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HARDNESS, MICROHARDNESS AND ELECTROCONDUCTIVITY OF ALLOYS WITH VARIABLE Cu CONTENT IN Cu-Al-Ag SYSTEM

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Abstract

The results obtained from the experimental determination of hardness, microhardness and electrical conductivity of the selected as-cast alloys along Ag0.5Al0.5-Cu vertical section in the ternary Cu-Al-Ag system, are represented in this paper. All microhardness and hardness measurements were carried out using standard procedure by Vickers method. Electrical conductivity was determined using "Institute dr. Förster SIGMATEST 2.06" device.

***Keywords**: Hardness, Microhardness, Electroconductivity, CuAlAg Alloys*

1. INTRODUCTION

For many years various groups of materials known as smart materials, have been studied regarding their special characteristics, by different disciplines of materials science. The main characteristic of these materials is that the change of external conditions leads to a change in the properties of the materials (mechanical, electrical, structural) [1]. A part of this large group are shape memory materials which include different kinds of materials from metal alloys to textile [2-3]. It is already well known that these materials are characterized with some special properties which are unique among all kinds of smart materials such as the shape memory effect, pseudoelasticity and in some cases biocompatibility. Among many different systems, Cu-Al based alloys belong to the shape memory materials, too. These materials have been studied for a long time in details and some of them have practical application, like the alloys of the Cu-Zn-Al and Cu-Al-Ni systems, but the interest does not cease and a huge number of investigations are carried on [1-10]. Such interest is caused by the fact that beside the appropriate properties, the production of alloys are less complicated and the costs are lower comparing to the alloys of other systems [10]. So, Cu-Al based materials are very good for application in engineering, space technology, medicine, bioengineering and others.

In the frame of research conducted in order to investigate as-cast alloys of the ternary Cu-Al-Ag system regarding thermal behavior, microstructure and phase equilibria, hardness, microhardness and electrical conductivity were determined, too. Obtained results of hardness, microhardness and electrical conductivity measurements for the alloys located in the area with constant Al:Ag molar ratio equal to 1:1 and variable molar ratio of Cu of the ternary Cu-Al-Ag system, are presented in this paper.

2. EXPERIMENTAL

As it was already mentioned above, all investigations were done with as-cast alloys. Samples were prepared by induction melting under argon atmosphere with total metal losses of the masses less than 1%. The purities of the constituent metals Cu, Al and Ag were 99.99%. Obtained samples were of cylindrical shape weighing about 3g, diameter 7mm and length 20mm. The hardness and microhardness measurements were done by Vickers standard method.

Hardness was determined at load of 10, 20 and 30N while microhardness at load of 100g. Microhardness measurements were done on the PMT-3 microscope hardness meter. All measurements were done in three points for each sample. Electrical conductivity measurements were carried out on "Institute dr. Förster SIGMATEST 2.06" device.

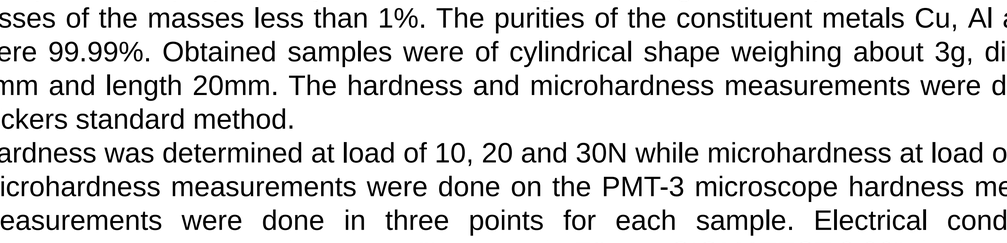
Composition and mass of selected as-cast alloys are presented in Table 1.

Table 1 - Composition and mass of investigated alloy

Sample	X_{Cu}	X_{Al}	X_{Ag}	m_{Cu}	m_{Al}	m_{Ag}
$Cu_{20}Al_{40}Ag_{40}$	0,2	0,4	0,4	0,5720	0,4858	1,9422
$Cu_{40}Al_{30}Ag_{30}$	0,4	0,3	0,3	1,1575	0,3686	1,4738
$Cu_{60}Al_{20}Ag_{20}$	0,6	0,2	0,2	1,7570	0,2487	0,9943
$Cu_{80}Al_{10}Ag_{10}$	0,8	0,1	0,1	2,3710	0,1258	0,5031

3. RESULTS AND DISCUSION

Selected alloys were located in section with variable molar ratio of Cu and equal molar ratios of Ag and Al, in ternary Cu-Al-Ag system, i.e. in the area along Ag0.5Al0.5-Cu vertical section, according to their chemical compositions. Micrographs of investigated sample alloys, obtained by optical light microscopy are presented in Figure 1.



a) b) c)

Figure 1. Microstructure of selected alloy samples (magnification 500x):
a) $Cu_{40}Al_{30}Ag_{30}$, b) $Cu_{60}Al_{20}Ag_{20}$, c) $Cu_{80}Al_{10}Ag_{10}$

3.1 Hardness measurements

Obtained results of the hardness measurement of the investigated sample alloys are shown in Table 2. The fact that various loads have been used for different samples leads to the conclusion that the maximal hardness value is measured at the sample alloy $Cu_{40}Al_{30}Ag_{30}$ at a load of 30 kg.

Table 2 - Results of the hardness measurements for selected alloy samples

Sample	HV
$Cu_{20}Al_{40}Ag_{40}$	284 (HV20)
$Cu_{40}Al_{30}Ag_{30}$	299 (HV30)
$Cu_{60}Al_{20}Ag_{20}$	149 (HV10)
$Cu_{80}Al_{10}Ag_{10}$	87,3 (HV10)

3.2 Microhardness measurements

Microhardness measurements of the selected sample alloys was carried out at a load of 100 g. Obtained results of the microhardness measurement of the investigated samples are presented in Table 3.

Table 3 - Results of the microhardness measurements for selected alloy samples

Sample	HV0.1			
	Measuring point 1	Measuring point 2	Measuring point 3	Mean values
$Cu_{40}Al_{30}Ag_{30}$	102	81	116	100
$Cu_{60}Al_{20}Ag_{20}$	211	198	216	208
$Cu_{80}Al_{10}Ag_{10}$	144	136	169	150

The maximum value of microhardness was determined for the $Cu_{60}Al_{20}Ag_{20}$ alloy sample and minimal for the alloy $Cu_{40}Al_{30}Ag_{30}$.

3.3 Determination of electrical conductivity

Values of electrical conductivity were determined only for sample alloy $Cu_{60}Al_{20}Ag_{20}$.

Table 4 - Results of electrical conductivity measurements

Alloy	Electrical conductivity (MS/m)			
	Measured values			Mean value
$Cu_{60}Al_{20}Ag_{20}$	6.5	6.1	7.1	6.566

4. CONCLUSION

As additional methods of characterization, hardness, microhardness and electrical conductivity measurements for selected as-cast alloys of the ternary Cu-Al-Ag system with variable molar ratio of Cu and equal molar ratios of Ag and Al, were carried out, too. Hardness and microhardness measurements were done by Vickers standard method. Loads of 10, 20 and 30 kg were used for hardness measurements. The maximal measured hardness value is obtained for sample $Cu_{40}Al_{30}Ag_{30}$ at load of 30 kg. Maximal microhardness was determined for the sample $Cu_{60}Al_{20}Ag_{20}$ and minimal for $Cu_{40}Al_{30}Ag_{30}$ alloy sample. Electrical conductivity was determined only for sample alloy $Cu_{60}Al_{20}Ag_{20}$ and its value was 6.566 MS/m.

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