

**UNIVERSITI TEKNOLOGI MARA**

**SUPERCONDUCTING PROPERTIES  
OF CALCIUM SUBSTITUTION AT  
BARIUM SITE OF POROUS YBCO  
CERAMICS**

**NORAZIDAH BINTI ABD WAHAB**

Thesis submitted in fulfilment  
of the requirements for the degree of  
**Master of Science**


**Faculty of Applied Sciences**

**September 2014**

## **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. The topic 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.

Name of Student : Norazidah binti Abd Wahab  
Student I.D. No. : 2010788213  
Programme : Master of Science (AS780)  
Faculty : Applied Sciences  
Thesis Title : Superconducting Properties of Calcium Substitution at Barium Site of Porous YBCO Ceramics  
Signature : ..........  
Date : September 2014

## ABSTRACT

The influence of Ca substitution on the superconductivity at the Ba site of porous  $Y(Ba_{1-x}Ca_x)_2Cu_3O_8$  ( $x = 0.00, 0.05, 0.10, 0.20, 0.30,$  and  $0.40$ ) samples were prepared via solid-state reaction method. The morphology and structural identification, elemental composition, critical temperature and critical current were determined by field-emission scanning electron microscopy (FESEM), X-ray diffraction (XRD), energy dispersive X-ray (EDX) and four-point probe method at the temperature within the range of 20 K to 300 K. Generally, the curves of normalized resistance for all samples displayed normal metallic behavior above  $T_{c\ onset}$ .  $T_{c\ zero}$  decreased from 84 to 68 K due to the charge consideration and ionic radii. The critical current density  $J_c$  was found to decrease as the concentration of Ca increased. The highest value of  $J_c$  was obtained at  $3.214\ A/cm^2$  at  $x = 0.05$ , which is higher than that of Ca-free porous YBCO.  $J_c$  decreased monotonically with the increase of Ca concentration. The substitution of Ca at the Ba sites does not alter the orthorhombic structure of the samples. However, the volume of the unit cell increases with Ca concentration. The grains are highly compacted and randomly distributed while the grain size tends to decrease as Ca concentration is increased. Samples with the heat treatment of  $900\ ^\circ C$  for five hours showed metallic behavior beyond the onset transition temperature,  $T_{c\ onset}$  and the  $T_{c\ zero}$  has improved for  $x = 0.05, 0.30$  and  $0.40$ , otherwise vice versa at  $x = 0.00, 0.10$  and  $0.20$ . Further substitution of Ca has reduced the grain size with randomly distributed microstructure. The heat treatment process does not affect the crystallographic structure and remains orthorhombic. EDX results show that there is no existence of sucrose.

## TABLE OF CONTENTS

	<b>Page</b>
<b>AUTHOR'S DECLARATION</b>	ii
<b>ABSTRACT</b>	iii
<b>ACKNOWLEDGEMENT</b>	iv
<b>TABLE OF CONTENTS</b>	v
<b>LIST OF TABLES</b>	viii
<b>LIST OF FIGURES</b>	ix
<b>LIST OF SYMBOLS</b>	xii
<b>LIST OF ABBREVIATIONS</b>	xiii
<b>LAYOUT OF THE THESIS</b>	1
<b>CHAPTER ONE: INTRODUCTION</b>	
1.1 Background of Study	2
1.2 Problem Statement	3
1.3 Objectives of Study	4
1.4 The Significance of Study	4
1.5 Scope and Limitation of The Study	5
<b>CHAPTER TWO: LITERATURE REVIEW</b>	
2.1 History of superconductor	6
2.2 Basic properties of superconductors	
2.2.1 Zero resistance	8
	v

2.2.2	Meissner effect	9
2.3	YBCO superconductor	10
2.4	Porous structure	12
2.5	Substitution phenomenon	14
2.5.1	Calcium properties	15
2.5.2	Substitution at Ba site	16
2.5.3	Ca substitution	17
2.6	Heat treatment	18
2.7	Density Measurement	18
2.8	X- Rays Diffraction	19

### **CHAPTER THREE: METHODOLOGY**

3.1	Preparation Of Samples	
3.1.1	Ca- Free $\text{YBa}_2\text{Cu}_3\text{O}_7$ Sample	21
3.1.2	Porous Ca- Free $\text{YBa}_2\text{Cu}_3\text{O}_7$ Sample	23
3.1.3	Porous Calcium Substituted $\text{Y}(\text{Ba}_{1-x}\text{Ca}_x)_2\text{Cu}_3\text{O}_7$ & Heat Treatment Process	25
3.2	Density Measurement	28
3.3	Sample Characterization	
3.3.1	X-Ray Diffraction (XRD)	29
3.3.2	Field Emission Scanning Electron Microscopy (FESEM)	29
3.3.3	Energy Dispersive X- Ray (EDX)	30
3.3.4	Resistivity Measurement, Critical Temperature ( $T_c$ )	30
3.3.5	Electrical Measurement, Critical Current Density ( $J_c$ )	32