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Bending induced recrystallization in CuAg conductor

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Introduction

During the manufacture of the magnets, nanostructured composite conductors with rectangular cross section are wound to small-diameter coils (less than 15 mm), and undergo large bending strain. The maximum bending strain even exceeds the elongation of conductor wires, which may cause premature failure. To understand the bendability of nanostructured composites, we conducted ex-situ bending test to analyze strain evolution near the outer side surfaces.

Experimental

Rectangular CuAg wire with a nominal cross section of 3.0 x 6.0 mm^2 with corner radii of 0.6 mm was made in the MagLab. To measure the microstrain, multiple Knoop indentations (Tukon 2100 microhardness tester) were marked across the 3 mm-thick surface on the wire. The values of indent diagonal length before and after bending were compared. Since failure does not occur on the compressive side, strain analysis was focused on the tension side. The microstructures were characterized using scanning electron microscope (SEM), sub-angstrom TEM/STEM (scanning transmission electron microscope, JEM, ARM200F) on cross sections.

Results and Discussion

CuAg wire was bent around the 6.3 mm pin to 173˚. In **Fig. 1**, the SEM images show the diagonal evolution of #1 indent after bending. #1 indent is about 0.4 mm from the outer surface of bending. No evident plastic deformation was observed on #1 indent. The long and short diagonal dimensions of indent were parallel and perpendicular to the wire axis. Bending true strain was determined to be around 45%, and outer surface bending true strain was extrapolated to be 53%, which far exceed the true strain measured from reduction-in-area (RA) of fracture (27~39%). **Fig. 2a** shows the deformation bands along the wire axis before bending. The average deformation bands or Ag fiber spacing is in the range of 18 nm. After bending, recrystallization was observed in coarse deformation bands, as seen in **Fig. 2b** indicated by white arrow. The occurrence of recrystallization during wire bending resulted in the release of the accumulated defects (high density of dislocations, dislocation-cell, etc), and reduced stored energy, which is responsible for the outstanding wire bendability.

Conclusions

The bending plastic deformation strain has been related to reduction-in-area at fracture [1]. However, the bending strain measured by knoops indentation method exceeds the RA of CuAg wire. The exceeded portion of bendability results from the recrystallization accompanying the severe bending deformation.

Acknowledgements

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References

[1] Han, K., *et al.*, IEEE Trans. Appl. Supercond., **26**, 8400804 (2016).

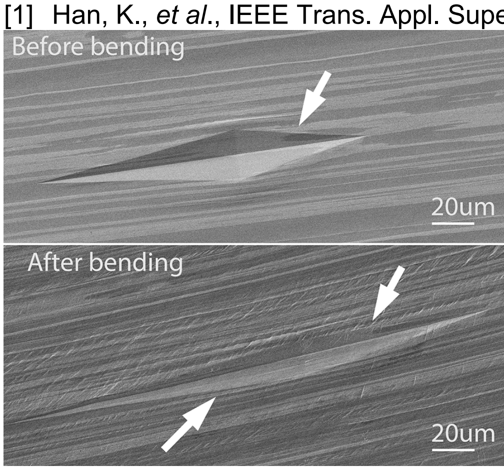

Fig. 1 #1 indent evolution before and after wire bending 143º

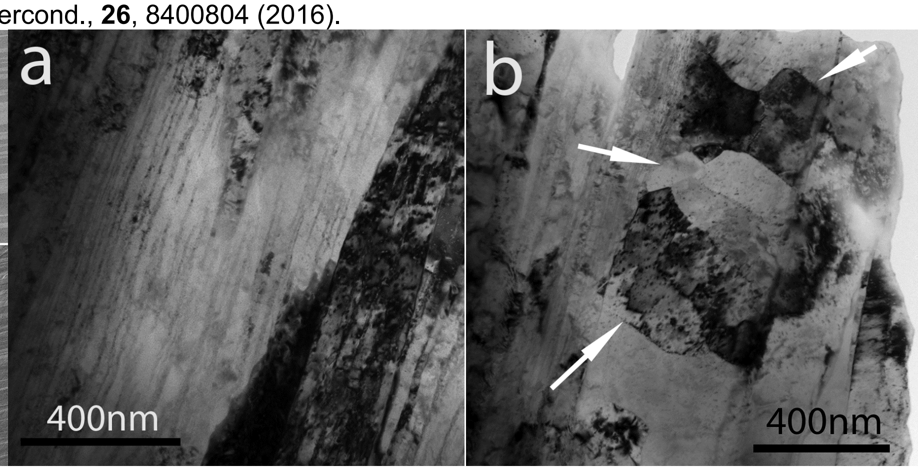

Fig. 2 a) fine deformation bands in high strength CuAg wire. b) recrystallization formed in coarse bands after bending deformation.