SYNTHESIS AND CHARACTERIZATION FOR A NEW FAMILY OF TI-CONTAINING SEPTENARY OXIDES WITH Tc,zero ABOVE 105 K


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Bulk superconductivity with Tc,zero above 105 K in Tl0.5Pb0.5(Ca1-xAx)Sr2Cu20y oxides (x=0.2, A=Y and rare-earth elements La, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb) with Tb2Cu2Oy-like structure was observed. For A=Ce and mischmetal, Tc,zero was found to be 95 K and 101 K with x=0.1. The results represent one of the few cases where chemical substitution has significantly raised Tc in a known compound. Single phase samples were prepared and were found to be highly reproducible and stable. Furthermore, the preparation conditions are much less stringent than those of other copper-based high-Tc superconductors.

1. INTRODUCTION

It is well known that high-temperature superconductivity near 90 K RBa2Cu30y compounds is almost independent of which trivalent rare earth element R is used. Exceptions to this rule are cerium1 and praseodymium2. Recently, it has been reported that partial substitution of Tl by Pb promoted the formation and stabilized the high-Tc phase as high as 122 K in the (Tl,Pb)-Ca-Sr-Cu-O system3. Hermann et al. found superconductivity at 80-90 K in Tl-(Ca,Y)-Sr-Cu-O system4. In this paper, we describe the successful fabrication and characterization of Tl0.5Pb0.5(Ca1-xAx)Sr2Cu20y system with A= Y, rare-earth elements and mischmetal.

2. EXPERIMENTAL

Appropriate amounts of high purity CaCO3, SrCO3, CuO and Y2O3 or rare-earth oxides or mischmetal (M) oxide were weighed stoichiometrically and ground in an agate mortar. The chemical compositions of the mischmetal oxide are composed of La2O3 (31.8%), CeO2 (24.5%), Pr6O11 (8.9%) and Nd2O3 (31.1%). The well-mixed powders were calcined at 920 °C in air for 12 hours to obtain the Ca-A-Sr-Cu-O precursor. The Ca-A-Sr-Cu-O powders were then mixed with appropriate amount of Tl2O3 and PbO, ground and pressed into a pellet of 2 mm in thickness and 10 mm in diameter under the pressure of about 2 ton/cm2. The pellets were wrapped in gold foils, sintered at 950 °C in flowing O2 for 3 hours, and followed by controlled cooling of 2 °C/min.

3. RESULTS AND DISCUSSION

Fig. 1 shows the temperature dependence of normalized resistance and magnetization curves for Tl0.5Pb0.5(Ca0.8Ho0.2)Sr2Cu2Oy superconductor. Low-field magnetization data were obtained using a superconducting quantum interference devices (SQUID, Quantum Design) from 200 K to 5 K. Meissner signal of this sample indicates the Tc,onset around 108 K and this result is consistent with the resistance measurement of Tc,zero= 108 K. Mass diamagnetic susceptibility -Xg at 5 K is 1.2x 10^-3 cm3/g (field-cooled at 100 G) for Tl0.5Pb0.5(Ca0.8Ho0.2)Sr2Cu2Oy.

Powder X-ray diffraction pattern in Fig. 2 show a preponderance of "1122" P4/mmm tetragonal phase with lattice parameters a= 0.380 nm and b= 1.194 nm for Tl0.5Pb0.5(Ca0.8Y0.2)Sr2Cu2Oy.
Temperature dependence of normalized resistance and magnetization curves for Tl0.5Pb0.5(Ca0.8Ho0.2)Sr2Cu2Oy sample.

EDAX analysis revealed that the composition of sintered Tl0.5Pb0.5(Ca0.8Y0.2)Sr2Cu2Oy superconducting samples were almost identical to their starting nominal compositions. No significant loss of either Tl or Pb was found in the process. The sintered samples were found to be remarkably homogeneous both in composition and structure. The proposed crystal structure deduced from high resolution electron micrographs and X-ray powder diffraction data is shown in Fig. 3.

4. CONCLUSIONS
The successful preparation of Tl0.5Pb0.5(Ca1-xAx)Sr2Cu2Oy superconductors with A = Y, rare-earth elements and mischmetal bears few significant impacts on the search for higher Tc new materials. A comparison with the superconducting properties in (Tl0.5Pb0.5)CaSr2Cu2Oy system indicates that the substitution of Ca by rare-earth elements was essential to promote Tc from 90 K to 110 K. This result is also quite different from the Tc decrease in Ce and Pr substituted of Y in YBa2Cu3Oy system.

REFERENCES