

TENSILE STRENGTH OF Cu-Cr ALLOY AT ELEVATED TEMPERATURE

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Lucrarea prezintă rezultatele analizelor metalografice și ale încercărilor mecanice efectuate asupra aliajului Cu-Cr (1%gr.Cr) la temperatura camerei și la temperatura de 300°C. Aliajul studiat este utilizat la confecționarea contactelor electrice. Aliajul a fost elaborat într-un cuptor cu inducție, plecând de la prealiaj Cu-25 %gr. Cr și Cu electrolitic. Analizele de microscopie optică sunt corelate cu încercările la tracțiune realizate la temperatura camerei și la temperatura de lucru a contactelor electrice (300°C).

The paper presents the results of micrograph analyses and mechanical tests of Cu-Cr (1%wt. Cr) alloys at home and at 300°C temperature. This alloy is used for made contact materials. The alloy (Cu-1wt.%Cr) was prepared by vacuum induction melting, starting with a master alloy with nominal composition of Cu-25 wt.% Cr and electrolytic copper (99,99%). Optical microstructure is correlated with tensile strength at 25°C and at 300°C (work temperature for electric contact).

Keywords: master alloy, electric contact, mechanical tests

1. Introduction

Copper-base contact materials have been used for their combination of high thermal and electrical conductivities.

Their main applications are: components for X-ray tubes, filaments, welding electrodes, electro voltaic solar cells with high conversion efficiency and primary for electric contacts [1].

Electric contacts for arc breaking close the circuits and lead the current, temporary or for long time. Also, they have the aims to open again the closed electrical circuits and to interrupt the electric current. Conditions are severe: high mechanical strength (tensile strength, elasticity); high electric and thermal conductivity; low and constant electric resistance; wear resistance; good corrosion resistance. It is impossible to satisfy all these requirements. A solution is to

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choose the material for every application by a compromise between the limited properties of high performance materials and the wanted properties [2].

For the moment, the best solution is to make electric contacts from two components: electric button (active components of electric contact) fabricated from ternary pseudo alloy, W-Ni-Cu (obtained by powder metallurgy) and contact support, fabricated from binary alloys Cu-Cr [3].

In this configuration the first component assures high resistance to electric arc and the second assures the high and constant mechanical properties (tensile strengths and elasticity) of the contact.

In the present work we study the microstructure and mechanical properties of a selected Cu-Cr alloy. This alloy can be strengthened by precipitation of Cr phase in a copper matrix by heat treatment.

According to the Cu-Cr binary diagram (Fig.1) when the content of Cr is between 1,7 and 40% at., the ordinary microstructures of as cast sample consist of b.c.c. Cr-rich dendrites distributed in an f.c.c. Cu-rich solid solution matrix.

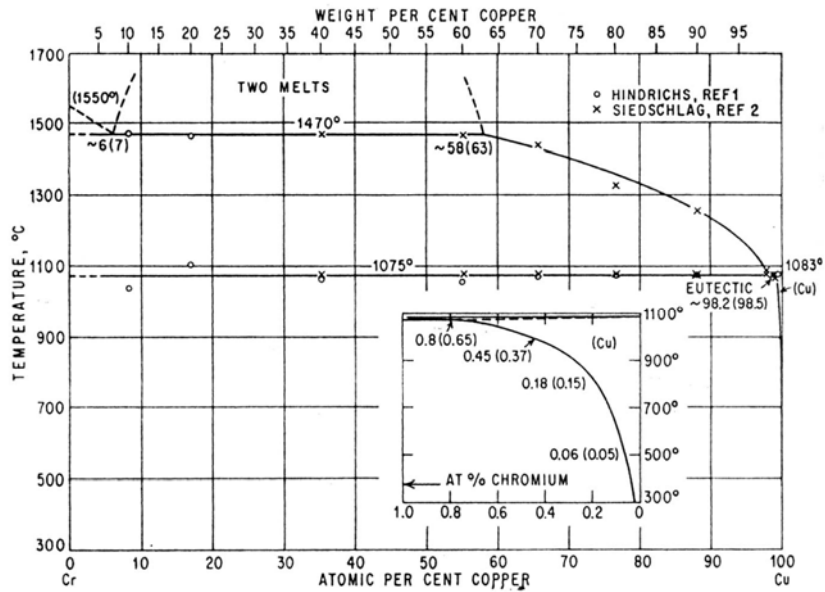


Fig. 308. Cr-Cu

Fig.1. Cu-Cr binary phase diagram [4].

2. Results and discussion

Starting with a master alloy with nominal composition of Cu-25 wt.% Cr and electrolytic copper (99,99%) we prepared by vacuum induction melting a Cu-1wt.%Cr alloy. The microstructure of Cu-25%wt.%Cr master alloy is presented in Fig. 2.

The microstructure of the sample was examined using an optical microscope NEOPHOT.

The samples were etched in a solution of 40 vol.% HNO₃ with water in balance.

The optical micrograph illustrates the microstructure of the master alloy prepared by vacuum induction melting – coarse dendrites of primary Cr-rich phase and fine interdendritic eutectic.

Morphology of Cr in Cu-Cr (1wt.% Cr) alloys depends on Cr contents (short bar, dendrite chromium). When Cu-Cr alloy has a hypereutectic composition, the microstructure of the alloy comprises primary α -Cu, dendritic Cr and an eutectic microconstituent.

The microstructure of Cu-Cr alloy containing 1wt.% Cr is presented in Fig.3.

It is known that the type, size and distribution of chromium particles have a strong effect on the mechanical properties of Cu-Cr alloys.

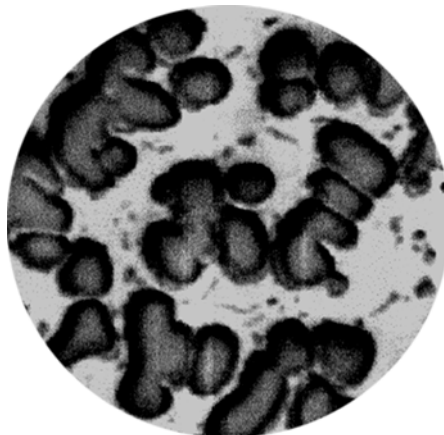


Fig. 2. Optical micrograph of Cu-25%wt.%Cr master alloy (x 100; gray, Cr-rich; light, Cu-rich)

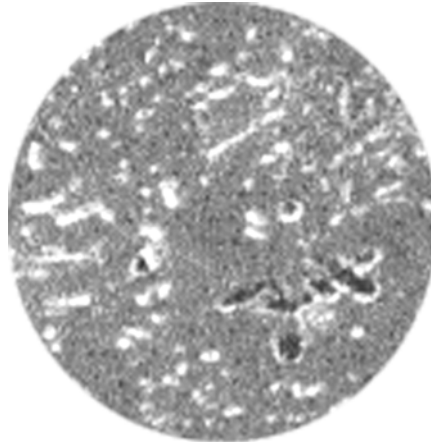


Fig. 3. Optical micrograph of Cu-Cr alloy containing 1% Cr. (x 100; gray, Cr-rich; light Cu-rich).

We prepared samples for tensile test at room temperature and also at 300°C. The samples were solute treated for 3 hours at 1000°C and afterwards they were aged at 475°C for 4 hours.

For sake of comparison in Table 1 we present the mechanical properties of Cu compared to Cr at elevated temperature [5]; the tensile strength of Cr is much higher than that of Cu at the same temperature.

Table 1

Mechanical properties of Cu compare to Cr at elevated temperature.

Temperature (°C)	Tensile strength [daN/mm ²]	Elongation (%)
25	(21-42)/ 84	(10-50)/ 0
200	(12-14)/23,5	(10-50)/0
300	(10-12)/15,5	(10-50)/3

The tensile strength of Cu-Cr alloys (1wt.% Cr) decreases with rising the test temperature, similar to most alloys. Table 2 present the tensile strength vs. temperature of Cu-Cr (1wt.% Cr) alloys.

Table 2

Mechanical properties of Cu-Cr (1%wt. Cr) alloys at room temperature and at 300°C.

Samples	Solute treating temperature/time [°C/h]	Age treating temperature/time [°C/h]	Test temperature		
			room temperature		300°C
			Tensile strength [daN/mm ²]	Elongation [%]	Tensile strength [daN/mm ²]
1	1000/3	475/4	34.2	9	25.8
2	987/3	478/4	34.3	9	25.2
3	990/3	468/4	33.5	10	26.1
4	996/3	470/4	33.0	10	25.9
5	1010/3	472/4	34.8	9	26.4
6	1005/3	472/4	32.0	10	25.7

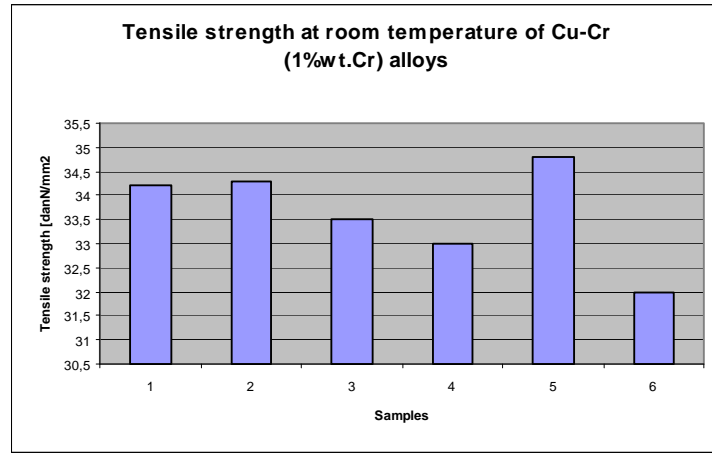


Fig. 3. Tensile strength for 6 determinations of Cu-Cr (1%wt. Cr) alloys at room temperature. Average value for tensile strength is about 33,6 daN/mm².

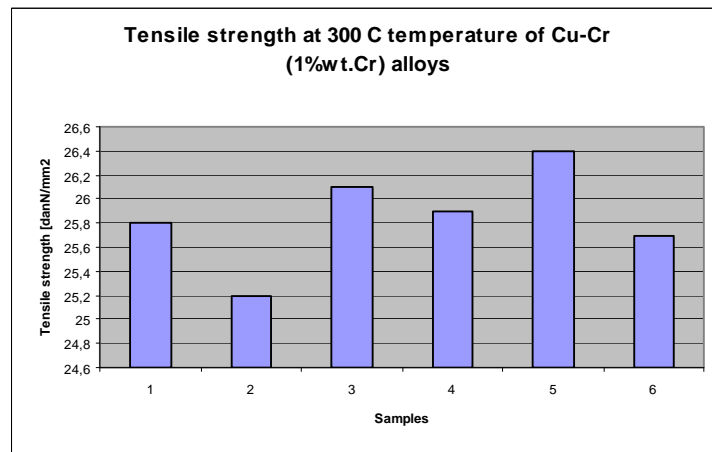


Fig. 4. Tensile strength for 6 runs of Cu-Cr (1%wt. Cr) alloys at 300°C temperature. Average value for tensile strength is about 25,8 daN/mm². The tensile strength decreases nearly 25% while temperature increases from 25°C to 300°C.

3. Conclusions

1. A procedure was proposed for preparing Cu-1% wt Cr alloys that proved to lead to good and uniform mechanical properties required by the applications of such alloys as severely stressed electrical contacts.
2. The good and uniform mechanical properties were the consequence of the fine microstructure obtained when the Cu-1% wt. Cr alloys were prepared

by vacuum induction melting from electrolytic copper (99.99) and a master alloy of nominal composition Cu-25% wt. Cr.

3. The measured values of the tensile stress for the heat treated Cu-1% wt. Cr alloys showed very little dispersion both at room temperature as well as at the service temperature (300°C).
4. At 300°C temperature, the tensile strength decreases nearly 25% in comparison with room temperature measurements.

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