EFFECTS OF GERMANIUM SUBSTITUTIONS AT Cu/Sr SITES ON FLUCTUATION INDUCED CONDUCTIVITY AND INTERPLANAR COUPLING OF Tl$_{0.85}$Cr$_{0.15}$Sr$_2$CaCu$_2$O$_{7-\delta}$ SUPERCONDUCTOR

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Thesis submitted in fulfillment of the requirements for degree of Master of Science

Faculty of Applied Sciences

September 2011
Author’s Declaration

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

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

This thesis describes the effects of Germanium (Ge) substitutions at Cu/Sr sites on fluctuation induced conductivity and interplanar coupling of Tl1212 layered structure. Two series of Tl1212 superconductors were synthesized from Tl0.85Cr0.15Sr2CaCu2-xGe2O7-δ (x=0-0.6) and Tl0.85Cr0.15Sr2-yGe2CaCu2O7-δ (y=0-0.3) nominal starting compositions using the conventional solid state method. Substitution of Ge⁴⁺ in place of Cu in Tl0.85Cr0.15Sr2CaCu2-xGe2O7-δ (x=0-0.6) series showed initial increase in zero critical temperature value, $T_c$ zero from 98 K (x=0) to 100 K (x=0.1) and in the range of 85-86 K for x=0.2-0.3. The slow decrease in $T_c$ zero is unexpected as tetravalent Ge⁴⁺ substitution is expected to strongly reduce hole concentration in the samples and suppress $T_c$ zero. While for substitution of Ge⁴⁺ in place of Sr in Tl0.85Cr0.15Sr2-yGe2CaCu2O7-δ (y=0-0.3) series, electrical resistance measurements showed the zero critical temperature value, $T_c$ zero were in the range of 90-98 K for y=0-0.15 and in range of 60-78 K for y=0.2-0.3. Analysis of excess conductivity behavior based on Aslamazov-Larkin model for the Ge free compound, revealed a 2D fluctuation behavior. However, substitution of Ge in both of the series induced 2D to 3D transition behavior with the highest transition temperature, $T_{2D,3D}$ observed at x=0.10 and y=0.10 samples. The analyses of Fourier transformation infrared (FTIR) and X-ray diffraction (XRD) data indicate increasing CuO inter-plane coupling with Ge substitution at both Cu and Sr-sites. The increment was suggested to cause sustenance of the high $T_c$ zero and metallic normal state behavior for x=0-0.30 and y=0.03-0.15 samples. This is supported by the excess conductivity analysis using the Lawrence Doniach model which also indicates an increase in the inter-plane coupling ($J$) values. It was suggested that the increase in inter-plane coupling may enhance correlation between the carrier of the superconducting samples which then decrease the anisotropy and resulted to better superconducting properties of the samples.
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