Heat Treatment on Properties of Cu-Fe High Strength Conductors

K. Han, L. Qu (FSU, NHMFL); X. Zuo (Northeastern University, PR China, NHMFL); L. Zhang (NEU); E. Wang (NEU)

Introduction

Cu-Fe composite is an important high strength conductor because of its relatively low cost and low melting temperature (making it is easy to cast the alloy) compared to other high strength composite conductors [1]. However, Cu-Fe composite has relatively high electrical resistivity because Fe may be trapped in Cu matrix as a solid-solution during the casting. Annealing treatment during the deformation process is an important method to promote precipitation of Fe from the solid solution, thereby improving the electrical conductivity of Cu-matrix composite conductors. We report our recent work on heat treatment on properties of Cu-Fe conductors.

Experimental

Cu-15 vol.% Fe composites produced by cold deformation were annealed for 1 h at various temperatures. The electrical resistivity, tensile strength, and microstructure were studied by four-probe technique, an MTS mechanical testing machine, and scanning electron microscopy (SEM), respectively. The Fe solubility in Cu-matrix was estimated from the saturation magnetization of the composites.

Results and Discussion

Fig. 1 shows the relationship between the mechanical strength and the electrical conductivity (%IACS= International Annealed Copper Standard) of the Cu-15 vol.% Fe composites heat-treated for 1 hour at various temperatures. Below 500°C, the electrical conductivity increases with increasing annealing temperatures, and then rapidly decreases with the annealing temperatures. The mechanical strength decreases with annealing temperature. Consequently, the strength-conductivity curve in Fig. 1 shows a reversed “C” shape and is different from other high strength conductors, such as Cu-Nb. This result indicates that Cu-Fe composites must be processed below 500°C if low electrical resistivity is desired. Our solubility measurement results reveal that the resistivity of impurity scattering from dissolved Fe is the major contributor to the resistivity of the composites if the phonon and dislocation scattering contributions to the electrical resistivity are considered to be constant. At annealing temperatures below 500°C, an increase of filament spacing (Fig. 2), reduction of interface area in unit volume, and precipitation of the Fe from the solid solution result in an increase of electrical conductivity with temperature. Above 500°C, Fe solubility in Cu-matrix increases rapidly with temperature, which directly results in a decrease of electrical conductivity.

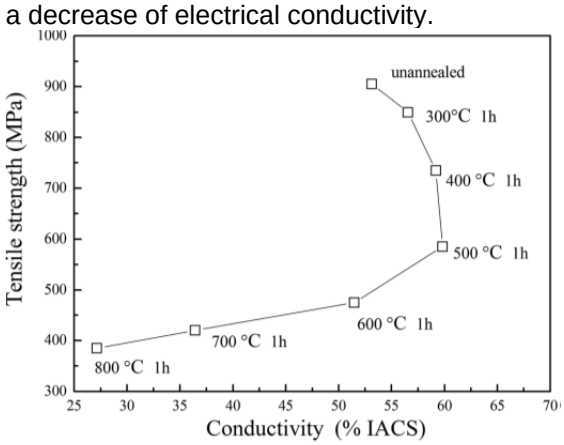

Fig. 1. Relationship between tensile strength and electrical conductivity of Cu-15 vol. % Fe composites annealed at various temperatures.

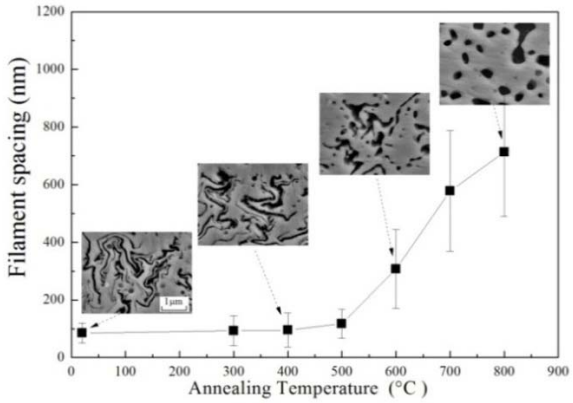

Fig. 2. Fe filament spacing and microstructure as a function of the annealing temperatures of Cu-15 vol.%Fe composites.

Acknowledgements

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References

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