بسم الله الرحمن الرحيم

شبكة المعلومات الجامعية
@ ASUNET

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الالكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها

علي هذه الأفلام قد أعدت دون أية تغيرات

يجب أن

تحفظ هذه الأفلام بعيدا عن الغبار

في درجة حرارة من ١٥-٢٥ مئوية ورطوبة نسبية من ٢٠-٤٠%

To be Kept away from Dust in Dry Cool place of 15-25- c and relative humidity 20-40%

بعض الوثائق الاصلية تالفة

بالرسالة صفحات

لم ترد بالاصل

EVALUATION OF SOME DIELECTRIC MATERIALS PREPARED BY SOLID-STATE REACTION

A thesis presented by

SHAIMAA MOHAMMAD MOHAMMAD BEHERY

(B.Sc. IN CHEMISTRY 2002)

(MAASARA CO.FOR ENGINEERING INDUSTRIES)

FOR THE PARTIAL FULFILLMENT OF THE DEGREE

OF

MASTER OF SCIENCE IN CHEMISTRY

(M.Sc.)

Submitted to

FACULTY OF SCIENCE

CAIRO UNIVERSITY

GIZA-EGYPT

2010

APPROVAL SHEET FOR SUBMISSION

Title of (M.Sc) thesis:

"Evaluation Of Some Dielectric Materials Prepared By Solid-State Reaction".

Name of the candidate: Shaimaa Mohammad Mohammad Behery

This thesis has been approved for submission by the supervisors:

1- Prof.Dr.Ezeldain Shafee

Signature

2- Prof.Dr.Mamdooh Abdelfattah Eisa

Prof.Dr.Mohammad.M. Shoukry

Chairman of Chemistry Department
Faculty of Science- Cairo University

Acknowledgements

All gratitude to "ALLAH" who guided and helped me to bring this thesis to light.

I wish to express my deep thanks to my supervisors, Prof. Ezeldain Shafee , and , Dr. Eng. Mamdooh Eisa. I thank them for helping me to maintain focus and direction throughout the research process, and for their attention to detail. I am appreciative of their kindness and encouragement, and for valuable guidance in all aspects of scientific research.

I wish also to express my deep thanks to "The technical Statue for development industries" for offering all the facilities available in its Laboratories.

I would like also to express my thanks to my parents, my brothers specially my brother Mustafa and all my family, for their continuous encouragement, continuous prays and effective support.

Statement

Beside the work carried out in this thesis, the candidate: Shaimaa Mohammad Mohammad had attended and successfully passed a final examination of M.Sc. courses (2007) in non organic chemistry covering the following topics:

1) Mechanism of inorganic reactions.
2) Chelatimetry.
3) Statistical thermodynamics.
4) Quantum chemistry.
5) Advanced analytical chemistry.
6) X-Ray and thermal analysis.
7) Adsorption chemistry.
8) Molten salts and Metallurgy.
9) Voltammetry.
10) Nuclear chemistry.
11) Group theory.
12) Electrochemistry.
13) Electro kinetic phenomena.
14) Catalysis.
15) Advanced inorganic chemistry.
16) Physical polymer.
17) Thermodynamics..
18) Solar energy.
19) Elucidation of molecular structure.
20) German language.

Prof.Dr.Mohammad.M. Shoukry

Chairman of chemistry department

Faculty of science-Cairo University

ABSTRACT

The solid solution of $PbZr_{1-x}Ti_xO_3$, known as lead-zirconate titanate (PZT), was probably one of the most important ferroelectric materials, especially due to its excellent dielectric, ferroelectric and piezoelectric properties. The highest piezoelectric coefficients of the PZT are found near the morphotropic phase boundary (MPB) ($0.46 \leq x \leq 0.49$), between the tetragonal and rhombohedral regions of the composition-temperature phase diagram.

In the present work, the formation mechanism of $Pb(Zr_{0.52}Ti_{0.48})O_3$: PZT solid solution prepared by the mixed oxides techniques consisting of PbO_2, TiO_2 and ZrO_2 was studied by X-ray diffraction (XRD), differential thermal analysis (DTA) and thermo-gravimetric analysis (TGA).. The first step is the decomposition of PbO_2 to PbO. The second step, above 500 °C, is the reaction of reactive PbO and TiO_2 to form $PbTiO_3$. When the saturated $PbTiO_3$ is submitted to a temperature increase, the interaction of PbO, ZrO_2 and TiO_2 inside the $PbTiO_3$ perovskite forming the PZT solid solution takes places. The optimum temperature of calcination for the formation of pure perovskite phase, was found about 800 °C for 2 h with a heating rate of 5 °C/min.

The sintering procedures were carried out at 900, 1000, 1100, 1200 °C for 4 h with a heating rate of 5 °C/min. The XRD pattern of the sintered PZT ceramics showed a coexistence of tetragonal and rhombohedral phases. The density of the ceramics reaches a maximum value of 7.62 g/cm^3 at 1100 °C and the average grain size increases with increasing sintering temperature.

The dielectric properties and the piezoelectric coefficients d_{33} increase with increasing sintering temperature and grain size. From a hysteresis study, the remanent polarization (P_r) and coercive field (E_c) of PZT ceramic sintered at 1200 °C are observed to be 45 uC/cm^2 and 16 kV cm^{-1}, respectively. The value of P_r increases and E_c decreases with increasing the temperature of sintering.

Key words: Solid-State , PZT , ferroelectric properties .

CONTENTS

CHAPTER 3 : RESULTS AND DISCUSSION

CHAPTER 1

INTRODUCTION

Introduction

1.1. Nonlinear dielectric materials

Nonlinear dielectric materials are characterized by the field dependence of the dielectric permittivity on the external electric field strength. In most of the dielectrics, the dielectric permittivity is linear or weakly depends on the electric field up to the breakdown values. In contrast, the ferroelectric materials usually exhibit nonlinear dielectric response for quite a large range of applied electric fields. Dielectric nonlinearity as many other ferroelectric properties such as pyroelectric effect, piezoelectricity, electrostriction, electrooptic effect, conductivity and others are closely linked to the variation of spontaneous polarization under influence of external factors. The study of dielectric nonlinearity and related phenomena in this class of dielectric materials is of interest since they are used in many areas of technology, engineering, and science, often under conditions where nonlinearity cannot be ignored.

1.2 Piezoelectricity

1.2.1 Basic definitions

It is generally believed that the piezoelectric effect was first suggested by Charles Coulomb Circa 1785 [1], but this phenomenon was not actually confirmed until about 1880 by Jacques and Pierre Curie. They found that when external stresses were applied by placing small weights on the surfaces of crystals such as quartz and Rochelle salt, electric charges developed on the surfaces proportional to the weights [1, 2]. The phenomenon was later named \piezoclectricity" where \piezo" is a Greek derivative meaning "to press" [1].

Many crystal classes exhibit electromechanical properties. Of these, piezoelectricity is probably the best known. In ordinary solids, a stress causes a strain proportional to an elastic modulus. Piezoelectricity is creation of an electric charge in addition to a strain, both of which are proportional to the applied stress [3]. This phenomenon is known as the direct piezoelectric effect, and can be described in tensor notation by:

$$P_i = d_{kij} T_{jk} \qquad (1)$$

where P_i is the polarization (charge per unit area), generated along the i-axis in response to the applied stress T_{jk}, and d_{ijk} is the piezoelectric coefficient (i, j & k = 1, 2 & 3). It is clear from Equation.1 that there is a linear relationship between the electrical and mechanical properties [4]. The converse piezoelectric effect describes an induced strain (S_{ij}) which is proportional (d_{ijk}) to an applied electric field E_k. This relationship is described in tensor notation as:

$$S_{ij} = d_{ijk} E_k \qquad (2)$$

The proportionality constant is numerically identical for both the direct and converse effects, and is called the piezoelectric coefficient [3]:

$$d = \frac{P}{T} = \frac{S}{E} \qquad (3)$$

A simplified notation is often used where one of the subscripts is dropped, and the piezoelectric coefficient becomes d_{ij}. Equations 1 and 2 then become:

$$P_i = d_{ij} T_j \qquad (4)$$

$$S_j = d_{ij} E_i \qquad (5)$$

Convention states that the subscript i (i = 1,2 &3) in Equations 4 and 5 indicate the third or z axis which is perpendicular to the plane of the electrodes, and the subscript j (j = 1,2 & 6) indicates the direction of the applied stress, or piezoelectrically induced strain. The most commonly