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Physical properties of single crystalline samples of the system $Y_xPr_{1-x}Ba_2Cu_3O_{7-\delta}$ obtained by using the self-flux growth method

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Abstract – In this work we show the structural and physical properties of $Y_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ (for $0 < x < 1$) superconducting single crystals, prepared by Pechini´s method. Remarkably, the whole series superconducts, as expected from previous results obtained in polycrystalline samples treated in Argon atmosphere instead of oxygen. We also show the influence on the superconducting properties of cationic doping. Finally, we also show here the influence of different types of crucibles used as support for the growth of single crystal, on samples properties.

Since the discovery of high temperature superconductivity on $YBa_2Cu_30_{7-\delta}$ (Y-123) there has been a great interest in substituting different elements for atoms on different sites of Y-123. Generally, the substitution of rare earth elements on the Y site does not show important effects on the magnetic and superconducting properties. One exception to this behavior is the substitution of Y for Pr[1]. Its partial substitution in a compound of the form $Y_xPr_{1-x}Ba_2Cu_3O_{7-\delta}$ quenches the superconductivity for a certain value of x. However, even today, the mechanism responsible for this suppression is not fully understood yet. Therefore, there is a great controversy respect to the mechanism responsible for this behavior in the $Y_xPr_{1-x}Ba_2Cu_3O_{7-\delta}$ system. However, superconductivity in $PrBa_2Cu_3O_{7-\delta}$ (Pr123) samples has been reported for many authors[2,3] where the method of synthesis appears to be responsible for the formation, or not, of the superconducting phase.

In this work we present the method to obtain single crystalline samples of the $Y_xPr_{1-x}Ba_2Cu_3O_{7-\delta}$ system and also a systematic study of their physical properties, specifically for the compositions x = 0; x = 0.25; x = 0.50; x = 0.75 and x = 1.0. We also study the influence of cationic doping in single crystals of the composition $PrBa_2(Cu_{1-x}M_x)_3O_{7-\delta}$ (M= Ga, Zn, Fe and Ni), obtained by the self-flux growth method. In order to study the fundamental properties specifically related to superconductivity, we have grown high-quality and impurity-free single crystals by using high-density homemade crucibles of SnO_2, $BaZrO_3$ and Al_2O_3 (Fig.1). The samples were prepared by the polymeric precursors phases method (Pechini´s method), recognized to produce very homogeneous samples reducing the presence of secondary phases, and also by the traditional solid-state method. The quality of all samples was checked by both x-ray diffraction (XRD) and scanning electronic microscopy (SEM) (Fig. 2). Through AC and DC magnetic susceptibility, and also resistivity measurements as a function of temperature, we have studied superconducting properties of the different members of the system $Y_xPr_{1-x}Ba_2Cu_3O_{7-\delta}$. Particularly, we have analyzed the low temperature magnetic behavior for samples of different compositions, treated in Argon atmosphere instead of oxygen.

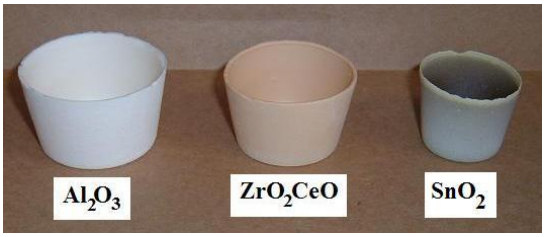

Figure 1: High-density homemade crucibles of Al_2O_3, ZrO_2CeO and SnO_2

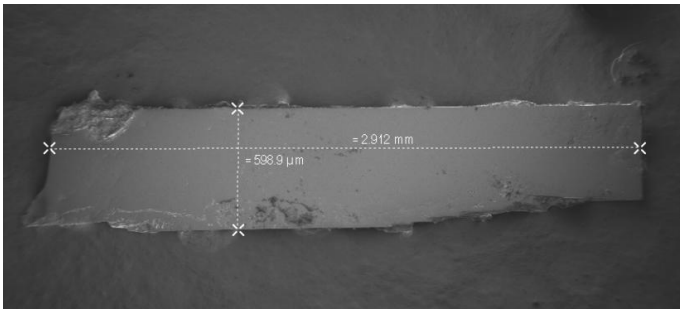

Figure 2: SEM photography of single crystalline sample of the $PrBa_2Cu_3O_{7-\delta}$

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