Project No. P02266-DC: Determination of the Upper Critical Field of Cuprates by Electrical Transport under High Magnetic Field

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Introduction

The upper critical magnetic field (H_{c2}), defined as the strength of the field that breaks the Cooper pairs, is one of the most characteristic parameters of high temperature superconductors (HTS). In response to its' importance in theory and application, intense efforts have been devoted to determine H_{c2} for different materials and different dopings. The reported results in the literature, however, are still highly controversial. We propose to perform magneto-transport measurements on the best $La_xSr_{2-x}CuO_4$ samples we synthesized covering the whole superconducting dome to retrieve the values of H_{c2} for different doping levels by studying the superconducting fluctuations at low temperature and under high magnetic field.

Experimental

The high quality single crystalline $La_xSr_{2-x}CuO_4$ thin films were synthesized by the Atomic-Layer-by-Layer Molecular Beam Epitaxy (ALL-MBE) technique located at Brookhaven National Laboratory. The measurements were conducted in cell 9 (31 T DC) magnetic field in the past year. Then we brought our own electronics, made connections with the probe, and performed our measurements to temperature as low as 300 mK and field up to 31 T. With our unique combinatorial sample synthesis technique [1], we performed 16-channel resistance/Hall effect measurement simultaneously to retrieve resistance/Hall resistance signal on 16 different dopings at the same time, greatly enhancing the output of the limited magnet time.

Results and Discussion

We obtained a large amount of high quality data from the magnet time given to us. Figure 1 is one example of the resistance vs. field (R(H)) data taken on one doping level of our film.

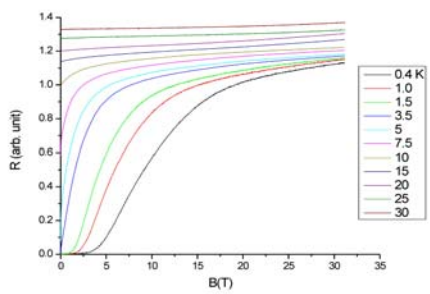

Figure 1: The magneto-resistance of overdoped $La_xSr_{2-x}CuO_4$ film over a series of temperatures.

The magneto-resistance is expected to show B^2 dependence for metals so this dependence could be used as an indication of the recovery of Fermi-liquid like behavior of cuprate. The critical field H_{c2} where the recovery occurs depends strongly on the temperature. By studying the doping dependence of $H_{c2}(T)$, we may find clues about the mechanism of the superconducting fluctuations and further the nature of the superconducting state.

Conclusions

We had a very successful magnet time for the past year and obtained high quality systematic magneto-transport data for more than 80 different dopings at a series of temperature and magnetic field.

Acknowledgements

Research supported by the U.S. Department of Energy, Basic Energy Sciences, Materials Sciences and Engineering Division and the US National Science Foundation award DMR-1157490.

References

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