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High-T_c Superconductivity in the Er–Ba–Cu–O and Related Systems*

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$ErBa_2Cu_3O_7$ and $Er_{0.5}Y_{0.5}Ba_2Cu_3O_7$ are both high-T_c superconductors attaining zero resistance above 80 K. Preliminary studies indicate that $Yb_{1-x}Y_xBa_2Cu_3O_7$ also exhibits zero resistance above 77 K.

High-temperature superconductivity in the Y–Ba–Cu–O system has been the subject of intense investigation in the last few weeks. The oxide phase responsible for high-temperature superconductivity in this system was identified in this laboratory to be $YBa_2Cu_3O_{7+\delta}$, with δ being less than -0.2 (*1*, *2*). A similar report has been provided by others (*3*). The pure compound shows zero resistance close to 90 K and exhibits a nearly 100% Meissner effect (4, 5). Encouraged by this finding, we have explored analogous compounds in the Er–Ba–Cu–O system. Since Er has a magnetic moment, any superconductivity found in this system would be of interest especially for high critical current applications.

We prepared $Er_{0.5}Y_{0.5}Ba_2Cu_3O_7$ and $ErBa_2Cu_3O_7$ by the solid state reaction of the component oxide at 1170 K, followed by annealing of the product for 8 hr in oxygen at 1100 K. X-ray patterns of the products so

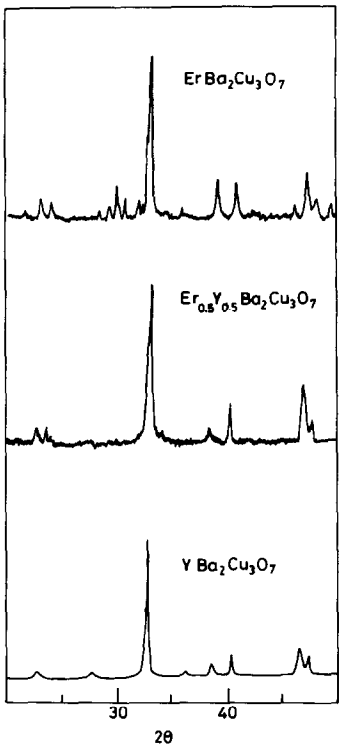

FIG. 1. X-ray diffraction patterns of $YBa_2Cu_3O_7$, $Er_{0.5}Y_{0.5}Ba_2Cu_3O_7$, and $ErBa_2Cu_3O_7$.

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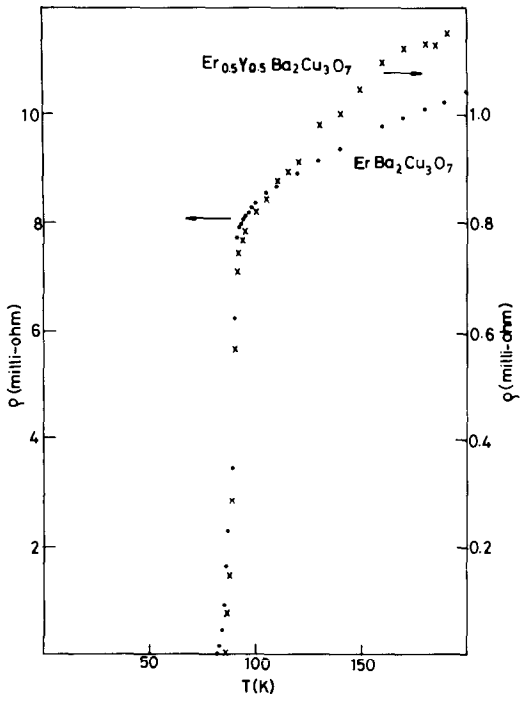

FIG. 2. Resistivity data of $Er_{0.5}Y_{0.5}Ba_2Cu_3O_7$ (crosses) and $ErBa_2Cu_3O$ (filled circles). Prolonged heating in O_2 at 1100 K further increases the temperature at which zero resistance is attained.

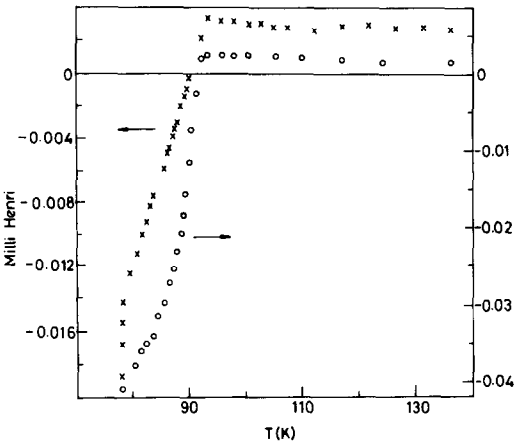

FIG. 3. AC susceptibility data of $Er_{0.5}Y_{0.5}Ba_2Cu_3O_7$ (circles) and $ErBa_2Cu_3O_7$ (crosses).

obtained are shown in Fig. 1. We readily see that the X-ray diffraction pattern of $Er_{0.5}Y_{0.5}Ba_2Cu_3O_7$ is similar to that of $YBa_2Cu_3O_7$, but the unit cell parameters are smaller (a = 3.89 Å, b = 3.86 Å, and c = 11.66 Å). $ErBa_2Cu_3O_7$ also exhibits essentially a perovskite pattern, with a minor impurity phase of Er_2BaCuO_5. Heating the oxide in oxygen for prolonged periods eliminates such a phase. The unit cell parameters of $ErBa_2Cu_3O_7$ are much smaller than those of $YBa_2Cu_3O_7$, as expected (a = 3.88 Å, b = 3.86 Å, and c = 11.64 Å).

In Fig. 2 we show the resistivity data of $Er_{0.5}Y_{0.5}Ba_2Cu_3O_7$ and $ErBa_2Cu_3O_7$. We see that the onset of superconductivity occurs at 91 and 92 K, respectively, and zero resistance occurs at 86 and 82 K. Zero resistance is obtained in $Y_{0.5}Er_{0.5}Ba_2Cu_3O_7$ at a slightly lower temperature than $YBa_2Cu_3O_7$ (90 K). We believe that this is due to the presence of a magnetic moment on Er. By prolonged annealing in O_2, it is possible to increase the temperature at which zero resistance is attained in $ErBa_2Cu_3O_7$ by 3 to 4 K, but this is still lower than that of $YBa_2Cu_3O_7$.

AC susceptibility measurements on $Er_{0.5}Y_{0.5}Ba_2Cu_3O_7$ and $ErBa_2Cu_3O_7$ show that Meissner effect is close to 8 and 30%, respectively (Fig. 3). This is possibly associated with the presence of a magnetic moment on Er ions.

Further studies are now in progress on other rare earth–Ba–Cu–O systems. Thus, $Y_{0.75}Yb_{0.25}Ba_2Cu_3O_7$ shows zero resistance close to 82 K and roughly 10% of Meissner effect. Preliminary studies have shown that the Ho–Ba–Cu–O system also exhibits high-T_c superconductivity above 77 K.

Acknowledgments

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