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EFFECT OF Eu_2O_3 NANOPARTICLES ON STRUCTURAL AND SUPERCONDUCTING PROPERTIES IN Bi(Pb)-2223 HIGH TEMPERATURE SUPERCONDUCTOR

NURBAISYATUL ERMIZA BINTI SUHAIMI

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ABSTRACT

The structural and superconducting properties of $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_3O_y$ (Bi(Pb)-2223) high temperature superconductor synthesized through solid-state reaction method with doping and addition of Eu_2O_3 nanoparticles have been studied. The samples of $Bi_{1.6}Pb_{0.4}Sr_2(Ca_{2-x}Eu_x)Cu_3O_y$ ($0.000 \leq x \leq 0.100$) for both high and low density together with $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_3O_y + xEu_2O_3$ ($0.0 \leq x \leq 1.0$) have been successfully prepared. In order to produce a low density sample, crystalline sucrose was added during pelletization process and burned at 400°C for two hours. The structural of the samples were studied using X-ray diffraction (XRD) analysis while the microstructural is investigate using Field-Emission Scanning Electron Microscopy (FESEM), Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray (EDX) spectroscopy for elemental analysis. The electrical and magnetic properties of the superconductor were investigated using the four-point probe method and Alternating Current Susceptibility (ACS), respectively. Substitution of Eu_2O_3 nanoparticles in both high and low density favours the growth of Bi-2212 phases more compared to addition samples. The substitution of Eu_2O_3 nanoparticles resulted in a change of crystallographic structure from tetragonal to orthorhombic in low density samples while the change occurred for $x > 0.0025$ for high density samples. However, the crystal structure remains unchanged in Bi(Pb)-2223 samples with addition Eu_2O_3 nanoparticles. As determined by FESEM and SEM investigations, the surface morphology of the microstructures degraded and the porosity increased towards the Eu_2O_3 nanoparticles concentration, which resulted in the degradation of the superconducting properties. However, low density samples adding with Eu_2O_3 nanoparticles showed better grain alignment compared to the substitution samples. From the resistivity measurement, the *R–T* curve showed a smooth resistivity curve for all samples that correspond to Bi-2223 phase one-step transition. Apparently, the T_c value of the high density Bi(Pb)-2223 was determined at 89 K while the T_c value is higher for low density sample at 99 K for both Eu-free samples. However, the T_c value decreases when substituted with Eu_2O_3 nanoparticles for both high and low density series. Sample with 0.2 wt% Eu_2O_3 nanoparticles yields the highest $T_{c\ \mathrm{zero}}$ at 89 K for addition series. Meanwhile, when the concentration of Eu_2O_3 nanoparticles increased, so did the J_c value. The J_c values of the samples with added Eu_2O_3 nanoparticles were found to increase compared to those of the substitution samples. The highest Jc enhancement was obtained for $x = 0.2$ wt% sample with 7.29 A/cm^2. The AC susceptibility measurement shows that intragranular peak, T_{pm} were observed in Bi(Pb)-2223 substituted samples. The optimum sample for high and low density doped with Eu_2O_3 nanoparticles are found at $x = 0.0025$ while for addition sample is found at $x = 0.2$ wt%. The present results show that addition sample yields greater value and performance compared to substitution samples. Overall, it can be concluded that doping and adding a small amount of Eu_2O_3 nanoparticles can enhance the structural and superconducting properties of the BSCCO system.

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TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 Background Study

Superconductivity is one of the greatest achievements discovered by scientists in the twentieth century. Onnes (1911) was accidentally discovered this phenomenon which electrical resistance in a material vanishes at certain temperature. They found that mercury displays a zero electrical resistance when it was cooled down to 4.2K. Hence, superconductor defines as a material which can conduct electricity without any resistance below a certain temperature and does not involve any energy release when carrying direct current. The electrical and magnetic properties of some materials called superconductors change and show zero electrical resistance and expel all the magnetic fields at very low temperatures. This condition of zero resistivity or infinite conductivity known as superconductivity can only be achieved when metal or alloy is cooled below certain temperature called critical temperature. In superconducting state, these materials have the ability to transport large DC currents with little or no loss of energy.

Superconducting materials can be classified into three groups which are metal-based system, copper oxides (cuprates) and iron-based superconductors (Hosono et al. 2018). Among those categories, cuprates exhibit admirable characteristics due to their strong magnetic field performance, zero energy losses and current-carrying capacity (Fallah-Arani, Baghshahi, and Sedghi 2021). One of the most well-known superconducting systems is Bi-Sr-Ca-Cu-O (BSCCO). BSCCO is one of the important categories of high temperature superconductors which do not contain rare earth elements. It consists of a two-dimensional layered (perovskite) structure where the superconducting phenomenon varies in copper oxide plane. BSCCO system has several advantages over the others such as environment friendly, higher critical current density and tolerate higher external magnetic fields. These features make the BSCCO system look promising for future applications. BSCCO compounds exhibit both an intrinsic Josephson effect and anisotropic (dimensional) behavior. The general formula for Bi-based high temperature superconductor can be stated as $Bi_2Sr_2Ca_{n-1}Cu_2O_{2n+4}$ and generally categorized into three different structures according to their 'n' values (Salleh, 2011) where the value of Tc increase as the value of 'n' increases. The 'n' values in these BSCCO systems refer to the different number of Cu-O planes which are