EFFECT OF INPUTS ON ELECTROPHYSICAL AND THERMOELECTRIC PROPERTIES OF GRANULAR SILICON

Sokhibova Zarnigorkhon Mutalibjon kizi
Andijan machine building institute

Abstract. This paper discusses the effect of additives on the electrophysical and thermoelectric properties of silicon-based thermoelectric materials and thermocouples. Increasing the thermoelectric, electrophysical and radiation resistance properties of nano- and micro-sized semiconductor materials, as well as the effect of alkali metals on them, the dependence of the physical properties of granulated semiconductors on thermal voltaic effects, and the mechanisms of manifestation of these effects were studied.

Key words: electrophysical properties, thermoelectric properties, radiation rays, input atoms, thermoelectric material, thermocouples.

Currently, there are a number of methods for manufacturing semiconductor-based, especially silicon-based thermoelectric materials and thermocouples, based on the creation of different energy levels in the semiconductor band gap. Silicon is one of the main materials widely used in the production of semiconductor devices, and it is specially alloyed with elements of groups III and IV of the Mendeleev table in order to have the necessary electrophysical properties. These impurity atoms form an impurity layer located in the band gap of silicon. The thermal conductivity of semiconductors and metals decreases dramatically as a result of the introduction of various types of dopant atoms. This is explained by the increase in structural inhomogeneity, which causes electron scattering. In alloys, the heat transfer coefficient increases with increasing temperature [1; 97 b, 2; 23-27 b]. In many research works, the mechanism of silicon powder pressing process for solar cells (SE) has been developed, and a two-step method of cleaning the surface of the plates obtained by vacuum sputtering from inclusions has been proposed [3; 79-82 b]. This assumption is incorrect for nanoparticles, since the properties of macroscopically sized materials are size-independent. Because, firstly, most of the atoms in nanoparticles are located on the surface, and secondly, this ratio depends on the size of the granule, which increases inversely with the linear size of the nanoparticle. If the grain size remains equal to the interatomic distance, almost all atoms will migrate to the surface. The properties of the atoms located on the surface of the granule and in its volume are significantly different, because their energy exchange with the external environment is different, and the amount of inputs increases from the volume of the granule to the surface [5; 264 b, 4; 624 b]. Another reason for the difference in the properties of nano- and macroscopic particles is quantum effects. If the size of the studied particle is less than 100 nm, then its properties are usually size-dependent. The electronic energy in such granules is quantized, the energy difference between individual levels is large, and quantum effects manifest themselves even at sufficiently high temperatures. In them, the bulk of the volume corresponds to the intergranular boundaries. Also, under the influence of electric current in granules, tunneling between electrons and separate granules, interference of electrons and the effect of atoms entering the electronic energy of the electric field created by separate granules (Coulomb barrier effect, single-electron transistors) [6; 176-182 b].

Currently, advanced scientific testing institutes of our republic and many countries of the world are working to increase the thermoelectric, electrophysical and radiation resistance properties of nano- and micro-sized semiconductor materials, as well as the effect of alkali metals on them, the dependence of the physical properties of granulated semiconductors on thermal voltaic effects and the manifestation of these effects. Many practical research studies are being conducted to study the mechanisms [6; 176-182 b]. It is known from the powder technology that granulated silicon contains metallurgical silicon impurities (Si $\rightarrow$ 98÷99%; Fe, Au, B, P, Ca, Cr, Cu, Mg, Mn, Ni, Ti, Various chemical elements (such as V $\rightarrow$ 1÷2%) can be preserved. We know that the introduction of alkali metal (Li, Na, K, Cs) atoms allows to obtain silicon-based p-n structures. The sensitivity of such structures to light rays is in the spectral maximum range of 0.8÷1 μm, and the efficiency is ~7.4%. The introduction of alkali metal atoms increases the radiation resistance of silicon-based semiconductor devices and SEs [7; 344 b]. In addition, scientific studies have shown that when the size of silicon granules and the amount of input atoms are changed under the influence of temperature, the values of ZT can be improved by 100 times compared to the silicon wafer, and ZT≈1 at 200 K has been achieved. Theoretically, independent measurements of the Seebeck coefficient, electrical conductivity, and thermal conductivities show that the increase in efficiency is caused by phonons.

Thus, alkali metal atoms interact with oxygen atoms and vacancies to form complex compounds. This process prevents the appearance of SiO_2 or Si_xO_y precipitates [8] on the surface of silicon granules, and also allows to eliminate new types of recombination centers that appear under the influence of temperature. In this case, electrical conductivity depends on the formation of electron-hole pairs in accessible states consisting of complex compounds formed with alkali metal atoms. An increase in the number of electron-hole pairs with temperature leads to an increase in the electrical conductivity of the thermoelectric material into which alkali metal atoms are introduced.

Based on the scientific researches considered in this way, it is possible to say that the precursors and alkali metal atoms form donor surfaces in granulated silicon. This, in turn, causes a change in the electrophysical and thermoelectric properties of the granules during the temperature change [9; 15-17 b]. The above considerations can be important in explaining the physical properties of granulated semiconductors under certain conditions, including the structure of granules, the formation of two adjacent areas, charge transfer processes between them, as well as other kinetic phenomena in micro- and nano-sized semiconductors.

LITERATURE

1. А.Г. Коротких. Теплопроводность материалов: учебное пособие. Томский политехнический университет. – Томск: Изд-во Томского политехнического университета, 2011. – 97 с.

2. Алексанян, А. Ю. Получение диодных гетероструктур p-Si / n-ZnO и исследование их вольтамперных характеристик / А. Ю. Алексанян, В. А. Геворкян, М. А. Казарян // Альтернативная энергетика и экология. – 2013. – № 6. – С. 23–27.

3. Зайнабидинов С.З., Абдурахманов Б.М., Алиев Р., Олимов Л.О., Мухтаров Э. Получение поликристаллических пластин из кремниевого порошка. // Гелиотехника. №3. 2005. - С.79-82.

4. Л.И. Трахтенберга, М.Я. Мельникова. Синтез, строение и свойства металл/полупроводник содержащих наноструктурированных композитов. Техносфера. Москва 2016. – С. 624

5. Викулин И.М., Стафеев В.И. Физика полупроводниковых приборов М.: Радио и связь, 1990, с.264

6. Iversena T.-G., Skotlanda T., Sandvig K. Endocytosis and intracellular transport of nanoparticles: Present knowledge and need for future studies. Nano Today, 2011. - P.176

7. Поликристаллические полупроводники. Физические свойства и применения: Пер. С англ. // Под.ред. Харбек Г. –М., «Мир». 1989. – С. 344

8. Патент РУз IAP № 05121, «Тепловольтаический преобразователь энергии» Абдурахманов Б.М., Адилов М.М., Аладьина З.Н, Ашуров М.Х., Ашуров Х.Б. Расмий ахборотнома, №11, 30.11.2015

9. S. Zaynabidinov, Z.M.Soxibova, M. Nosirov. A method for determining the thermal conductivity of granulated silicon in which alkali metal atoms are included. // The Way of Science International scientific journal, 2022. № 3 (97), (Global Impact Factor 0.543, Австралия). - P. 15-17