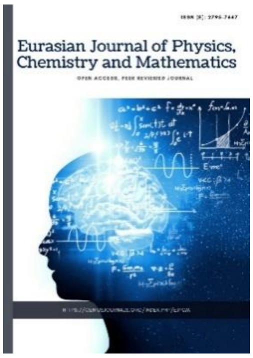

Preparation Of Micro- And Nano-Sized Granulated Zn-Sb Compound Based On Powder Technology And Development Of Resistance Heating Method.

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ABSTRACT

In this article, the technology of preparing Zn-Sb compound prepared in powder technology and the methods of obtaining thermoelectric material by heat joining with resistance means are analyzed. A mechanical method was used to prepare the semiconducting Zn-Sb compound, zinc-antimony particles were placed in a ceramic container and crushed to a nano-size, and placed in a special ceramic-shaped cylindrical tube, heated and thermally treated in several stages. One of the most important factors in obtaining the thermoelectric parameters of this compound is determined by the degree of fineness of the powder.

Keywords: Powder technology, micro and nano size, thermoelectricity, resistance heating, microphotography, granular intermetallic compound, thermal conductivity.

Introduction.

Due to constantly decreasing fuel reserves and the fact that existing energy resources are harmful to the environment, the energy sector faces a number of difficult challenges, including the task of developing methods for creating environmentally friendly types of renewable energy, free from harmful ones. Currently, systematic work is underway to develop energy resources materials and their implementation. Here, a number of developed countries are achieving significant results in the production of thermoelectric materials and the manufacture of thermoelectric devices based on them.

It is known that the efficiency of a thermoelectric material is $ZT=\alpha^2\sigma T/\lambda$ and its main parameters are electrical conductivity (σ) and Seebeck coefficient (α), on the other hand, electrical resistance (ρ) and thermal conductivity. (λ) should be low. Semiconductor materials meet these requirements due to their low thermal conductivity. Therefore, in recent years, interest in studying the thermoelectric properties of semiconductor materials has increased.[1-2]

Material And Methods.

Currently, there are several methods of obtaining thermoelectric materials, in particular, Zn-Sb-based thermoelectric materials can be obtained in general, based on technologies such as melting, smelting, alloying and pressing of the initial alloy in a vacuum or in an environment protected by an inert gas. The method we offer is called the powder technology method, and it differs from other types of technologies, such as sol-gel, or casting thermoelectric material, and it is simple compared to other technologies and does not require complex technological processes. Due to the fact that the process of powdering crystals using traditional powdering technology is carried out by mechanical methods, intrusions from the external environment lead to the formation of various defects in the volume or surface of the material. One of the disadvantages of powder technology is the contamination of powders during the process from raw materials to powder preparation.[3-4]

Figure 1. A ceramic container that performs the powdering process.

In order to solve these problems, washing and vacuum drying are carried out to clean the powders. The powdering process continues until the Zn-Sb particles are reduced to micro and nano size. Using a special mortar, the compound is ground up to several times. The resulting Zn-Sb particle is examined on a 1600X 2MP Digital microscope. If the particle becomes micro-sized, the process is stopped and the next step is taken. Below you can see the microscopic state of the micro-sized granulated Zn-Sb compound. [5-6]

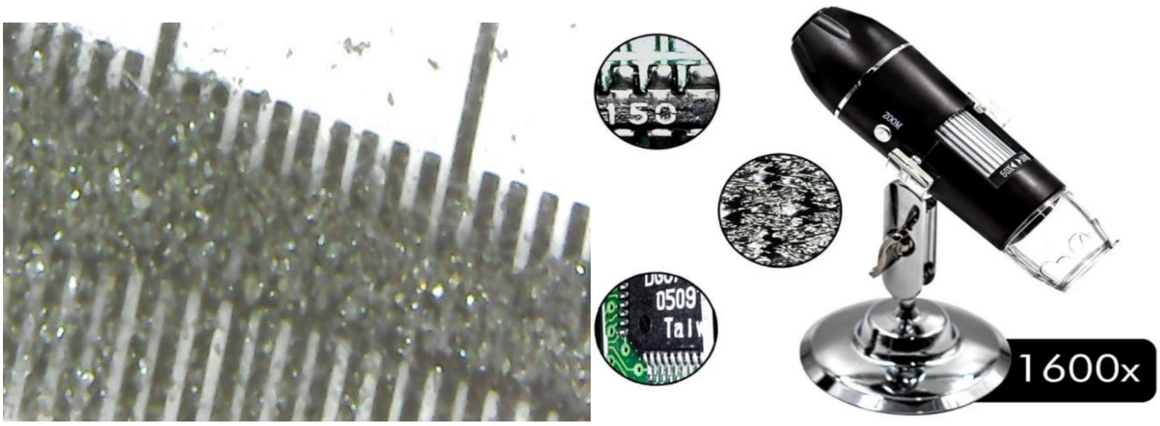

Figure 2. Microscopic view of micro-sized granulated Zn-Sb compound.

Results.

It is known that the structure and morphology of granulated semiconductor particles depend on the technology of their production [7]. For example, the structure of particles obtained on the basis of powder technology can be conditionally divided into 3 parts (Fig. 3). It is known from the powder technology that the powdering process is performed mechanically. In a mechanical method, the phenomenon of friction causes the powder particles to heat up. In our opinion, the heating process does not occur uniformly throughout the volume of the powder particle. That is, there is a temperature difference along the size of the particle. As a result, due to heating, the surface temperature of the particle is higher than in the volume ($T3 \leq T2 \leq T1$, Fig. 3).

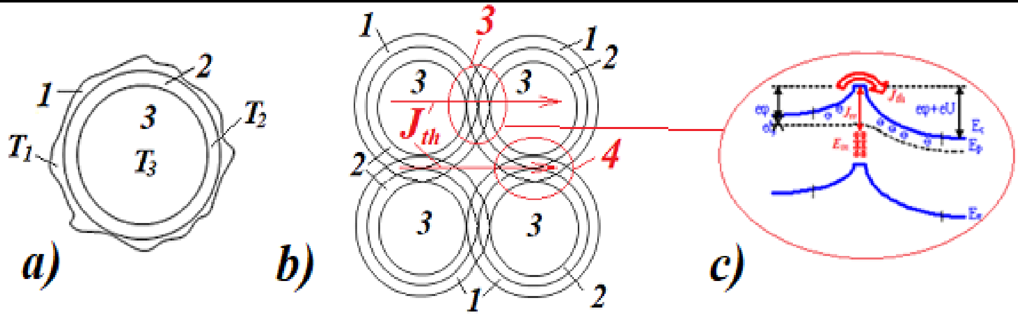

Figure 3. Zn Sb particle structure (a), location (b), zone diagram of the interparticle boundary region (c).

The method we propose is a mixture of semiconducting Zn-Sb particles with the help of 70% ethyl alcohol. the conducting metal is pressed together with rods, and then, close to the melting temperature of the Zn-Sb compound, by heating and joining the particles at temperatures T=400-600 °C, a rod-shaped Zn-Sb polycrystal with a diameter of 1 mm is formed. This method is called resistance heating method is a fairly simple method of converting electrical energy into heat, and serves to meet the heat demand of many medium and low temperature processes, as well as some high temperature processes. This method is a very effective method of electric heating. Therefore, this method is widespread in many sectors of the national economy and household life. resistance heating is used in the following fields: low-temperature heating - < 673...873 K (heating air, water and drying agricultural products), high-temperature heating - < 1473...1523 K (finding metals, heat in processing [8].

Figure 4 depicts a simplified scheme of samples heated by the resistance method or Yegor and Disselkhorsta method. ZnSb particles (1) are placed in a tube-shaped dielectric (2). Two of the particles (A and B) are pressed by copper contacts (MA and Mb) as shown in Figure 3. The pressure force is R=30÷50 kilograms. In this case, the sample can be imagined in the form of a sturgeon. The Yegor and Disselkhorsta method can be used to determine the thermal conductivity of sturgeon-shaped samples [5-6].

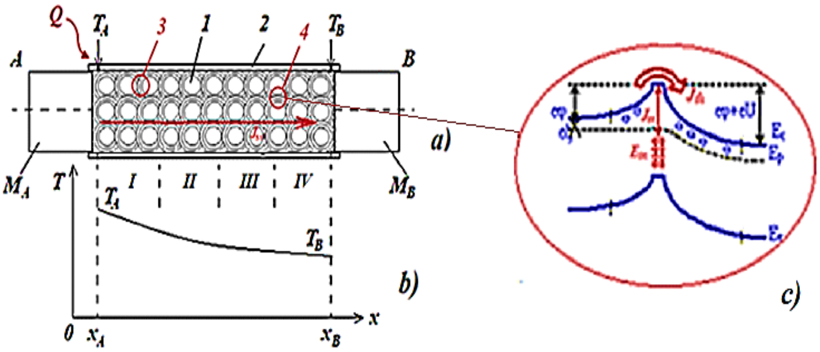

Figure 4. A simplified scheme of measuring samples based on the Yegor and Disselhorsta method (a), temperature difference (b), zone diagram (c). Here, 1 – granulated ZnSb particles, 2 – heat-resistant dielectric case, 3 and 4 – interparticle boundary area, ohmic contact and thermocouples in area A and B, respectively, M_A and M_B and TA and T_B.

Conclusion.

The proposed method of preparing thermoelectric materials allows to expand the raw material base of thermoelectric materials based on ZnSb, reduce the cost of materials preparation, and ensure independent change of thermoelectric parameters of the material. It meets the requirements as raw materials and main characteristics are fundamentally different from existing analogues.

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