Magnetism, and Magneto-Transport in Ferromagnetic Superconducting Rutheno-Cuprates Ru$_{1-x}$Nb$_x$Sr$_2$(Eu$_{1.5}$Ce$_{0.5}$)Cu$_2$O$_{10}$

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Introduction

Rutheno-cuprates show coexistence, at atomic level, of superconductivity and ferromagnetism originated in the Cu-O$_2$ and Ru-O$_2$ planes [1]. However, a satisfactory understanding of how the superconducting and magnetic order parameters interact with each other has not yet been reached. In this project we synthesized samples substituting the magnetic Ru ion for a non-magnetic ion like Nb with the same valence and similar ionic radio with the aim to clarify the magnetic mechanism involved.

Experimental

Polycrystalline rutheno-cuprates (Ru$_{1-x}$Nb$_x$)Sr$_2$(Eu$_{1.5}$Ce$_{0.5}$)Cu$_2$O$_{10}$, x=0, 0.2, 0.4, 0.6, 0.8 and 1, were synthesized by solid-state reactions. Resistance was measured using a standard four contact probe as a function of temperature and magnetic field; DC Magnetic susceptibility, Zero Field Cooling and Field Cooling (ZFC-FC) measurements in the range of 2-300 K, and hysteresis loops were performed in a commercial PPMS (Quantum Design). Some of the results were published already [2,3].

Results and Discussion

Figure 1 shows the superconducting transition temperatures, at the onset ($T_c^{\text{onset}}$) and zero resistance ($T_c^0$). Most resistivity changes are evident for higher Nb doping amounts and superconductivity is destroyed for x = 1. Important characteristics like the upper critical field ($H_{c2}$), penetration depth and coherence length have been studied by suppressing superconductivity with magnetic fields, as figure 2 shows for the x=0.6 sample. Figure 3 shows ZFC-FC magnetization vs. T data for 4 compositions, the branching at different temperatures evidences the magnetic transition for each composition. The composition with the highest Ru content shows a more complex behavior than the other samples, a more detailed set of compositions with tiny amounts of Nb is necessary (lower than 0.2) in order to understand the huge induced magnetic effects as well as a magnetic phase diagram, which can be constructed by an ac susceptibility characterization.

![Figure 1. $T_c^{\text{onset}}$, $T_c^0$ vs. Nb content](image1)

![Figure 2. R vs. H, x=0.6.](image2)

![Figure 3. Mag vs. T, ZFC-FC](image3)

References