Temperature Dependent Magnetization and Critical Current Density in Pr doped HTS $YBa_2Cu_3O_x$

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In present study we have studied the variation of magnetization versus applied field up to 4 T over a wide temperature range from 10 K to 70 K for Pr doped polycrystalline $YBa_2Cu_3O_x$. The critical current density has been calculated based on the magnetization measurements. Our titration measurements yielded an oxygen content of x=6.98 for the 400°C-annealed sample and x=6.62 for the 600°C-annealed sample. The electrical resistivity experiments showed transition temperature T_c. values of 91 K and 63 K for the samples annealed at 400°C and 600°C, respectively.

Keywords: Magnetization, Current density, Superconductivity.

1. INTRODUCTION

Since the discovery of high-temperature superconductors, most research activities have been directed to the study of the fundamental physical properties of the materials. Flux pinning mechanisms in Pr doped $YBa_2Cu_3O_x$ has been one of the most important subjects in high T_c, superconductivity research [1]. The critical current density enhancement depends on correct identification of the pinning mechanisms, which is essential to the potential application of high T_c superconductors. Although sintered polycrystalline Pr doped $YBa_2Cu_3O_x$ has been shown to carry extremely low transport critical current density J_c compared to that of conventional superconductors, large hysteresis has been observed in the magnetization measurements [2, 3]. In the present study we report the magnetization data up to 4 T taken at different temperatures for Pr doped polycrystalline $YBa_2Cu_30_x$.

2. EXPERIMENTAL STUDY

The samples were prepared by using conventional ceramic processing techniques. Y_2O_3, Pr_6O_{11}, CuO, and $BaCO_3$ powders were thoroughly ground. They were dried and calcined in air at 950°C for 4 h. The calcination was repeated three times with intermediate grindings. The calcined powders were pressed into pellets. The pressed pellets were sintered in air at 950° C for 4 h. After sintering, the pellets were quenched from the sintering temperature to 400° C and 600° C.and annealed at these temperatures for 18 h. Finally, the samples were quenched again to room temperature on an aluminium plate with a polished surface. Electrical resistivity versus temperature data were taken by using the conventional four-prob technique. The magnetization experiments were performed on a commercial SQUID magnetometer at different temperatures up to 4 T [4, 5].

3. RESULTS AND DISCUSSION

The magnetization data for the 400°C-annealed sample at temperatures 10 K, 30 K and 70 K are shown in Figure 1. It can be seen in Figure 1(a) the sample has a high magnetization hysteresis at 10 K. The field required to close the hysteresis loop is approaching 4 T. It can be seen in the figure that the magnetization hysteresis is gradually reduced to the minimum value with the increasing field. The sample exhibits different behavior as the temperature is raised to 30 K and 70 K shown in Figure 1(b) and Figure 1(c). It is clear that the hysteresis is rapidly reduced with the increasing field up to the applied field value near 1 T.

The magnetization data taken at 10 K, 30 K and 70 K for the 600° C-annealed samples are shown in Figure 2. It can be seen in the figure, all the curves have similar characteristics except that the width of their hysteresis loops is consistently reduced as the temperature increases from 10 K to 70 K.

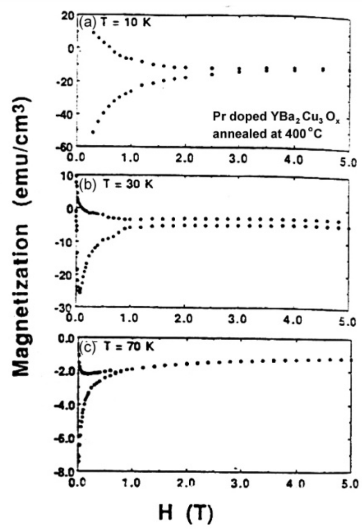


Fig. 1: Magetization curves for the sample annealed at 400° C.

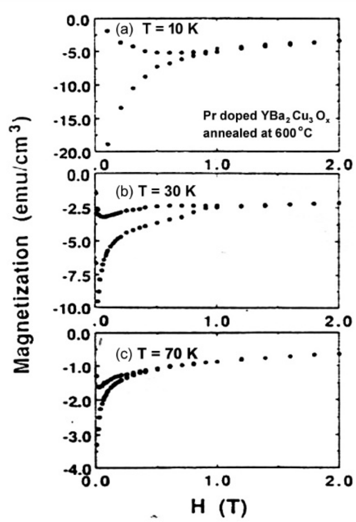
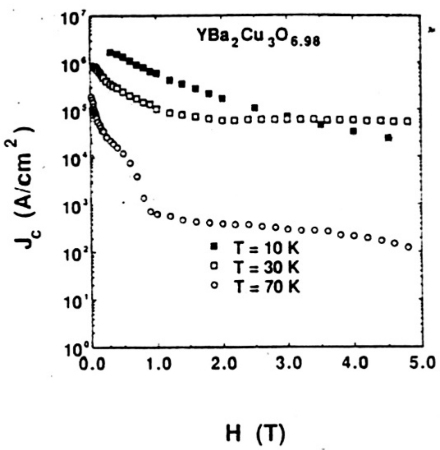


Fig. 2: Magetization curves for the sample annealed at 600° C.

The calculated critical current density Jc for the two samples annealed at 400°C and 600°C are plotted against the applied field shown in Figure 3 and Figure 4 respectively. It can be seen in Figure 3, the sample has high J_c values at low fields. However, the critical current density behavior is quite different at various temperatures. At 10 K, the J_c gradually decreases with increasing field up to 4 T. At 30 K and 70 K, the J_c values drop rapidly up to 1 T and then remain constant up to 4 T. Similar J_c characteristics are observed in the 600°C-annealed sample shown in the Figure 4. It can be seen that J_c value at 10 K gradually decreases as the applied field increases. Although the overall magnitude of J_c has decreased as temperature is raised to 30 K. At 50 K J_c again dropes quickly to a very low value near 1 T.



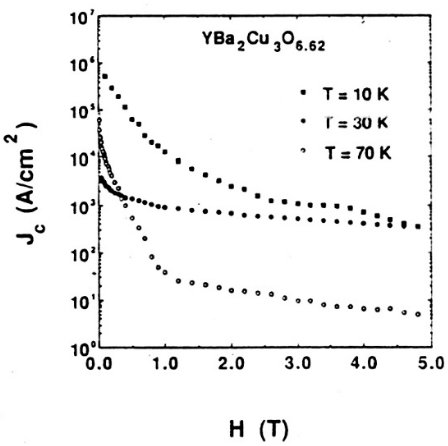


Fig. 3: Critical current density vs field for the sample annealed at 400° C.

Fig. 4: Critical current density vs field for the sample annealed at 600° C.

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