COMBE samples consistency test via transport and thermodynamic measurements

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Introduction

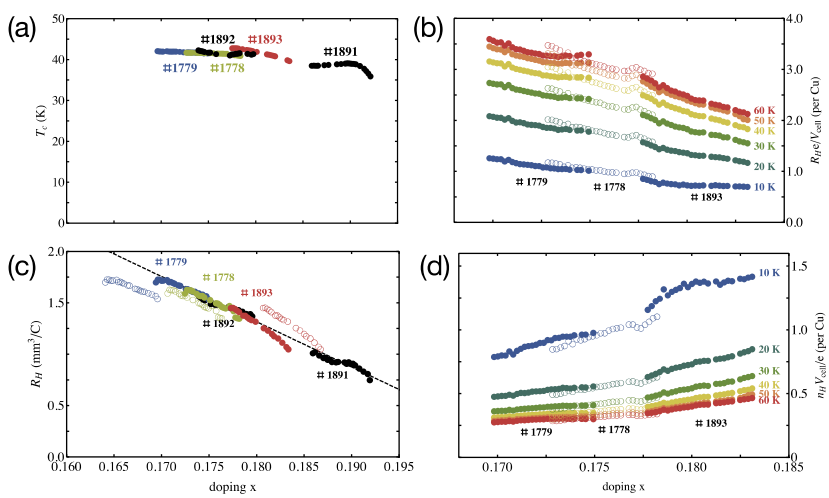
To a great extent the current success in understanding high-temperature superconductors, such as iron or copper based systems, is a result of our ability to follow transport and magnetic properties with respect to doping. This provides a unique opportunity to follow universal features of complex condensed matter systems even though microscopic understanding is lacking. The unique advantage of samples grown using Combinatorial Molecular Beam Epitaxy (COMBE) is that transport properties can be studied with substantially higher doping resolution compared to that of conventional samples. The gradient of the doping across these samples is highly controlled; however, the average doping can be relatively uncertain. This can pose a problem when studying properties over a broad range in doping requiring multiple samples. In this study we have developed a procedure to identify the median doping in a sample via measurements of transport properties in high magnetic fields.

Experimental

Our samples, grown by Ivan Bozovic at Brookhaven National Laboratory, require the large bore of the 60 T controlled-waveform magnet due to their unusually large size (10 mm x 10 mm). We have developed custom instrumentation at Pulsed-Field Facility and the DC facility, to measure up to 30 doping simultaneously, which allows full utilization of pulsed-field magnet time. Furthermore, the measurements ensure identical temperature continuous for all the doping channels a unique feature of the current setup.

Results and Discussion

The open circles in Fig. 1c indicate the Hall coefficient at 200K plotted versus nominal doping for each sample. For each individual sample the evolution of the Hall coefficient is continuous and smooth. Yet, when comparing Hall coefficient in different samples marked differences are obvious. To alleviate this problem the nominal doping for each sample is shifted such that the Hall coefficient for multiples samples falls on a smooth curve, shown with full circles in Fig. 1c. This defines the “physical” doping for each sample which will be used for further research coming from these samples. Fig 1a shows superconducting transition temperature plotted vs. physical doping. We see that the doping dependence is smooth. Fig 1b shows coefficient measurements in high-field field performed in long pulse magnet at Los Alamos. Plotted vs physical doping the Hall coefficient is continuous across multiple samples and shows consistent temperature evolution. These will be used study quantum criticality in cuprates in our future research. Fig 1d shows the same data as in Fig 1b presented here as hall number.



Acknowledgements

A portion of this work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490, the State of Florida, and the U.S. Department of Energy.