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Mechanical Behavior of the Polycrystalline Cu-13.7%Al-4%Ni Alloy

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Abstract – The Cu-Al-Ni alloys, based on the intermetallic Cu_3Al, belong to the large family of metallic alloys that undergo reversible martensitic transformation (RMT). Compared to the monocrystalline alloys, the conventional Cu-Al-Ni polycrystalline alloys are extremely fragile, what justifies the relevance of new production methods. On the other hand, it is very important to understand the behavior of these alloys under compression, to the appropriate use of some mechanical properties useful for their application. The polycrystalline Cu-13.7Al-4Ni alloy participates in a complex process that involves RMT, elastic and plastic deformation, under loading.

The Cu-Al-Ni alloys, based on the intermetallic Cu_3Al, belong to the large family of metallic alloys that undergo reversible martensitic transformation (RMT) and present non-elastic effects, including the shape memory effect (SME). It is known that Cu-Al-Ni monocrystals present better characteristic of SME when compared to the polycrystalline materials, which shows great fragility [1]. With the objective of improving ductility, the plasma melting technique has been explored as an alternative in the production of these alloys. The objective of this work is to understand the behavior of the polycrystalline Cu-13.7Al-4Ni alloy under compression, to the appropriate use of useful properties for their application.

In the present work a polycrystalline Cu-13.7%Al-4%Ni alloy, produced by plasma melting and injection molding was investigated. The alloy was heat treated at 850°C for 15 minutes and cooled in water at room temperature. X-ray diffraction, electrical resistance and optical microscopy analyses were used to characterize the alloy. The compressive deformation test until the fracture was performed in the specimen at room temperature in a 5582 INSTRON model machine. The fracture surface was analyzed by scanning electron microscopy. The alloy has four metastables phases: the β'_1 and γ'_1 martensitic phases, the β_1 phase of high temperature and the Al_7Cu_4Ni phase, called R phase, Fig. 1(a). The critical temperatures of RMT were determined as M_f = 31ºC, M_s = 40ºC, A_s = 43ºC e A_f = 50ºC, Fig. 1(b). It is observed inside the grains the presence of martensite plates, Fig. 1(c). The β_1 phase of high temperature is presented as phase matrix and two distinct morphologies, namely, fine needles, are characteristic for the β'_1 phase and thin in cross-V, are characteristic for the γ'_1 phase [1], Fig. 1(d). The stress – strain behavior in compression, Fig. 2(a), shows two regions. The region 1 corresponds to the elasticity of the self-accommodation martensite, reorientation of the structure inside the grains and to the elastic deformation of the martensitic structure, to 14,5% in deformation and stress of ~1080 MPa. In region 2, the sample is in the plastic deformation regime until a maximum stress of ~1200 MPa and 19,5% of deformation. There is the occurrence of intergranular fracture due to the accumulation of irreversible defects in the grain boundaries. The plane of fracture displays the *"river patterns",* typical of rupture in cracks, which is the result of propagation through the main fracture, Fig. 2(c). The alloy participates in a complex process involving the RMT, elastic and plastic deformation under compression loading.

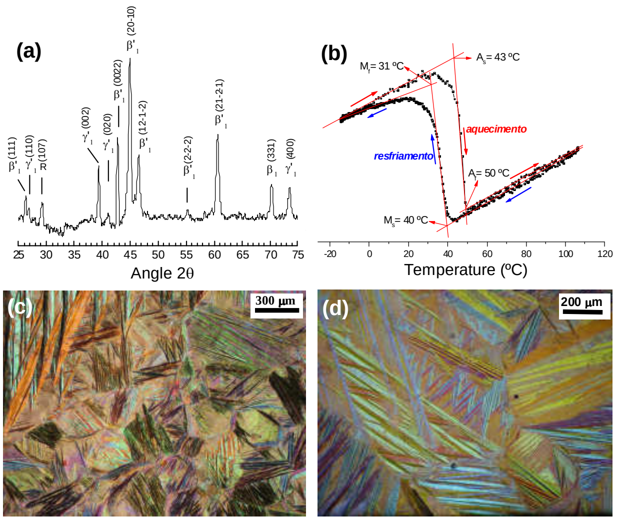

Figure 1: a) XRD patterns. **b)** Electrical resistance curve. **c)** Morphologic aspect of the alloy Cu-13.7Al-4Ni in the initial state.

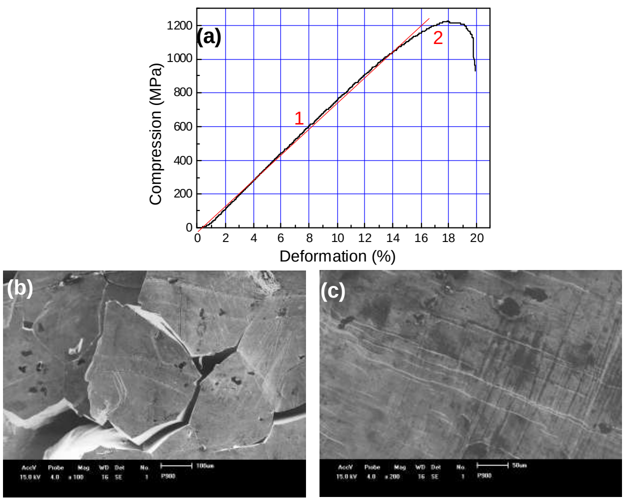

Figure 2: a) Stress - Strain curve up to fracture for the Cu-13.7Al-4Ni alloy. **b,c)** SEM micrographs of the fracture surface.

[1] K. Otsuka and C.M. Wayman, Shape Memory Materials, (1999) University Press, USA. 284p.