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PHYSICAL-CHEMICAL PROPERTIES OF (Cu-Sn) -Mo COMPOSITE MATERIALS

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ABSTRACT

The article is devoted to the study of corrosive and thermal stability of materials composition on the basis of copper, obtained by the EB-PVD method.

It is shown in this work that corrosion of (Cu-Sn)–Mo composites have got the electrochemical mechanism from dissolution of a more active metal of molybdenum. Chemical composition of composite material affects corrosive properties of material: at the increase of maintenance of molybdenum in the copper matrix corrosive and thermal stability is decreasing, in comparison with the pure copper. The special decreasing of the corrosive stability is definite during concentration of molybdenum of about 12.56 %. This is explained by the considerable increase of quantity of micro-galvanic pairs.

KEYWORDS: Composite Materials, Corrosive and Thermal Stability

1. Introduction

Traditional lower alloying copper based alloys, the so-called bronzes, are used for manufacturing electric contacts, as they are poorly sensitive to overheating, give in well to welding and soldering, are corrosion stable in atmospheric conditions, have high elastic properties and electrical conductivity. At the same time, contacts that do not contain silver in their composition based on copper and molybdenum, which were obtained by a method of electron-beam vaporization and the subsequent condensation in vacuum have begun to be used recently for their efficiency and reliability [1,2]. In consideration of sufficiently high corrosion properties of tin bronzes, on the one hand, and high technical characteristics of Cu-Mo composites, on the other hand, obtaining of (Cu-Sn)-Mo composite materials condensed of a vapor phase for electric contacts with a small amount of tin doping (to 3.76 wt.%) to the copper matrix and the study of their corrosive and thermal stability are of a great interest.

2. Description of experiment

Condensed materials (Cu-Sn) -Mo of a plate-form with dimensions of 350x250x (0.8... 1.2) mm were obtained through a method of electron-beam vaporization and subsequent condensation in vacuum [3]. The content of molybdenum in condensates varied from 0 up to 12.56 %. The tin, which enters the composition of a copper matrix in amount of 3.76 %, forms solid solutions with copper [4].

Corrosive stability of condensates was studied by a gravimetric method [5]. Samples of the area 1 cm^2 were placed in a corrosive medium (distilled water) during 100 hours after preliminary clearing and degreasing. The sample control of weight changes for each sample was realized every 20 hours. Research work was carried out under static conditions. Analysis of a corrosive stability in atmospheric conditions was supplied by the thermal analysis of composite of different molybdenum doping up to the temperature of 1000^{o}C.

Condensates of Cu-Mo system are a mixture of two noninteracting metals. The results of our previous research works of Cu-Mo composites prove that molybdenum doping in a copper matrix decreases corrosive stability of condensates of a Cu-Mo system for a little and mechanical characteristics are improved significantly [6].

The research of composite (Cu-Sn)-Mo materials shows that the corrosive stability of composites depends on the contents of molybdenum. With the increase of molybdenum concentration up to 12.56 % weight loss increases also (fig. 1)

This phenomenon is connected to the flow of the electrochemical corrosion that is the result of several coupled reactions: molybdenum and copper oxidation, formation of Mo_2O_3 and MoO_3, Cu_2O and CuO oxides. According to the data that the oxygen enters the water environment in a stationary mode in

insignificant amounts, molybdenum and copper oxidation occurs very slowly up to steady oxides of MoO_3 and CHO. It is necessary to note, that with increase of the contents in molybdenum system up to 12.56 % the processes of oxidation accelerate, pointed out by the increase of weight losses (fig. 1, curve 4). As a result of aeration increase of the environment in dynamic conditions the oxygen concentration in water increases, the process of oxidation accelerates. The oxide formation on a surface brings about the increase of samples weight, and as the molybdenum concentration grows in condensates, far more intensively molybdenum oxide formation occurs, therefore weight losses for a composite with the molybdenum contents in amount of 12.56 % are the lowest (fig.2, curve5).

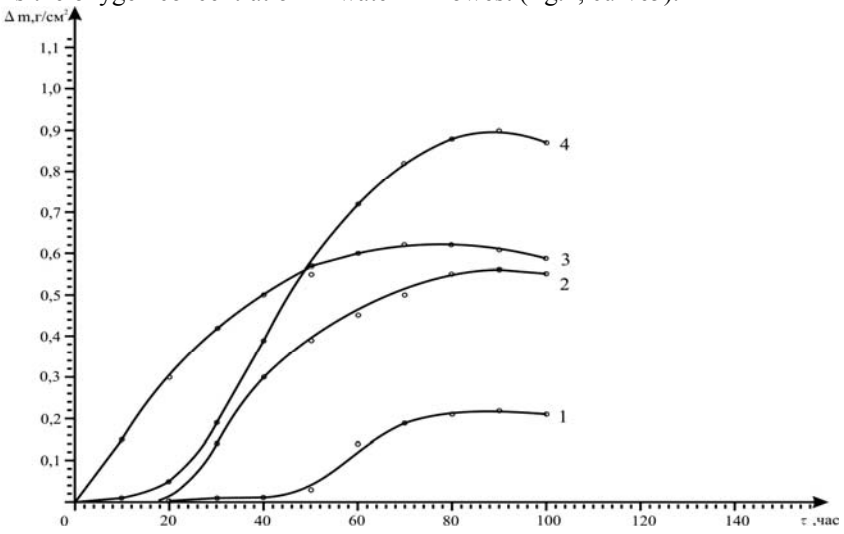

Fig. 1. *Change of a condensate weight (Cu-3.76%Sn)-Mo in stagnant distilled water depending on the content of molybdenum: 1 - (Cu-3.76%Sn); 2 - (Cu -3.76%Sn) -1.82%Mo; 3 - (Cu-3.76%Sn) -4.28%Mo; 4- (Cu-3.76%Sn) -12.56%Mo*

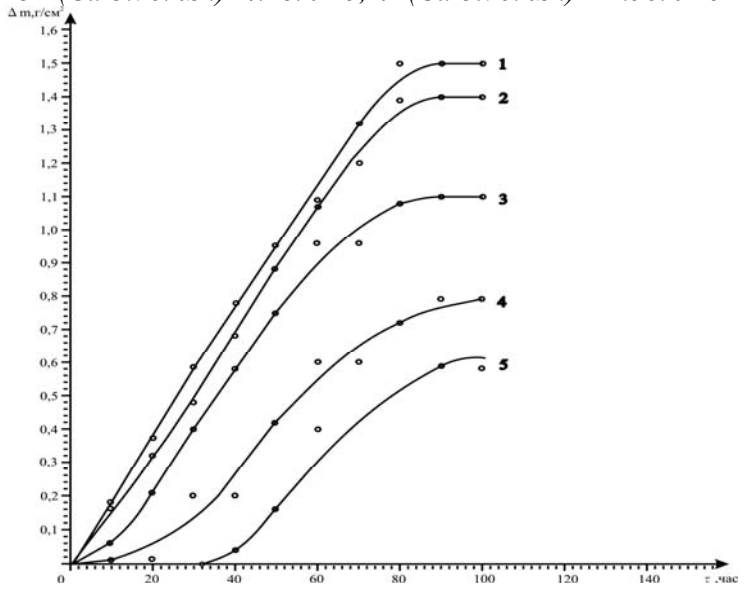

Fig. 2. *Weight change of condensates (Cu-3.76%Sn)-Mo in mobile distilled water depending on the molybdenum contents: 1 - (Cu-3.76%Sn); 2 - (Cu-3.76%Sn) -1.82%Mo; 3-(Cu - 3.76%Sn)-4.28%Mo; 4-(Cu - 3.76%Sn)-8.53%Mo; 5- (Cu-3.76%Sn) - 12.56%Mo*

Determination of the level of the composites thermal stability for the performance of the condensation process was studied perform of a 390-650 mg was taken, was placed in a platinum crucible and then thermal stability of a composition of (Cu-Sn) -Mo was observed in a range of temperatures (up to 1000^{o}C). A stability rating of the diphase condensed materials was made by differential thermal analysis

and differential thermal gravimetry with a sensitivity of 1/5 and 1/10 according to the derivatograph ОД-103 system Paulic - Paulic - Erden with a speed of heating 10^{o}C/min. As it can be seen from Fig. 2 with the increase of molybdenum concentration up to 12.56 % in (Cu-Sn) -Mo system significant changes of thermal stability are observed. Since temperature is of 70^{o}C, there is an oxidation process following oxide formation of SnO, which proceeds by a small speed (0,16 mg/min) for all molybdenum concentrations and is expressed by endothermic peaks (at temperature range of minima 70 and 100^{o}C). These results are well conformed to the literary data, from which it is known, that the formation of tin oxide (II) is accompanied by heat absorption (ΔH = 349.6 joule/mole). In a temperature range of 100-500^{o}C the reduction of the weight of samples is observed on DTG curves caused by tin oxide (II) presence which exists in metastable state at low temperatures and decomposes at temperatures higher than 400 ^{o}C under the scheme [7]:

$4\ SnO = Sn_3O_4 + Sn.$

In process of concentration growth of more refractory molybdenum component, there is a reduction of weight losses (Fig. 3).

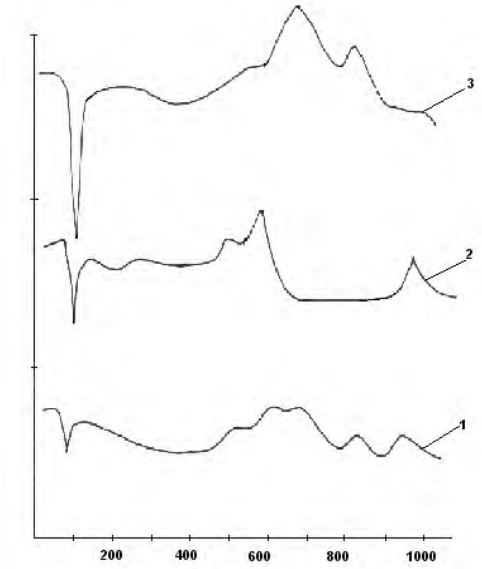

***Fig. 3**. DTG curve of (Cu-3,76%Sn) -Mo system: 1 - (Cu-3,76%Sn) -1,82%Mo; 2- (Cu-3,76%Sn) -4,28%Mo;3-(Cu-3,76%Sn) -12,56Mo*

The absence of the effect at the temperature range of 600^{o}C on a DTG curve for pure copper allows us to draw the conclusion that exothermic peaks on DTG curves correspond to the process of molybdenum oxidation. Characteristic property for the given systems is the multistage character of oxidation and different speed of oxidation at separate stages of the process.

The process of oxidation begins in the temperatures range above 550^{o}C, at which the speed of oxidation is 0.4 mg/min and increases up to 1,0 mg/min at the temperature of 650 ^{o}C. Weight of samples thus grows. That fact draws our attention upon the introduction of small amounts of molybdenum doping in condensates strongly increasing the system oxidation speed and samples weight in the range of high temperatures. To compare characteristics of oxidation process it is expedient to carry out the analysis of thermal behaviour of objects with various molybdenum concentrations at temperature of 750^{o}C, which correspond to the end of oxidation process of the system. The comparison of results shows, that with the increase of molybdenum doping in (Cu-Sn) -Mo system the weight of samples and speed of oxidation process grow up to 3.2 mg/min, i.e. the thermal stability of system reduces a little.

3. Conclusion

The investigation of (Cu-Sn) -Mo composite materials corrosion was made by Gravimetric method. It is shown that, with the increase of molybdenum concentration at the constant tin contents (3.76 %) weight losses in system are increased.

With a help of DTG method it is shown that from the temperature of 70^{o}C there begins a formation of tin oxide, which is accompanied by endothermic peaks.

It is established that a speed of oxidation process of (Cu-Sn) -Mo composite materials grows up to 3.2 mg/min with the increase of the molybdenum contents up to 12.56 %.

References

[1]. **Grechanyuk I. N., Grechanyuk, V.G., Rudenko I.F., Sviridova T.N. -** *Destruction of Composite Material Cu-Mo-Y-Zr in water environments* // Electrical contacts and electrodes. – Kiev: Naukova Dumka, 1999. - P. 125 - 134.

[2]. Grechanyuk I. N., Grechanyuk, V.G., Emelyanov B.M., Rudenko, I.F. - *Corrosion of Composite Materials based on copper, used for electrical contacts* // Electrical contacts and electrodes. - Kiev: Naukova Dumka, 1998. - P. 140 – 144.

[3]. Movchan B.A, Malashenko I.S. - *High-Temperature Coat Besieged in Vacuum*. - Kiev: Naukova Dumka, 1983 - 230 p.

[4]. *Diagram of a condition of binary metal systems* // the Directory under edited by Lyakisheva N.I.. - t. 2, 1997. - P. 323-326

[5]. *Unified technique of laboratory tests of the efficiency of corrosion inhibitor in water systems*. - Riga: Institute of Inorganic Chemistry AS Lithuania SSR, 1980. - 29 p.

[6]. Grechanyuk V.G., Topal V.I., Emelyanov B.M., Grechanyuk N.I., Zabolotskaya D.K., Pushechnikova L.V. - *Influence of molybdenum contents on the depth of corrosion damages and structure of a surface layer of condensates Cu-Mo* // Problems of Special Electrometallurgy. - Kiev: Naukova Dumka, 1987. – P. 27-30

[7]. *Physico-chemical properties of oxides* // the Directory. Under edition of Samsonov G.V. - M.: Metallurgy, 1978. - P. 429.