FORMATION AND CRITICAL CURRENT DENSITIES OF DOPED Tl-1212 HIGH TEMPERATURE SUPERCONDUCTORS

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ABSTRACT

Ti substituted TlSr-1212 type phase high-temperature superconductor with nominal starting composition $Tl_{0.8}Pb_{0.2}Sr_{2-x}Ti_xCa_{0.9}Y_{0.1}Cu_2O_7$ (x = 0-0.7) have been investigated. The normal state resistivity of the system showed metallic behavior for $x \leq 0.5$, semimetal-like behavior for $x = 0.6$ and semiconductor-like behavior for $x = 0.7$. $Tl_{0.8}Pb_{0.2}Ca_{0.9}Y_{0.1}Cu_2O_7$ was observed to superconduct with $T_{c\ onset}$ of 90 K and $T_{c\ zero}$ of 21 K. Substitution of Ti with $x = 0.1$ in place of Sr caused $T_{c\ zero}$ to dramatically increase to 56 K. Further increase in Ti content ($0.1<x<0.6$) did not improve $T_{c\ zero}$ significantly and $T_{c\ onset}$ was maintained at around 90 K. Room temperature resistivity was observed to initially decrease with increasing Ti content for $x = 0.1$ before increasing for $0.2 \leq x \leq 0.7$. The critical current density (J_c) measured around 20 K indicates maximum value of J_c at $x = 0.3$. The results were discussed in terms of changes in the valences of metallic ions and the optimum average Cu valence. The possible valence states of Ti in the Tl-1212 phase were also estimated. Results of structural investigations using x-ray diffraction are discussed.

CHAPTER I

INTRODUCTION

1.1 BASIC PROPERTIES OF SUPERCONDUCTORS

Superconductivity is a phenomenon which refers to the abrupt drop to zero electrical resistance of certain materials. Generally, the electrical resistivity of a solid is determined by a number of factors. Conduction electrons are scattered by the deviations from a perfect lattice due to structural defects or impurities in a crystal. The higher the temperature the more phonons are present, there is an electron-phonon interaction which scatters conduction electrons and causes further resistance. Hence, the electrical resistance of a solid should decrease as the temperature decreases but a residual resistance is expected even near absolute zero due to crystal imperfections. However, the electrical resistance of some solids disappears completely below a certain temperature called the critical temperature T_c. This remarkable phenomenon is known as superconductivity. Besides their zero electrical resistance, superconductors also show another non-typical behavior i.e. perfect diamagnetism. This is the ability of the material to expel or exclude external magnetic field from its interior. The most interesting consequence of this behavior is the ability to levitate a permanent magnet