STRUCTURE AND TRANSPORT PROPERTY OF NANOLAMINATE Cu/Nb COMPOSITE FOILS BY A SIMPLE ONE-STEP FABRICATION ROUTE

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Introduction

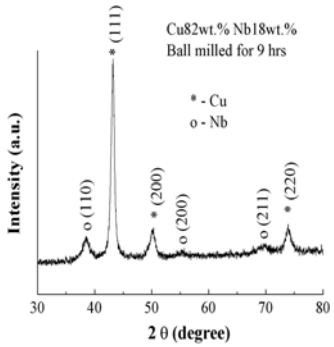
Cu-Nb composites show a unique combination of mechanical and transport properties and are therefore suitable materials for high-field resistive and pulsed magnets. [1,2] There are several established fabrication routes for multifilamentary wires, multilayered thin films and bulk sheets of Cu-Nb composites. [1, 2] They include the arc melting- hot extrusion - cold drawing route [1, 2] and cyclic bundling- hot extrusion- cold drawing route, [1, 2] consolidation of cryomilled Cu/Nb powders, [3] magnetron sputtering [4] etc. All of these approaches require complicated and labor-intensive fabrication procedures. [1-4] This paper reports a simple one-step approach to fabricate bulk Cu/Nb composite foils with a unique nanolaminate structure. The bulk samples were directly made by continuous high-energy ball milling at room temperature without any subsequent consolidation, heat treatments and severe plastic deformation required in any other established methods. [1-4]

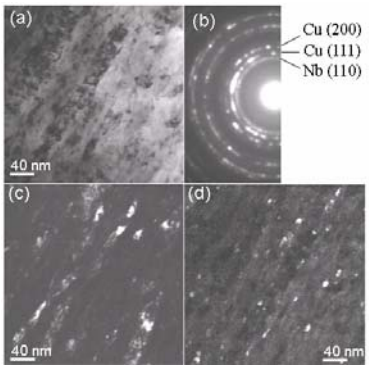
Experimental

Cu82wt.%Nb18wt.% composite bulk foils were prepared by continuous ball milling of a mixture of elemental powders of Cu and Nb in ultra-high purity argon for 9 hrs at room temperature. The as-milled foil samples were examined by X-ray diffraction, scanning and transmission electron microscopes, conventional four-probe technique, and Vickers hardness tester.

Results and Discussion

The as-milled Cu82wt.%Nb18wt.% sample shows $(111)_{Cu}$ and $(110)_{Nb}$ out-of-plane textures (see Fig.1), which was not reported in the ball-milled alloys. Bulk composite foils with nanolaminate Cu/Nb structure were obtained directly from the ball milling for 9 hrs (see Fig.2). The nanolamellae align along the foil longitudinal direction. Cu nanolamellae consist of elongated Cu nanograins while Nb nanolamellae consist of parallel bands of discrete Nb nanoparticles. The average thickness of individual lamella is about 25 nm for Cu and 6 nm for Nb, respectively. The average grain sizes of Cu and Nb are 10 and 6 nm, respectively. As-milled foil shows a hardness of 445 HV. It is distinct from reported works that superconductivity with low T_c ~ 2.0 K persists in Nb nanoparticles with unusual low critical size of 6 nm for superconducting transition (see Fig.3).





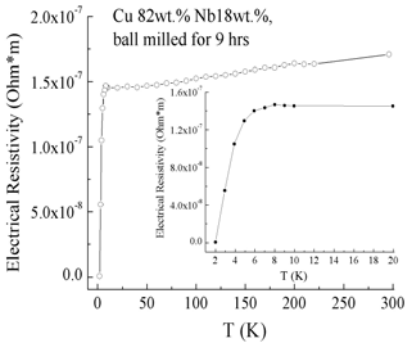


Fig.1 XRD pattern of as-milled Cu/Nb sample; Fig.2 TEM image of sample in Fig.1; Fig.3 Resistivity of the sample in Fig.1

Conclusions

This work reports a simple, efficient and inexpensive one-step fabrication method for making bulk Cu/Nb composite foils with a unique combination of nanolaminate structure, mechanical and transport properties. Further work will be undertaken to improve both the strength and conductivity for the application in magnets.

Acknowledgements

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References

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