Magneto-Optical Study of Bulk Current Flow in Well-Connected Pnictide Compounds after Mechano-Chemical Synthesis

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Introduction

At present day superconducting materials are needed in many high current applications used in industry. New forms of Fe-based superconductors are very promising for application to magnets, and other devices. Here we report that Fe-based superconductors like $BaFe_2As_2$ (Ba-122) and $Ba_{0.6}K_{0.4}Fe_2As_2$ (K-doped Ba-122) with very high critical current density above 0.1 MA cm^2 at 4.2 K and self-field (SF) were successfully synthesized by mechano-chemical reaction using high-impact ball milling. The high global critical current in these ceramics was supported by transport measurements and Magneto-Optical Imaging, as seen from Fig.1.

Experimental

Magneto-Optical Imaging (MOI) together with transport and magnetization measurements by SQUID, as well SEM and X-ray diffraction, were used for the characterization of physical properties of Ba-122 and BaK-122 synthesized under three different conditions: (a) at 1120^0C and 193 MPa hot isostatic press (HIP), (c) at 600^0C at ambient pressure (AP=1 bar) and (e) in HIP (600^0C, 193 MPa) (see Fig.1).

Results and Discussion

The MO images in figure 1 clearly show that cracks and grain boundary phases can significantly block current for samples 1120^0C HIP and 600^0C AP. Sample 600^0C HIP was free of cracks and grain-wetting phases and had the highest J_c with weak field dependence at high fields and temperatures. Its J_c is above 10^5 A/cm^2 at low fields at $<$ 10 K, which is around the values required for practical applications. If J_c can be increased by a factor of 10 in field, K-doped Ba-122 would be useful for high field applications in the temperature range obtainable by cryo-coolers and liquid H_2.

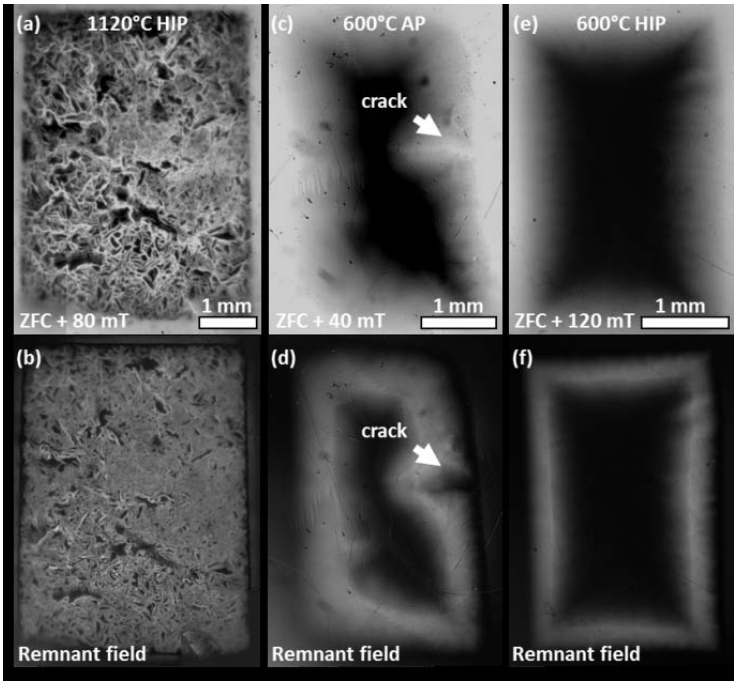

Fig.1. Magneto-optical images showing flux penetration after zero-field-cooling (ZFC) the sample to 10 K and applying the magnetic field shown in the images, for samples (a) 1120^0C HIP, (c) 600^0C AP, and (e) 600^0C HIP. (b), (d), and (f) are magneto-optical images of the remnant magnetic flux after the field was removed. These correspond to (a), (c), and (e), respectively.

Conclusions

Our results showed that promising synthesis conditions have been found for Fe-based superconductors. Magneto-Optical and transport measurements proved high global critical current 10^5 A/cm^2 at low fields at $<$ 10 K, which is close to that needed for practical applications. These results were published in reference [1].

Acknowledgements

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References

[1] Weiss, J. D., et al., SUST, **26**, 074003 (2013).