PULSED-FIELD TUNNEL-DIODE OSCILLATOR MEASUREMENTS OF Hg-BASED HIGH-T<sub>C</sub> CUPRATES

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Introduction

Inspired by previous success identifying the upper critical field in the canonical high-T<sub>c</sub> cuprate Sr<sub>0.9</sub>La<sub>0.1</sub>CuO<sub>2</sub> (SLCO) [1] from tunnel diode oscillator (TDO) measurements of polycrystals in pulsed fields, we hoped to extend this work to the mercury-based cuprates. Whereas SLCO is the most three-dimensional of all high-T<sub>c</sub> cuprates, with a c-axis coherence length that exceeds the interplane spacing, the Hg-based cuprates are very two-dimensional with strong confinement of the superconducting wave function to the copper-oxygen planes. The upper critical field is very difficult to measure in low-dimensional superconductors since superconducting fluctuations and vortex motion act to broaden the transition in the electrical resistivity, magnetization, and other DC probes of the superconducting transition.

Experimental

The samples consisted of polycrystalline HgBa<sub>2</sub>Ca<sub>3</sub>Cu<sub>4</sub>O<sub>10</sub> (Hg1234) (T<sub>c</sub> = 127 K) and grain-aligned HgBa<sub>2</sub>Ca<sub>4</sub>Cu<sub>5</sub>O<sub>12</sub> (Hg1245) (T<sub>c</sub> = 110 K). The samples were placed in one of two counter-wound copper coils which form part of a resonant circuit containing a tunnel-diode. Changes in the penetration depth of the sample cause adjustments to the inductance of the coil, and in turn affect the resonant frequency of the circuit. The axis of the coil was oriented perpendicular to the magnetic field direction to minimize pickup of the external magnetic field. Measurements were conducted in pulsed magnetic fields up to 65 T at the NHMFL in Los Alamos.

![Fig. 1. TDO measurements in pulsed fields of grain-aligned Hg1245 (T<sub>c</sub> = 110 K) and polycrystalline Hg1234 (T<sub>c</sub> = 127 K).](image)

Results and Discussion

Although a sharp feature was observed at T<sub>c</sub> for both samples in zero-field temperature sweeps, no clear upper critical field transition was observed in pulsed-field measurements. For the Hg1245 sample, there is a broad maximum near 10 T, that could be related to antiferromagnetic order in that sample coexisting with superconductivity. The higher field data is almost indistinguishable from the background, which suggests that the grain size in these samples is comparable to the penetration depth. In the Hg1234 sample, the diamagnetic signal of superconductivity can be seen, but the transition is very broad. Most likely, fluctuations still play a role even at MHz frequencies.

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References