specific resistance ρ is determined by the relationship between the current I passing through the sample and the voltage drop U. Using the above method, we can see that the current depends on the power and voltage given in Pic. 5 below.



Pic. 5. VAX when a constant current is applied to the sample using the four-probe method. Sample thickness d-0.2mm.

The Van der Pau method is also very suitable for determining the relative resistance of arbitrary specimens [12, 13]. The method shown in Pic. 6 also uses cells consisting of 1 to 4 probes. Initially, current is supplied through probes 1 and 2, and voltage drop is measured using probes 3 and 4. In this case, the current is applied in reverse, ie through probes 2 and 3, and the voltage drop is determined through probes 1 and 4. The resistance for the above condition is determined using the following equation.

$$R_1 = \frac{U_1}{I_1} \; and \; R_2 = \frac{U_2}{I_2}$$

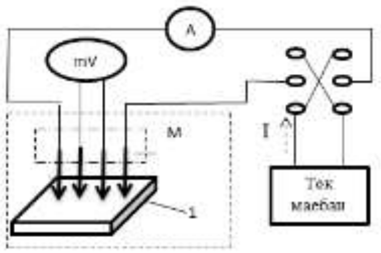
They have the following relationship to each other

$$\exp\left(-\pi\frac{d}{p}R_1\right) + \exp\left(-\pi\frac{d}{p}R_2\right) = 1$$

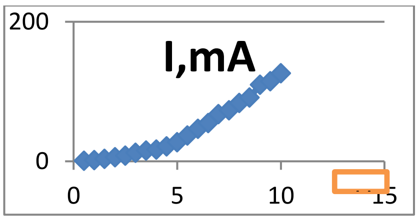
In this case, it is not possible to determine whether R_1 *and* R_2 are directly related. Therefore, to determine the correction coefficient R_1 / R_2 and if $R_1 < R_2$, the correction coefficient "f" can be given by the following equation using R_2/R_1.

$$\rho = \frac{\pi d}{ln2} \cdot \frac{R_1+R_2}{2} f \quad \text{or} \quad \rho = \frac{\pi d}{ln2} \cdot \frac{U}{I} f$$

Where d is the sample thickness.



Pic. 6. Van der Pau method



Pic. 6. VAX when the sample is given a constant current using the Van der Pau method. Sample thickness d-0.1.8mm

The Van der Pau method is also effective for determining the specific resistance of flat surface plates.

4. CONCLUSION

As a result of the experiments, it can be concluded that due to the presence of energy layers in the outer layer of granulated semiconductors, it was observed that they form an electric charge. As the size of the granules decreases, the oxidation of the surfaces also results in the formation of energy fields on the surfaces of the granules. Each edge of the granules is affected by the migration of charge carriers.

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