Study of Phase Formation In The Cute-As$_2$Te$_3$ System

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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$_3$Te$_2$ 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$_2$As$_3$Te$_5$ composition. Compounds Cu$_2$As$_3$Te$_5$ melts incongruently at 360 °C. Solid solutions based on As$_3$Te$_2$ reaches 8mol. % and based on CuTe solid solutions are practically not installed. Cu$_2$As$_3$Te$_5$ and As$_3$Te$_2$ compound form a eutectic composition of 45mol. % As$_3$Te$_2$ 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$_3$Te$_2$ system. The aim of this work is to synthesize and study the interaction in the CuTe-As$_3$Te$_2$ system, as well as to search for new semiconducting phases and solid solutions. The CuTe compound melts incongruently at 360 °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$_{2}$h[8]. According to [9], the CuTe compound melts incongruently at 400 °C. The As$_3$Te$_2$ compound melts with an open maximum at 381 °C and crystallizes in monoclinic syngony with lattice parameters: $a = 14.339; b = 4.006; c = 9.873$Å, β = 95°, sp. gr. C$_{2h}$/m, the density is $\rho = 6.25g/cm^3$ [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$_3$Te$_2$ system were synthesized in a single-temperature furnace by the ampoule method from the CuTe and As$_3$Te$_2$ 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$_3$Te$_2$ 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$_3$Te$_2$ system are compact in gray. The system alloys are resistant to water and organic solvents. They dissolve well in acids HNO$_3$ and H$_2$SO$_4$. Alloys rich in As$_3$Te$_2$ also dissolve in alkalis (NaOH, KOH). The DTA of the CuTe-As$_3$Te$_2$ system showed that the thermograms of the alloys show two and three endothermic effects related to solids and liquidus. The results of the microstructural analysis show that all alloys of the CuTe-As$_3$Te$_2$ system are two-phase. Only based on As$_3$Te$_2$ there is an insignificant range of solid solutions, and based on CuTe, solid solutions are practically not found. This indicates that the CuTe-As$_3$Te$_2$ 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 70 mol% \( \text{As}_2\text{Te}_3 \). It was found that the diffraction patterns of alloys with the marked compositions, in addition to the composition of 50 and 92-100 mol% \( \text{As}_2\text{Te}_3 \), other alloys consist of mixed diffraction lines of the initial components. Content 50 mol% corresponds to the formula \( \text{Cu}_3\text{As}_4\text{Te}_9 \). The data obtained indicate that the CuTe-As\(_2\)Te\(_3\) 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 \( \text{Cu}_3\text{As}_4\text{Te}_9 \). The \( \text{Cu}_3\text{As}_4\text{Te}_9 \) compound melts congruently at 320 °C. In the system at room temperature, solid solutions based on \( \text{As}_2\text{Te}_3 \) reach 8 mol% CuTe, while solid solutions based on CuTe have practically not been established. CuTe and \( \text{As}_2\text{Te}_3 \) form a eutectic with coordinates 45 mol% \( \text{As}_2\text{Te}_3 \) temperature 265 °C.

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