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Graphene doped metal oxide based thermoelectric materials production method

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Abstract

Thermoelectric energy conversion is the process of converting heat energy directly into electrical energy or electrical energy into heat energy with the highest efficiency. Thermoelectric energy conversion is provided by thermoelectric modules made of p-type and n-type semiconductor materials. Thanks to the heat entering the module, the energy levels of some electrons increase and as the electrons are released, they leave holes in the semiconductor material. Electrons are carried from n-type, holes are carried from p-type semiconductor material. Thus, the circuit is completed. Important results have been obtained in the production of thermoelectric systems with nanotechnological methods. For this reason, materials with the highest homogeneity are produced in the electrospin mechanism, which is a nanotechnologic method. One of the important factors in increasing homogeneity is the preference of additives that enter between metal oxide particles. The best example of this is provided by the graphene doping. Efficiency is also expected to be high in the production of graphene-doped metal oxide-based thermoelectric-materials.

Introduction

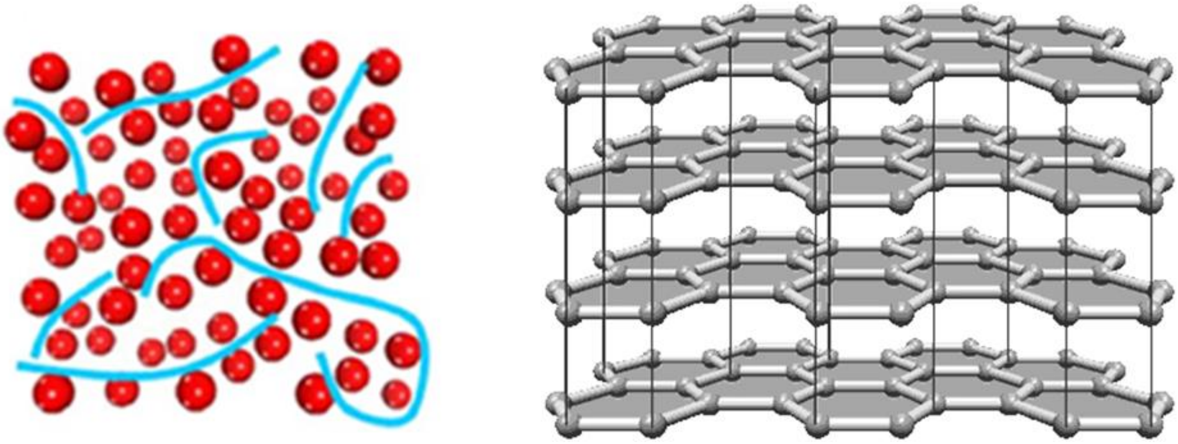
Thermoelectric energy conversion is the process of directly converting heat energy into electrical energy or reversely, converting electrical energy into heat energy with the highest efficiency.

Thermoelectric energy conversion is provided by thermoelectric modules, and the modules consist of a combination of two p-type and n-type semiconductors. The heat entering the module increases the energy levels of some of the electrons in the module. As electrons become free, they leave holes (holes) in the semiconductor material. Electrons are carried from n-type and holes are carried from p-type semiconductor material. As long as there is a temperature difference in the heat exchangers at the top and bottom of the modules, electrons and holes are constantly displaced, producing electricity.

Thermoelectric materials should be selected from materials with high electrical conductivity and low thermal conductivity. For this reason, one-dimensional nano-rod, nano-wire and nano-fiber materials are focused on. In recent years, semiconductor metal oxide materials have started to be preferred instead of the frequently used Bi2Te3 based semiconductors. The method of obtaining composite metal oxides with chemical compounds are doped with thermoelectric bismuth-based alkaline earth metals and a material with high thermoelectric properties such as graphene and the method of obtaining these nanostructures as thermoelectric energy. related to increasing the conversion efficiency.

Graphene are materials with extraordinary two-dimensional properties. The elements that make up the composite to be prepared in this project will be selected by examining their superior thermoelectric properties. In addition, when graphene is added to these materials, it is aimed to increase the thermoelectric efficiency significantly. One of the most important factors in the preference of graphene is the huge thermoelectric effect of graphene. The importance of graphene as a thermoelectric property is stated in the article of Dragoman et al. [1].

When graphene is used, metal structures are placed between the graphene layers (Figure 1). Thus, when we form a nanocomposite, we increase the electrochemical performance of the material by filling the gap between the layers. This provides a great advantage in terms of the importance of the contribution.



(a) (b)

Figure 1. (a) Graphene sheets and metal oxide particles (b) Layered graphene sheets

In order for a thermoelectric material to have high thermoelectric performance, its electrical conductivity must be high and its thermal conductivity must be low. For this reason, thermoelectric materials should be selected from materials with high electrical conductivity and low thermal conductivity. In order to increase the thermoelectric performance measure, it is necessary to reduce the phonon contribution that affects the thermal conductivity, and this is made possible by nanostructures formed by various methods.

Previously, composites such as Bi2Te3, PbTe, Si-Ge were produced [2,3]. The high toxicity of thermoelectric materials, being quite expensive, and most importantly, their unstable structure that can corrode at high temperatures, especially in air, has prevented the commercialization of these materials [4]. In recent years, various metal oxide ceramic materials have been produced to develop thermoelectric materials. Because these materials are resistant to high temperatures, non-toxic and low cost [5].

Experimental Method

Firstly, PVA solution with deionized water is prepared by dissolving the PVA powder in ultrapure distilled and deionized water and heating it at 80 °C while stirring for 3 h, then it is cooled to room temperature (Figure 2a). Then, metal acetates and nitrate are solved into ultrapure water and acetic acid solution were produced. Graphene is added to these solutions. Then, PVA is added into all of the solution, so the solutions which will be used electrospinning process are produced. Nano-sized fibers are produced from these solutions by electro-spinning technique (Figure 2b).

The obtained fibers are dried and subjected to heat treatment in the calcination furnace. At the end of this process, nano-sized powdered metal oxide is obtained. These powders are sintered into pellets and thermoelectric properties are measured.

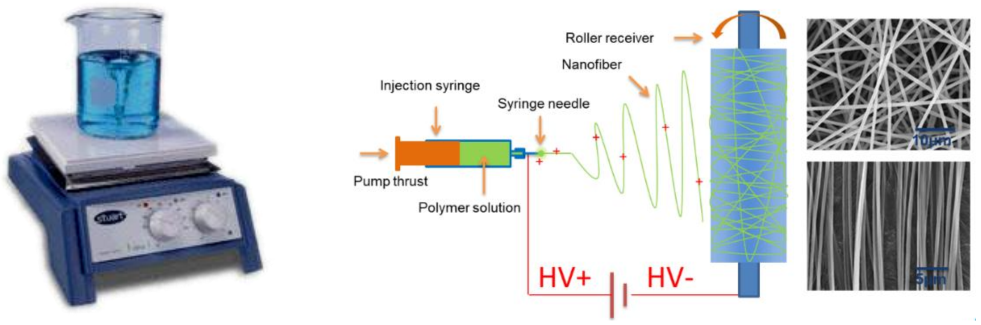


Figure 2. (a) Preparing polymer-metal salts solution (b) Schematic diagram of the electrospinning method [6]

Conclusion

Homogeneous distribution of metal oxide materials and particle size are very important in terms of efficiency in the production of solar cells and thermoelectric modules. The most important advantage of the method is that it allows the particles to be produced in nano size and to obtain a 99% homogeneous distribution. In addition, the production process is easy and low cost. It does not contain toxic substances harmful to the environment and human health.

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