Critical currents and high magnetic field scales in SmFeAs(O,F) single crystals: promising for applications

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The electronic properties in the Fe-pnictide superconductors are well studied on a microscopic level and by now a comprehensive picture has been assembled. The potential for applications is not yet explored, however, and is the subject of our study. The layered structure of the Fe-pnictides might be of particular concern, since the extreme electronic anisotropy in the cuprates poses a well-known problem for effective flux pinning.

We have combined a novel structuring technique of single crystals, employing focused ion beam (FIB) cutting, and pulsed magnetic fields to 65T, to study simultaneously the electronic dissipation for currents flowing along and perpendicular to the Fe-As layers. In addition to the direct measurements of j_c on a microbridge with $< 0.5\ \mu m^2$ cross-section, sensitive to dissipation on the $10^{-8}\ \Omega$cm level, we have are also derived critical current densities on the $10^{-14}\ \Omega$cm level from magnetization loops M(H).

Three main results characterize the low temperature (liquid He) intra-grain critical current densities in SmFeAs(O,F) with T_c near 50K : (1) a very high field scale for low dissipation, far in excess of 50 T, (2) high current densities at a level $> 2\ 10^6\ A/cm^2$ with weak field dependence up to 14T, and (3) essentially no dependence of j_c on the direction of the applied magnetic field. Therefore, these intra-grain critical current properties indicate that Fe-pnictide superconductors are intrinsically promising materials and grain boundary issues, metallurgical and other technical challenges are worth further exploration.

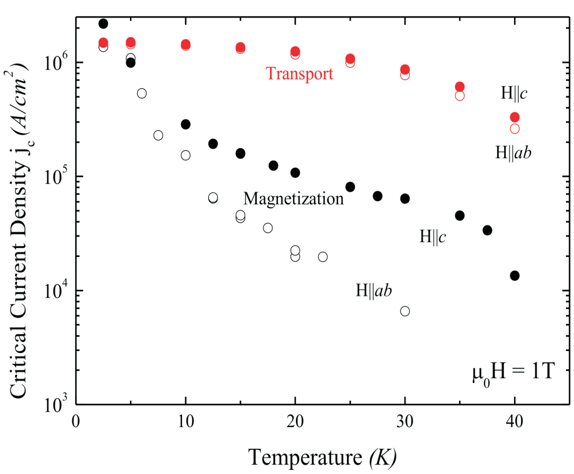

Figure 1: Critical current density in 1T magnetic field parallel and perpendicular to the Fe-As layers. At low temperatures, j_c is high and essentially independent of the applied field direction.

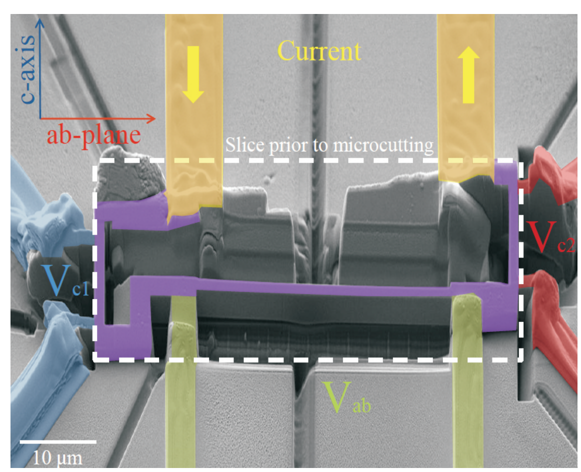

Figure 2: A FIB cut crystal for four-probe resistivity measurements with current flowing through one bar along the Fe-As layers (*ab*-crystal plane), and two bars perpendicular to them. (*c*-crystal axis)