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Experimentally investigation of thermoelectric materials based on Bi_2Te_3: Energy conversion system

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Abstract. The studied thermoelectric materials based on Bi_2Te_3 attracted researches attention, due to thermoelectric properties allow direct conversion between thermal and electrical energy. In this work, we examined the (0001) surfaces for investigated $A^V{}_2B^{VI}{}_3$ crystals before and after irradiation implementing the AFM method. We have been studied the fractality of formed nano-objects and resulting in the formation of nanoislands on different scales.

Keywords: Energy, energy conversion, nanoislands, thermoelectric material.

1. Introduction

High progresses of thermoelectric semiconductor materials that can potentially straight and reversibly convert heat to electrical energy have thus attract increasing attentions by scientific researchers. These energy transfer system is an environment-helpful energy conversion technology with the preferences of minor size, high validity, no chemical pollutants particles and practicability in a wide temperature diapason.

The stages of nucleation, the separative growth of the embryos of the new phase, coalescence, and the late phase, i.e., ostwald maturation (OS), in which the growth of larger islets is accomplished by the dissolution of smaller ones. They considered the processes of islet growth, which are controlled not only by the diffusion rate, but also by the rate of of atoms across the boundary between the diffusion source and the islet. Thus, in [1] a very important problem is the nucleation stage nucleus size distribution function formed at the nucleation stage is subject to fluctuational blurring.

For the synthesis of investigated crystals of the fusion of islands of a new phase on a substrate is usually reduced to liquid-like (like two drops of a liquid) and solid-phase (like sticking of two solids) two main types.

2. Experiment and discussion

In this work, we analyzed the conditions for the onset of the Ostwald maturation (OS) stage, taking into account fluctuations. Coalescence of large islands in the condensed stage continues with a delayed process. Substantial of channels and voids take places both by formation of new nuclei in them and by fitting of atoms openly from the molecular beam. Combination of slight and large islands in the condensed stage proceeds differently. The nuclei coalesce without coming into contact with each other. The transfer of matter in this case is carried out by surface diffusion. Such germs can also move mechanically on the surface and merge with each other. The islets larger than 20 nm in cross-section coalesce on contact with each other by surface self-diffusion and mass transfer through the contact isthmus. At the same time, volumetric self-diffusion occurs. If two islands with different orientation coalesce, an internal interbrain boundary occurs. Such a boundary shifts and leaves the coalescing formation by volumetric diffusion. The chemical components from which the phase island is formed can diffuse to it in various ways [2]. One of the components can enter the surface islands through surface diffusion and the other through diffusion in the gas phase. In the case of island growth on the interlayer surface, their rate is defined by the intensity of the supply of matter and the intensity of heat removal from their surface.

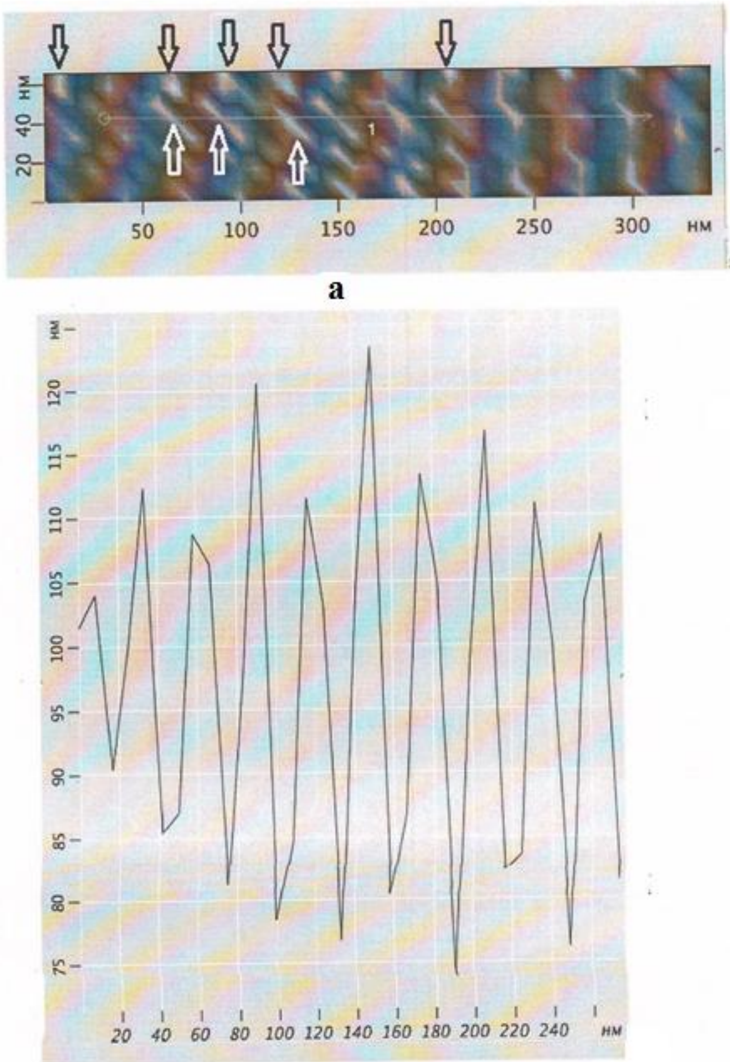

Figure 1. The AFM image of the (001) tellurium surface: island-type nanodefects are marked in the upper figure (arrows point down), the lower arrows mark two-dimensional defects with curved ends. The profilogram indicates the nanoscale nature of the surface structures: the width of the nanoobjects is ~20 nm, the height is ~35 nm.

It is assisted basically by the case that they are the origin usefully information about the nature of the interaction between host atoms of crystal migrating over the surface (0001) of the compound and elements of the real structure of pore patterns (see Figure 1) with nanoscale parameters. This process is a very significant in scattering of electrons and phonons in structure during the formation of nanostructured compounds. In this case, NRs of vrious altitudes at the base obtain the structure of nanopores. The nanoislands shaped at the sites of pore nucleation on the surface (0001) Bi_2Te_3 compound (see Figure 2). The X-ray diagram after irradiation for Bi_2Te_3+Te shown in Figure 3.

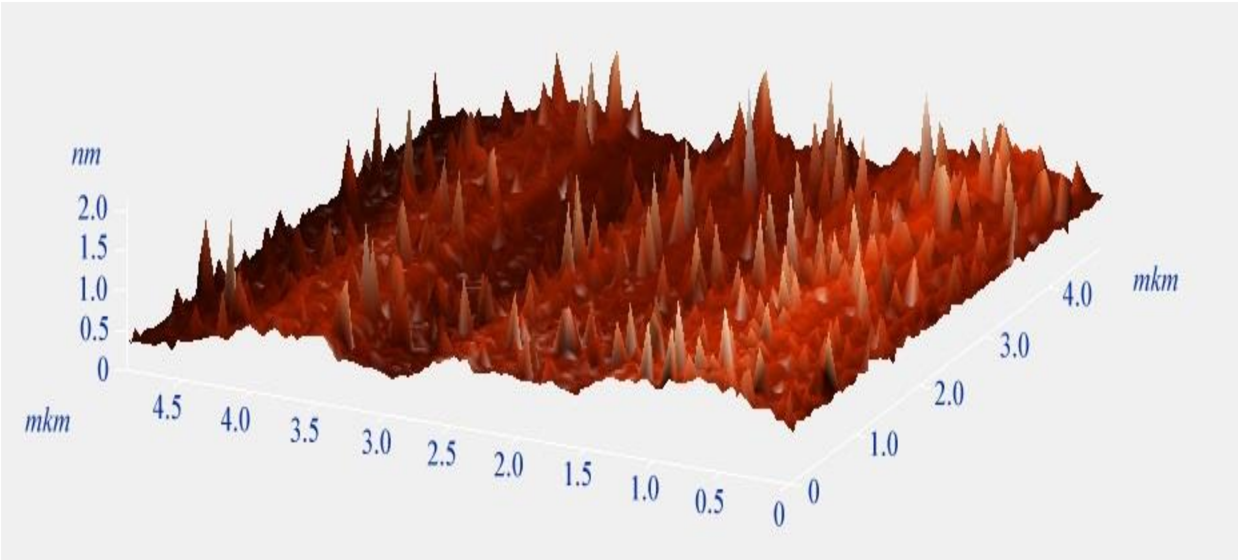

Figure 2. Nanoislands formed at the sites of pore nucleation on the (0001) Bi_2Te_3 surface.

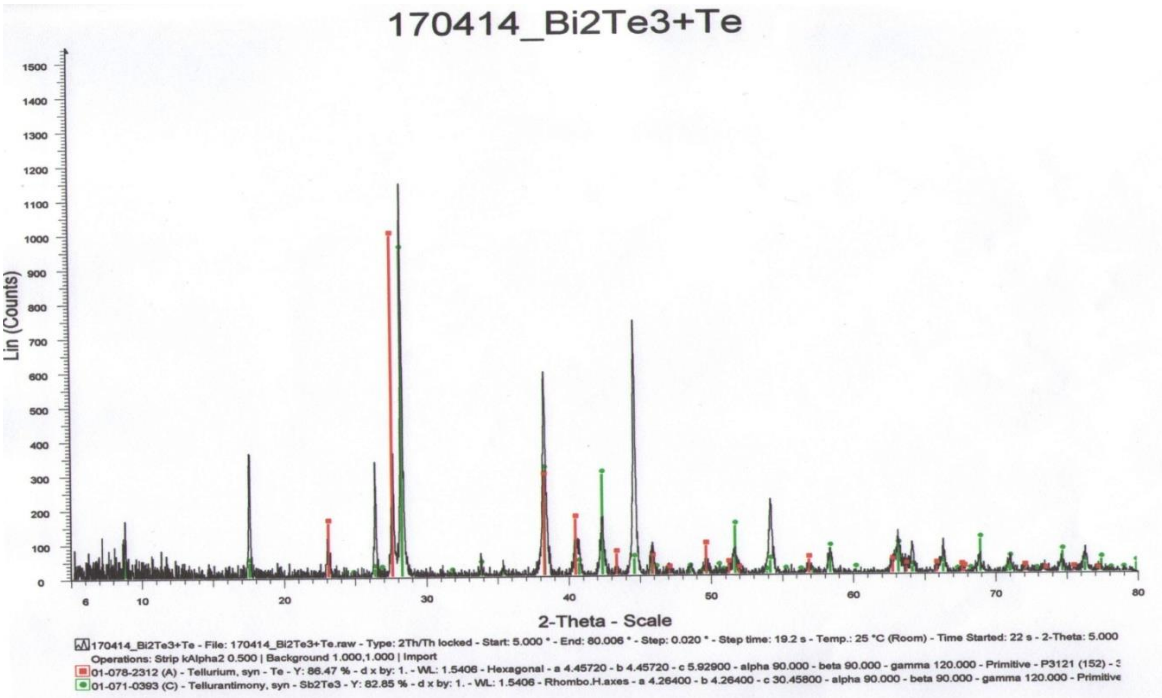

Figure 3. X-ray diagram after irradiation of Bi_2Te_3+Te.

The minimum critical size of a nucleus in a pore is defined by the thermodynamics treatment of nucleation and the primary concentration of host atoms in structure shaping a cluster in the pore space [3]. The some smaller size of clusters are shaped with an increasing in the pore size. The comparing the surface morphology of the phases that fabricate the Bi_2Te_3-Te eutectic system before and after irradiation process. In this case the absorbed dose is about of 30 Mrad (see Figure 4). Figure 5 shows the X-ray diffraction pattern of eutectic after Bi_2Te_3+Te irradiation with 30 Mrad.

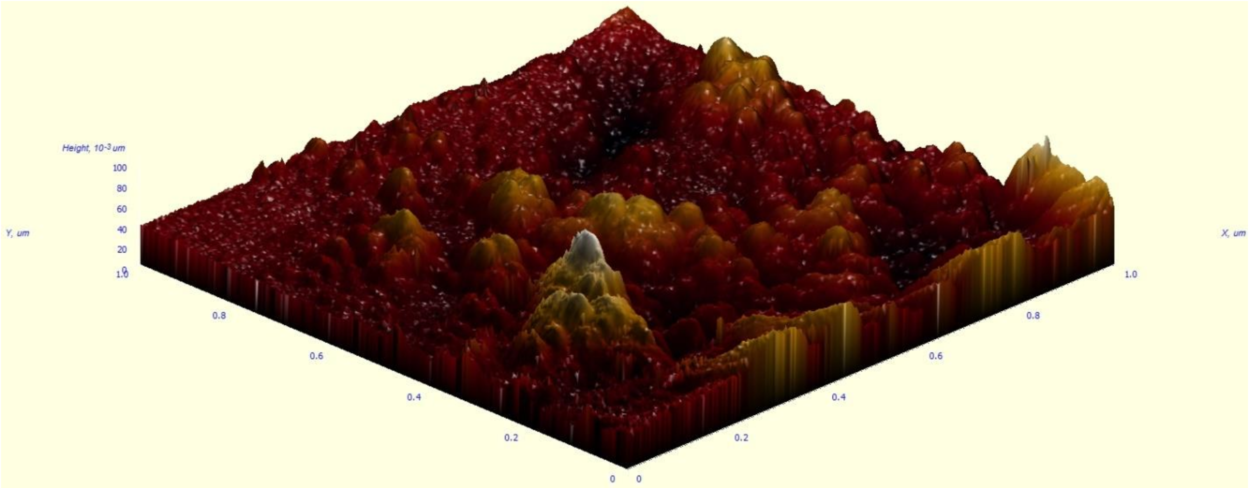

Figure 4. The shaping of cut nanoislands on the surface (0001) for Bi_2Te_3 compound after irradiation process (30 Mrad).

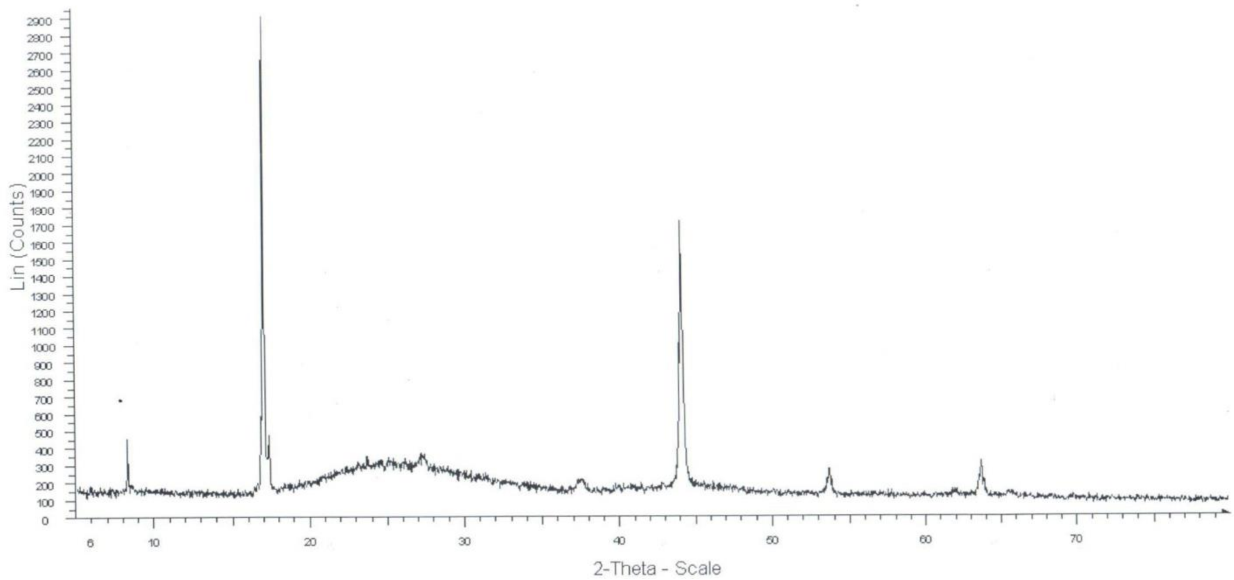

Figure 5. X-ray diffraction pattern of eutectic after Bi_2Te_3+Te irradiation with 30 Mrad.

We see that in Figure 4 of these processes, mutual collisions of islands can also appear, escorted by their diffusion merging. From the provided experiments on the growth of nanoobjects obtained that the form of nuclei on the surface of structure modifications in their growth process. This fact cut or conversely gets unstable of structure. The cut of nanofragments are shaped by the intercalation of atoms of compound onto the surface (0001) of layered materials [4]. The islands grow at the phase of Oswald maturation under reservations of dislocation diffusion. In the procedure of bunch from dislocations, the islands initiate to face in the process of maturation. As the form of the cut grows, the

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speed decreases remarkably. From Figure 4 variations the phase of composition, which is coordinated with the flood of radiation defects along the interfaces in irradiation process.

3. Conclusion

Thermoelectric materials are environmentally friendly, thus providing a solution for energy crisis and pollution; however, the thermoelectric conversion efficiency is low and mainly limited by the performance of thermoelectric materials. It follows from general considerations that, underneath the affect of radiation defects, a nanostructure can as well get amorphous or conversely, facilitate removal due to the availability of plural interfaces of configuration. Mechanisms of NR generation on the surface (0001) of Bi_2Te_3 compound at the phase of Ostwald maturing; this is a model for investigating the processes of production of self-organized nanoobjects on the (0001) surface of Bi_2Te_3 layered materials. Affinity in the investigation of physical processes in interlayer island systems is handled basically by the case that they are an origin of useful knowledge about the nature of the interaction between the host atoms of compounds migrating over the surface (0001) of the Bi_2Te_3 and elements of the real structure of pore patterns. The sequence of processes of combination of vacancies and concentration small pores in Bi_2Te_3 leads to enlargement of pores.

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