

EFFECT OF Cr_2O_3 ON THE TRANSITION TEMPERATURE AND PHASE
FORMATION OF $\text{Ti}_{2-x}\text{Cr}_x\text{Ba}_2\text{CaCu}_2\text{O}_{8.8}$ SUPERCONDUCTOR

(Kesan Cr_2O_3 Terhadap Suhu Peralihan dan Pembentukan Fasa Superkonduktor
 $\text{Ti}_{2-x}\text{Cr}_x\text{Ba}_2\text{CaCu}_2\text{O}_{8.8}$)

Syahrul Humaidi^{1*} and Roslan Abd Shukor²

¹Department of Physics,
FMIPA-Universitas Sumatera Utara, Jln Bioteknologi 1, Medan 20155, Indonesia

²Department of Applied Physics,
Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

*Corresponding author: syahrul1@usu.ac.id

Received: 13 November 2019; Accepted: 3 September 2020; Published: xx October 2020

Abstract

The Ti-based high T_c superconductors, $\text{Ti}_{2-x}\text{Cr}_x\text{Ba}_2\text{CaCu}_2\text{O}_{8.8}$ (Tl2212) have been prepared via the solid-state reaction method. The substitution of Cr into the Ti-site was aimed to investigate the role of Cr on the transition temperature and phase stability of the Tl2212 phase. $\text{Ba}_2\text{CaCu}_2\text{O}_y$ precursor material was synthesized using BaCO_3 (99.9%, Aldrich), CaO (99.99%, Alfa Aesar), and CuO (99.9%, Alfa Aesar) powder as the starting compound. The powders were mixed and sintered at 900 °C for 24 hours before cooled to room temperature. The precursor was mixed with Ti_2O_3 (99.9%, Alfa Aesar) and Cr_2O_3 (99.9%, Merck) powders before being pressed to obtain $\text{Ti}_{2-x}\text{Cr}_x\text{Ba}_2\text{CaCu}_2\text{O}_8$ pellet. The pellets were heated at 900 °C with oxygen flow for 4 minutes. The transition temperature, T_c was determined using the standard four-point probe electrical resistance measurements from 50 K to 300 K with a constant current of 20 mA. The phases were determined by powder X-ray diffraction (XRD) method using CuK_α source with $\lambda = 1.5418$ Å. Based on XRD analysis, the $x = 0, 0.2$, and 0.6 showed unit cell belonging to the $14/\text{mmm}$ space group. In the $x = 0.4$, the space group changed to $\text{P}4/\text{mmm}$ which is the Tl1212 phase. It was found that the optimum composition was $\text{Ti}_{1.8}\text{Cr}_{0.2}\text{Ba}_2\text{CaCu}_2\text{O}_{8.8}$ and the maximum zero-resistance temperature, $T_{c=0}$ was 96 K, and the onset temperature, $T_{c=onset}$ was 116 K. It was observed that the transition temperatures decreased with increasing Cr_2O_3 . The volume fraction of the Tl2212 phase in this composition was 88% with the c -lattice parameter equals to 29.388 Å. Superconductivity was destroyed in the $x = 1.0$ samples.

Keywords: transition temperature, structure, Tl2212 phase

Abstrak

Superkonduktor suhu tinggi berasaskan Ti iaitu, $\text{Ti}_{2-x}\text{Cr}_x\text{Ba}_2\text{CaCu}_2\text{O}_{8.8}$ (Tl2212) telah disediakan melalui kaedah tindak balas pepejal. Penggantian Cr pada kedudukan Ti dilakukan untuk menyelidik peranan Cr terhadap suhu genting dan kestabilan fasa

Commented [nb1]: Addition of: (-)

Abd-Shukor

Syahrul

Shahrul & Roslan: EFFECT OF Cr_2O_3 ON THE TRANSITION TEMPERATURE AND PHASE FORMATION OF $\text{Ti}_{1-x}\text{Cr}_x\text{Ba}_2\text{CaCu}_2\text{O}_{8-\delta}$ SUPERCONDUCTOR

pada 900 °C dengan aliran gas oksigen selama 4 menit. Suhu peralihan, T_c ditentukan dengan pengukuran rintangan elektrik menggunakan kaedah piawai empat titik dalam suhu 50 K hingga 300K dengan bekalan arus malar 20 mA. Pecahan fasa diperolehi daripada kaedah pembelauan serbuk sinar-X (XRD) menggunakan sinar $\text{CuK}\alpha$ dengan panjang gelombang $\lambda = 1.5418\text{\AA}$. Berdasarkan analisis XRD, sampel $x = 0, 0.2$, dan 0.6 adalah pada kumpulan ruang 14/mmm. Untuk sampel $x = 0.4$ kumpulan ruang berubah menjadi P4/mmm iaitu fasa yang berlainan (Ti1212). Didapati bahawa suhu peralihan sifar maksimum, $T_{c\text{ sifar}}$ adalah 96 K dan suhu peralihan mula, $T_{c\text{ mula}}$ adalah 116 K bagi komposisi $\text{Ti}_{1-x}\text{Cr}_x\text{Ba}_2\text{CaCu}_2\text{O}_{8-\delta}$. Pecahan isipadu daripada fasa Ti2212 dalam sampel ini adalah 88% dengan parameter kekisi c bersamaan 29.388 Å. Sifat superkonduktor hilang pada komposisi $x = 1.0$.

Kata kunci: suhu peralihan, struktur, fasa Ti2212

Introduction

High temperature superconductor (HTSC) based on copper oxides have critical temperature greater than 77 K (above liquid nitrogen temperature). Some of the common types of HTSCs include YBaCuO (YBCO), BiSrCaCuO (BSSCO), TiBaCaCuO (TBCCO), HgBaCaCuO , and HgTlBaCaCuO . Many efforts are being made to enhance the transition temperature of HTSCs. Some researchers modified the fabrication techniques of the materials [1-4]. Most of the research works [5-9] deal with doping and atomic substitution. The thallium-based copper oxide superconductor consists of several phases with a different number of copper oxide layers. Previous works on thallium-based high temperature superconductor concentrated on several phases of Tl-based HTSCs. T_c of $\text{TlBa}_2\text{CaCu}_2\text{O}_{7-\delta}$ (Ti1201) was around 70 K [10], whereas $\text{Tl}_2\text{Ba}_2\text{CaCu}_2\text{O}_{8-\delta}$ (Ti1212) had T_c of 110 K [11]. The $\text{TlBa}_2\text{Ca}_3\text{Cu}_4\text{O}_{11-\delta}$ (Ti1234) was reported with T_c of around 114 K [12].

The role of Cr at the Tl-sites in Tl-based superconductor has been widely studied. Chromium is an effective element for substitution in Tl-Sr-Ca-Cu-O systems [13]. There have been several reports on the effect of Cr on the superconductivity of Tl-1212 phase. The substitution of Cr for Tl or Ca site improves the superconducting behavior. Tl, Ba, Sr, Ca substitution improves the

has been observed that the volume fraction of Ti2212 phase increased as Te content was increased [19]. It is interesting to investigate the effects of Cr in other phases of the Tl-based superconductor. In this paper, we report the effects of Cr on the superconducting properties and phase formation of the Tl-2212 phase.

Materials and Methods

Samples with the nominal starting composition $(\text{Ti}_{1-x}\text{Cr}_x)\text{Ba}_2\text{CaCu}_2\text{O}_8$ with $x = 0.0, 0.2, 0.4, 0.6$, and 0.8 were prepared by the solid state reaction method. Appropriate amounts of high purity (>99.99%) BaCO_3 , CaO , and CuO were mixed completely using an agate mortar to obtain a homogeneous mixture. The precursor powders were heated at 900 °C for 24 hours with several intermittent grinding. Appropriate amounts of Ti_2O_3 and Cr_2O_3 with appropriate mole% were then added to the precursor and completely mixed before being pressed into pellets with 1.3 cm diameter and 0.2 cm thickness under 7 ton/cm² of pressure. The pellets were heated at 900 °C in flowing oxygen for 4 minutes. This was followed by furnace cooling to room temperature. An excess of 10% Ti_2O_3 was added to compensate for the thallium lost during heating.

The dc electrical resistance measurements were performed between 50 K and 300 K. The four-point

Commented [nb2]: h is replaced with y

