Synthesis of Superconducting $(Ba_{0.6}K_{0.4})Fe_2As_2$ Polycrystalline Bulk with High Critical Current Density

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Introduction

Ferropnictide superconductors, discovered in 2008, have gotten a lot of attention due to robust properties relevant for applications such as high local critical current density (J_c) and high upper critical fields. Grain boundaries that exist in polycrystalline material needed for applications were thought to block current. Careful synthesis of $(Ba_{0.6},K_{0.4})Fe_2As_2$ (Ba-122) by mechanical alloying and consolidation resulted in bulk polycrystalline material with J_c over 0.1 $MAcm^{-2}$ (4.2 K, 0 T) which is comparable to the Ba-122 wires made by the authors [1].

Experimental

$(Ba_{0.6}K_{0.4})Fe_2As_2$ was synthesized by mechanical alloying the elements in a high energy ball mill. The as-milled powder was than consolidated at 600 °C for 10 hours in a hot isostatic press (HIP) under 192 MPa of pressure. To further homogenize the material, the material was re-milled and a second consolidation was done under the same HIP conditions. The material was characterized in a 14 T Oxford vibrating sample magnetometer. Global J_c was calculated from the width of the magnetization hysteresis using the Bean model.

Results and Discussion

When the elements are milled together, a reaction occurs between the elements that results in the formation of Ba-122. Due to mechanical attrition, a nanocrystalline powder is obtained. Pressing the powder into a pellet and reacting at a relatively low temperature (600 °C) results in a dense bulk with untextured grains that have an average diameter around 100-200nm. Due to the low-temperature heat treatment, grain boundaries are free of grain–boundary-wetting phases that tend to block current. **Figure 1** shows magnetization J_c as a function of applied magnetic field. The 0 T J_c is over 10 times higher than any reported bulk ferropnictide material. As reported for wires made by us [1], the small grain size and low anisotropy may play a crucial role in the high J_c. The ability to synthesize large pieces of bulk Ba-122 with J_c comparable to wires will allow researchers to produce quality permanent magnets from bulk Ba-122 material.

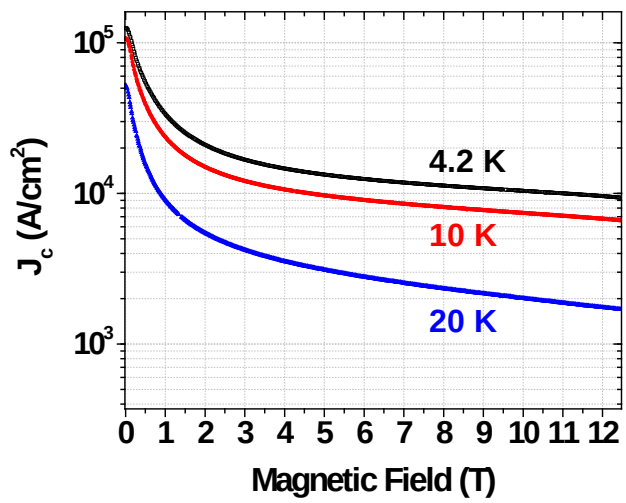

Figure 1. Magnetization J_c of K-doped Ba-122 bulk as a function of applied magnetic field at 4.2 K, 10 K, and 20 K.

Conclusions

Bulk K-doped Ba-122 was synthesized by mechanical alloying followed by a low temperature heat treatment. The material was shown to have high global J_c that is comparable to the best ferropnictide wire in the literature.

Acknowledgements

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References

[1] Weiss, J.D., *et al.*, Nature Materials, **11**, 682-685 (2012).