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CHARACTERIZATION AND ELECTRICAL CONDUCTIVITY MEASUREMENTS OF THE Au-In-Sb SYSTEM

Dragana Živković
University of Belgrade, Technical Faculty
VJ 12, 19210 Bor,
Serbia

Lidija Gomidželović
Copper Institute
Zeleni bulevar bb, 19210 Bor,
Serbia

Vladan Ćosović
Aleksandar Grujić,
Institute of Chemistry, Technology and Metallurgy
Njegoševa 12, 11000 Belgrade,
Serbia

ABSTRACT
The Au-In-Sb system presents one among potential lead-free solder alloys, which has been investigated recently. The results of characterization of chosen alloys in the AuIn-Sb section of this system are presented in this paper including data obtained using differential-thermal analysis, optical microscopy, hardness and electrical conductivity measurements.
Keywords: AuIn-Sb system, phase equilibria, characterization

1. INTRODUCTION

Gold and gold alloys are widely applied in modern technical branches – electronics, communications, space and aero technologies, chemistry and medical science, etc. [1,2] They are known for good mechanical and thermal properties, as well as corrosion consistency. Owing to formation of low temperature eutectic with other elements, gold alloys are often used as solder alloys in electronics. Indium-based, lead-free solders alloys belong to a group of solders considered as a possible alternative to conventional Pb-bearing solders in step soldering, which are required for high density packaging of multi-chip modules demanding a number of solders with melting points over a wide temperature range.

The Au-In-Sb system belongs to the group of potential candidates for lead-free solder materials [3-5]. Therefore, mentioned gold-based system is the subject of different investigations lately [4,6-9], for its phase diagram of ternary Au-In-Sb system is of importance in predicting the interface reactions between In-based solders and Au-substrate, which can provide a tool for design a potential interface.

The results of characterization and electrical conductivity measurements of the AuIn-Sb system are presented in this paper. The investigations were performed using different experimental methods – differential thermal analysis, optical microscopy, hardness and electrical conductivity measurements.

2. EXPERIMENTAL

Investigated samples were chosen in the AuIn-Sb section of the Au-In-Sb system. The samples were prepared using metals - gold, indium and antimony of 99.99% purity. The composition and masses of chosen samples are given in Table 1.

DTA measurements have been carried out on the Derivatograph 1500 (MOM Budapest) apparatus under following conditions - air atmosphere, heating rate 10 $^oC/min$, T_{max}=1073 K. As a referent material during measurements was used Al_2O_3. The precision of the measurement in the investigated temperature interval was ±5 ^oC.

Table 1. Composition and masses of the investigated samples

Alloy	x_{Sb}	x_{Au}	x_{In}
A1	0	0.5	0.5
A2	0.05	0.475	0.475
A3	0.2	0.4	0.4
A4	0.28	0.36	0.36
A5	0.4	0.3	0.3
A6	0.65	0.175	0.175
A7	0.85	0.075	0.075

Microstructure analysis of investigated samples was performed by optical microscopy, using a Reichert MeF2 microscope (magnification 500x). Solution of 1:1 HNO_3 was applied for structure development.

Electrical conductivity of investigated materials was measured using the standard apparatus – Foerster SIGMATEST 2.069 eddy current instrument for measurements of electrical conductivity of non-ferromagnetic metals based on complex impedance of the measuring probe with diameter of 8 mm.

Hardness measurements were done using standard procedure according to Vickers.

3. RESULTS AND DISCUSSION

The results of the DTA heating measurements are presented in Figure 1. In order to test reproducibility of the results every measurement run was repeated, but no significant temperature deviation was found between the first series and repeated series of DTA measurements.

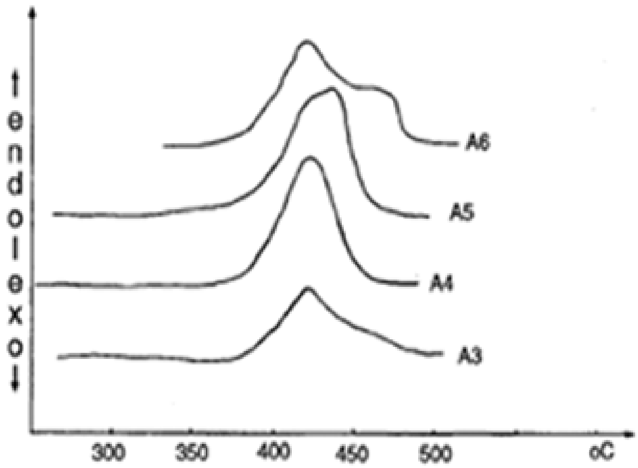

Figure 1. DTA curves for samples with x_{Sb} = 0.2, 0.28, 0.4 and 0.65(heating rate of 10° C/min, air atmosphere)

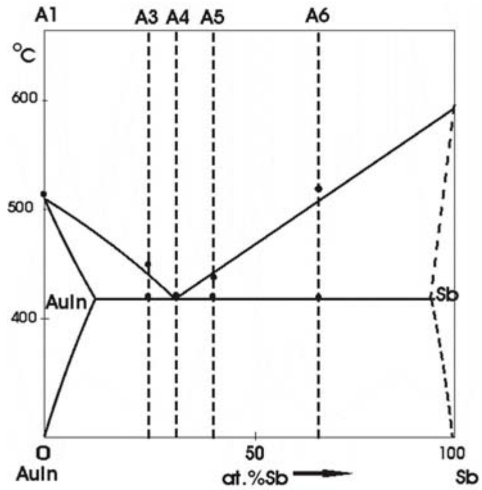

Figure 2. Phase diagram of AuIn-Sb section [8]

The quasibinary eutectic reaction L↔AuIn+Sb occurs at 420 °C in this system. The eutectic concentration was found to be 28 at% Sb. Graphical representation of the obtained phase diagram for AuIn-Sb system [8], compared with literature data [5], is given in Figure 2. It could be noticed that the phase diagram boundaries from DTA measurements in this work are in good agreement with existing literature data.

Characteristic microphotographs recorded by optical microscopy for the samples with 20, 28, 40 and 65 at% Sb are given in Figure 3. The quasibinary hypoeutectic alloys, presented in the widest part of the concentration range, solidify with the primary crystallization of the intermetallic compound AuIn (light regions) and the /Sb/-based phase (dark regions).

The results of hardness measurements are shown in Figure 4, in the form of hardness dependence on antimony composition. It may be noticed that in concentration range over x_{Sb} > 0.05 hardness decreases.

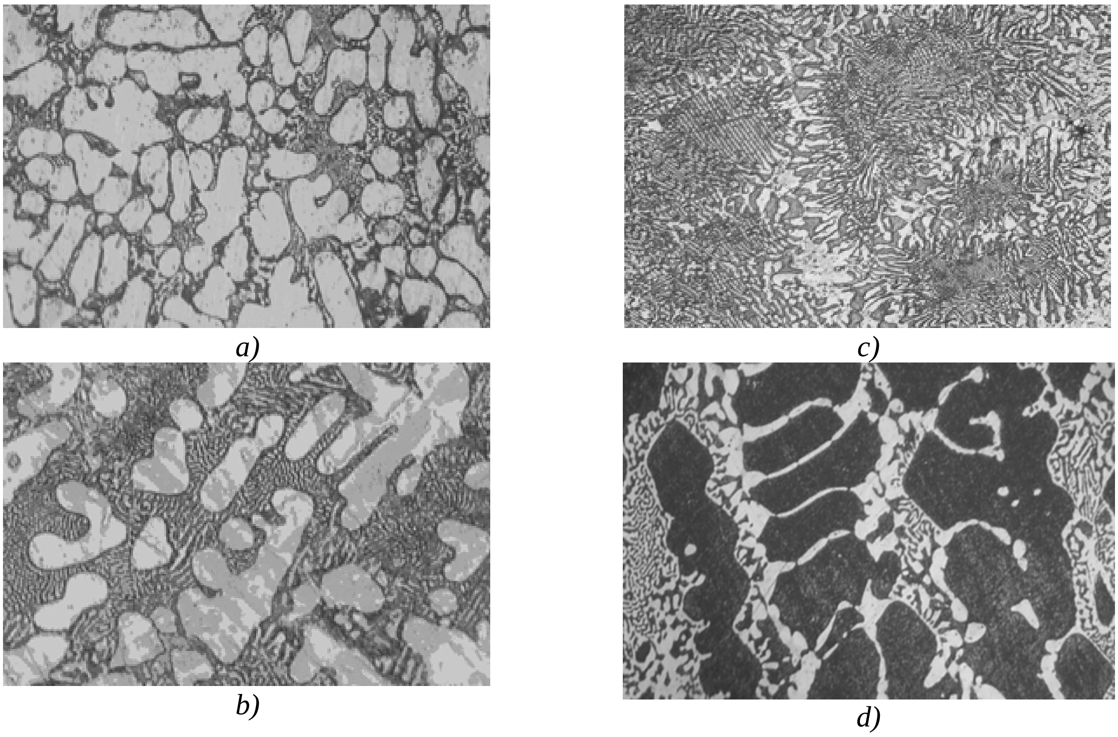

Figure 3. Characteristic optical microphotographs (500x) for: a) A3, b) A4, c) A5, d) A6

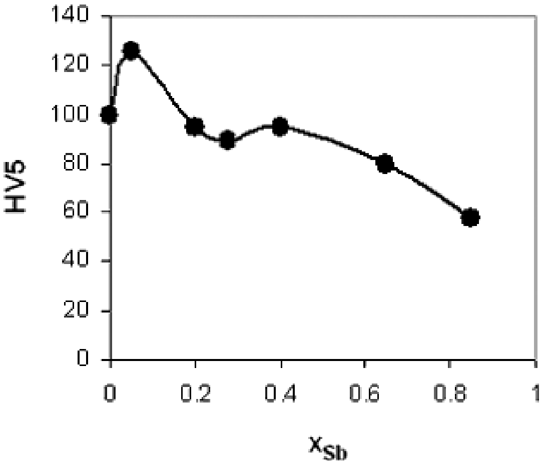

Figure 4. Hardness vs. composition for chosen alloys in the AuIn-Sb section

The results of electrical conductivity measurements are presented in Table 2 (three series of measurements) and Figure 5, where electrical conductivity dependence on composition is showed. As can be seen, the electrical conductivity decreases rapidly with antimony concentration increase in the investigated alloys.

Table 2. Measured values of electrical conductivity for investigated Au-In-Sb alloys

Alloy	**Electrical conductivity (MS/m)**		
A1	12.94	12.77	12.99
A2	7.396	7.546	7.339
A3	5.660	5.664	5.572
A4	5.533	5.522	5.536
A5	4.287	4.283	4.268
A6	2.667	2.633	2.644
A7	0.5475	0.6700	0.4948

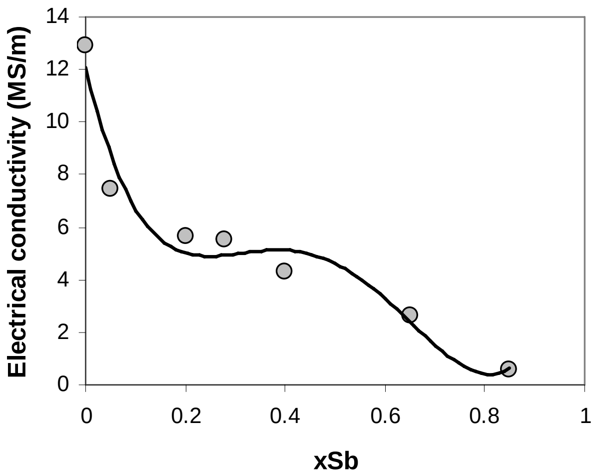

Figure 5. Electrical conductivity vs. composition

4. CONCLUSIONS

The Au-In-Sb alloys from the section AuIn-Sb has been characterized using different experimental methods, such as DTA, LOM, hardness and lectrical conductivity measurements. Based on obtained data, phase diagram of this system is constructed, showing quasibinary eutectic reaction L↔AuIn+Sb at temperature of 420 ^oC, which is confirmed by applied optical microscopy results. Measured values of hardness and electrical conductivity show rapid decrease by antimony content increase in the investigated alloys.

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