CORRELATION BETWEEN MICROSTRUCTURE AND PROPERTIES OF SILICONIZED BRONZES

Zoltan MARKOS[1]

Abstract: *The study shows some test results about siliconized biphasic tin bronzes. The siliconizing thermochemical treatment has been done in sealed boxes, in a powdery medium with paste. Depending on treatment parameters, different thickness and chemical composition diffusion layers have been obtained. After the microstructural investigations using scanning electronic microscopy and electron probe microanalysis, the Si and Sn atoms diffusion mechanism and the correlation between microstructure of the diffusion layer and properties of siliconized bronzes were established.*

Key words: *siliconizing, bronze, diffusion layers properties.*

1. Introduction

The siliconizing thermo-chemical treatment aims at obtaining diffusion layers enriched in silicon for pieces surfaces in order to improve the corrosion resistance.

The special alloyed bronzes with Si, besides the high mechanical properties, show a very good corrosion resistance in different acids, alkali, seawater etc. Some examples of such components are: gears, bushings, plain bearing etc.

The main of thermo-chemical treatment siliconizing appliance for Cu-Sn alloys is to obtain same structure components in diffusion layer with higher mechanical characteristics and a better wear and corrosion resistance.

The paper presents the correlation between the parameters of treatment and the structure and properties of diffusion layer.

The obtained structures in the layer are composed of a Cu-Si-Sn solid solution mixed whit other chemical compounds, including Cu_2Si, Cu_3Si, Cu_5Si, Sn_5Cu_6 etc. which enable to enhance the mechanical properties of the treated samples [1].

2. Experimental Details

The experimental tests were done at different temperatures, namely 600 °C, 650 °C and 700 °C, during 4 hours. The siliconizing process has been produced in sealed boxes, in a pulverous environment with paste [2].

To carry out the experimental tests, these prismatic samples (10x10x12 mm) were utilized, made of Cu-Sn14 STAS 197/1-80. The active paste has been obtained at ferro-silicon (with 73% Si, having a granulation smaller than 0.2 mm), with soda water glass. The activating agent employed was ammonium chloride. The experimental tests were carried out in a furnace.

Biphasic bronzes have within their structure a solid solution α and eutectic (α+δ) [4]. The α phase is a solid solution of tin

[1] Dept. of Materials Engineering and Welding, *Transilvania* University of Braşov.

substitution in Cu in a face centered cubic lattice. The δ phase from eutectic is an electronic compound ($Cu_{31}Sn_8$) presenting a high hardness.

From Cu-Si diagram [4] on can observe that Cu dissolves Si up to a concentration of 11…12 at%, forming a substitution solid solution, in a face centered cubic lattice.

After the thermo-chemical treatment at different temperatures, the diffusion layers were checked in some micro sections that have been created in order to carry out the observation by optical microscopy and electron probe microanalysis [3]. Also, the micro hardness of constituents was measured.

3. Results and Discussion

Figures 1 and 2 show the repartition of elements (SiK, SnL and CuK) in two points.

The electron probe microanalysis results for every analyzed point for the siliconized samples are presented in Table 1.

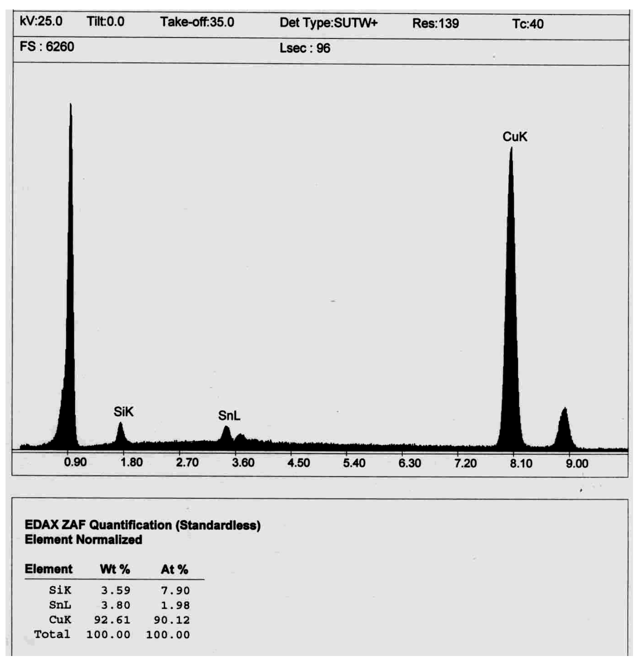


Fig. 1. *The microanalysis results for siliconizing at 650 °C*

The electron probe microanalysis results Table 1

Temperature	El. At %	Distance from margin to core [mm]										
		0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5
600 °C	Si K	10.54	9.57	6.68	1.37	0.77	-	-	-	-	-	-
	Sn L	0.92	1.26	4.94	7.10	7.40	-	-	-	-	-	-
	Cu K	88.54	89.17	88.38	91.53	91.83	-	-	-	-	-	-
650 °C	Si K	8.50	7.90	7.79	8.04	6.60	5.93	4.87	4.67	4.12	2.30	-
	Sn L	1.94	1.98	1.99	2.41	2.77	2.73	3.46	3.92	4.17	8.14	-
	Cu K	89.56	90.12	90.22	89.55	90.63	91.3	91.6	91.4	91.7	89.5	-
700 °C	Si K	4.67	4.61	4.56	4.91	4.35	4.22	4.50	4.16	3.65	2.87	1.42
	Sn L	3.66	3.50	3.80	3.83	4.07	4.45	5.09	5.52	6.41	7.09	7.56
	Cu K	91.69	91.89	91.64	91.26	91.56	91.3	90.4	90.3	89.9	90.0	91.0

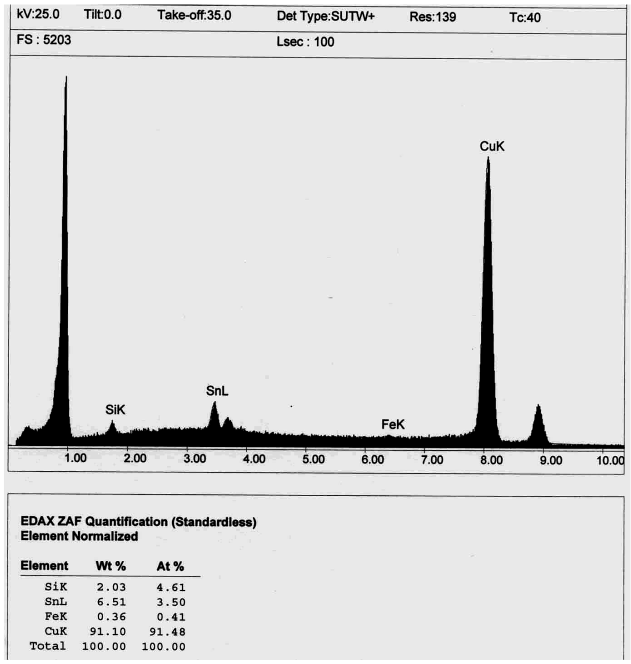
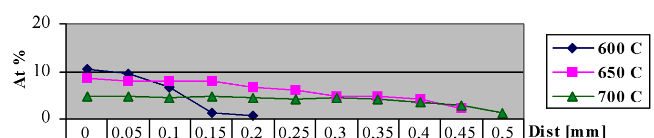


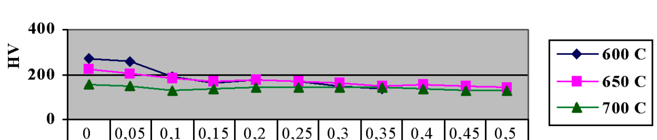
Fig. 2. *Microanalysis results for siliconizing at 700 °C*

The repartition of Si in diffusion layers at different siliconized temperatures is presented in Figure 3. One can observe that the treatment temperature has great influence over the thickness and the Si concentration of the siliconized layer. Within the 600 °C (Table 1), it is possible to obtain a diffusion layer of which content of Si should approach



Dist [mm]	0	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5
600 C	10,5	9,57	6,68	1,37	0,77						
650 C	8,5	7,9	7,79	8,04	6,6	5,93	4,87	4,67	4,12	2,3	
700 C	4,67	4,61	4,56	4,91	4,35	4,22	4,5	4,16	3,65	2,87	1,42

Fig. 3. *Si repartition in diffusion layer*



Dist. [mm]	0	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5
600 C	274	256	188	165	176	171	149	134			
650 C	221	203	181	168	179	171	166	152	159	147	139
700 C	157	149	131	135	139	141	145	139	135	130	127

Fig. 4. *The variation of microhardness in diffusion layer*

the silicon solubility limit in a copper (11…12 at % Si). At 700 ^{o}C the thickness of diffusion layer growth, but the Si concentration decreases.

The Si concentration influences the hardness of layer (Figure 4). At 600 ^{o}C the micro hardness is within the interval 274…188 μHV. At 700 ^{o}C, the silicon concentration in layer is smallest and the micro hardness is within the interval 157…135 μHV.

4. Conclusion

By siliconizing, the treatment parameters have a great influence on properties of diffusion layers. It is adequate to choose the temperature which assures the highest concentration of Si in diffusion layer (600 ^{o}C). The high concentration of Si ensures also high hardness (274…188 μHV) what improve the wear resistance of siliconized pieces.

References

1. Markos, Z., et al.: *Studii şi cercetări privind silicizarea bronzurilor* (*Studies and Researches Concerning Bronzes Silicising*). In: Proceedings of the International Conference on Materials Science and Engineering, BRAMAT'01, Braşov, Vol. II, 2001, p. 341-344.
2. Markos, Z., Florea, R.: *Influence du procede de chauffage sur les resultats d'enrichissement de silicium.* In : Buletinul Universităţii Braşov, Vol. XXXI, Part II, 1989, p. 159-165.
3. Markos, Z., Szabo, P.J.: *The Influence of Temperature on Diffusion Mechanism at Bronze Siliconizing*. In: Proceedings of the International Conference on Materials Science and Engineering, BRAMAT'03, Braşov, 13-14 March 2003, p. 139-143.
4. Massalski, T.B.: *Binary Alloy Phase Diagrams.* Second Edition. ASM International, USA, 1990.