(T,H=const) and (H,T) Phase Diagram Determination for Fe(SeXTe1-X)

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Introduction

Defying all conventional wisdom, superconductivity has been found in a variety of Fe-based pnictides and chalcogenides, with transition temperatures as high as 50 K. The simplest of these is $Fe(Se_xTe_{1-x})$ with transition temperatures in the range of 10 K. The bulk compound with x = 0 is not superconducting. However we have recently found that thin films with x = 0, even grown on glass, are in fact superconducting. The apparent $H_{c2}(0)$ of these films, from a WHH analysis, exceeds 150 T. Further, there is an interesting, Kondo-like upturn preceding the superconducting transition. The purpose of this experiment was to determine the actual value of $H_{c2}(0)$ for x = 0.1 (grown on $SrTiO_3$) and x = 0 (grown on glass) and to follow the Kondo-like behavior for fields above $H_{c2}(0)$.

Experimental

Thin films of $FeSe_{0.1}Te_{0.9}$ that were deposited on $SrTiO_3$ were brought to the Los Alamos National Laboratory for measurements in the High-Field Facility. Samples were cut to size and wired with twisted leads in a four probe configuration before resistance measurements in the 60 Tesla short-pulse magnet at temperatures ranging from 0.67-10.4 K.

Results and Discussion

The results of the high-field resistance measurements are shown below in Fig. 1. It is clear that the superconductivity of the $FeSe_{0.1}Te_{0.9}$ is suppressed by the field. Upon increasing temperature, the R(H) curves are shifted to lower magnetic fields. After complete suppression of the superconducting state, there remains significant negative magnetoresistive behavior all the way up to 60 T. At 0.67 K, the field at the midpoint of the transition, $\mu_0 H_{c2}^{mid}$, is ~44 T. The zero-temperature upper critical field extrapolated from the low-temperature data is nearly three times smaller than the Werthamer–Helfand–Hohenberg theory estimate.

Conclusions

There are evidently two possible regimes when it comes to superconductors with Kondo impurities[1], either T_K is significantly less than T_C, in which case the magnetic impurities are pair-breaking in the style of Abrikosov-Gorkov, or T_K is greater than T_C meaning that the pair spins are Kondo screened and do not participate in pair breaking. However, this also means that electrons with energies in excess of T_K, but less than ω_D do not form pairs. $FeSe_{0.1}Te_{0.9}$ on STO clearly falls into the second category

Additional calculations by Matsuura, et al. in the region where $T_K > T_{c0}$ found that the initial slope of $H_{c2}(T)$ was slightly improved over the expected BCS values. This would undoubtedly lead to an overestimate of $H_{c2}^{orb}(0)$ in the case where the enhanced slope of $H_{c2}(T)$ persists through a significant fraction of the measurements. The unusually high WHH estimates of the upper critical field as well as the often significant variation in T_c among the various chalcogenide superconductors such as $FeSe_{0.1}Te_{0.9}$ could potentially be the result of Kondo impurities. If so, then the design and control of these impurities will play a crucial part in the material's applicability.

Acknowledgements

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References

[1] Matsuura, K. et al, PTP **57,** 713 (1977)

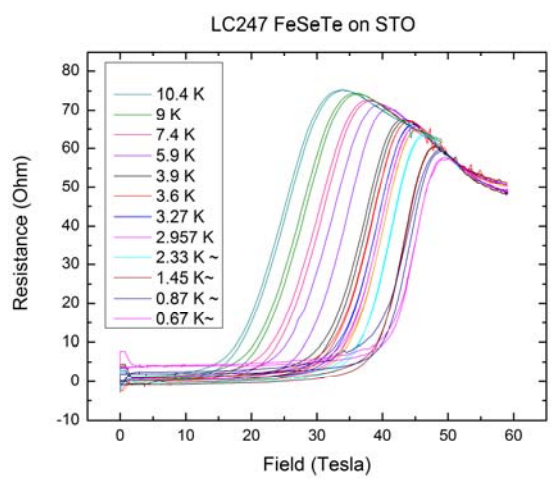

Fig.1 Resistance as a function of magnetic field at specified temperatures.