Do Grain Boundaries in Pnictide Superconductors Transmit Supercurrent?

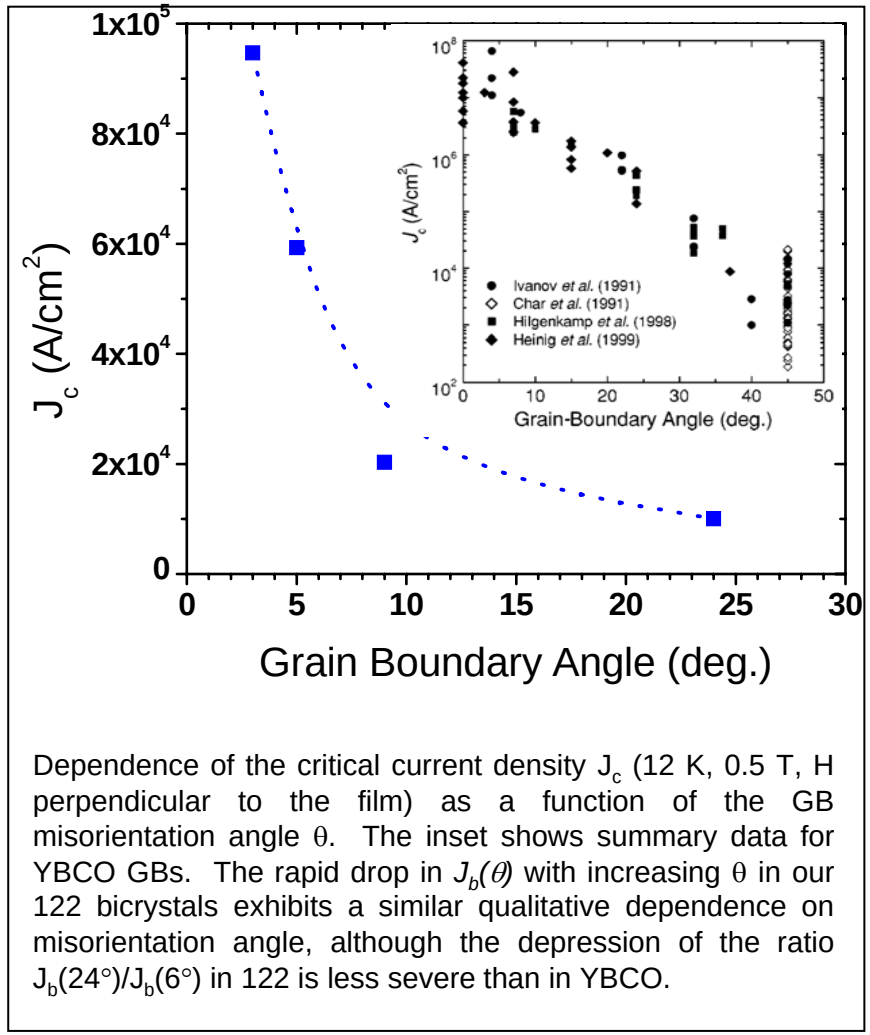
2009 NHMFL Science Highlight for NSF

DMR-Award 0654118

Applied Superconductivity Center

In the recently discovered pnictide superconductors, novel Cooper pairing mediated by magnetic Fe ions leads to the second class of materials with T_c above 50 K. Here we show that the critical current density J_b across [001] tilt grain boundaries (GBs) of thin film $Ba(Fe_{1-x}Co_x)_2As_2$ bicrystals is strongly depressed, exhibiting weak link GB behavior similar to high-T_c cuprates like YBCO. Our results raise the question as to whether weak-linked GBs are characteristic of high-T_c superconducting compounds developed from parent non-superconducting states with competing orders, low carrier density, and unconventional pairing symmetry.

S. Lee[1], J. Jiang*[2], J. D. Weiss[2], C. M. Folkman[1], C. W. Bark[1], C. Tarantini[2], A. Xu[2], D. Abraimov[2], A. Polyanskii[2], C. T. Nelson[3], Y. Zhang[3], S. H. Baek[1], H. W. Jang[1], A. Yamamoto[2], F. Kametani[2], X. Q. Pan[3], E. E. Hellstrom[2], A. Gurevich[2], C. B. Eom[1], D. C. Larbalestier[2], "Weak link behavior of grain boundaries in Co-doped $BaFe_2As_2$ pnictide superconductors" ArXiv 0907.3741 submitted. [1]U. of Wisconsin, [2]NHMFL, and [3]U. of Michigan



Dependence of the critical current density J_c (12 K, 0.5 T, H perpendicular to the film) as a function of the GB misorientation angle θ. The inset shows summary data for YBCO GBs. The rapid drop in $J_b(\theta)$ with increasing θ in our 122 bicrystals exhibits a similar qualitative dependence on misorientation angle, although the depression of the ratio $J_b(24°)/J_b(6°)$ in 122 is less severe than in YBCO.

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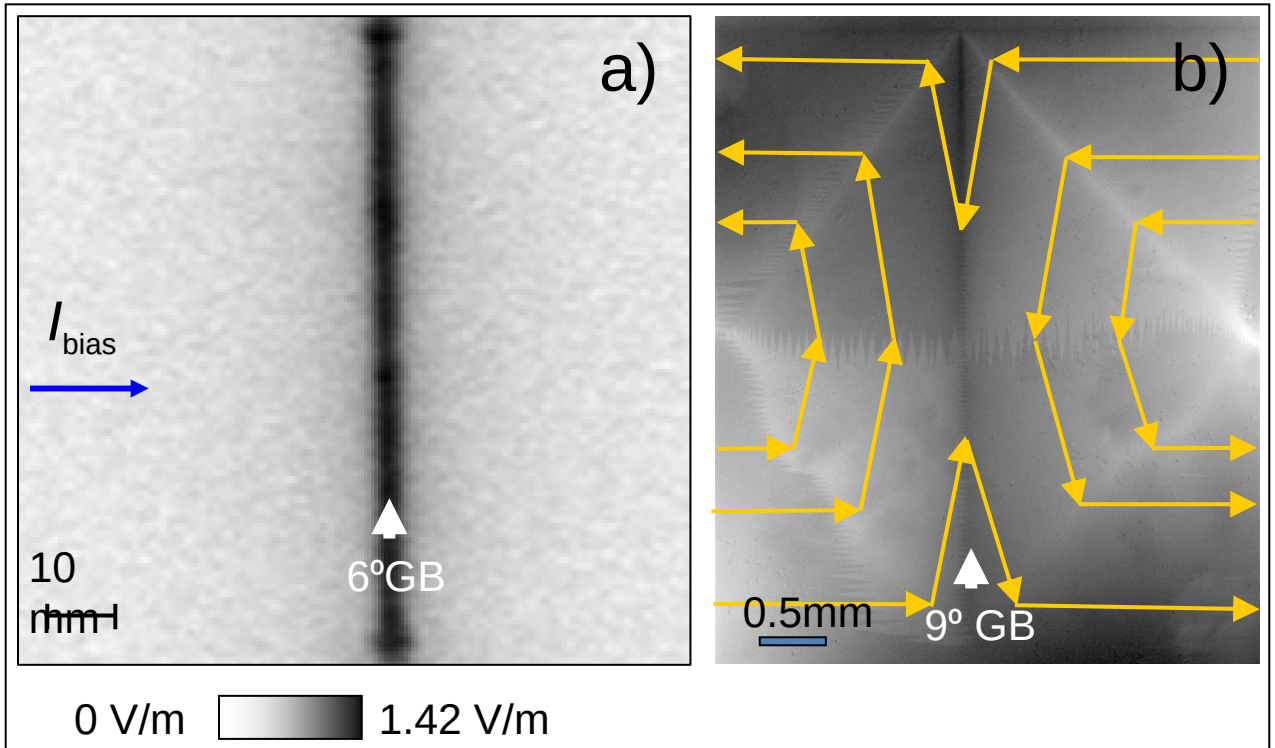

The images above show that depressed superconductivity at the grain boundary (GB) adds dissipation (the left hand image is an image of the local electric field developed at a 6º GB) while the image at the right is of the current stream lines turning due to the blocking effect of a 9º GB.

Images taken at the NHMFL.

These films were grown in a collaboration between Chang-Beom Eom's group at the U. of Wisconsin and the Applied Superconductivity center at the NHMFL (groups of Eric Hellstrom, Alex Gurevich, and David Larbalestier). High resolution transmission electron microscopy in X. Pan's group at the U. of Michigan showed that the grain boundaries were structurally clean.

An undergraduate at Florida State U., Jeremy Weiss, the 3rd author, made key contributions to the manufacture of the targets needed for the pulsed laser deposition.

One broader impact of the study is that suppression of superconductivity at even such simple interfaces suggests a general susceptibility of low carrier density superconductors to structural disorder, possibly due to a reversion towards the parent non-superconducting state, as is well known in the cuprates.