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Short Communication

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X-Ray and Morphological Analysis of InAs-CrAs Eutectic Nanocomposite Systems

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Abstract: InAs-CrAs systems are synthesized by the vertical Bridgman–Stockbarger method. XRD analysis and microstructural study of InAs-CrAs composites show that CrAs metallic inclusions are uniformly distributed in the InAs matrices. By investigating of microstructure of InAs-CrAs eutectic composite by electron microscope, it has been established that the interfacial zone between the semiconductor matrix and metallic inclusions is generated. In computations of effective electrical and thermal conductivity of the composite were taken into account the role of these interfacial zones.

Keywords: XRD, SEM, EDX analysis, Eutectic composites.

1. Introduction

Diluted magnetic semiconductor materials based on A3B5 compounds and 3d-metals eutectic composites, having a stable composition and properties,are promising materials for spintronic devices. One of the main features of eutectic composites obtained based on InAs, InSb, GaSb, GaSe and 3d - transition elements is the anisotropy in kinetic coefficients depending on the direction of metal needles. [1-5]. These composites, which combines both semiconductor and metallic properties, behave as nonhomogeneous semiconductors since metal needles are distributed parallel to the crystallization direction. The composites formed by the 3d-transition metals are considered to be diluted magnetic semiconductors. Recently, the recent discovery of superconductivity in chromium arsenide CrAs has attracted a lot interest [3] because this material has been synthesized looking for superconductivity on the verge of the antiferromagnetic order by means of the application of external pressure. According to the results of these studies, the connection between the ferromagnetic constituents perpendicular to the crystallization axis in the CrAs junction is antiferromagnetic. Consequently consideration of the InAs-CrAs systems is of substantial interestl [4-7]. The present paper is devoted to synthesis and structure investigated of InAs-CrAs systems.

2. Materials and Methods

Preparation of eutectic composites based on GaSb, InSb semiconductor compounds and 3d transition metals has been described in our previously published articles [1-3]. The structure of InAs-CrAs eutectic composites was studied with an electron microscope (FESEM) and X-ray spectrograph.

InAs-CrAs systems are synthesized by the vertical Bridgman–Stockbarger method. To obtain the InAs-CrAs eutectic composite, 98.3 wt % InAs and 1.7 wt % CrAs are filled into a quartz ampoule and a vacuum is created at a pressure of 10^{-2} Pa. The ampoule is kept in an electric oven at a temperature of 1250 K for 4 hours with vibration, it is turned off and cooled to room temperature. Then, oriented crystallization is carried out using the vertical Bridgman method. InAs-CrAs eutectic composites were synthesized with different crystallization rates. Temperature gradient 20÷30K, crystallization speed 1.2 mm/minute; 0.6 mm/min and 0.3 mm/min were selected.

It has been determined that a coating is formed around needle-shaped metal phases that are arranged parallel to each other along the crystallization axis and are evenly distributed in the main matrix.

3. Results and Discussion

Diffraction patterns of InAs-CrAs eutectic composite are shown in Fig. 1. These figures also show data on the diffraction patterns for InAs and CrAs compounds. Analysis of XRD spectra confirmed that this system is diphasic: the most intense peaks corresponding to the (101), (200), (112), (121), (220), (004), (301), (123), and (312) Muller index are identical to the InAs matrix, while the weak peaks found at 2θ = 29.6 º, 44.08º, 52.2º, and 69.13º coincide with the CrAs lines having a orthorhombic structure.

Based on SEM examinations (Figs.2), the needle-shaped metallic inclusions with a diameter of about 0.6-1.5 μm, a length of 20÷50 μm and a density of ~5.8x10^4 mm^{-2} are uniformly and parallel distributed in the InAs matrix.

It was found that the matrix contains In = 63.2wt%, As= 36.8 wt% (Fig.3, spectrum 1), the inclusion are contained Cr = 17.8 wt%, As = 82.2 wt% (Fig.3, spectrum2). The results corresponded to the composition of the matrix and inclusions. Fig.4 shows elemental maps of Cr, In and As from the cross sections along the lateral direction of the needle phases, respectively and black colour indicates the absence of this element.

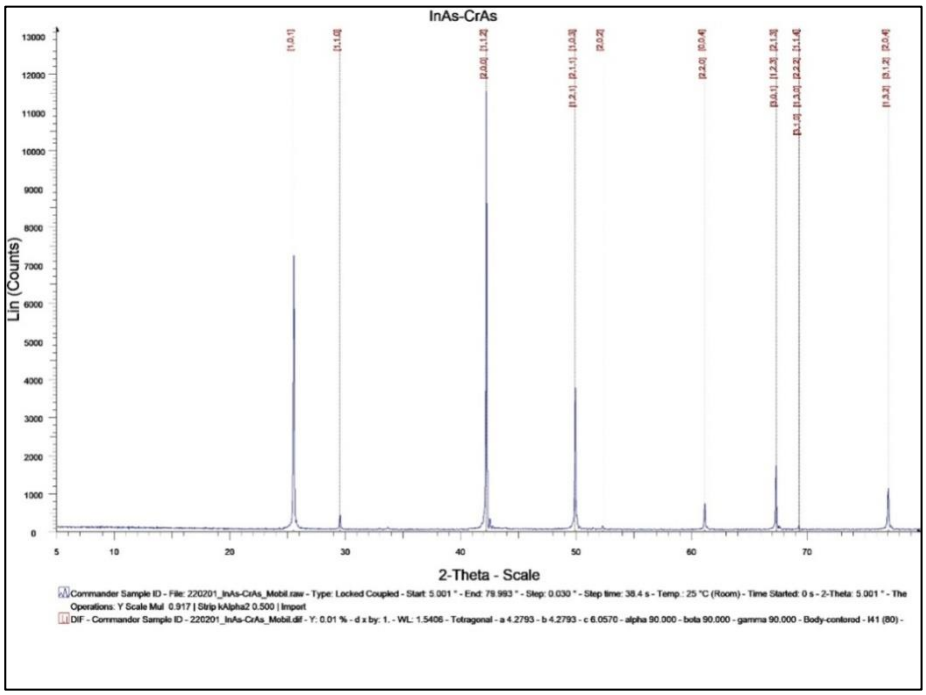

Figure 1 X-ray spectrum of InAs-CrAs eutectic composite.

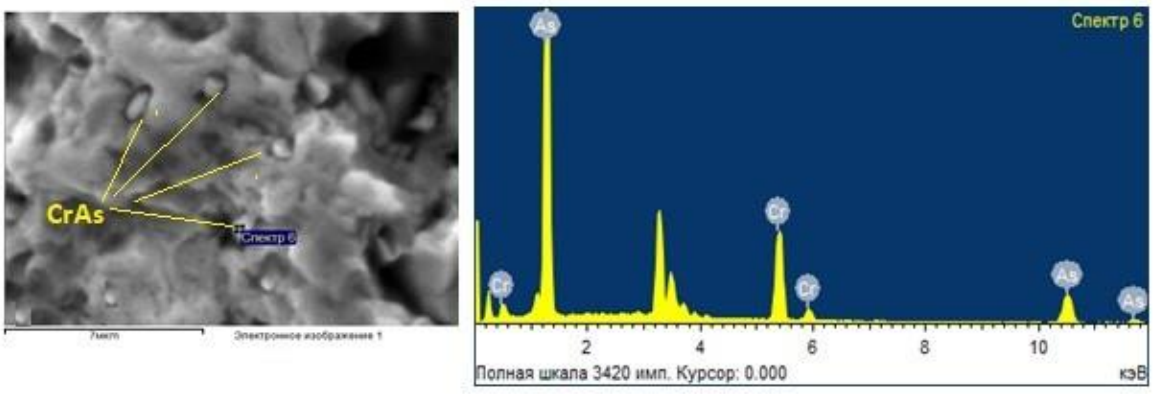

Figure 2. SEM micrographs of InAs-CrAs showing cross sections of the samples along the lateral directions of the CrAs phase.

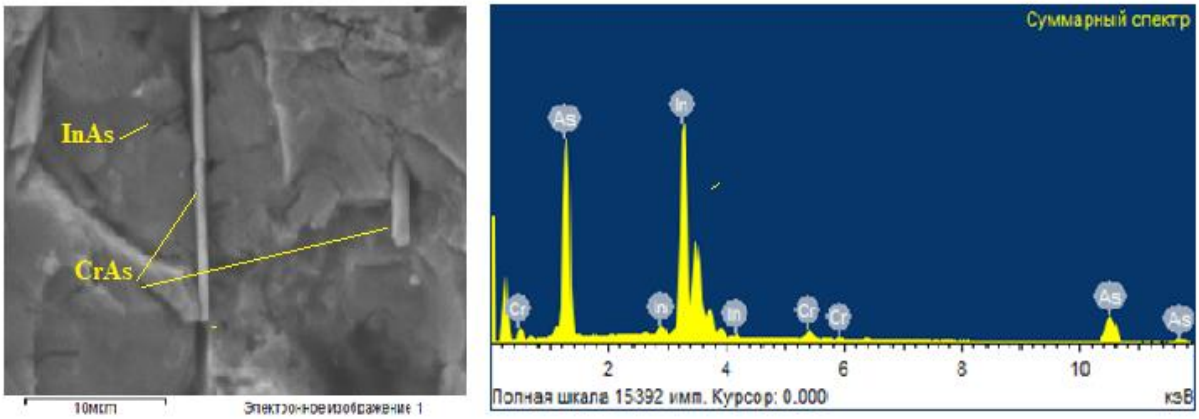

Figure 3. X-ray spectra of InAs-CrAs eutectic obtained with SEM–EDX from the needle and matrix phases along the lateral directions of the specimens.

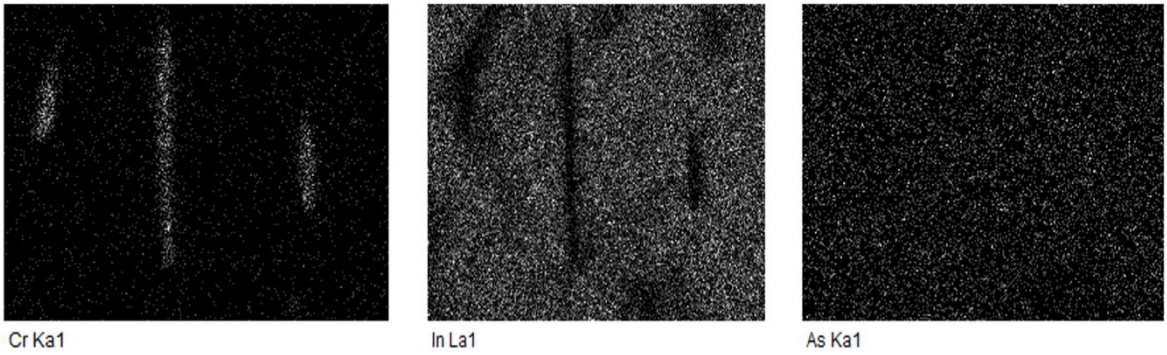

Figure 4. Element map of the InAs-CrAs composite.

4. Conclusion

XRD, SEM and EDX analysis show that the obtained composites present two phase system, so that the observed intense peaks are related to the InAs matrix and weaknesses - to the CrAs inclusions. In the InAs-CrAs eutectic, the length of the metal needles is 30-50 μm, and the diameter is ~1.6 μm. As can be seen from the pictures, the metal rods are evenly distributed in the direction of crystallization in the matrix. The two phaseness of the InAs-CrAs composite have been confirmed by the microstructure and morphology studies.

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Does this article screened for similarity?

Yes

Author contribution statement

Both the authors equally contributed to this work.

Conflict of interest

The Authors declares that there is no conflict of interest anywhere.

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