Surface topography of the InSb-MnSb thin films

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In that report we observe a semiconductor eutectic composite InSb-MnSb thin films, prepared by the "flash evaporation" method. The atomic force microscopy and the scanning electron microscopy were employed for investigation microstructure and surface relief of the InSb-MnSb thin films.

Eutectic composites based on compounds of groups III-V with 3d-transition metals consisting of a semiconductor matrix and metallic inclusions are of interest because of the preservation of the microstructure at the melting point, the repeatability and stability of the characteristics.Their behavior is similar to inhomogeneous and degenerate semiconductors, and physical properties depend on the electronic configuration of the 3d elements, the geometry of the inclusions and the features of the formation of interphase zones. The presence of ferromagnetic metallic inclusions makes them promising for creating injectors of spin-polarized electrons.

In this paper presented, the results of studying the topography of the surface thin films of InSb-MnSb are presented. The microstructure and physical properties of an eutectic composite based on InSb and GaSb have been previously studied [1-2].

Thin films of the InSb-MnSb eutectic composite were obtained by the method of "flash evaporation", the thickness of which was 0.4-1.0 μm. The films were studied by electronic scanning microskopy (Oxford Instruments) and atomic force microscopy (microtest machines NT-206, tips Mikromasch CSC 38) in contact mode. To evaluate the surface, at least 5 scanning sites were selected from different sections of the surface with a size of 20×20 μm^2 and 5×5 μm^2, which allowed averaging the parameters of the relief. The processing of the obtained data was carried out with the help of the program "SurfaceXplorer" according to the technique described in [3].

AFM studies have shown that the typical surface of thin films of the InSb-MnSb eutectic composite has a complex microrelief. When the size of the scanning regions is 20×20 μm^2 (Fig. 1a), evenly distributed structural formations of a round shape with a diameter of 0.5-2 μm with an average height of 0.8-0.9 μm are observed on the surface, as seen from the section profile (Fig. 1b). Between these formations there are structural objects of a much smaller size.

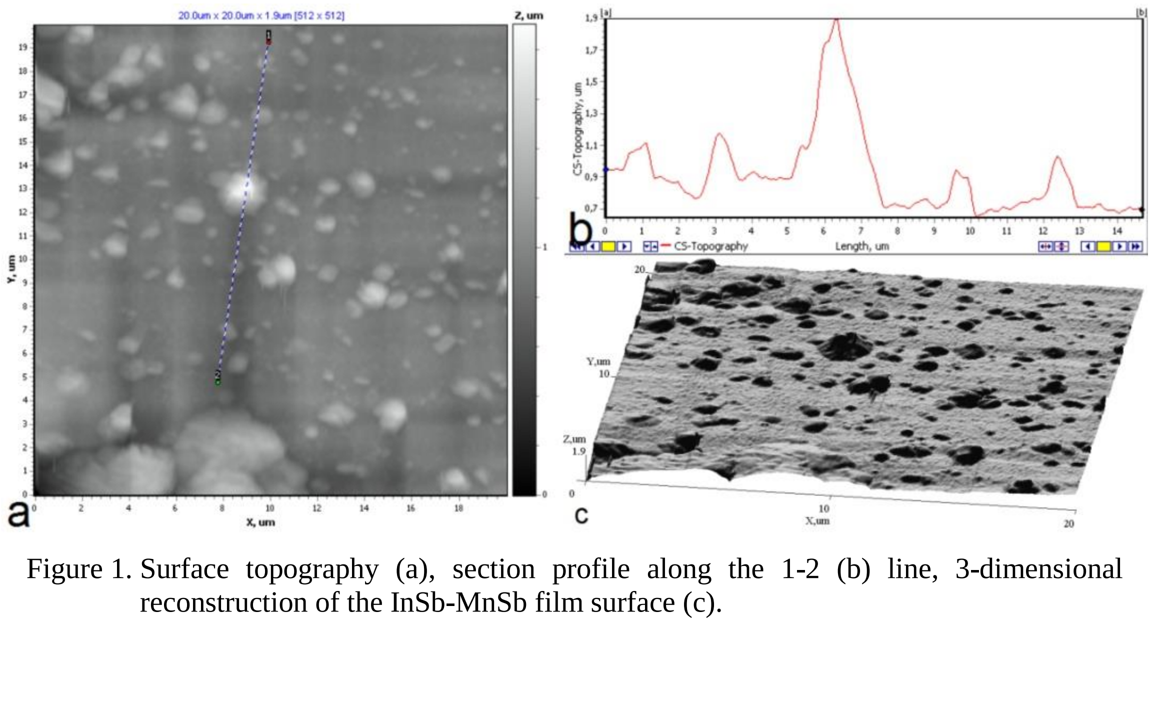

Figure 1. Surface topography (a), section profile along the 1-2 (b) line, 3-dimensional reconstruction of the InSb-MnSb film surface (c).

The average arithmetic roughness of the surface, averaged over 5 values, with this site selection is Ra = 78.3 nm, the rms roughness Rq = 103.3 nm. The ratio of the total surface area to the projective area is 1.14. The distribution of heights for these sites is shown in Figure 1b, and an analysis of the orientation of the surface structures is also given, which allows one to assert that there is no expressed orientation. In addition, in the lower left corner of the presented AFM image, it is possible to notice rounded structures measuring 8-12 μm across, which agrees well with the SEM image.

Based on AFM images, the multifractal dimension of the surface was calculated by the horizontal section method (area perimeter). In calculating the fractal dimension, the systematic deviation characteristic of the method of horizontal cross sections was taken into account [4]. An analysis of the fractality of the investigated sites with 500 sublayers gives an average value of fractal dimension 2.79

In addition, a study was made of the intergrain space at a higher resolution of scanning, as well as areas containing anomalous topographic structures for these surfaces. In particular, when the size of the scanning region is 5×5 μm^2, the AFM images obtained are in good agreement with the SEM data shown in Figure 2. In the regions between the large structures, in both cases a fine-grained structure is clearly visible. In addition to the above features of topography on the surface, the presence of ordered long oblong structures 1.2-1.4 μm in length with a width of ~ 0.1 with a height of 0.15-0.2 μm was observed. The appearance of these structures can be either a feature of the flow of some processes during the application of coatings or a defect in the surface treatment before application.

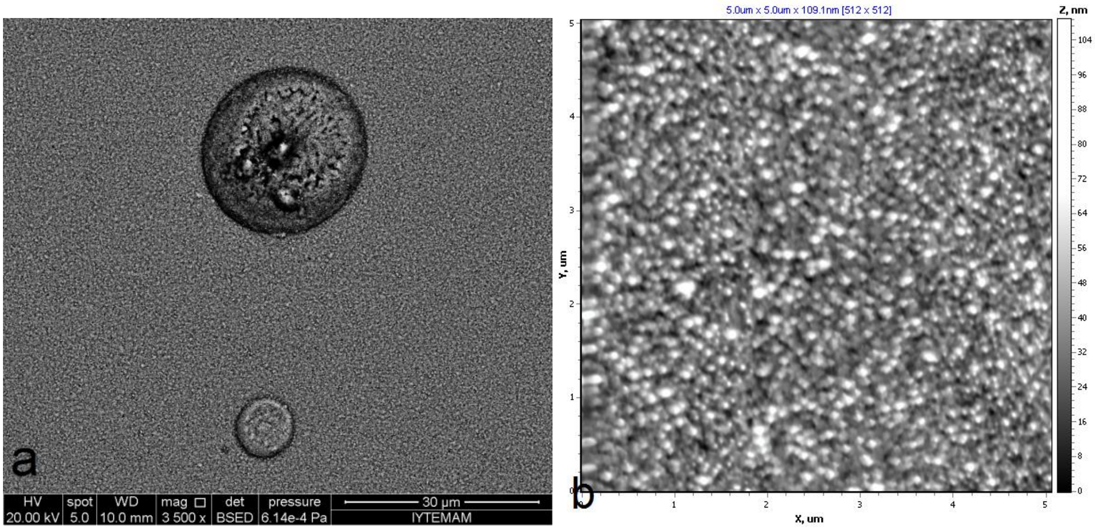

Figure 2. The microstructure of the InSb-MnSb thin film (3500 magnification) and the InSb-MnSb surface topography when scanning on a 5×5 μm^2 site.

These regions are characterized by the absence of any significant structures, but a fine-grained structure with a predominant height of ~ 30 nm is observed. Grains of irregular shape with a size of 40-80 nm in diameter also do not have a pronounced orientation. This leads to a decrease in the mean arithmetic and rms roughness values to Ra = 9.4 nm and Rq = 12.2 nm, respectively. In this case, the average value of the fractal dimension of the sites studied increases somewhat in comparison with the main relief and reaches 2.82, which indicates a developed "bulk" surface. This confirms the high surface quality and sufficiently high uniformity of the coating application.

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