

IDENTIFICATION OF BERYLLIDE PRECIPITATES IN Cu-Ni-Be ALLOYS

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Nowadays, the Cu-Ni-Be alloys are used for many commercial applications such as for electronic connectors, switches and relays in electronic devices or for heat sinks^{1,2}. These applications have been possible because of the excellent combination of strength and electrical conductivity found in these alloys^{3,4}. In order to increase the strength, ductility and formability while maintaining high electrical conductivity, new thermomechanical treatments have been explored. The high strength of Cu-Ni-Be alloys is thought to be due in part to the enhanced precipitation of a nickel-rich beryllium intermetallic phases from the supersaturated solid solution but has also been attributed to the dislocation structure and texture formed after thermomechanical treatment¹⁻⁴.

This work has been conducted to study the effect of heat treatment on precipitate structure, chemistry and distribution by a combined TEM, X-ray EDS and EELS analysis. The composition of the alloy used in this study was Cu-2.2%Ni-0.6%Be after a two sequences of thermo-mechanical treatments³. X-Ray analysis were done on precipitates which were at the very edge of the hole in the thinned samples. For quantitative chemical analysis⁵, the Cliff-Lorimer K-factor approach was utilized with the following relationship $C_{Ni}/C_{Cu} = K_{Ni-Cu} (I_{Ni}/I_{Cu})$. In this expression, C_x refers to the elemental concentrations and I_x refers to the X-ray peak integral intensity. For this analysis we use the following theoretical Cliff-Lorimer constant $K_{NiCu} = 1.08$. Analyses were done on, at least, four particles of each precipitate types and the average values obtained are reported.

The microstructure of this alloy, consisted mainly of equiaxed grains with two different kinds of precipitates (Figure 1). The obtained structure and chemistry of these two precipitates are: a-Large primary precipitates of sizes in the range of 0.5 to 1.5 μm ; b-Small secondary precipitates of dimensions 5 to 80 nm (Figure 2). A simple cubic structure B2-CsCl type was observed for both primary and secondary precipitates. The final aging treatment has an effect on the size and spatial distribution of the secondary precipitates. The precipitates are randomly oriented with respect to the matrix. In both samples (samples A and B), the primary beryllides exhibited a chemistry corresponding to the composition $\text{Cu}_{1-x}\text{Ni}_x\text{Be}$ with x being 0.8 and with a lattice parameter of 0.263 nm. The secondary precipitates had a lower Ni content of 0.73 and 0.68 for samples A and B, respectively, and with lattice parameter of 0.264 nm. Since the two equilibrium γ -CuBe and β -NiBe phases of lattice parameters of 0.271 nm and 0.261 nm, respectively, are isostructural, a linear relationship between composition x and lattice parameter is assumed, viz. according to Vegard's law. The reported lattice parameter for the primary beryllide is surprising since it is larger than any value between the Cu-Be and Ni-Be phases. The structure and chemistry of secondary beryllides are similar to earlier studies except for the fact that the secondary beryllides do not exhibit any orientation relationship with respect to the matrix. Rioja and Laughlin⁶ found out that coherent secondary precipitates exists only when the precipitation sequence $\text{G.P.} \Rightarrow \gamma'' \Rightarrow \gamma' \Rightarrow \gamma$ is followed. The phase diagram for the Cu-Ni-Be system is not known but our results indicate that the aging temperatures were such that the initial metastable precipitates, the GP (Guinier-Preston) zones which establish the orientation relationships for the subsequently formed γ' (secondary precipitates), were bypassed leading to the formation of non-oriented secondary beryllides. These distribution

variations might have some effects in some properties of the alloy, e.g., the strengthening ($\approx 700\text{Mpa}$) and the electrical conductivity ($\approx 60\%\text{IACS}$).

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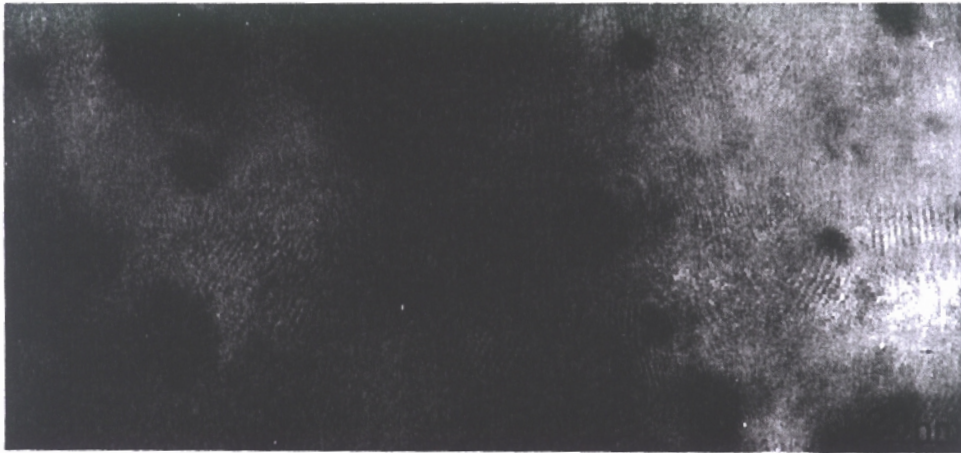


Figure 1-TEM micrograph of secondary beryllides of a Cu-2.2%Ni-0.6%Be alloy

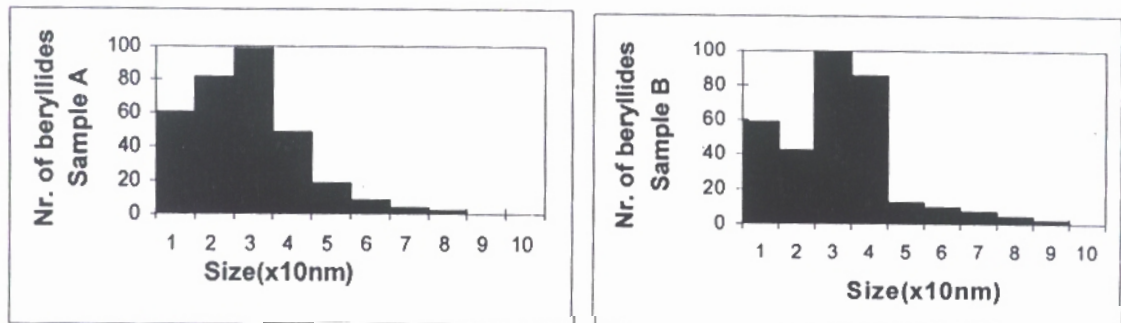


Figure 2-Size distribution profile of secondary beryllides
(Sample A $\Rightarrow T_{\text{AGING TIME}}=380^{\circ}\text{C}$; Sample B $\Rightarrow T_{\text{AGING TIME}}=425^{\circ}\text{C}$)