SPINODAL DECOMPOSITION IN Cu-Fe ALLOYS

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The Cu-Fe phase diagram indicates solid-state immiscibility at low temperatures; however non-equilibrium processing such as melt-spinning or mechanical alloying are able to produce supersaturated CuFe solid solutions in all the composition range, with an fcc structure for Fe contents lower than 60at% and a bcc structure for higher Fe contents. Upon heating, these metastable solid solutions decompose into the equilibrium Cu-rich fcc and Fe-rich bcc phases [1,2].

In the present work we report on the nanostructures and phase decomposition observed by transmission electron microscopy in melt-spun Cu-Fe alloys. The alloys with a nominal composition of (Cu80Fe20)99B3 were prepared by induction melting Cu, Fe (and B) of 99.99 % purity in quartz tube under argon; the alloys were then melt-spun also under argon, onto a copper wheel turning at about 80m/s. The ribbons were thinned by ion-beam milling and examined in a 120kV Philips CM120 microscope equipped with a EDAX microanalyses system.

Figs. 1 and 2 show TEM bright field micrographs of the melt spun ribbon. Within the Cu matrix many Fe rich areas can be found; in Fig.1 such an area corresponds to the dark drop-like region and in Fig.2 to the elongated ellipsoidal region. The fine structures observed within these globules have already been reported elsewhere [3].

Clear evidence of a spinodal decomposition process in this system is given in the TEM bright field micrograph of Fig.3. A modulated or lamellar structure, with a modulation period of about 9 nm, is observed in a different Fe-rich area embedded in the Cu matrix.

Nano-beam electron diffraction observations indicated that the matrix has an fcc structure, corresponding to (110) zone axis in the orientation used for the micrograph of Fig.3, and that the region with the modulated structure has two sets of diffraction patterns. The first nano-diffraction pattern corresponds to the fcc matrix (110) zone axis while the second pattern corresponds also to an fcc structure but to the (123) zone axis. This result together with EDS nanoprobe chemical analysis indicates that the Fe layer in the modulated structure has a metastable fcc structure (γ-Fe) which resulted from the spinodal decomposition process of the undercooled Fe-rich regions during liquid quenching.

References

Fig. 1. TEM bright field micrograph of the melt spun Cu-Fe ribbon.

Fig. 2. TEM bright field micrograph of the Cu-Fe ribbon. Darker region is Fe-rich.

Fig. 3. TEM bright field micrograph with the modulated structure which resulted from spinodal decomposition in Fe-rich regions. The diffraction pattern corresponds to the matrix.