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Approaching isotropy in the vortex system of SmFeAs(O,F) at extreme magnetic fields

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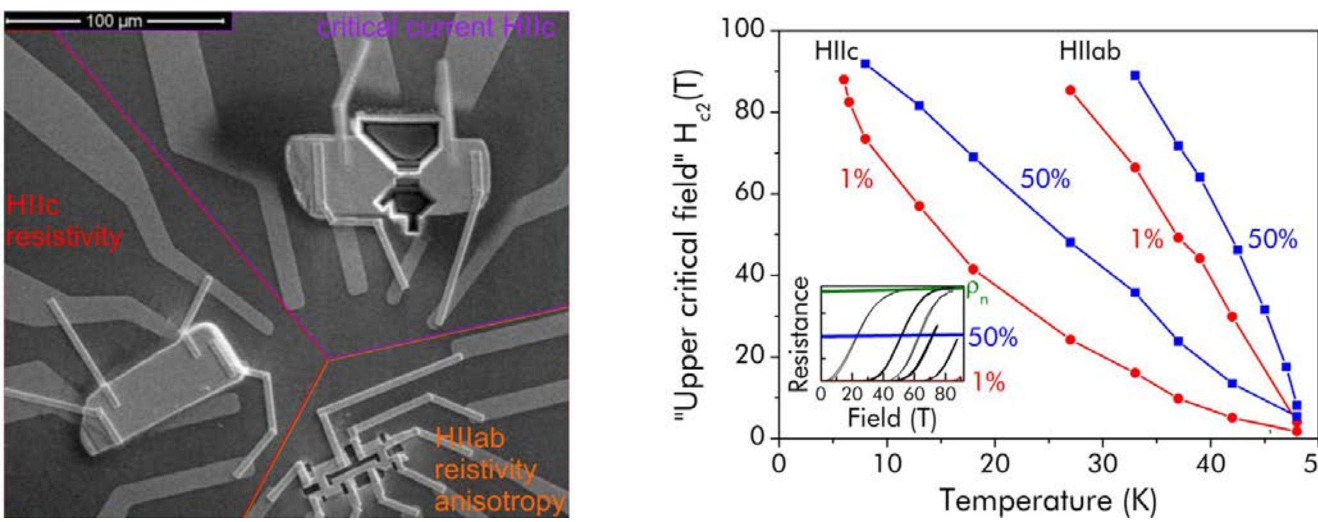
Introduction

The role of anisotropy in the iron-pnictides is one of the key questions in understanding their high-temperature superconductivity. The inherent layeredness of these systems, consisting of FeAs layers separated by various layers, gives rise to an upper critical field anisotropy $\gamma(T_c) \sim 3$ in the "122" system (i.e. $(Ba,K)Fe_2As_2$) and up to 6-8 in the "1111" system (i.e. SmFeAs(O,F)). In the "122" compounds, this anisotropy is known to decrease upon cooling, converging to almost isotropic superconductivity at lowest temperatures[1]. This can be understood through a particular temperature dependence of the inter- and intra-band scattering. The "1111" class is naturally more anisotropic due to the thicker SmO blocking layer, and the much higher upper critical fields (H_{c2}, HIIab(0)>>100T) cannot be reached at low temperature. Despite this challenging field requirement, the aim of this project is to discern whether this emergent isotropy in the "122" materials is a property of all FeAs classes.

Experimental

Focused Ion Beam (FIB) micromachined samples have in the past proven to be particularly well suited for pulsed magnetic fields[2]. Employing the micrometer precision of the FIB, we fabricated three individual samples on a 2x2mm chip and thus maximized the acquired transport data per pulse. This allowed to measure resistivity in two different crystals - one oriented for HIIc and one for HIIab, with currents along different crystal directions (JIIc and JIIab) - as well as critical currents using a novel pulsed current scheme in each pulse.

Results and Discussion



Figures: (left) SEM Image of the sample assembly. It features 3 different crystals, 2 for resistivity along various current and field orientations (see text) as well as one optimized for critical currents. (right) Upper critical field values, estimated at 50% and 1% criteria of the normal state resistance. The 1% curve might be closer to the irreversibility line, where the 50% is generally believed to resemble H_{c2}. The inset shows the raw data as well as the criteria used to extract these values.

In the 100T magnet, the transition curves of SmFeAs(O,F) (T_c~50K) could be followed to low temperatures. The upper critical field as well as the "irreversibility line" for both field directions have now been experimentally confirmed to exceed 100T below 8K. The 1% curve for HIIc continues to steepen at lower temperatures and shows a pronounced upturn below 10K, while the HIIab lines show negative curvature. While even in the 100T magnet we cannot directly access the anisotropy below 30K, these new extended measurements clearly indicate a reduction in anisotropy in SmFeAs(O,F) similar to $(Ba,K)Fe_2As_2$, despite its more pronounced layeredness.

Acknowledgements

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References

[1] Yuan, H.Q. et al., *Nature* **457**, 565-568 (2009)
[2] Moll, P.J.W. et al., *Nature Materials* **9**, 628-633 (2010)