UNIVERSITI TEKNOLOGI MARA

EFFECTS OF Ta SUBSTITUTION AND ADDITION OF NANO-MgO PARTICLES ON FORMATION AND SUPERCONDUCTIVITY OF TlSr1212 CERAMICS

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ABSTRACT

In this work, the effect of tantalum (Ta) substitutions at the Sr-site on superconductivity of $Tl_{0.9}Bi_{0.1}Sr_{2-x}Ta_xCa_{0.9}Y_{0.1}Cu_2O_7$ ($x = 0 - 0.40$) series and the effect of nanosize MgO particles on 1212 phase formation and transport critical current density, J_c in external magnetic field for $Tl_{0.9}Bi_{0.1}Sr_{1.95}Ta_{0.05}Ca_{0.9}Y_{0.1}Cu_2O_7 + y$MgO ($y = 0 - 0.8$ wt.%) series and $Tl_{0.5}Pb_{0.5}Sr_{1.8}Yb_{0.2}CaCu_2O_7 + z$MgO ($z = 0 - 0.80$ wt.%) series superconductors were investigated. Results of tantalum substitution at Sr-site in $Tl_{0.9}Bi_{0.1}Sr_{2-x}Ta_xCa_{0.9}Y_{0.1}Cu_2O_7$ ($x = 0 - 0.40$) series showed that the best superconducting behavior occurred at $x = 0.05$ with $T_{c\,onset}$ of 96 K and $T_{c\,zero}$ of 65 K. Higher Ta substitution caused gradual deterioration of superconductivity, accompanied by a change of normal state behavior from metallic to semiconductor-like behavior with increasing Ta. SEM investigation showed changes in grain size with Ta substitution. Results of electrical measurements on $Tl_{0.9}Bi_{0.1}Sr_{1.95}Ta_{0.05}Ca_{0.9}Y_{0.1}Cu_2O_7 + y$MgO ($y = 0 - 0.8$ wt.%) series superconductor revealed the highest transport critical current density J_c (at 20 K) of 28 A/cm^2 at $y = 0.2$ wt.%. Samples with $y = 0 - 0.40$ wt.% showed a rapid drop of J_c at low fields (< 0.1 Tesla) before a slower deterioration at higher fields (> 0.1 Tesla). This indicates the presence of weak links at low fields and dominance of strong links at higher fields. The smallest drop of J_c was observed for sample $y = 0.2$ wt.%. SEM results for these series showed no significant difference in microstructure between MgO added samples. Results of electrical measurements on $Tl_{0.5}Pb_{0.5}Sr_{1.8}Yb_{0.2}CaCu_2O_7 + z$MgO ($z = 0 - 0.80$ wt.%) series revealed the highest J_c (at 30 K) of 16 A/cm^2 for $z = 0.1$ wt.%. The behavior of J_c in external fields also indicates presence of weak links at low fields. The smallest drop of J_c was observed for $z = 0.1$ wt.%. SEM micrographs of MgO added samples showed smaller grain size compared to pure samples. The enhanced J_c at $y = 0.2$ wt.% for the $Tl_{0.9}Bi_{0.1}Sr_{1.95}Ta_{0.05}Ca_{0.9}Y_{0.1}Cu_2O_7 + y$MgO series and $z = 0.1$ wt.% for the $Tl_{0.5}Pb_{0.5}Sr_{1.8}Yb_{0.2}CaCu_2O_7 + z$MgO series is suggested to be due to flux pinning as a result of the MgO additions. In conclusion, substitution of $Ta_{0.05}$ at Sr-site successfully stabilized the 1212-phase during synthesis of Tl1212 superconductors. The addition of a moderate amount of nano-MgO particle before final sintering improved transport critical current density and enhanced flux pinning ability of the Tl-1212 superconductors.

Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of University Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated of acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

In the event that my thesis be found to violate the conditions mentioned above, I voluntarily waive the right of conferment of my degree and agree to be subjected to the disciplinary rules and regulations of University Teknologi MARA.

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CHAPTER 1

INTRODUCTION

Superconductors are materials that have zero resistance when applied with current flow. Superconductivity was first discovered in 1911 by the Dutch physicist, Heike Kammerlingh Onnes, who was studying the resistance of solid mercury at cryogenic temperatures using the recently-discovered liquid helium as a refrigerant (Onnes, 1911). At the temperature of 4.2 K, he observed that the resistance abruptly disappeared. In 1913, lead was found to superconduct at 7 K. Another materials tungsten and nobium for example superconduct below 10 K.

Many other elements, compounds and alloys were soon found to be superconductors. In 1941 another conventional superconductor, niobium nitride (NbN) was found to superconduct at 16 K. In 1950, V_3Si was found to superconduct at 17 K. In the following year in 1954, an alloy of niobium and tin (Nb_3Sn) with a critical temperature of 18.1 K was discovered. In 1970, $Nb_3(AlGe)$ was found to superconduct at 21 K while in 1973, Nb_3Ge was found to superconduct with T_c of 23 K (Gavaler, 1973).

Another important characteristic of superconductor is perfect diamagnetism. W.Meissner and R. Ochsenfeld discovered the Meissner effect in 1933 (Bourdillon et al. 1994). This is the capability of the material to eliminate an external magnetic field from its interior. The important behavior for this phenomenon is the ability of superconductor material to levitate permanent magnets on their surface.