53rd International October Conference on Mining and Metallurgy
3 - 5 October 2022, Bor, Serbia
https://ioc.irmbor.co.rs

CHARACTERISATION OF THE CuAlAg ALLOYS WITH 90 at. % Cu

Zdenka Stanojević Šimšić[1], Ana Kostov[1], Aleksandra Milosavljević[1], Emina Požega[1]

[1]Mining and Metallurgy Institute Bor, Zeleni bulevar 35, 19210 Bor, Serbia,
zdenkassh@irmbor.co.rs

Abstract

This work represents the results obtained from the microstructural characterization and experimental determination of hardness, microhardness and electrical conductivity, of the selected as-cast alloys with copper content of 90 at. %, in the ternary Cu-Al-Ag system. Microstructural characterization of the investigated alloys was done by a light optical microscopy using a Reichert MeF2 microscope. Microhardness and the hardness measurements were done usingthe standard procedure by the Vickers method. Determination of the electrical conductivity was done bythe "Institute dr. Förster SIGMATEST 2.06" device.

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

1 INTRODUCTION

Nowadays the smart materials are well known term in material science which involves different groups of materials with different properties and practical applications. It is characteristic for these materials to react to the effect of the environment, i.e., depending on the change of external conditions, there is a change in the material properties (mechanical, electrical, structural) [1]. The Shape Memory Alloys, (SMAs), are the smart materials which react to the temperature change which causes a change in structure. These materials have been studied for several decades regarding their properties which are convenient for different purposes. The CuAlAg alloys belong to this group of materials and have been studied over the last twenty years [2-7], but the scientists are still interested to study these materials further.

The results represented in this work are an addition to the characterization of the CuAlAg alloys with 90 at. % of Cu content [7].

2 EXPERIMENTAL

All investigations were done with the as-cast alloy samples of the 99.99% purities of the constituent metals, Cu, Al and Ag. Samples preparation was done by the induction melting under the argon atmosphere with the total metal losses of samples less than 1%. All alloys were melted and cooled repeatedly due to the improvement of compositional homogeneity.

A study of the microstructure of the investigated alloys has been done by a light optical microscopy using a Reichert MeF2 microscope. The applied magnifications were 200 and 500. The hardness measurements were carried out using the Vickers standard method at a load of 10N. The microhardness values were measured by the Vickers standard method, on a PMT-3 microscope hardness meter at load of 100g. The electrical

conductivity measurements were carried out on the "Institute dr. Förster SIGMATEST 2.06" device.

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

Table 1 *Composition and mass of investigated alloy samples*

Sample	X_{Cu}	X_{Al}	X_{Ag}	m_{Cu}	m_{Al}	m_{Ag}
A1	0.9	0.02	0.08	4.3090	0.0407	0.6503
A2	0.9	0.04	0.06	4.4168	0.0833	0.4999
A3	0.9	0.06	0.04	4.5299	0.1282	0.3418
A4	0.9	0.08	0.02	4.6491	0.1755	0.1754

3 RESULTS AND DISCUSSION

Investigated the as – cast alloys, A1, A2, A3 and A4, which compositions are given in Table 1, belong to the section with 90 at. % of copper, according to their chemical compositions and calculated phase diagram [7]. On the basis of calculated vertical section with 90 at. % of copper, (Figure 1), the phases that exist in the investigated alloys are the copper-based solid solution, (Cu) and silver-based solid solution, (Ag), [7].

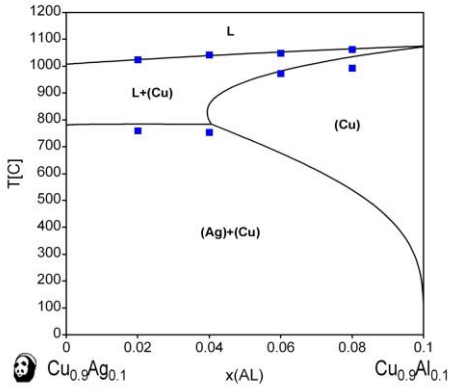

Figure 1 *Calculated vertical sections of the Cu-Al-Ag ternary system with the constant copper content of 90 at. % compared with the DTA results [7]*

Microstructure of the investigated alloys are presented in Figures 2 – 4, respectively.

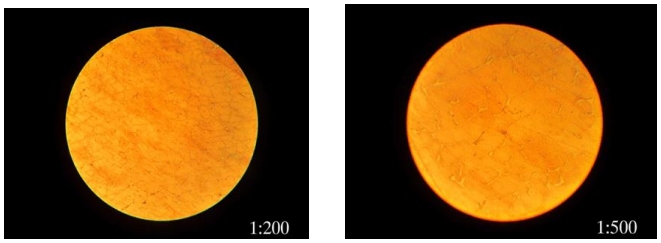

Figure 2 *Sample alloy A1 ($Cu_{90}Al_2Ag_8$)*

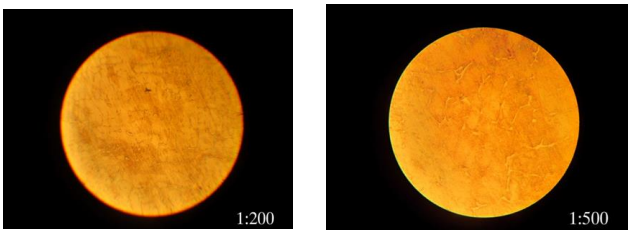

Figure 3 *Sample alloy A2 ($Cu_{90}Al_4Ag_6$)*

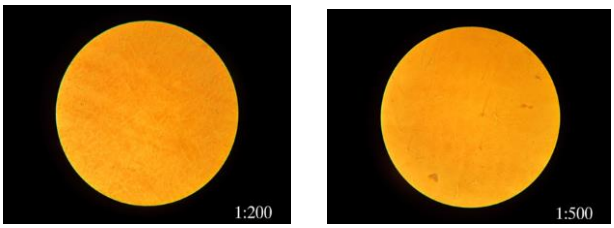

Figure 4 *Sample alloy A3 ($Cu_{90}Al_6Ag_4$)*

The microstructure of copper-rich alloy samples (90 at. % Cu), presented in Figures 2 - 4, consists of the primary crystals of solid solution on the basis of copper (Cu) and solid solution on the basis of silver (Ag), in the form of a precipitate along the edges of copper crystals.

3.1 Hardness measurements

Presented values of the measured hardness of the investigated alloys along the vertical section with 90 at. % Cu, show a lower value of hardness at higher values of aluminum content.

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

Sample label	Sample	HV10
A1	$Cu_{90}Al_2Ag_8$	67.7
A2	$Cu_{90}Al_4Ag_6$	67.5
A3	$Cu_{90}Al_6Ag_4$	60.7
A4	$Cu_{90}Al_8Ag_2$	54.2

3.2 Microhardness measurements

The lowest values of microhardness were measured in the alloy A4 ($Cu_{90}Al_8Ag_2$), and it was measured at three measuring points, respectively 58, 60, 56 HV0.1 as it can be seen in Table 3.

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

Sample label	Sample	HV0.1		
		Measuring point 1	Measuring point 2	Measuring point 3
A1	$Cu_{90}Al_2Ag_8$	95	103	116
A2	$Cu_{90}Al_4Ag_6$	111	109	109
A3	$Cu_{90}Al_6Ag_4$	109	101	98
A4	$Cu_{90}Al_8Ag_2$	58	60	56

3.3 Electrical conductivity

The measured values of electrical conductivity are shown in Table 4. The alloy $Cu_{90}Al_2Ag_8$ was with the highest value of electrical conductivity.

Table 4 *Results of the electrical conductivity measurements for selected the as-cast alloy samples*

Sample label	Sample	Electrical conductivity (MS/m)		
A1	$Cu_{90}Al_2Ag_8$	13.8	14.4	12.2
A2	$Cu_{90}Al_4Ag_6$	9.4	9.9	9.7
A3	$Cu_{90}Al_6Ag_4$	7.7	7.4	7.4
A4	$Cu_{90}Al_8Ag_2$	6.1	5.8	6.7

4 CONCLUSION

This work represents the results obtained from the microstructural characterization and experimental determination of hardness, microhardness and electrical conductivity of the selected as-cast alloys with copper content of 90 at. %, in the ternary Cu-Al-Ag system. Microstructural characterization of the investigated alloys was done by the light optical microscopy. The microstructure of the investigated alloys, consists of the primary crystals of solid solution on the basis of copper (Cu) and solid solution on the basis of silver (Ag), in the form of a precipitate along the edges of copper crystals. All microhardness and hardness measurements were done using the standard procedure by the Vickers method. The alloy with the lowest aluminum content and the highest silver content (A1) was with the highest value of electrical conductivity. The lowest hardness and microhardness values were measured in the alloy A4 ($Cu_{90}Al_8Ag_2$).

ACKNOWLEDGEMENTS

This work was done with the financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia, within the financing of scientific research work at the Mining and Metallurgy Institute Bor, according to the Contract No. 451-03-68/2022-14/ 200052.

REFERENCES

[1] I.N. Qader, M.K.F. Dagdelen, Y. Aydogdu, A Review of Smart Materials Researches and Applications, El-Cezerî Journal of Science and Engineering, 6 (3) (2019) 755-788.
[2] K. Otsuka, K. Shimizu, Y. Suzuki, Y. Sekiguchi, C. Taki, T. Homma, S. Miyazaki, Splavi s Effektom Pamjati Form, Metallurgija, Moskva, 1990, p. 123. (In Russian)
[3] M.O. Göka, M.Z. Bilira, B.H. Gürcüm, World Conference on Technology, Innovation and Entrepreneurship, Procedia - Social and Behavioral Sciences, 195 (2015) 2160-2169.
[4] W. Witusiewicz, U. Hecht, S. G. Fries, S. Rex., J. Alloy. Comp., 385 (2004) 133-143.
[5] A.T. Adorno, R.A.G. Silva., J. Alloy. Comp., 473 (2009) 139-144.
[6] U. Böyük, N. Marasli, E. Çadırlı, H. Kaya, K. Keslioglu., Curr. Appl. Phys., 12 (2012) 7-1
[7] Z. Stanojević Šimšić, D. Živković, D. Manasijević, T. Holjevac Grgurić, Y. Du, M. Gojić, S. Kožuh, A. Kostov, R.Todorović, Journal of Alloys and Compounds 612 (2014) 486-492.