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XRD INVESTIGATIONS OF SOME MULTIFUNCTIONAL ALLOYS BASED ON SILVER, TIN AND INDIUM

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Abstract

In this paper, multifunctional alloys based on silver, tin and indium were investigated. Only small part of characterization methods was performed because there were complex investigations in domain of mentioned alloys. So, XRD results of some Ag-In-Sn alloys were presented here.

***Keywords**: XRD, silver, tin, indium, multifunctional alloys*

1. INTRODUCTION

One of the greatest challenges in materials science is to produce material which will be useful and applicable in as many areas as possible. Those so-called new materials have to be multifunctional, for example, they must have certain properties to satisfy the needs in industry as well as in medicine. Therefore, from the list of all metals and alloys we want to pick some or group of elements, which are accessible, affordable, ecological, compatible with each other, etc. and to investigate it. That not an easy way, and investigations may last for years.

Among elements that might be useful in electronics as well as in medical applications are silver, gold, copper, gallium, indium, tin etc. Indium as addition to many alloys improves some properties [1, 2]. This element is versatile, conductive and with low melting point. In soldering, its ductility allows some materials with different coefficient of thermal expansion to joint and also improve the resistance to thermal fatigue. Indium is an ideal for bonding materials especially for non-metals bonding. As a metal with low melting point, it can be useful in various combinations and applications. With gallium, it creates alloys which are liquid at room temperature. In addition to silver and tin, or SAC (Sn-Ag-Cu) alloys it creates the whole spectra of ecological solder alloys (lead and cadmium free solders) [2, 4]. It can be used in alkaline batteries to replace toxic mercury compounds. Its oxides together with tin (ITO) also can be used in thin films for many purposes [1-4].

So, alloys with indium can have wide range of applications, from solders to radiation therapy shielding, and therefore those alloys can be multifunctional. However, for investigations of all necessary properties that are needed for various applications, there are lots of characterization methods that must be used such as LOM, XRD, SEM-EDS etc.

In order to achieve the appropriate physical, mechanical and chemical properties of some alloys, it is necessary to know dependence of desired properties of the final

microstructure and the chemical composition of the alloy and the conditions at which the process is carried out. As with most alloys (especially multi-component) have more than one phase transformations, to meet these requirements is necessary to know the phase diagram of the system. Unlike the binary and some ternary systems whose phase diagrams determined experimentally, the phase diagrams of multicomponent systems can be determined by calculation, i.e. programming using specialized software packages. Phase equilibria investigations from binary to multicomponent alloys are also essential because together with characterization methods give complete picture of particular alloy. We have to mention that phase diagrams for all constitutive binary systems are constantly improved by researchers from all over the world, which is reflected in big databases [5].

In this paper only the small part of XRD results are given as a part of complex investigations in domain of silver, gold, tin, indium, copper and gallium combinations.

2. EXPERIMENTAL

The samples were first melted in an air atmosphere in an electric furnace up to 873K, then annealed at 473K and cooled to room temperature, at a cooling rate of 5 K / min. Prepared samples were characterized with XRD on Siemens apparatus, using Cu-anticathode and Ni-filters (40 kV, 20 mA) and therefore diffractograms for alloys were obtained.

The compositions of all investigated samples in this work only, are given in Table1.

Table 1. *Composition of Ag-In-Sn investigated alloys*

alloy	Composition, at%		
	Ag	In	Sn
A1	20	40	40
A2	50	15	35
A3	70	9	21

It should be noticed that these compositions were chosen to explain only the difference in XRD results, because the list of all investigated Ag-In-Sn samples is much longer considering various implementation of these alloys as multifunctional materials. Considering the influence of tin and indium especially, compositions with higher percent of those elements in alloys were discussed in the frame of lead-free solder alloys in previous papers [4 - 6].

3. RESULTS AND DISCUSSION

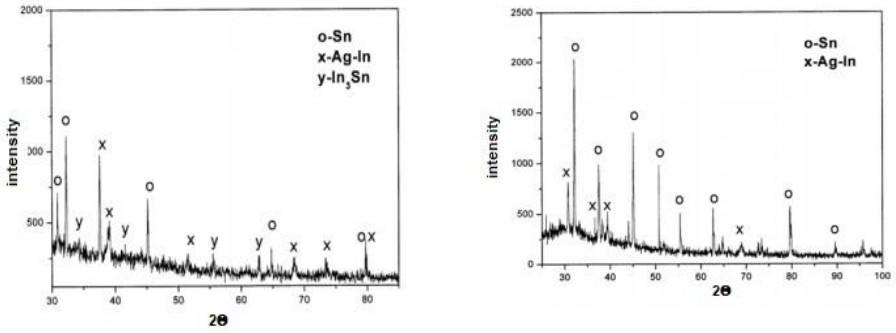
From all investigated alloys based on silver, tin and indium, XRD results for chosen ones are given in Table 2 and in Figure 1.

Table2. *XRD results of Ag-In-Sn alloys*

alloy	XRD			
	Sn	Ag-In	In_3Sn	$InSn_4$
A1	+	+	+	+
A2	+	+	+	
A3	+	+		

The XRD results pointed out that all of investigated alloys had Sn based matrix with phase rich on silver and indium. The presence of In3Sn and InSn4 phase is characteristic for alloys with higher content of indium, and in alloys with higher content of silver and indium the intermetallic compound may be formed which is confirmed by different characterization methods such as SEM-EDS, microhardness, electrical conductivity.

Also, in alloys with higher content of indium (like A1 and A2) the presence of detected In_3Sn and $InSn_4$ phases was confirmed by DSC investigations, caused by low melting In-Sn area. According to microstructural investigations and thermodynamic calculations the presence of these XRD phases was also confirmed [6].



Ag50 In15Sn35 alloy Ag70 In9Sn21 alloy

Figure 1. *XRD diffractograms of Ag-In-Sn alloys*

4. CONCLUSION

Development of multifunctional materials based on silver, tin and indium is one of the global trends in the world in terms of environmental protection, especially as lead free solder alloys. These studies are comprehensive and containing a large number of experiments, methods and analyzes, so in this paper only one part of XRD results is presented.

XRD results showed the presence of tin based matrix in all Ag-In-Sn alloys, as well as phase rich on silver and indium. The presence of possible intermetallic compounds varies in accordance with silver and indium content in alloy. Phases in low melting indium-tin area like In_3Sn and $InSn_4$ were detected too.

All of presented XRD results were confirmed by different characterization methods such as LOM, SEM-EDS, DSC etc. as well as thermodynamic optimization by Calphad method and phase diagram calculation by Pandat software.

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