

**EFFECTS OF ADDITIVE ELEMENTS: CESIUM,
CERIUM, ZIRCONIUM AND GERMANIUM ON
CRYSTAL STRUCTURE AND DIELECTRIC
PROPERTIES OF CALCIUM COPPER
TITANATE CERAMICS**

WORAWUT MAKCHAROEN

**DOCTOR OF PHILOSOPHY
IN MATERIALS SCIENCE**

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่

Copyright© by Chiang Mai University

All rights reserved
THE GRADUATE SCHOOL
CHIANG MAI UNIVERSITY

MARCH 2011

**EFFECTS OF ADDITIVE ELEMENTS: CESIUM,
CERIUM, ZIRCONIUM AND GERMANIUM ON
CRYSTAL STRUCTURE AND DIELECTRIC
PROPERTIES OF CALCIUM COPPER
TITANATE CERAMICS**

WORAWUT MAKCHAROEN

**A THESIS SUBMITTED TO THE GRADUATE SCHOOL IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY**

IN MATERIALS SCIENCE

**THE GRADUATE SCHOOL
CHIANG MAI UNIVERSITY**

MARCH 2011

EFFECTS OF ADDITIVE ELEMENTS: CESIUM, CERIUM, ZIRCONIUM AND
GERMANIUM ON CRYSTAL STRUCTURE AND DIELECTRIC PROPERTIES OF
CALCIUM COPPER TITANATE CERAMICS

WORAWUT MAKCHAROEN

THIS THESIS HAS BEEN APPROVED
TO BE A PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
IN MATERIALS SCIENCE

EXAMINING COMMITTEE

U. Intatha.....CHAIRPERSON
Dr. Uraivan Intatha

Gobwute Rujijanagul..... MEMBER
Associate Professor Dr. Gobwute Rujijanagul

Tawee Tunkasiri..... MEMBER
Professor Emeritus Dr. Tawee Tunkasiri

J. Tontrakoon..... MEMBER
Associate Professor Dr. Jerapong Tontrakoon

K. Pengpat..... MEMBER
Assistance Professor Dr. Kamonpan Pengpat

S.I.R...... MEMBER
Dr. Sukum Itsayem

THESIS ADVISORY COMMITTEE

Gobwute Rujijanagul..... ADVISOR
Associate Professor Dr. Gobwute Rujijanagul

Tawee Tunkasiri..... CO-ADVISOR
Professor Emeritus Dr. Tawee Tunkasiri

J. Tontrakoon..... CO-ADVISOR
Associate Professor Dr. Jerapong Tontrakoon

S.I.R...... CO-ADVISOR
Dr. Sukum Itsayem

23 March 2011

© Copyright by Chiang Mai University

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University

All rights reserved

ACKNOWLEDGEMENTS

Foremost, I would like to express my gratitude to my advisor Assoc. Prof. Dr. Jerapong Tontrakoon and Assoc. Prof. Dr. Gobwute Rujijanagul. Their guidance and support in numerous ways made my study enjoyable and encouraged me to explore the deeper knowledge and experiences in ceramics research. Also, I wish to thank my graduate committee members Prof. Dr. Tawee Tunkasiri, Asst. Prof. Dr. Kamonpan Pengpat, Dr. Sukum Itsayem and Dr. Uraiwan Intatha for their truly interest in my research and devoting their valuable time to serve as member of examination committee.

Thanks to my group member and my friend at Oregon State University Chien-Chih Huang, Seunghwa Kwon, Eric Patterson, Yu Hong Jeon, Narit Triamnak and many others who I have worked hard and played hard with over the one years. I also would like to thanks Prof. Dr. David P. Cann for his insightful advice, time and patience in teaching me the principles of detailed technical advice and a lot of support in the program.

Honest thanks and truly gratefulness are given to the Development and Promotion of Science and Technology Talents Project (DPST) and Thailand Research Found (TRF) for provide me financial support throughout this study.

Throughout this work, I am very fortunate in having opportunities to work with many great people, my senior alumni and friends at Chiang Mai University, Mr. Weeraphong Sungwarl, Mr. Chatchai Krua-In, Mr. Parkpoom Jarupoom, Mr. Nuttapon Pisitpipathsin, Mr. Krit Sutjarittangtham, Miss Navavan Thongmee, Miss Nittaya

Jaitanong, Miss Nattaya Tawichai, for all the immeasurable help and encouragement during on and off-campus life.

Most of all I would like to thank people who take care of me, especially my parents and my brother. I would never finish this study without their encouragement and full support. I owe everything I have and everything I have become to my family whose love and support cannot be overstated. Finally thank you Miss Kornwika Stainkaln for standing by me and giving me warm regards through it at all.

Worawut Makcharoen

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved