

RAMAN SCATTERING OF InSb-CrSb, InSb-Sb, GaSb-CrSb EUTECTIC COMPOSITES

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Semiconductor-metal InSb-CrSb, InSb-Sb, GaSb-CrSb eutectic composites are synthesized by the vertical Bridgman method. The interphase zones around metallic inclusions in GaSb-CrSb, InSb-CrSb and InSb-Sb eutectic composites have been revealed by study of the structure and elemental composition. It has been found that the peaks detected in the Raman spectra correspond to the GaSb and InSb compounds and Sb-Sb bond.

Keywords: Eutectic composite, Raman Scattering; SEM structure, X-ray diffraction

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1. INTRODUCTION

One of the main features of eutectic composites obtained based on InSb, GaSb 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, NiAs-type hexagonal structure CrSb has been widely studied as a suitable material for spintronics [6-10]. According to the results of these studies, the connection between the ferromagnetic constituents perpendicular to the crystallization axis in the CrSb junction is antiferromagnetic. Consequently consideration of the InSb-CrSb, InSb-Sb and GaSb-CrSb systems is of substantial interest. The present paper is devoted to synthesis, structure and Raman scattering investigated of InSb-CrSb, InSb-Sb and GaSb-CrSb eutectic composites.

2. EXPERIMENTAL DETAILS

2.1 Synthesis

In order to synthesize InSb-CrSb, InSb-Sb, and GaSb-CrSb eutectic composites, InSb and GaSb are first synthesized: the stoichiometric quantities of In and Sb, Ga and Sb are melted together and treated with horizontal zone alloy. The velocity along the melting zone crystallization was 12mm/h.; the concentration of carriers in InSb and GaSb compounds was $n=2 \times 10^{16}$ and $p=1.8 \times 10^{17}$ at room temperature, respectively.

Eutectics with the following mixtures: InSb and 0.6% CrSb for InSb-CrSb, InSb and 37.3% Sb for InSb-Sb, GaSb and 13.4% CrSb for GaSb-CrSb systems were filled into quartz ampoules at a pressure of 10^{-2} Pa. The ampoules were stored in an electric oven at 1200K for 4 hours and cooled to room temperature. At the next stage, InSb-CrSb, InSb-Sb and GaSb-CrSb composite crystallization is carried out by the vertical Bridgman method with different crystallization rates:

1.2mm/min.; 0.6mm/min. and 0.3mm/min. at temperature gradient 20-30K [5].

2.2 Characterization

The X-ray spectra of the InSb-CrSb, InSb-Sb and GaSb-CrSb composites were made by the Advance-D8 diffractometer ("Bruker"). The source of radiation was the $\text{CuK}\alpha$ -anode, operating at a voltage of 40kV and a current of 40 mA. The wavelength of the radiation was $\lambda=1.5406\text{\AA}$, and the angle between the falling X-rays and the sample was $2\Theta=5\div 80$. Microstructure analysis was performed on surface of the samples parallel and perpendicular to crystallization directions by the Zeiss SigmaTM Field Emission, SEM-Scanning Electron Microscope.

3. DISCUSSION

Diffraction patterns of GaSb-CrSb eutectic composite are shown in Fig. 1. Analysis of XRD spectra confirmed that this system is diphasic: the most intense peaks corresponding to the (111), (200), (220), (311), (222), (400), (331), (420), and (422) Muller index are identical to the GaSb matrix, while the weak peaks found at $2\theta=30^\circ$, 44.08° , 52.12° , and 54.13° coincide with the CrSb lines having a hexagonal structure with lattice parameters of $a=4.121$, $c=5.467$, $c/a=1.327$, and the P63/mmc space group.

Fig. 2 shows the diffraction patterns of the InSb-CrSb eutectic composite. The most intense peaks corresponding to the (111), (220), (311), (400), (311), (422) $v\alpha$ (511) Muller index are identical to the InSb matrix, while the weak peaks found at $2\theta=30^\circ$, 44.08° , 52.12° , and 54.13° coincide with the CrSb line.

Fig. 3 shows the diffraction patterns of the InSb-Sb eutectic composite. The most intense peaks corresponding to the (111), (220), (311), (400), (311), (422) $v\alpha$ (511) Muller index are identical to the InSb matrix, while the weak peaks found at $2\theta=30^\circ$, 44.08° , 52.12° , and 54.13° coincide with the CrSb line.

Shown in Fig. 4 the structure of the films is it can be seen structural formations of a round shape are evenly distributed on the surface of the film.

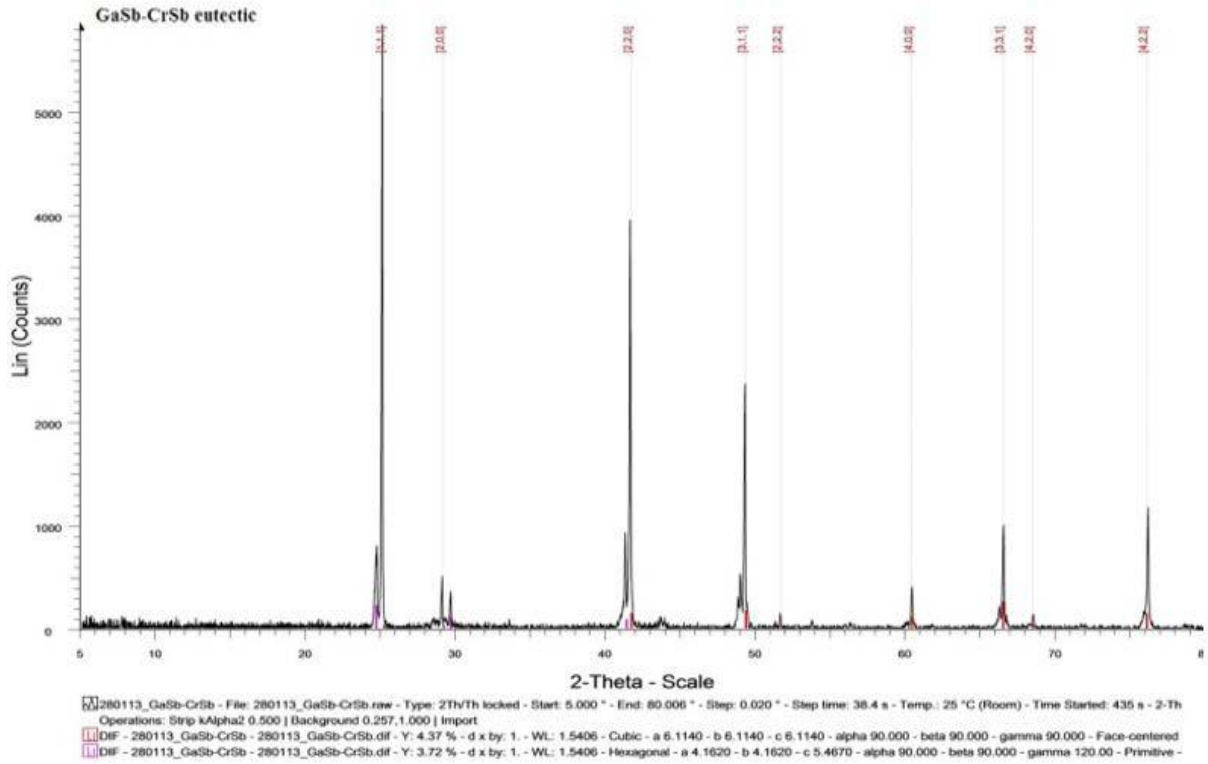


Fig. 1. X-ray spectrum of GaSb-CrSb eutectic composite.

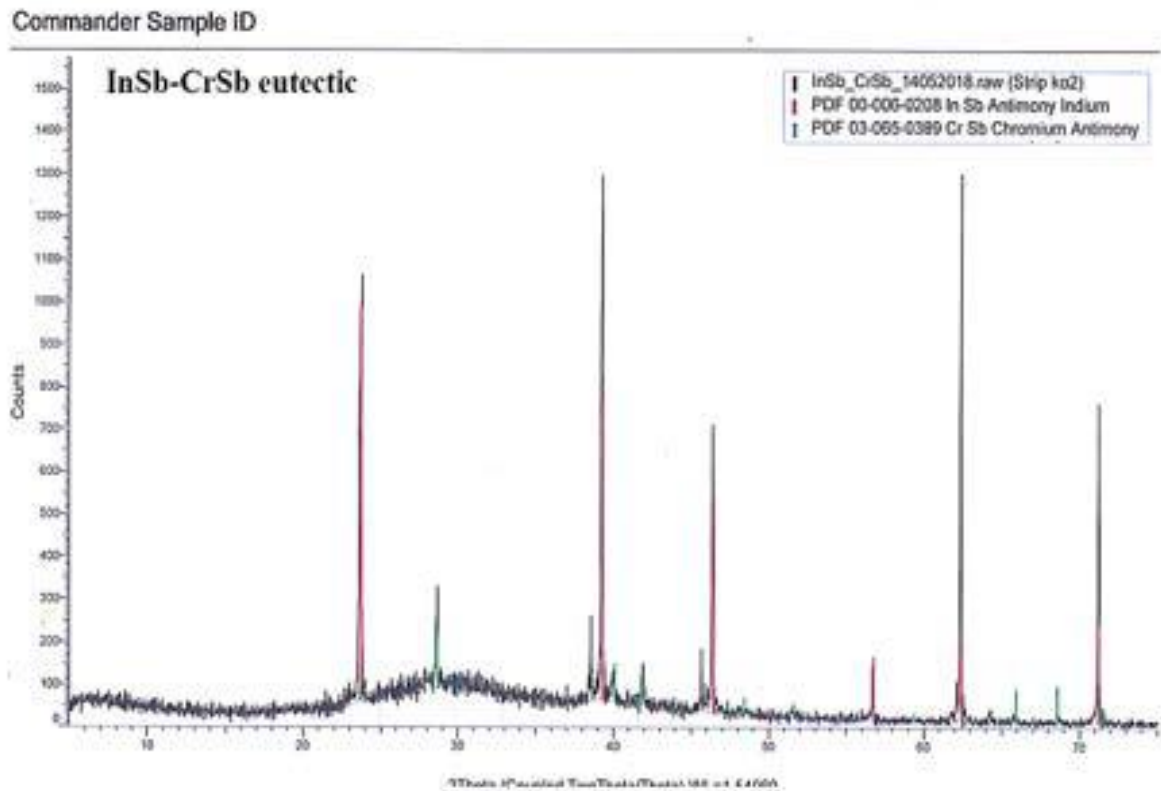


Fig. 2. X-ray spectrum of InSb-CrSb eutectic composite

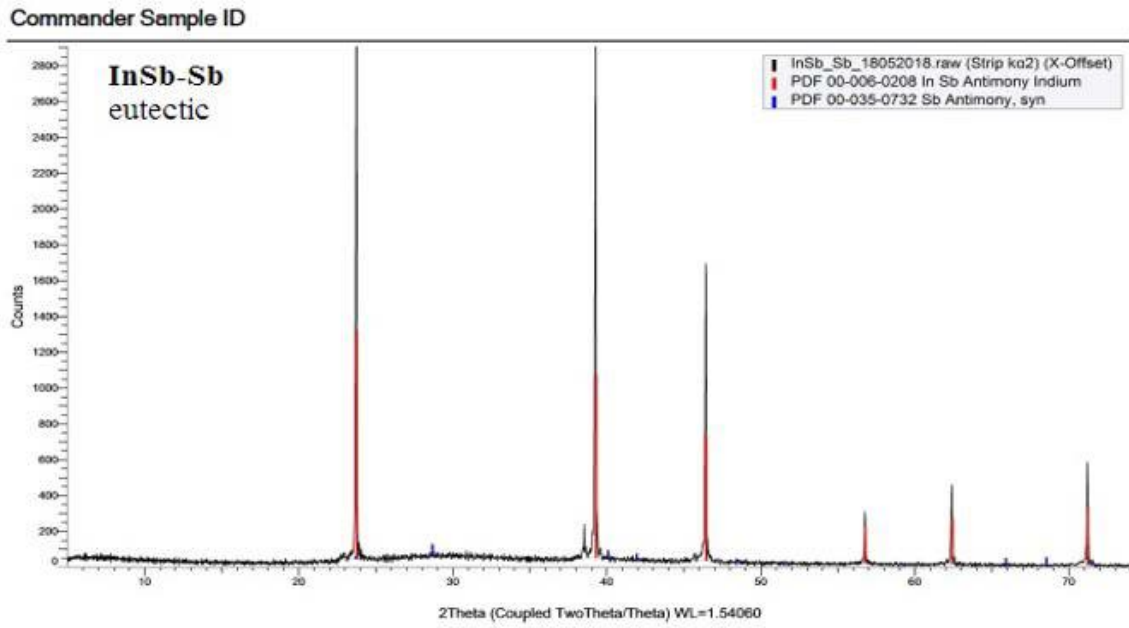


Fig. 3. X-ray spectrum of InSb-Sb eutectic composite

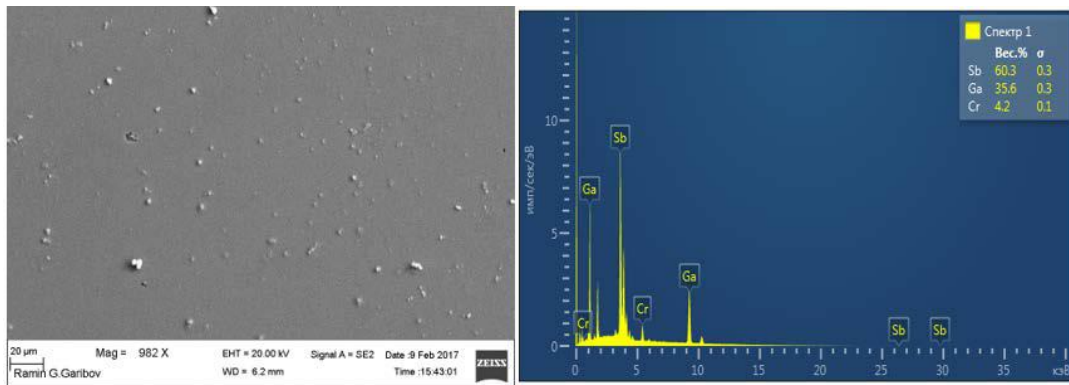


Fig. 4. X-ray spectra of GaSb-CrSb thin film obtained with SEM-EDX

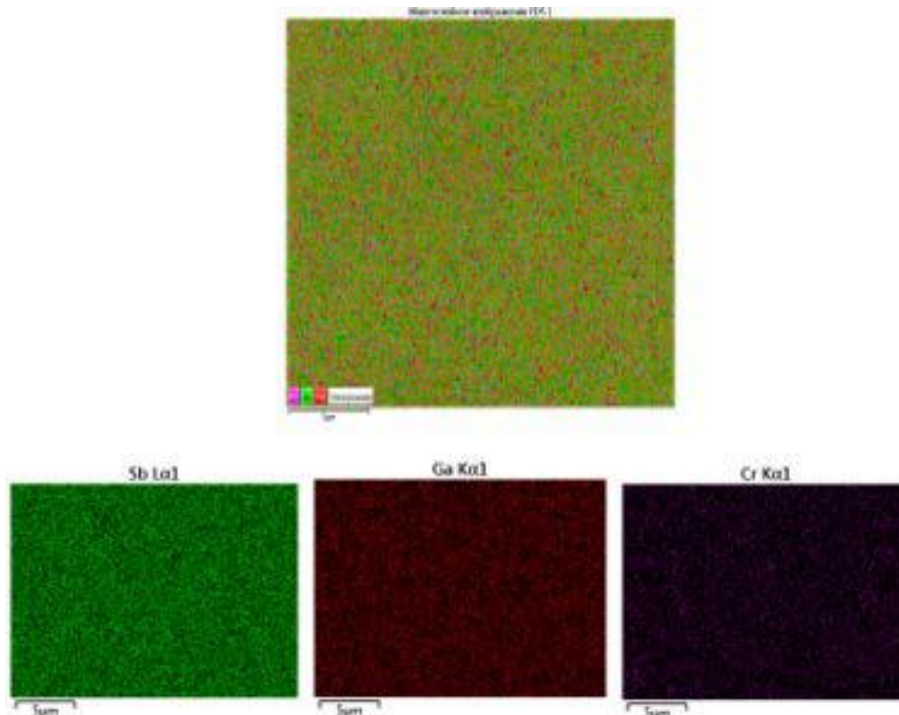


Fig. 5. Element map of the GaSb-CrSb composite

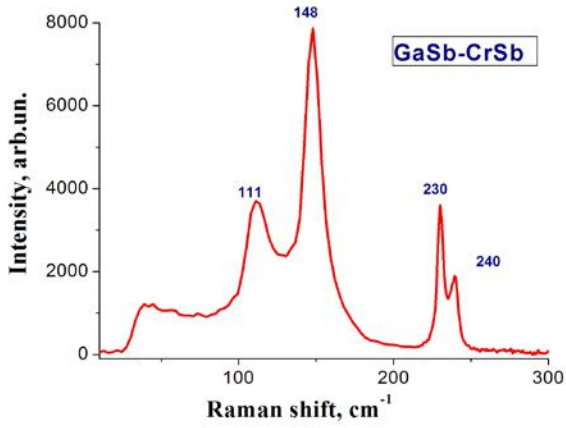


Fig. 6. Raman spectra of GaSb-CrSb eutectic composite.

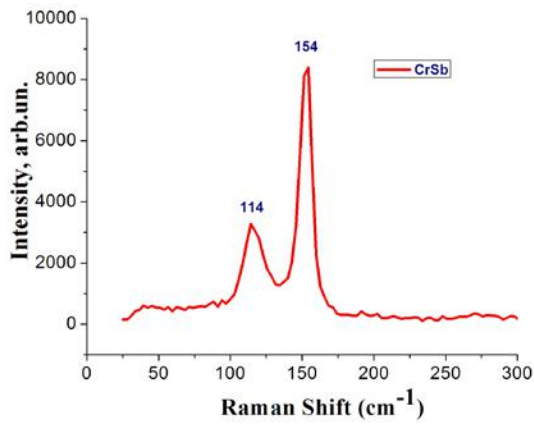


Fig. 7. Raman spectra of CrSb compound

The length of the metal rods (1-1.6 μm in diameter) is 10-100 μm in InSb-CrSb composite, 30-50 μm in GaSb-CrSb, 40-100 μm in InSb-CrSb. As it is seen from Fig. 4, the metal rods are evenly distributed in the matrix in the direction of crystallization. Fig.5 shows an element map of the GaSb-CrSb eutectic alloy. In the specific map, the colours red, blue and green indicate Sb (L), Cr (K) and Ga (K), respectively and black colour indicates the absence of this element.

Raman analysis is an important tool to study atomic interactions in semiconductors and the dynamics of the crystal lattice [12-15]. Raman analysis were investigated to confirm the existence of two-phase and inter-phase zones in the GaSb-CrSb, InSb-CrSb, InSb-Sb eutectic composites at room temperature. Fig.7 and Fig.8 shows the Raman lines at about 111 cm^{-1} , 148 cm^{-1} , 230 cm^{-1} , 240 cm^{-1} are the mode LO GaSb-CrSb eutectic composite, and 114 cm^{-1} , 154 cm^{-1} , 240 cm^{-1} for CrSb compound.

Some parameters of semiconductor-metal type InSb-CrSb, InSb-Sb, and GaSb-CrSb eutectic composites are shown in the table [1, 4, 5].

Fig.8 (a) and (b) are shows the Raman lines about InSb-CrSb composite are 101 cm^{-1} , 145 cm^{-1} , 174 cm^{-1} and (b), respectively, at 101 cm^{-1} , 150 cm^{-1} and 240 cm^{-1} .

Thus, X-phase analysis of InSb-CrSb, GaSb-CrSb and InSb-Sb alloys is a composite composite comprising matrix (InSb and GaSb) and porous metal coatings (CrSb and Sb) based on studies in optical and electron microscopes. The Raman spectra obtained in the InSb-CrSb and GaSb-CrSb compositions only characterize the Sb-Sb bond [13,15].

Eutectic composites	Metal phase weight %	Needles density, mm^{-2}	Needles diameter, μm	Needles length, μm	Crystallization speed, mm/min	Concentration, cm^{-3}
InSb-CrSb	0,6	$0,6 \times 10^4$	1	100-200	1,2	$p=2 \times 10^{17}$
InSb-Sb	37,6	$2,5 \times 10^4$	1,6	40-100	1,4	$p=10^{17}$
GaSb-CrSb	13,4	$5,2 \times 10^4$	1,4	30-50	0,3-0,6	$p=8 \times 10^{17}$

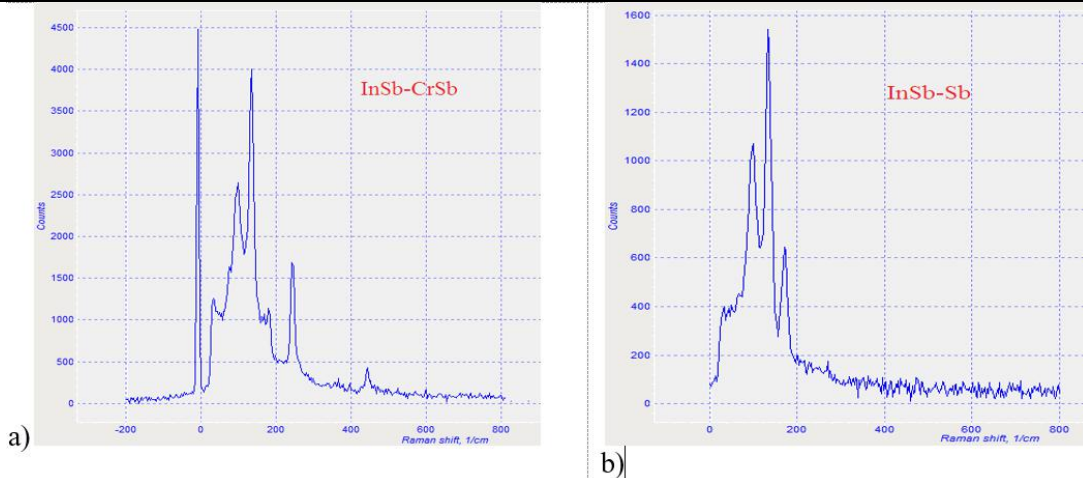


Fig. 8. Raman spectra of InSb-CrSb (a) and InSb-Sb (b) eutectic composites

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