Current Transport at Grain Boundaries in Superconducting Ba(Fe\textsubscript{1-x}Co\textsubscript{x})\textsubscript{2}As\textsubscript{2} Bicrystals


Introduction
Grain boundaries (GBs) transparent to current are intrinsic to Nb-Ti, Nb\textsubscript{3}Sn and MgB\textsubscript{2}. The ferropnictide superconductors, have important application properties, namely T\textsubscript{c} up to 55 K, H\textsubscript{c2} of 100 T or more, strong vortex pinning, moderate anisotropy, and H\textsubscript{tr} close to Hc2, leaving open only the key question whether GBs can transmit current. Here we report the explicit study of this vital property, using extensive transport, magneto-optical (MO), low-temperature laser scanning microscopy (LTLSM), and high resolution transmission electron microscopy (HRTEM) investigations of Ba(Fe\textsubscript{1-x}Co\textsubscript{x})\textsubscript{2}As\textsubscript{2} (Ba-122) epitaxial thin film bicrystals

Experimental
Epitaxial ~350 nm thick Ba-122 thin films were grown in-situ on [001] tilt (100) SrTiO\textsubscript{3} bicrystal substrates. Four-circle x-ray diffraction showed excellent epitaxy with cube-on-cube, in-plane epitaxial relationship with the substrates. We performed detailed studies of the grain and GB critical current densities J\textsubscript{c} (T,B) and J\textsubscript{gb} (T,B) for the bicrystals.

Results
Shown in Fig. 1 are representative LTLSM and MO images of 6° and 9° bicrystals, which demonstrate the significant current-blocking effect of even low-angle GBs. The MO image in Fig. 1b shows that the 9° [001] tilt GB can transmit only about 10% of the intragrain critical current. Fig. 2 shows that J\textsubscript{gb} (12K, 0.5T) falls off by an order of magnitude as θ increases from 3 to 24°. This qualitative behavior is similar to J\textsubscript{gb} (θ) for [001] tilt GBs in YBCO. The 3° GB in Ba(Fe\textsubscript{1-x}Co\textsubscript{x})\textsubscript{2}As\textsubscript{2} does not obstruct supercurrent, while at higher angles J\textsubscript{gb} (θ) becomes much smaller than the grain J\textsubscript{c}.

Conclusion
We have developed a process for growing pnictide Ba-122 single crystal thin films. J\textsubscript{gb} across [001] tilt GBs of thin film Ba(Fe\textsubscript{1-x}Co\textsubscript{x})\textsubscript{2}As\textsubscript{2} bicrystals is strongly depressed, similar to high-T\textsubscript{c} cuprates. Our results raise the question as to whether weak-linked GBs are characteristic of high-T\textsubscript{c} superconducting compounds developed from parent non-superconducting states with competing orders, low carrier density, and unconventional pairing symmetry.

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References