PHYSICO-CHEMICAL INVESTIGATION OF PHASE EQUILIBRIUM IN THE $SrIn_3$-SrSe SYSTEM

Sultanova A.,
Doctoral student
Yagubov N.,
Doctor of Chemistry, prof.
Baku State University
Aliyev I.,
Doctor of Chemistry, prof. hands. lab.
Institute of Catalysis and Inorganic Chemistry named after M.F.Nagiyev
of the Ministry of Science and Education of the Republic of Azerbaijan
Ahmedova C.,
Ph.D., Associate Prof
Adiyaman University, Faculty of Arts and Sciences,
Department of Chemistry, Turkey
Qafarova G.
Researcher
Istitute Physics of the Ministry of Science and Education
of the Republic of Azerbaijan
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Abstract

The phase equilibrium in the $SrIn_3$-SrSe system was studied using complex methods of physicochemical analysis: differential thermal analysis (DTA), X-ray diffraction analysis (XRD), microstructural analysis (MSA), as well as density and microhardness, and a T-x phase diagram was constructed. It has been established that the phase diagram of the $SrIn_3$-SrSe system is a partially quasi-binary cross section of the Sr-In-Se ternary system. It has been established that eutectic equilibrium and peritectic transformation take place in the system. A microstructural analysis of the alloys of the system was carried out and it was found that at room temperature solid solutions based on the SrSe compound reach 3 mol % $SrIn_3$, and solid solutions based on $SrIn_3$ are practically not established.

Keywords: phase equilibrium, quasi-binary, eutectic, peritectic, density

Introduction

Elements of main subgroup II are chemically very active substances and react with strong heat release with chalcogenides. Therefore, when reacting these elements with chalcogenides, it is necessary to take into account temperature conditions. Meanwhile, calcium chalcogenides and ternary systems based on them have been studied in many more systems than strontium and barium chalcogenides. Chalcogenides of elements of the calcium subgroup and ternary systems based on them were studied by the authors of works [1-4]. Systems based on strontium and barium chalcogenides have been little studied. Compounds such as $A^{II}MeX_2$, $A^{II}Me^2X_4$ (A^{II}-Ca,Sr; Me-Ga,In; X-S,Se,Te) exhibit strong luminescent properties due to the action of activators [5-7].

Previously, we studied a series of Ca-Ga(In)-Se ternary systems [8-10]. The $SrIn_3$-SrSe system has not been studied.

The purpose of this work is to study phase equilibria in the $SrIn_3$-SrSe system, construct its phase diagram and detect solid solution regions.

The $SrIn_3$ compound is an intermetallic compound, melts incogruently at 540°C and crystallizes in the hexagonal syngony, lattice parameters: a = 6.69 Å; c=5.481 Å sp. gr. $P6_3/mmc$ [12]. The SrSe compound melts congruently at 1600˚C and crystallizes in the cubic synqgony, with lattice parameters: a = 6.243 Å, sp. gr. Fm3m, density $\rho = 4.50$ g/cm^3 [13].

Experimental part

Alloys of the $SrIn_3$-SrSe system were synthesized from the components $SrIn_3$ and SrSe in a quartz ampoule into which air was sucked to a pressure of 0.133 Pa in the temperature range 800-1200°C. The alloys were subjected to heat treatment for 240 hours at a temperature of 500°C to homogenize them. Equilibrium samples were studied by methods of physicochemical analysis (DTA, XRF, MCA, as well as density and microhardness measurements).

Differential thermal analysis of the samples was carried out on a Kurnakov pyrometer NTR-73. Al_2O_3 was used as a standard; the heating rate was 10 min/min.

X-ray phase analysis was performed on a D2 PHASER X-ray diffractometer. A CuKα cathode and a Ni filter were used as irradiators. Microhardness was calculated using a PMT-3 metallographic microscope. Microstructure analysis was carried out using a MIM-8 microscope. The density of the samples was determined by the pycnometric method using toluene as a filler.

Results and its discussion

Alloys of the $SrIn_3$-SrSe system in the range of 0-60 mol % SrSe are compact masses and have a bright black color.

Differential thermal analysis of the alloys of the system shows that two and three endothermic effects are observed in their thermograms. A large number of thermal effects in the system indicates that a complex interaction is occurring.

Fig. 1. Microstructure of alloys of the $SrIn_3$-SrSe system.
1-30 mol %, 2-70 mol %, 3-97 mol % SrSe.

By analyzing the microstructure, it was established that there are single-phase and two-phase alloys in the system. In Fig. 1 shows the microstructure of alloys containing 30, 70 and 97 mol % SrSe. As can be seen from Figure 1, SrSe samples containing 30 and 70 mol. % are two-phase, while a single-phase sample containing 97 mol. % SrSe is a solid solution alloy based on the SrSe compound.

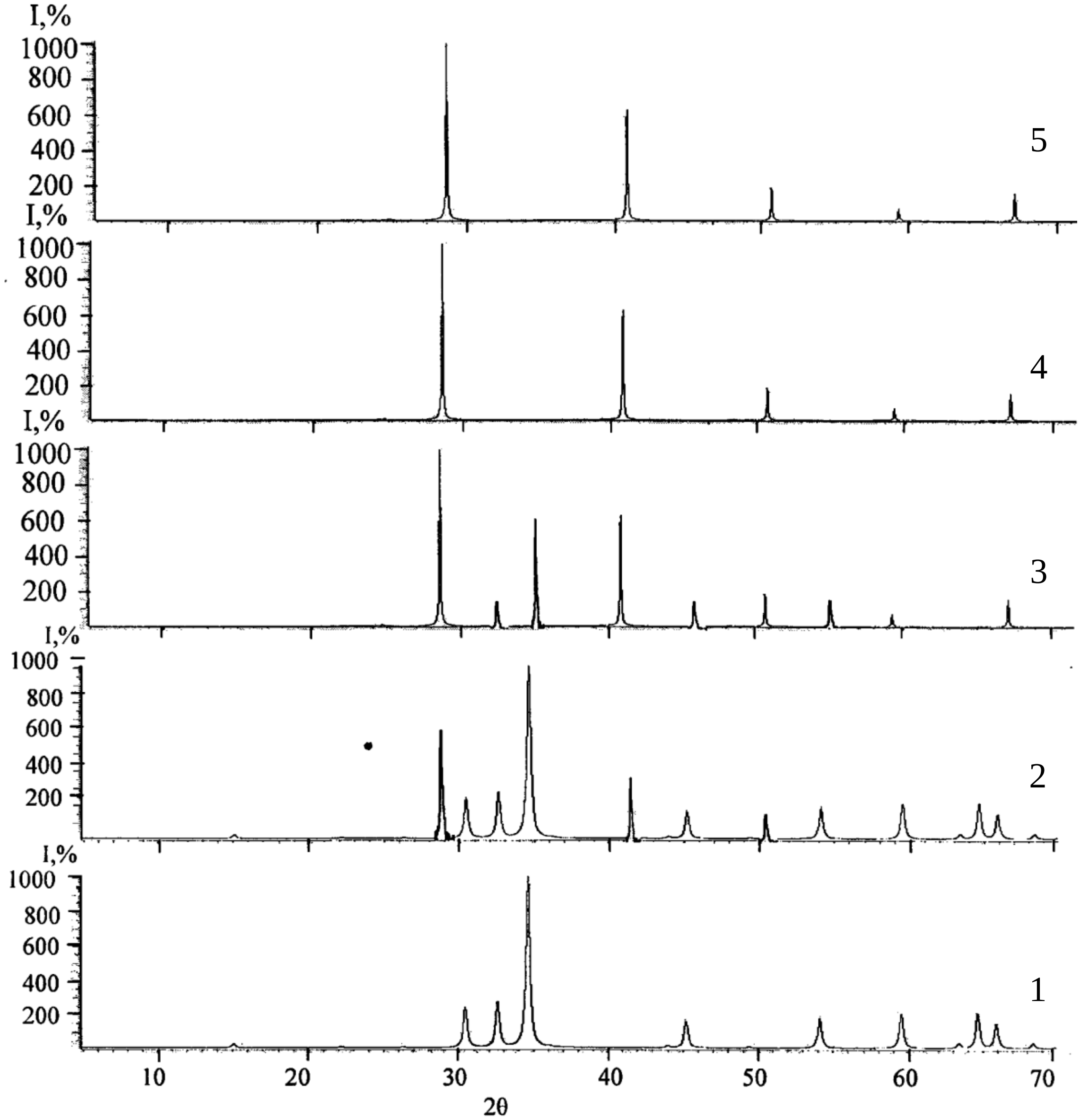

Fig. 2. X-ray diffraction patterns of the $SrIn_3$-SrSe system.
1- $SrIn_3$, 2-30, 3-70, 4-97, 5-100 mol % SrSe.

The results of DTA and microstructure analysis were monitored by X-ray diffraction analysis. For this purpose, X-ray diffraction analysis of alloys containing 30, 70 and 97 mol % SrSe (Fig. 2). As a result of X-ray diffraction analysis, it was established that in the diffraction patterns of alloys containing 30 and 70 mol % SrSe, a mixing of the diffraction lines of the $SrIn_3$ and SrSe compounds is observed. Diffraction lines present in the diffraction pattern of a sample containing 97 mol % SrSe are identical to the diffraction lines of the SrSe compound, that is, the sample is a solid solution alloy based on SrSe.

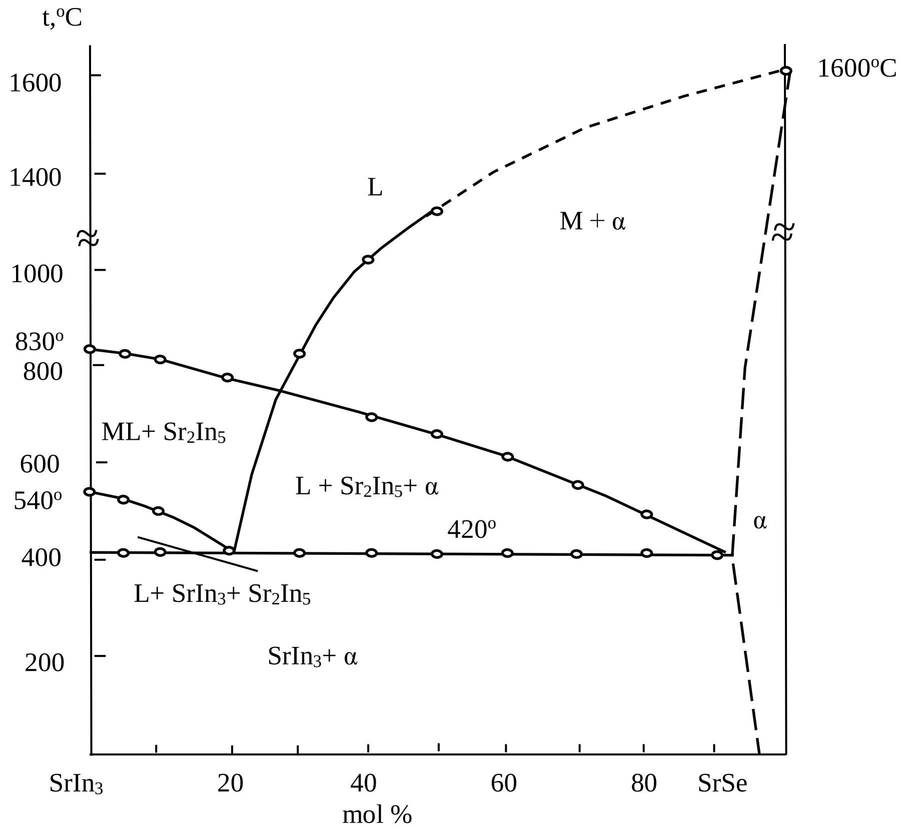

Fig.3. Phase diagram of the $SrIn_3$-SrSe system.

Thus, based on the results of physicochemical analysis methods, a phase diagram of the $SrIn_3$-SrSe system was constructed (Fig. 3). The phase diagram of the system is partially quasi-binary and is characterized by eutectic equilibrium and peritectic transformation. The $SrIn_3$-SrSe system is partially non-quasi-binary, since the $SrIn_3$ compound has a peritectic nature. In the system, the $SrIn_3$ compound is decomposed as follows: $SrIn_3 \leftrightarrow M + Sr_2In_5$.

The liquidus of the system is limited by the monovariant equilibrium curves of the Sr_2In_5 compound and the α-solid solution obtained on the basis of SrSe. In the system above the solidus line in the range of 0–97 mol % SrSe, a three-phase field is formed, consisting of (M + Sr_2In_5+$SrIn_3$) and (M+$SrIn_3$+α). Two-phase alloys consisting of ($SrIn_3$+α) crystallize below the solidus line. The system also undergoes peritectic transformations M + $Sr_2In_5 \leftrightarrow SrIn_3$ at 420°C.

Table 1.

Composition of alloys of the $SrIn_3$–SrSe DTA system, results of density and microhardness measurements

Composition, mol %		Thermal effects, °C	Density q/cm³	Microhardness, MPa	
$SrIn_3$	SrSe			$SrIn_3$	α
				P=0,20 N	P=0,10 N
100	0.0	540, 830	5,24	1700	–
95	5,0	420,520,820	5.28	1700	–
90	10	420,500,800	5,22	1700	–
80	20	420,780	5,10	1700	–
70	30	420,825	5,02	1700	1280
60	40	420,700,1020	4,94	–	1280
50	50	420,660,1220	4,87	–	1280
40	60	420,610	4,79	–	1280
30	70	420,550	4,72	–	1280
20	80	420,500	4,65	–	1270
10	90	420	4,57	–	1270
0,0	100	1600	4,50	–	1250

As a result of measuring the microhardness of alloys of the $SrIn_3$–SrSe system, two different microhardness values were obtained. The microhardness value 1700 MPa corresponds to the microhardness value of the $SrIn_3$ compound. The microhardness of α-solid solutions based on the SrSe composition ranges from 1250 to 1280 MPa.

Results

Using the methods of physicochemical analysis, the phase equilibrium in the SrIn3-SrSe system was studied and its T-x phase diagram was constructed. It has been established that the $SrIn_3$-SrSe system is a partial quasi-binary cross section of the Sr-In-Se ternary system. Eutectic equilibrium and peritectic transformation are formed in the system. In the $SrIn_3$-SrSe system, the area of the solid solution based on the SrSe compound at room temperature is 3 mol %, and the region of the solid solution based on $SrIn_3$ is practically undefined.

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