Magneto-Optical and Electromagnetic Study of Intergrain Critical Current in Fine-Grain $(Ba_{0.6}K_{0.4})Fe_2As_2$ Wire and Bulks

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Introduction

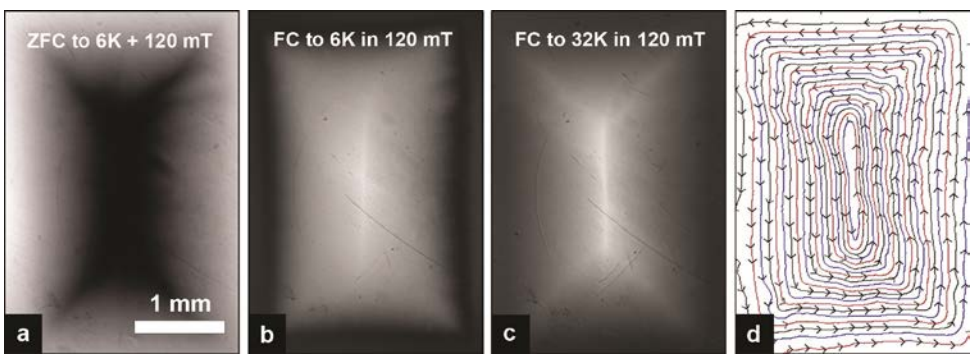
Magneto-Optical Imaging (MOI) together, supplemented by other electromagnetic techniques, SEM and TEM, were successfully applied to new forms of Fe-based superconductors, where the balance of pinning and connectivity between grains (weak links) is still under debate. Here we report that under certain synthesized conditions untextured polycrystalline $(Ba_{0.6}K_{0.4})Fe_2As_2$ bulks and round wires with high grain boundary density have transport critical current well over 10^5 Acm^{-2} (SF, 4.2 K), more than 10 times higher than critical current density of any other ferropnictide wire. The high global critical current was well supported by MOI.

Experimental

Magneto-Optical Technique, Electromagnetic Measurements, as well SEM and TEM were used for the characterization of physical properties of bulk and wire materials. The very fine grains with size ~200 nm, after the ball-milling, were synthesized under high pressure using chemical reaction at temperature well below the melting temperature of secondary phases.

Results and Discussion

Figure 1 demonstrates uniform high density global critical current in a rectangular piece of K-doped Ba-122 bulk material with magnetic fields perpendicular to plain of the sample (thickness = 0.7 mm). (a) MOI of partial flux penetration after zero-field-cooling (ZFC) the sample to 6 K and applying a magnetic field of 120 mT and (b) MOI of trapped magnetic flux in a sample field-cooled (FC) to 6 K in an external magnetic field of 120 mT. (c) MOI of trapped magnetic flux in a sample FC to 32 K in an external magnetic field of 120 mT.



Current stream lines (d) calculated for (c) illustrates that even at temperature near T_c global current circulates inside the bulk rather uniformly. The low temperature synthesis described above, minimizes the formation of current-blocking FeAs secondary phases, avoiding any wetting of the GBs. TEM observation confirms that most GBs are clean and well-connected providing one important reason why grain boundaries are transparent in both bulk and wire $(Ba_{0.6}K_{0.4})Fe_2As_2$ forms.

Conclusions

Our research showed that high global critical current density in the pnictide compound $(Ba_{0.6}K_{0.4})Fe_2As_2$ with small and randomly oriented grains is possible and that there is much less sensitivity to grain misorientation than is seen in the cuprates. The J_c values are close to those needed for practical applications.

Acknowledgements

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References

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