Influence of annealing on the microstructure of the Cu-10Ni-5.5Sn alloy

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Supersaturated solid solutions Cu-rich Cu-Ni-Sn alloys have merit the attention of many authors because they can be strengthened by aging and can be used in industrial applications where high strength and high conductivity are required1-3.

The structure and mechanical properties of a ternary alloy Cu-10wt. % Ni-5.5 wt. % Sn (Cu10Ni5.5Sn hereafter) has been studied. The sample has been prepared by melting a stoichiometric mixture of pure Cu, Ni and Sn and the as-cast alloy was homogenized at 800 ºC for 10 days in argon atmosphere and then quenched from this temperature to room temperature. The XRD diagram of the ingots obtained by this way pointed out that the sample was constituted by a single cubic α phase. The Rietveld fitting of the Xray diagram show that the samples present preferred orientation along the (1 1 0) axis. The microcharacterization from the structural and chemical point of view the alloy before and after treatments at 350 ºC during 2 hours under N_2 were analysed with TEM and ED techniques.

The obtained result before treatment are presented in figure 1, the TEM micrograph shows a lot of dislocations and the corresponding EDP indicates that the alloy is formed by two different phases even though it was not visible in the microstructure, one is the copper itself along the $[110]_{Cu}$ zone axes (dot EDP) The other one is a nanocrystalline structure of $CuNiO_4$ (ring EDP, ref. code 004-0836).

Figure 2 shows the ED obtained results of the alloy after aging at 350 °C. The electron diffraction patterns show satellite spots or superstructure maxima, in order to identify the source and crystal structure of the superlattice; several lattice sections were obtained varying the g vector.

The EDP along the $[001]_{Cu}$ zone axis (fig. 2a) presents the maxima belonging to the Cu subcell (***Fm-3m***) and satellite spots flanking the $\{200\}_{Cu}$ reflexions. However the shape of these satellites is different (fig. 3b): scattering peaks appeared at $(010)_{Cu}$; $(1½0)_{Cu}$ elongated along the $[h00]_{Cu}$ direction (blue marked) and $(100)_{Cu}$; $(½10)_{Cu}$ elongated along $[0k0]_{Cu}$ (red marked) indicating that there is disorder in such reciprocal directions. The third type of spots appears at $(110)_{Cu}$ without elongation (green marked). The existence of satellites along the [001] direction in reciprocal space indicate the presence of <100> composition fluctuations in real space. It is known that the DO_{22} structure give rise to satellite spots and superlattice reflexions at $\{1\ 1/2\ 0\}_{Cu}$ positions in the *f.c.c.* reciprocal lattice[4-5] and similar, however in this case the elongated maxima indicate that the structure is not very well ordered in the stretched out direction.

Fig 3c,d is a EDP along $[011]_{Cu}$ and all the maxima can be indexed in the DO_{22} structure (***Pm3m***) keeping the elongated directions in (100) like in the [001] zone axis and (0-11).

Maintaining the (0-22) maxima, two different zone axes appear: [111] (fig. 2e,f) and [211] (fig. 2g,h). In the first one a lot of diffuse scattering can be observed that look like satellites surrounding the main spots that belongs to a Cu subcell. Some of those satellites are stretched out and can be indexed in the DO_{22} structure and the others are round and scattered appeared at $(4/3\ 2/3\ 2/3)_{Cu}$

Finally, in the second one, the [211] zone axis, it was observed that the -204 vectors were subdivided into four equal parts in reciprocal space and scattered elongated peaks appeared at {-1/2 0 1) positions of the disordered fcc reciprocal lattice. The other diffused round maxima appeared at $(-1/2\ -1/2\ 3/2)_{Cu}$.

The ED results of this study indicate that in several regions of the ternary alloy Cu-Ni-Sn the $(cu_xNi_{1-x})_3Sn$ with DO_{22} structure nucleate heterogeneously, however this structure is not very well ordered as the elongated diffuse scattering shows.*References*

References

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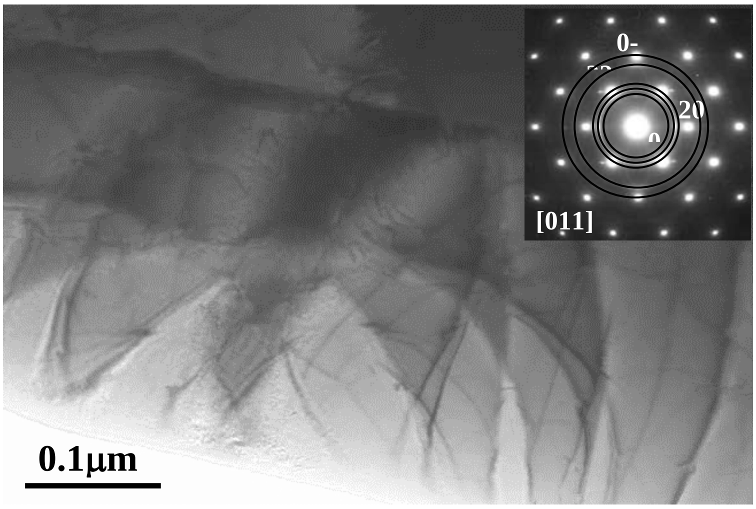

Figure 1. *TEM BF micrograph and the corresponding EDP of the Cu-10Ni-5.5Sn alloy before aging. The EDP spots are coming from the single copper crystal along the $[011]_{Cu}$ zone axes and the EDP rings from the $CuNiO_4$ nanocristals.*

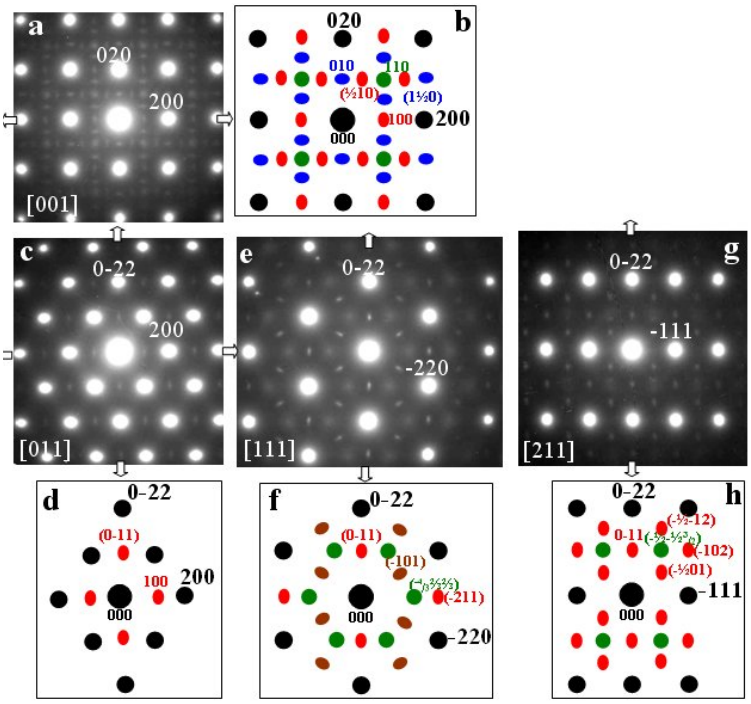

Figure 2. *EDPs and TEM results corresponding to the Cu-10Ni-5.5Sn alloy after aging at 350 °C during 2 hours under N_2. The ED patterns along four different zone axes show superstructure maxima related with the DO_{22}-$(Cu,Ni)_3Sn$ phase.*