

EFFECT OF OXYGEN STOICHIOMETRY ON T_C OF BI-BASED SUPERCONDUCTORS

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The role of oxygen stoichiometry on T_C is relatively well established on $\text{La}_2\text{CuO}_{4+x}$ and the $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ (123) superconductors[1,2], as compared to the Bi-based superconductors. In this paper we will present results of our investigations on the effects of oxygen stoichiometry on the transition temperature T_C of $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+x}$ (2212 phase), and Pb-doped $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10+x}$ (2223 phase). We show that the effects of oxygen stoichiometry on T_C of these two phases are very different. These results might be helpful in understanding the mechanism of superconductivity in the Bi-based superconductors.

The 2212 and 2223 phases of Bi-based superconductors were synthesized using appropriate amounts of analytical grade Bi_2O_3 , PbO , SrCO_3 , CaCO_3 and CuO by the solid state reaction method. Some details of the method to produce the 2212 phase with excess oxygen has been recently reported[3]. Experiments on the thermal cycling of the annealed samples to affect change in oxygen stoichiometry are done using TGA (Thermogravimetric Analysis) technique which allows us to monitor weight changes of $\sim 0.01\%$, followed by magnetic and resistivity studies to observe changes in T_C and superconductivity. In Fig.1, we present recent results on the change in T_C for the 2212 phase vs weight change produced by thermal cycling (heating in air to different temperatures up to 850°C and cooling in air or Ar)[3]. An increase of T_C from 70 to 95 K for 2212 phase corresponding to weight loss of 0.16% is observed. This is opposite to the effect of oxygen stoichiometry on T_C for the $\text{La}_2\text{CuO}_{4+x}$ and the 123 systems. In a $\text{Bi}_{1.6}\text{Pb}_{0.4}\text{Sr}_2\text{Ca}_3\text{Cu}_4\text{O}_x$ sample, consisting of mainly 2223 phase with small amount of 2212 phase, it is observed that as T_C of the 2212 phase increases from 70 K to above 90 K with weight loss of $\sim 0.2\%$, the T_C of the 2223 phase decreases from 110 K to 106 K. This leads us to infer that excess oxygen resides in different locations in the two phases, viz. Bi-O double layers in the 2212 phase, triple Cu-O layers in addition to Bi-O double layers in the 2223 phase.

In a recent paper, Hybertsen and Mattheiss[4] have used band structure calculations on the idealized (2212) structure to show that excess oxygen can reduce the metallic conductivity of the Bi-O layers, suppressing T_C . However the actual structure of the 2212 phase differs from the idealized structure and we have no proof that excess oxygen resides in the double Bi-O layers of the 2212 phase. Experiments planned for the near future may determine the location of excess oxygen in the Bi-based systems. These results will also be presented.