High-magnetic-field annealing on Microstructure and Mechanical Properties of Cu-Fe and Cu-Ag composites

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Introduction

Cu-based in-situ composites have attracted considerable attentions due to their achievable high strength and conductivity [1]. Numerous investigations have indicated that annealing or aging played an important role in the microstructure redistribution and enhancement of properties [2] [3]. Magnetic field annealing might affect the nucleation and growth of precipitate because magnetic field can affect convection and phase transformation in these systems.

Experimental

Cu-Ag was casted with and without high magnetic field (HMF) and then cold drawn. Cold -rolled Cu-Fe composites were heat treated at 285°C, 400°C, and 500°C for 2 hours with and without 25T HMF at NHMFL cell 7 DC resistive magnet. Post-magnetic field annealed samples were further cold-rolled to 99.2% reduction in area. Microstructure and hardness were examined using the facilities at NHMFL.

Results and Discussion

The hardness of rolled Cu-Fe samples is shown in Fig. 1 as a function of annealing temperatures. With increasing annealing temperatures, the hardness decreased in most of the rolled Cu-Fe composite. This might be related to the coarsening of α-Fe fibers. At deformation reduction of 95%, the hardness of samples treated under 25 T was lower than that under 0 T. At higher reduction, the hardness of samples under 25 T was much higher than that under 0 T. These changes in trend might be a result of the impacts of HMF annealing on strain-hardening. In Cu28wt%Ag composites, we found that an external 12 T HMF decreased the spacing of nano-sized Ag precipitates by 24% because of the increased growth velocity of Ag precipitates during the subsequent solid reaction after casting [4].

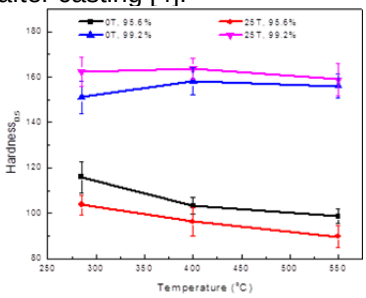

Fig. 1 The hardness of samples with and without 25T high magnetic field

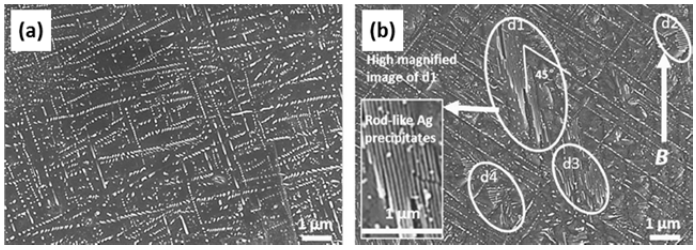

Fig. 2 SEM images of Cu28%Ag alloys (a) without magnetic field, (b) with a 12 T high magnetic field

Conclusions

Hardness of as-rolled Cu-Fe composite is related to the annealing temperatures and magnetic fields. The 25-T magnetic field annealing appears to increase strain-hardening rate in Cu-Fe composite. In Cu28 wt%Ag composites, magnetic field decreased the spacing of nano-sized Ag precipitates.

Acknowledgements

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References

[1] Biselli C., *et al*. Acta mater., **44**, 493-504 (1996).
[2] Wu Z. W., *et al*. Journal of alloys and compounds, **467**, 213-218 (2009).
[3] Qu L., *et al*. Materials Science and Engineering A, **528**, 2532-2537 (2001).
[4] Zuo X. W., et al. Materials Science and Engineering A, 619, 319-327 (2014).