STRUCTURE OF SOLID SOLUTIONS BASED ON $Bi_2B^{VI}_3$ AND $Sb_2B^{VI}_3$ (B^{V1} - Se, Te)

Xolmatova Ruxshona Musinjon qizi
Fergana State University, 3rd year student of Physics

ABSTRACT

This article presents the crystal lattice structure of $Bi_2B^{VI}_3$ and $Sb_2B^{VI}_3$ (B^{V1} - Se, Te) solid alloys, changes in their parameters under a certain temperature.

Key words: *solid alloy, solid solution, stoichiometric composition, crystal lattice, crystal lattice parameters*

АННОТАЦИЯ

В статье представлена структура кристаллической решетки твердых сплавов $Bi_2B^{VI}_3$ и $Sb_2B^{VI}_3$ (B^{V1} - Se, Te) изменение их параметров при определенной температуре.

Ключевые слова: *твердый сплав, твердый раствор, стехиометрический состав, кристаллическая решетка, параметры кристаллической решетки.*

ANNOTATSIYA

Ushbu maqolada $Bi_2B^{VI}_3$ va $Sb_2B^{VI}_3$ (B^{V1} - Se, Te) qattiq qotishmalarning kristall panjara tuzilishi, ma'lum harorat ostida ularning parametrlari o'zgarishlari keltirilgan.

Kalit so'zlar: *qattiq qotishma, qattiq eritma, stexiometrik tarkib, kristall panjara, kristall panjara parametrlari.*

One of the pressing issues in the world is the implementation of the mutual conversion of heat and electricity through thermoelectric materials with high efficiency without harming the atmosphere in obtaining environmentally friendly electricity. Ushbu $Bi_2B^{VI}_3$ va $Sb_2B^{VI}_3$ (B^{V1} - Se, Te) Among the chalcogenides that are components of solid solutions based on $Bi_2B^{VI}_3$ and $Sb_2B^{VI}_3$ (B^{V1} - Se, Te) bismuth telluride has been studied in the most detail. Thermoelectric materials based on bismuth antimony telluride and selenide with high thermoelectric properties and characteristics are important in creating thermoelectric devices. Such thermoelectric materials are widely used in generators, refrigerators, thermostats, air conditioners and other devices to convert heat energy directly into electricity. Therefore, solid solutions based on bismuth telluride (Bi2Te3) have the best thermoelectric properties in the temperature range of 200-600 K.

Bi2Te3 forms continuous isomorphous solid solutions with Bi2Se3 and Sb2Te3. A number of conditions must be met for this:

1) initial compounds must belong to the same symmetry class and have lattices with similar parameters;

2) atoms replacing each other should not differ greatly in size and be similar in chemical properties.

All these conditions are well fulfilled for Bi2Te3 Bi2Se3 and Sb2Te3 (Table 1).

Table 1. Space group and lattice parameters of Bi2Te3, Sb2Te3 and Bi2Se3 at T= 300 K

Compound Lattice	Space group	parameters, Å	
Bi_2Te_3 [35]	$D^5_{3d}(R\bar{3}m)$	4,3835	30,487
Sb_2Te_3 [51]	$D^5_{3d}(R\bar{3}m)$	4,275	30,490
Bi_2Se_3 [50]	$D^5_{3d}(R\bar{3}m)$	4,134	28,546

Covalent radii for Se, Bi, Te and Sb are respectively: 1.17; 1.51; 1.37 and 1.41 Å. In Bi2Te3 - Sb2Te3 solid solutions, Bi sites are replaced by Sb atoms.

$Te^{(1)}$ - Sb - $Te^{(2)}$ - Bi - $Te^{(1)}$

In Bi2Te3 - Bi2Se3, the Se atom is primarily located in $Te^{(1)}$ and $Te^{(2)}$ and forms the following chains:

- $Te^{(1)}$ -Bi-Se-Bi- $Te^{(1)}$ -

Or -Se-Bi- $Te^{(2)}$ -Bi- $Te^{(1)}$ -.

Lattice parameters of Bi2Te3 - Sb2Te3 and Bi2Te3 - Bi2Se3 - were measured in [42, 46, 48, 50]. Data for the first solid solution are shown in Figure 1, and for the second - in Figure 2. The parameter a obeys Wegart's rule in both cases.

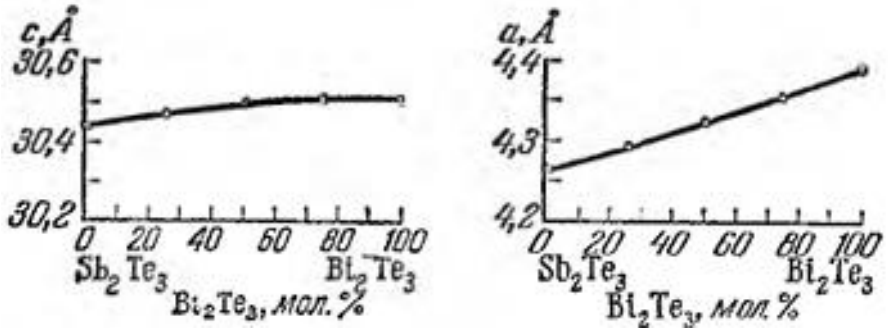

Figure 1. Variation of a, c parameters depending on the composition of the Bi2Te3 - Sb2Te3 solid solution system.

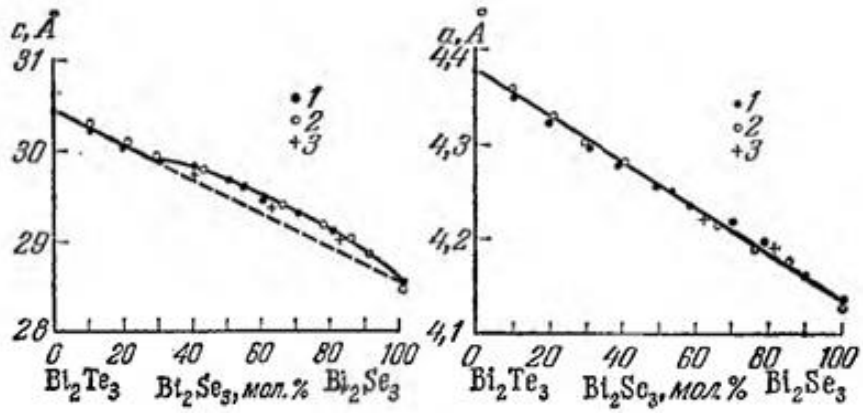

Figure 2. Dependence of parameters a and c on composition in Bi2Te3 - Bi2Se3 solid solution: 1 - hardened samples; 2, 3 - single crystals grown at a speed of 1.2 and 0.2 mm/h, respectively.

It decreases when going from Bi2Te3 to Sb2Te3 and Bi2Se3, mainly because the substituent atoms (Se and Sb) are smaller compared to the matrix atoms (Te and Bi).

The c parameter changes in a more complex way depending on the composition of the solid solution. So, for example, in Bi2Te3 - Bi2Se3, c decreases linearly only up to 30 mol% Bi2Se3, after which a deviation from Wegart's law is observed (Fig. 3). In this solution, Se replaces Te(2) until the composition Bi2Te2Se, and only then Te(1).

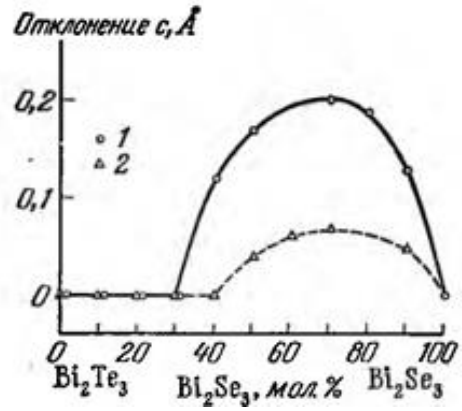

Figure 1.9. Deviation from Vegart's law for parameter c in Bi2Te3 - Bi2Se3 solid solution: 1 - data obtained from work; 2 - [48].

A deviation from Vegart's law in parameter c is observed near Bi2Te2Se. This may be due to changes in van der Waals interactions between individual quintets. It is known that such an interaction is stronger between identical systems (Te(1) - Te(1)) or Se - Se) than between dissimilar systems (Te(1) - Se) is stronger. If this assumption is correct, the maximum deviation from Wegart's law should be for a Bi2Se3 composition of 67 mol%, which corresponds to a 50% to 50% mixture of Te and Se atoms in the Te(1) layers. will come. This is well confirmed by experience (see Figure 1.9).

REFERENCES

1. Azimov, T., Gajnazarova, K., & Onarkulov, K. (2020). Method for determining the contact resistance of thermoelements. *Euroasian Journal of Semiconductors Science and Engineering*, *2*(5), 11.
2. Karimberdi, O., Usmanov, Y., & Toolanboy, A. (2020). Semiconductor sensor for detecting volume changes at low temperatures. *European Journal of Molecular & Clinical Medicine*, *7*(2), 2353-2358.
3. Onarkulov, K., Gaynazarova, K., & Tashlanova, D. (2022). Termoelektrik samaradorlikni qotishmalardagi elektronlar va teshiklarning harakatchanligiga bog‘lanishi. *Science and innovation*, *1*(A4), 56-59.
4. Egamberdiyvich, O. K., Yakub, U., & Ma'Rifjonovich, A. T. (2020). Semiconductor sensor for detecting volume changes at low temperatures. *Austrian Journal of Technical and Natural Sciences*, (1-2), 16-20.
5. Ma'Rifjonovich, A. T., & Egamberdiyvich, O. K. (2020). Effect of commutation solder on the operating characteristics of cooling elements based on bismuth and antimony chalcogenides. *Austrian Journal of Technical and Natural Sciences*, (1-2), 21-25.
6. Azimov, T. M., Gaynazarova, K. I., Onarkulov, M. K., & Yuldashev, A. A. (2021). Thermoelectric and Galvanomagnetic Properties of the Alloy Bi 2 Te 3+ 0.04 Weight% Ni in the Temperature Range 77÷ 300 K. *American Journal of Modern Physics*, *10*(6), 124-128.
7. G‟aynazarova Kizlarxon Isroilovna, Turg’unboyeva Madina Salimjon qizi. PROPERTIES OF ELECTROPHYSICAL PARAMETERS OF SOLID ALLOYS BASED ON Sb-Bi-Te. STUDY OF STOCHIOMETRICAL COMPOSITION IN OBTAINING TERTIARY COMPOUNDS. Scientific aspects and trends in the field of scientific research International scientific-online conference Part 9 APRIL 30th colletions of scientific works Warsaw 2023.
8. Kizlarkhan Gaynazarova, Gulsunoy Hoshimova. CRYSTALLOGRAPHIC STRUCTURE, TEXTURE AND PREFERENTIAL ORIENTATION IN VEILS. Scientific aspects and trends in the field of scientific research International scientific-online conference Part 9 APRIL 30th colletions of scientific works Warsaw 2023.
9. G’aynazarova Kizlarxon Isroilovna. CHARACTERISTICS OF MOBILITY IN TERTIARY SOLID SOLUTIONS. Материалы международной конференции «Оптические и фотоэлектрические явления в полупроводниковых микро- и наноструктурах» Фергана-2023.с.112-114.
10. K.Onarqulov, K.G’aynazarova. THERMAL CONDUCTIVITY OF THERMOELECTRIC COMPOUNDS BASED ON $Bi_2(B^{VI})_3$ va $Sb_2(B^{VI})_3$, (B^{VI}–Se,

Te). Материалы международной конференции «Оптические и фотоэлектрические явления в полупроводниковых микро- и наноструктурах» Фергана-2023.с.26-27.

11. Q.I.Gaynazarova. CRYSTAL STRUCTURE OF CHALCOGENIDES OF THERMOELECTRIC ALLOYS BASED ON $Bi_2(B^{VI})_3$ and $Sb_2(B^{VI})_3$, (B^{VI}–Se, Te). Материалы международной конференции «Оптические и фотоэлектрические явления в полупроводниковых микро- и наноструктурах» Фергана-2023.с.110-112.

12. Onarqulov, K. (2023, November). N-TIPLI VISMUT TELLURIDI VA SELENID QOTISHMALARI. In *Fergana state university conference* (pp. 299-300).

13. G'aynazarova, Q. (2023, November). BI-SB QOTISHMALARIDA HOLL EFFEKTI VA HARAKARCHANLIK. In *Fergana state university conference* (pp. 302-305).

14. Kizi, K. E. F., Ugli, K. S. K., & Gaynazarova, K. I. (2023). ELECTROPHYSICAL PARAMETERS OF COMPLEX SOLID COMPOUNDS. *Oriental renaissance: Innovative, educational, natural and social sciences*, *3*(10), 167-171.

15. Onarkulov, K., Gaynazarova, K., & Tashlanova, D. (2022). RELATIONSHIP BETWEEN THERMOELECTRIC EFFICIENCY AND MOBILITY OF ELECTRONS AND HOLES IN ALLOYS. *Science and Innovation*, *1*(4), 56-59.