Highlights

RESEARCH AREA 1 - Superconductors and Innovative materials for Energy and Environment - 2024

Effects of K excess in microstructure of $(Ba_{0.6}K_{0.4})Fe_2As_2$ superconducting powders

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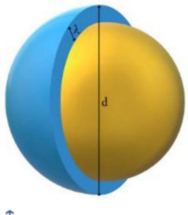
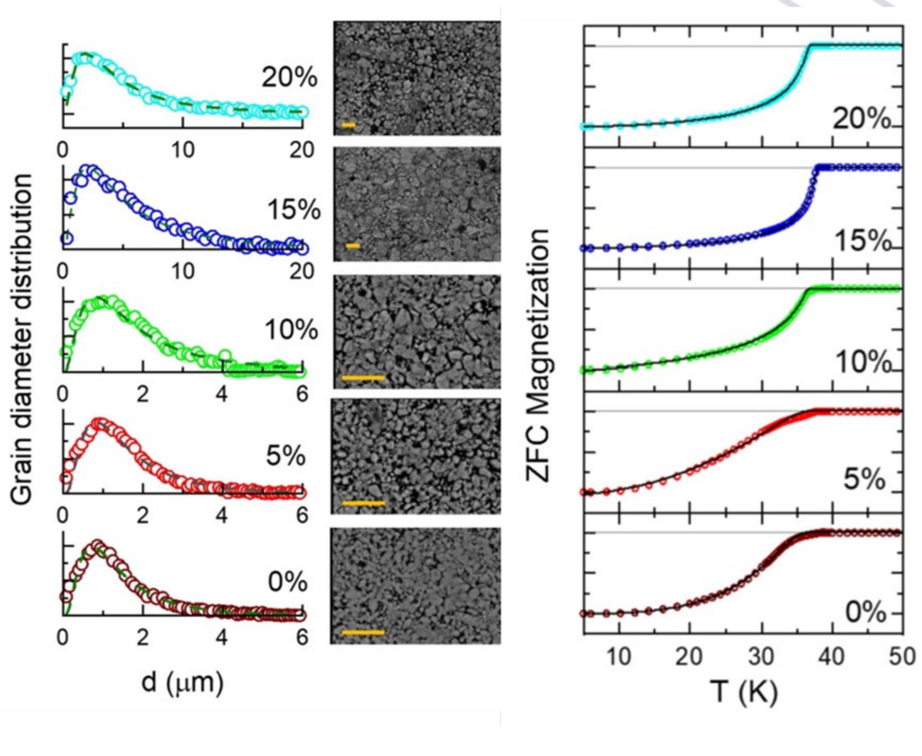
Superconductor Science and Technology

Iron-based superconductors (IBSs), and in particular the $(Ba,K)Fe_2As_2$ (Ba-122) family, are promising materials for high-field applications due to their high upper critical fields, low anisotropy, and good grain boundary connectivity. For practical implementation in Powder-In-Tube (PIT) conductors, the optimization of precursor powder microstructure is essential, as properties such as grain size and phase purity strongly affect both mechanical processing and transport performance.
In this work, we investigate the effect of potassium (K) excess (δ) on the synthesis and microstructure of optimally doped $(Ba_{0.6}K_{0.4+\delta})Fe_2As_2$ powders, with δ up to 0.08 (20% excess K). A synthesis route combining high-energy ball milling and heat treatment in a rotating furnace was developed to minimize potassium losses and ensure homogeneous mixing. This method enables the production of nearly single-phase superconducting powders across all compositions.
X-ray diffraction and EDS analyses show that the powders are highly pure, with only minor secondary phases. Despite the initial K excess, the final K/Ba ratio within the superconducting phase slightly decreases with increasing δ, suggesting that excess potassium mainly influences the synthesis process rather than being incorporated into the lattice.
A major result is the strong dependence of grain size on potassium excess. SEM analysis reveals a lognormal grain size distribution, with the average grain size increasing from about 1.6 µm in stoichiometric samples to approximately 8.3 µm at 20% K excess. This tunability is particularly relevant for PIT processing, where powder granulometry affects deformation and current-carrying properties.
Magnetization measurements confirm high-quality superconducting behavior for all samples, with a critical temperature around 38 K and negligible variation across the series. The analysis of magnetization curves, accounting for grain size distribution and London penetration depth, indicates that transition broadening is mainly due to finite grain size effects.
Overall, potassium excess promotes grain growth and improves phase formation without significantly altering superconducting properties. The proposed synthesis method provides a simple and scalable route to produce high-quality Ba-122 powders with controlled microstructure, offering valuable perspectives for the optimization of PIT superconducting wires and tapes.

Grain size distribution and lognormal fit (left) obtained from SEM images (center) for samples prepared with different K excess. The marker in the SEM micrography correspond to 10 µm.
ZFC magnetization curves vs temperature measured by DC SQUID (right). The experimental data (symbols) are fitted by theoretical curves (lines) obtained considering the effect of Ginzburg-Landau temperature dependance of the London penetration depth in the magnetic screening.





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