

SYNTHESIS AND STRUCTURAL ANALYSIS OF InSb-Mg₃Sb₂ COMPOSITES

ABSTRACT

InSb-Mg₃Sb₂ systems are synthesized by the vertical Bridgman–Stockbarger method. InSb and Mg₃Sb₂, a form of lamellar eutectic. XRD analysis and microstructural study of InSb-Mg₃Sb₂ composites show that Mg₃Sb₂ lamellar uniformly distributed in the InSb matrices. The initial and final melting temperatures for InSb-Mg₃Sb₂ eutectic alloys are 770K and 772K, respectively.

Keywords: XRD, SEM and EDX analysis, eutectic alloy, lamellar, Raman spectra.

1. Introduction

Remarkable achievements have been in the development of high-performance thermoelectric (TE) materials in recent years. Although challenges still exist in further enhancing ZT and developing highly efficient thermoelectric devices for commercial applications, which require multidisciplinary and intense effort, the TE field will have a future [1-3].

Thermoelectric materials provide a clean and reliable way of generating electricity from waste heat. The deployment of thermoelectric materials for deriving an enhanced figure of merit (ZT) for power generation in inexpensive is important.

The Mg₃Sb₂-based Zintl compound is a promising candidate for a high-performance thermoelectric material with the advantage of the component elements being low cost, non-toxic and earth-abundant. Since the ZT of the Mg₃Sb₂ compound is very low and degrades above 900 K the pure phase is not a good candidate for thermoelectric applications. Further investigation of the InSb+Mg₃Sb₂ eutectic composite along with the correlation of microstructure to thermoelectric properties might be worthwhile for the optimization of this system [4-9]. Here, we investigate a Zintl compound of Mg₃Sb₂ and InSb+Mg₃Sb₂ eutectic composites' physical-chemical properties and applications.

2. Experimental

InSb-Mg₃Sb₂ eutectic composites were prepared by using the vertical Bridgman method. InSb and Mg₃Sb, form a lamellar eutectic. The eutectic concentration is 2.2 percent by weight Mg₃Sb₂. The rate of the crystalliza-

tion front was about 1.2 mm/min. XRD intensity data were collected on an Advance-D8 diffractometer using CuK α radiation. Scanning Electron Microscope (SEM), equipped “With Oxford EDS” и “And HKL EBSD”, were used to characterize the morphology of the specimens and to obtain qualitative information on the elemental composition of the samples, respectively.

3. Results and discussion

Diffraction patterns of the InSb-Mg₃Sb₂ eutectic composite are shown in Fig. 1. The most intense peaks corresponding to the (111), (220), (311), (400), (311), (422) və (511) Muller index are identical to the InSb matrix, while the weak peaks found at $2\theta = 34.08^\circ$, 47.12° , and 57° coincide with the lamellar Mg₃Sb₂ line.

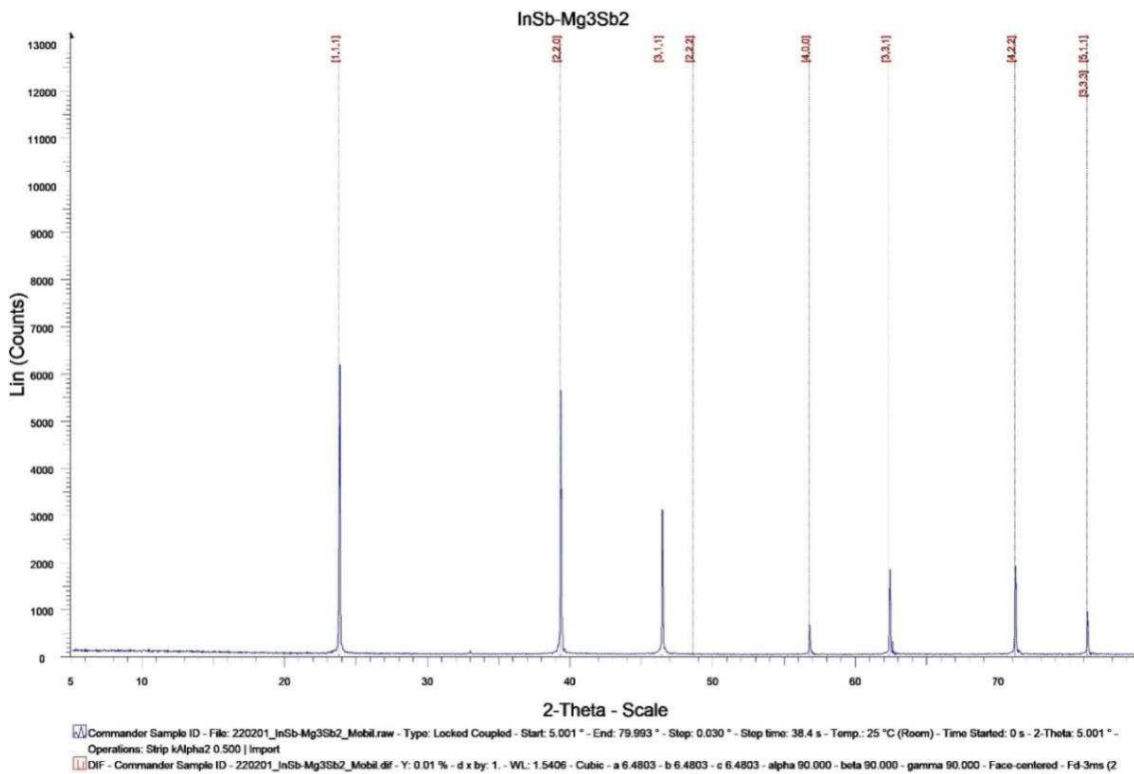


Fig. 1 – X-ray spectrum of InSb+Mg₃Sb₂eutectic composite

Based on SEM examinations (Fig.2), the Mg₃Sb₂ lamellar inclusions with a length of 20÷50 μm and a density of $\sim 6,4 \times 10^4 \text{ mm}^{-2}$ are uniformly and parallel distributed in the InSb matrix. It was found that the InSb-Mg₃Sb₂ eutectics contains In = 47.83wt%, Mg = 1.12wt%, and Sb = 51.05 wt%. The data correspond to the stoichiometric composition of the matrix and inclusions.

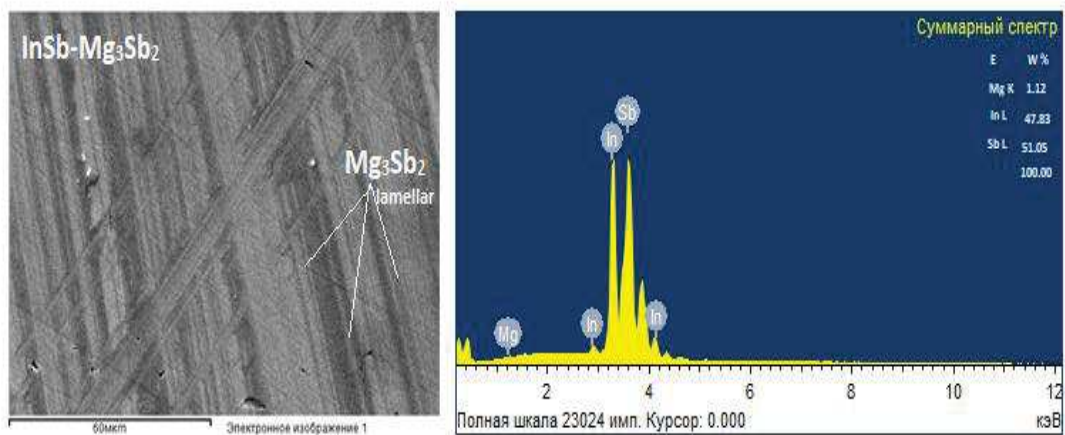


Fig. 2. X-ray spectra of InSb+Mg₃Sb₂ eutectic composite obtained with SEM–EDX from the lamellar and matrix phases along the lateral directions of the specimens

In this paper, we analyzed InSb-Mg₃Sb₂ systems using Raman spectroscopy (Fig.3). These samples consist of two phases which are a consequence of eutectic reactions.

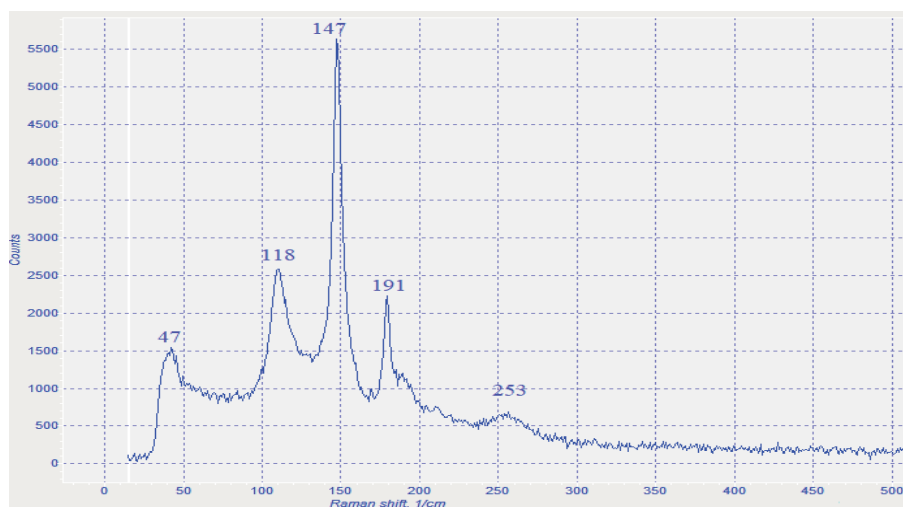


Figure 3 – Raman spectrum of the InSb-Mg₃Sb₂ bulk sample at 300 K

Analysis of microscopic areas of larger samples and identification of coexisting phases were carried out by micro- Raman spectroscopy. By analyzing the Raman spectra, phases have been identified. Raman spectra of InSb-Mg₃Sb₂ eutectic composites were experimentally obtained for the first time. The Raman analysis is an important tool to study atomic interactions in semiconductors and the dynamics of the crystal lattice [10]. Raman analysis was investigated to confirm the existence of two-phase and inter-phase zones in the InSb-Mg₃Sb₂ lamellar eutectic composites at room temperature. Fig.7 shows the Raman lines at about 47cm⁻¹, 118 cm⁻¹, 191 cm⁻¹ are the

mode LO InSb-Mg₃Sb₂eutectic composite, and 118 cm⁻¹, 253 cm⁻¹ for Mg₃Sb₂ compound.

4. Conclusions

The electron microscopy (SEM) and XRD studies of InSb-Mg₃Sb₂ eutectic have confirmed that the systems consist of a semiconductor matrix (InSb) and oriented (Mg₃Sb₂) lamellar inclusions. The initial and final melting temperatures for this eutectic composite are 770K and 772K, respectively. It has been found that the peaks detected in the Raman spectra correspond to the InSb-Mg₃Sb₂ alloys and Mg₃Sb₂ bond.

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