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Creep of Cu-V and Cu-Ti alloys, obtained by reactive milling.

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Abstract – The effect of TiC and VC nanocarbides developed in situ by reactive milling in a copper matrix, on the temperature-softening resistance and creep behavior of the alloys was studied; also the types of employed mills (atrittor and Spex) were considered. The best results were obtained for the copper alloy reinforced with TiC carbides and produced in a Spex mill. Explanations of the observed mechanical behavior are given, based in observations by X-rays diffraction and by high-resolution electron microscopy.

Reactive milling (RM) has shown to be an efficient process to produce an *in-situ* dispersion of nanoceramic in a copper matrix, thus improving the materials creep performance [1]. Results of our research group have shown that such alloys can be strengthened by a dispersion of TiC y Al_2O_3 nanoparticles, and that at about 500°C the predominant creep mechanism is the dislocation detachment from particle-matrix interface, within copper grains [1].

In this work, the effect of different alloying elements (Ti or V) and of the type of employed mill (Spex or atrittor) on the microstructure and on the temperature-softening resistance and creep behavior of copper base alloys prepared by RM is studied. In an atrittor mill, a Cu-V alloy was prepared, milling for 30 h at 500 rpm, while in a Spex mill, Cu-V and Cu-Ti alloys were produced, milling for 10 h at 1.200 rpm. In all cases, toluene was employed as milling media, to provide the C necessary for the *in-situ* formation of carbides (VC or TiC). The target was always to obtain 5 % volume percent (vol.%) of carbides in copper. The milled powders were then encapsulated under vacuum and consolidated by extrusion at 750 °C.

As shown in Table 1, after milling, composition, grain size (DRX) and dislocation density (DRX) of powders were measured; from V and Ti compositions, the (maximum) theoretical amount of carbides that could be formed in each alloy was calculated. For an evaluation of the alloys softening resistance under high temperatures, the alloys were heat treated at different temperatures for 1 h and their room-temperature microhardness was then measured. As seen in Fig. 1, the Cu-V alloy prepared in the Spex mill is harder than the Cu-V alloy prepared in the atrittor mill, even though the latter material contained a higher amount of V and, accordingly a lower amount of VC is expected. It is also there observed in Fig. 1 that, among the three alloys under study, the TiC one, prepared in the Spex mill, is the one that presents the higher softening resistance and hardness. Creep results at 500 °C are show in Fig. 2 where it can be observed that they are in general good agreement with the above softening ones. Thus, again the Cu-Ti alloy, prepared in the Spex mill, presents the highest creep resistance. Having into account that this Cu-Ti alloy is the one that should present (theoretically) the lower amount of carbides volume fraction, this behavior could be ascribed to a finer dispersoid and grain size and a higher dislocation density and dispersoid temperature stability in the Cu-Ti alloy (see Table 1).The mechanical results are discussed in relation with microstructural observations performed by transmission electron microscopy of high resolution and X-rays diffraction.

Table I: Chemical analysis (weight %); estimated vol.%; grain size; dislocation density in copper powders..

Alloy	Mill	V	Ti	C	N	O	Fe	%v VC	%v TiC	Grain size,nm	Dislocation density, m-2
Cu-V	Atritor	2,7	--	0,54	0,01	0,3	--	5		65	$7{,}70\times10^{15}$
Cu-V	Spex	1	--	0,5	0,01	0,32	0,13	1,9		39	$7{,}6\times10^{17}$
Cu-Ti	Spex	--	0.6	0.77	0.01	0.37	0.13		1,4	35	$9{,}6\times10^{17}$

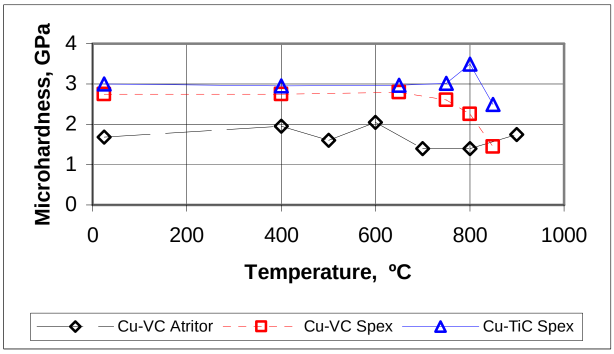

Figure 1:Hardness of copper alloys after 1h annealing

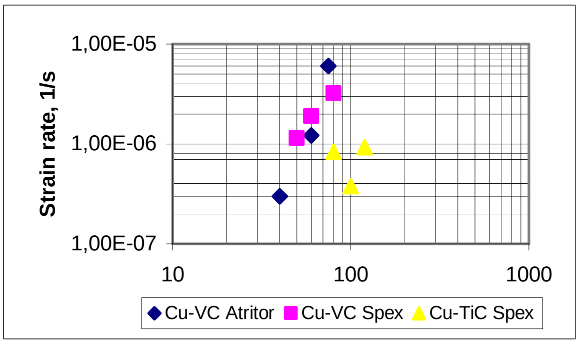

Figure 2: Creep behavior of Cu-V and Cu-Ti alloys. 500ºC.

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References [1] R.G. Espinoza, R.H. Palma, A.O..Sepúlveda, A.P. Zúñiga,.*Mater. Sci. and Eng. A*, 498 (2008) 262-269.