VORTEX-MATTER STATES IN $Y_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ FILMS IN MAGNETIC FIELDS UP TO 45 TESLA

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Introduction

In a number of high-T_c superconductors, it has been observed that the irreversibility line, H(T*), (also referred to as the vortex-glass melting line, $H_g(T)$) undergoes a crossover from a $(1-T^*/T_c)^{3/2}$ temperature dependence in the range $0.6\ T_c \leq T < T_c$, to an exponential form, $H_g(T) \sim \exp(-aT)$, at lower temperatures [1,2]. In earlier work on thin films of the high-T_c system $Y_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ in magnetic fields up to 30 tesla (at NHMFL, Tallahassee), we also observed such a crossover at $T = 0.6\ T_c$. By extending magneto-transport measurements to fields up to 45 tesla, we observe that the $H_g(T < 0.6\ T_c)$ line is consistent with both an exponential form, and that of a power law dependence, with a second transition at $T = 0.3\ T_c$.

Experimental

Thin film samples of $Y_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ (x = 0.1 - 0.4), have been investigated via DC transport measurements in slow swept (3T/min) and static magnetic fields up to 45 tesla and to temperatures as low as 1.4 K (45 T magnet, NHMFL, Tallahassee). The films are expitaxial with a <001> orientation on $LaAlO_3$ substrates. The magnetic field is applied so that H || c. Corrections for the Cernox thermometers in magnetic field were carried out by the procedure established in ref [3].

Results and Discussion

The magnetic field – temperature (H – T) phase diagram of the doped high-T_c cuprate system $Y_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ (x = 0. - 0.4) has been extended to high magnetic fields previously unexplored for this system. The data conform to a scaling form of the vortex-glass melting line where $H_g(T)_i = A_iH_0(1-T/T_c)^{n_i}$ with $n_1 \approx 1.2$, $0.6T_c \leq T < T_c$; $n_2 \approx 2.0$, $0.3T_c \leq T < 0.6T_c$; $n_3 \approx 3.1$, $\alpha(x)T_c < T < 0.3T_c$, where $\alpha(x = 0.1 - 0.3)T_c$ is the lowest temperature measured, and $\alpha(x = 0.4) = 0.15$. For x = 0.4 it was observed that $H_g(T)$ begins to saturate below $0.15\ T_c$. The fields at which the power law dependence of the H_g line crosses over are denoted by H_1^* and H_2^*. It was found that $H_2^* \approx 3\ H_1^*$ for all concentrations x. The H-T phase diagram and the scaled $H_g(T,x)$ lines are shown in figures 1 and 2 below. The scaled $H_g(T)$ line for x = 0.2 is displayed alone in figure 3.

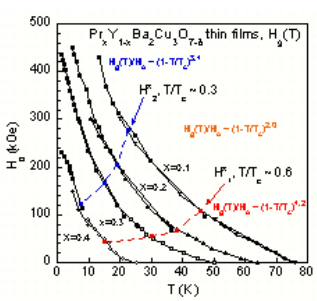

fig. 1. H-T phase diagram

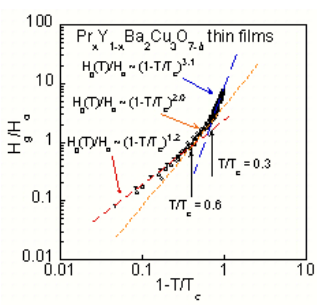

fig. 2. Scaled $H_g(T,x)$ for x = 0.1-0.4

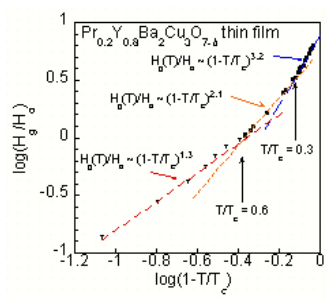

fig .3. Scaled $H_g(T,x=0.2)$

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References

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