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Magnetization study of mercurocuprate $(Hg,Re)Sr_2CuO_{4+\delta}$

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Abstract. The nominal $(Hg_{1-x}Re_x)Sr_2CuO_{4+\delta}$ ($x = 0.10$ and 0.20) samples were synthesized at $\sim 920°C$ in partial vacuum. The compound with $x = 0.10$ exhibits superconductivity at ~ 54 K while the composition $x = 0.20$ is non-superconducting down to 5 K. On cooling below 10 K in an applied field of 4 kOe, the former causes a noticeable upturn in the field cooled (FC) magnetization signal. Such a change in magnetic response is also reflected in the magnetic hysteresis loop generated at 9 K. We attribute this effect to a paramagnetic contribution arising from Re in (Hg,Re)-1201 phase.

Keywords. Superconductivity; Hg-cuprate; magnetization; magnetic hysteresis.

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1. Introduction

In Hg-based cuprate superconductors, Re substitution at the Hg site has shown beneficial effects on the phase formation and chemical stability [1–4]. Our interest has been focussed on the synthesis and study of the Ba-free, $(Hg_{1-x}M_x)Sr_2CuO_{4+\delta}$ (M = Cr, Mo or Re), referred to as (Hg,M)-1201 phase. Recently, we reported the results of $(Hg,M)Sr_2CuO_{4+\delta}$ (M = Cr or Mo) system [5,6]. Since only a few reports are available on (Hg,Re)-1201, further investigations on this system are desirable. Hahakura *et al* [1], however, have observed that the stabilization of superconducting (Hg,Re)-1201 phase requires a lower content (x) of Re vis-à-vis Cr or Mo [1]. Therefore, in this work, we report on the synthesis, characterization and superconducting properties of nominal composition $(Hg_{1-x}Re_x)Sr_2CuO_{4+\delta}$ ($x = 0.10$ and 0.20).

2. Experimental

The samples of nominal composition $(Hg_{1-x}Re_x)Sr_2CuO_{4+\delta}$ ($x = 0.1$ and 0.2) were prepared at elevated temperature ($\sim 920°C$ for 16–32 h) under partial vacuum using appropriate proportions of high purity HgO and laboratory prepared $Re_xSr_2CuO_y$ ($x=0.10$ and 0.20) precursors in a vacuum-sealed quartz tube. The details of the sample preparation are given elsewhere [7]. The phase purity of the samples was checked by powder X-ray diffraction (XRD) Philips model PW1710. The dc-magnetization measurements were carried out using an E.G.&G. P.A.R. vibrating sample magnetometer (VSM model 4500) in field-cooled (FC) and zero field-cooled (ZFC) conditions. Magnetic hysteresis loop (M–H) was generated at 9 K using VSM.

3. Results and discussion

A typical XRD pattern (figure 1a) of (Hg,Re)-1201 sample shows that the main peaks are due to tetragonal 1201-type structure [1]. A few additional peaks due to minor impurity phases, viz., $SrCuO_2$ and Sr_2CuO_3, were also identified [1,3,4]. Figure 1b shows the dc-magnetization measurement in field-cooled (FC) and zero field-cooled (ZFC) conditions for $x = 0.1$ at 500 Oe applied field as a function of temperature. For this composition, a T_c^{onset} of $\sim$ 54 K was observed. However, no superconductivity was found for $x = 0.20$ composition down to 5 K even at low applied field of 10 Oe. Since this sample was not superconducting, further studies were not conducted on this sample. A similar result was also reported earlier by Calleja *et al* [3] and Peacock *et al* [4]. For $x = 0.10$ composition, higher applied field (4 kOe) causes a noticeable upturn in the FC magnetization signal at below $\sim$ 10 K. The temperature at which the magnetization shows the minimum increases with applied field. This is also reflected in the magnetic hysteresis loop (M–H) generated at 9 K (figure 1c).

The M–H curve shown in figure 1c looks like a hybrid between that normally obtained for superconducting sample and a paramagnetic magnetization curve. As the field is increased, a low field diamagnetic signal emerges. It can be seen from the hysteresis loop that the superconducting contribution by magnetization is superimposed on paramagnetic contribution arising from rhenium ions. A similar paramagnetic behavior was observed for (Hg,Re)-Ba-1223 system [8], which was not observed in undoped Hg-Ba-1223 system [9]. These results indicate that superconductivity of Cu–O sub-lattice and paramagnetism of Re–O sub-lattice exist in the $(Hg_{0.9}Re_{0.1})Sr_2CuO_{4+\delta}$ system.

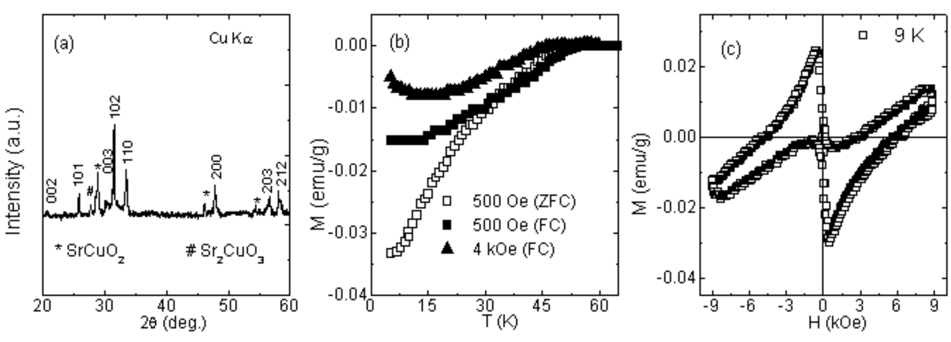

Figure 1. (**a**) XRD, (**b**) dc-magnetization and (**c**) M–H hysteresis of $(Hg_{0.9}Re_{0.1})Sr_2CuO_{4+\delta}$.

4. Conclusion

The nominal $(Hg_{1-x}Re_x)Sr_2CuO_{4+\delta}$ ($x = 0.10$ and 0.20) samples were synthesized in partial vacuum and characterized by XRD, dc-magnetization and M–H hysteresis. The $x = 0.10$ sample exhibits superconductivity at $\sim$ 54 K, while for $x = 0.20$ composition no superconducting signature was observed down to 5 K. The paramagnetic behavior observed in the former is probably due to Re ions in the (Hg,Re)-1201 phase.

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