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Short Communication

Study of Phase Formation In The Cute-As_2te_3System

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Abstract

By the methods of DTA, XRD, MSA, as well as by measuring the microhardness and determining the density of the alloys, the CuTe-As_2Te_3 system was studied and a phase diagram was constructed. The system state diagram is of the eutectic type and is characterized by one chemical compound of $Cu_3As_4Te_9$ composition. Compounds $Cu_3As_4Te_9$ melts incongruently at 320 °C. Solid solutions based on As_2Te_3 reaches 8mol. % and based on CuTe solid solutions are practically not installed. $Cu_3As_4Te_9$ and As_2Te_3 form a eutectic composition of 45mol. % As_2Te_3 and temperature of 265 °C.

Keywords: Eutectic; Incongruent; Microhardness; Density; Syngony

Introduction

It is known that compounds and solid solutions based on arsenic chalcogenides occupy an important place among the materials used in optoelectronics [1-3]. Copper chalcogenides and alloys based on them as thermionic and superionic materials are widely used in radio and electronic engineering [4,5]. Some quasi-binary sections with the participation of arsenic chalcogenides and the Cu-As-Se (Te) ternary system have been investigated in the literature [6,7]. However, there is no data in the literature on interactions in the CuTe-As_2Te_3 system. The aim of this work is to synthesize and study the interaction in the CuTe-As_2Te_3 system, as well as to search for new semiconducting phases and solid solutions. The CuTe compound melts incongruently at 367 °C and crystallizes in a rhombic syngony with unit cell parameters: a= 3.16; b= 4.07; c= 6.92 Å, sp. gr. Pmmm-D^{13}_{2h} [8]. According to [9], the CuTe compound melts incongruently at 400 °C. The As_2Te_3 compound melts with an open maximum at 381 °C and crystallizes in monoclinic syngony with lattice parameters: a= 14.339; b= 4.006; c= 9.873Å, β= 95°, sp.gr. C_2/m, the density is ρ= 6.25g/cm^3 [10].

Experimental Part

The synthesis of the initial components of the system, which was carried out from the elements Cu-99.97; tellurium Te-99.998, and arsenic 99.99 taken in stoichiometric proportions. Triple alloys of the CuTe-As_2Te_3 system were synthesized in a single-temperature furnace by the ampoule method from the CuTe and As_2Te_3 components. Taking into account the peritectic nature of the formation of the CuTe compound, annealing was performed for 350h at a temperature of ~ 20 °C below the final crystallization temperature.

The study of the CuTe-As_2Te_3 ternary system was carried out by methods of physicochemical analysis: Differential Thermal (DTA), X-ray Phase (XRD), Microstructural (MSA), as well as density determination and microhardness measurement.

Result and Discussion

The obtained alloys of the CuTe-As_2Te_3 system are compact in gray. The system alloys are resistant to water and organic solvents. They dissolve well in acids HNO_3 and H_2SO_4. Alloys rich in As_2Te_3 also dissolve in alkalis (NaOH, KOH). The DTA of the CuTe-As_2Te_3 system showed that the thermograms of the alloys show two and three endothermic effects related to solidus and liquidus. The results of the microstructural analysis show that all alloys of the CuTe-As_2Te_3 system are two-phase. Only based on As_2Te_3 there is an insignificant range of solid solutions, and based on CuTe, solid solutions are practically not found. This indicates that the CuTe-As_2Te_3 section is quasi-binary, of the eutectic type.

To confirm the results of DTA and MSA analyzes, an X-ray phase analysis of alloys of the system 30, 50, and 70mol % As_2Te_3. It was found that the diffraction patterns of alloys with the marked compositions, in addition to the composition of 50 and 92-100mol % As_2Te_3 other alloys consist of mixed diffraction lines of the initial components. Content 50mol. % corresponds to the formula $Cu_3As_4Te_9$. The data obtained indicate that the CuTe-As_2Te_3 system contains one and two-phase alloys. The state diagram of the system is quasi-binary, eutectic type, characterized by the presence of one chemical compound of the composition $Cu_3As_4Te_9$. The $Cu_3As_4Te_9$ compound melts with an open maximum at 320 °C. $Cu_3As_4Te_9$ and As_2Te_3 form a eutectic of 45mol % As_2Te_3 and melts at 265 °C. The CuTe compound melts incongruently at 400 °C, above the peritectic temperature it decomposes according to the following reaction: CuTe ↔ L + Cu_4Te_3. In the concentration range, 0-25mol % As_2Te_3 primary crystals of Cu_4Te_3 are precipitated from the liquid. During secondary crystallization, three-phase regions are formed (L + Cu_4Te_3 + $Cu_3As_4Te_9$).

When measuring the microhardness of the alloys of the system, three different values of microhardness were established. The microhardness value for the CuTe compound varies in the range (400-530) MPa. The microhardness value (1960-1980) MPa corresponds to the microhardness of the $Cu_3As_4Te_9$ compound. The microhardness values for the α-solid solution based on As_2Te_3 vary from 1650MPa to 1850MPa.

Conclusion

The interactions between CuTe and As_2Te_3 are investigated in a wide concentration range and the T-x phase diagram of the system is constructed. It has been established that the CuTe-As_2Te_3 system belongs to the eutectic type. One chemical compound $Cu_3As_4Te_9$ is formed in the system. It was found that $Cu_3As_4Te_9$ compounds melt congruently at 320 °C. In the system at room temperature, solid solutions based on As_2Te_3 reach 8mol % CuTe, while solid solutions based on CuTe have practically not been established. CuTe and As_2Te_3 form a eutectic with coordinates 45mol % As_2Te_3, temperature 265 °C.

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