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Research Article

Preparation of Composite Materials in the System Sb_2Se_3- $Cu_2Cr_4Te_7$

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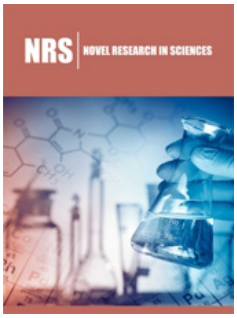

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Abstract

The Sb_2Se_3-$Cu_2Cr_4Te_7$ systems were investigated by the methods of physicochemical analysis (DTA, XRD, MSA, as well as density determination and microhardness measurements) and a phase diagram was constructed. According to the preliminary thermal analysis of the alloys of the system, it has shown that two and three endothermic effects are found in the system. It was found that the state diagram of the system is partially quasi-binary. It was found that, in the solid state, solid solutions based on Sb_2Se_3 extend to 4mol% $Cu_2Cr_4Te_7$, and on the basis of $Cu_2Cr_4Te_7$ up to -15mol% Sb_2Se_3. The magnetization and magnetic permeability of $(Cu_2Cr_4Te_7)_{1-x}(Sb_2Se_3)_x$ solid solutions were measured depending on the composition and temperature.

Keywords: System; Phase; Microhardness; Solid solution; Crystal system

Abbreviations: DTA: Differential Thermal; XRD: X-Ray Diffraction; MSA: Microstructural Analysis

Introduction

It is known that chalcogenides of the main elements of subgroup V and ternary compounds and solid solutions based on them are widely used in optical devices in microelectronics as materials with high photosensitivity and thermoelectric properties. $As_2X_3 \rightarrow Sb_2X_3 \rightarrow Bi_2X_3$ are chalcogenide compounds, sulfur and selenide compounds being photosensitive [1-4], and telluride compounds increase thermoelectric properties [5,6]. In the interaction of copper and chromium chalcogenides, the obtained compounds $CuCr_2Se_4$, $CuCr_2Te_4$, $Cu_2Cr_4Te_7$ are ferromagnetic semiconductor materials [7,8]. By chemical interaction between the light-sensitive compound Sb_2Se_3 and the ferromagnetic compound $Cu_2Cr_4Te_7$, magneto-optical composite materials can be obtained that retain the properties of both components. Based on this, the study of the interaction between Sb_2Se_3 and $Cu_2Cr_4Te_7$ compounds is of scientific and practical importance. The aim of this work is to obtain magneto-optical composite materials in the Sb_2Se_3-$Cu_2Cr_4Te_7$ system, as well as to search for the region of solid solutions. The Sb_2Se_3 compound is obtained with open maxima and melts congruently at 890K, crystallizes in an orthorhombic system with lattice parameters: a=11.633; b=11.780; c=3.985Å, sp.gr. Pbnm-D^{2h}_{16}, density ρ=5.843g/cm³ and microhardness Hμ=1200MPa [9]. The $Cu_2Cr_4Te_7$ compound melts incongruently at 1273K and there is a large homogeneity region near it [10].

Experimental Part

The synthesis of alloys of the Sb_2Se_3-$Cu_2Cr_4Te_7$ system was carried out both from binary compounds and from elementary components by the method of direct ampoule melting in evacuated quartz ampoules. The alloys obtained were subjected to homogenizing annealing at 723K for 350h. Equilibrium alloys of the system were investigated by Differential Thermal (DTA), X-Ray Diffraction (XRD), Microstructural Analysis (MSA) and density determination and microhardness measurements. DTA was performed on an NTR-73 pyrometer using a combined Pt-Pt/Rh thermocouple. X-ray phase analysis was performed by recording a diffractograms on a D2 phaser. Microstructural studies were carried out using an MIM-8 metallographic microscope. Microhardness was measured on a PMT-3 device. To measure the magnetic susceptibility of the samples, they were carried out in the temperature range 150-600K on a magnetic balance with electromagnetic compensation. To measure the magnetization of the synthesized samples, a Voner-type vibration magnetometer was used [9,10].

Result and Discussion

To study the Sb_2Se_3-$Cu_2Cr_4Te_7$ system, samples were synthesized in a wide range of concentrations, each 5-10mol%. Cooling of alloys that were carried out with the furnace turned on. The alloys are obtained in a compact form. Their color changes from gray to brilliant gray. DTA of alloys of the Sb_2Se_3-$Cu_2Cr_4Te_7$ system show that there are three effects on the thermograms of almost all alloys. In the area of 0-20mol.% $Cu_2Cr_4Te_7$, two heating effects are obtained. The study of the microstructure of the annealed samples showed that single-phase alloys exist only near the initial components. The rest of the alloys in the system are two-phase. In order to refine the results of DTA and MSA, X-ray phase analysis was performed. For alloys containing 4,20,70 and 85mol.% $Cu_2Cr_4Te_7$, X-ray diffraction patterns were taken. XRD of the annealed alloys of the Sb_2Se_3-$Cu_2Cr_4Te_7$ system showed that the diffraction patterns of cast alloys of 20 and 70mol% $Cu_2Cr_4Te_7$, intense diffraction lines are observed, which consist of the diffraction line of the initial components. This means that these samples are two-phase alloys. Diffraction lines of the sample 4mol.% $Cu_2Cr_4Te_7$ do not differ from the diffraction lines of the Sb_2Se_3 compound, only differ in interplanar distances. This composition belongs to the field of solid solutions based on Sb_2Se_3, and the sample is 15mol% Sb_2Se_3 also belong to the region of solid solutions based on $Cu_2Cr_4Te_7$. To study the magnetizing ability of solid solution alloys in the temperature range 11270-1370K, samples 2,3 and 5mol% Sb_2Se_3 were synthesized. The alloys were heat treated at 773K for 100 hours for homogenization. The magnetization of samples 2,3 and 5mol.% Sb_2Se_3 was carried out in the temperature range 150-600K. Even in the absence of an external magnetic field, substances with strong magnetization are called ferrimagnets. A decrease in magnetization is observed depending on the temperature and composition. For samples containing 2,3 and 5mol% Sb_2Se_3, the Curie temperature in a very weak magnetic field of 1.0 Erst was 280 and 330K. The magnetic permeability is measured in a magnetic field H=10k Erst. The value of the molar susceptibility of the samples was determined by the formula $\chi=\chi_0\cdot(m_0/m)(i/i_0)$ M where χ_0- is the specific magnetic susceptibility of the standard (Mohr's salt), m_0 and m are the mass of the standard and the sample, M is the molecular weight of the sample.

Conclusion

Chemical interactions in the Sb_2Se_3-$Cu_2Cr_4Te_7$ system were studied by methods of physicochemical analysis (DTA, XRD, MSA, as well as density determination and microhardness measurements). DTA of the samples showed that there are two and three endothermic effects on the thermograms. It is revealed that the phase diagram of the Sb_2Se_3-$Cu_2Cr_4Te_7$ system is purely quasi-binary. In the system, solid solutions based on Sb_2Se_3 reach 4mol%, and based on $Cu_2Cr_4Te_7$ - upto -15mol%. The magnetization and permeability of $(Cu_2Cr_4Te_7)_{1-x}$ $(Sb_2Se_3)_x$ solid solutions were measured depending on the composition and temperature.

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