Preparation of PZT Nanopowders via Sol-Gel Processing

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ABSTRACT

Lead zirconate titanate (PZT) nanopowder of molar composition 52/48 ($Pb(Zr_{0.52}Ti_{0.48})O_3$) was prepared by a modified sol-gel processing method. The starting chemicals used for the preparation of PZT precursor were lead (II) acetate trihydrate, zirconium (IV) propoxide, titanium (IV) isopropoxide, acetylacetone and 1,1,1-tris (hydroxymethyl) ethane. The as-reacted precursor and heat-treated powders at different temperatures were characterized, using thermogravimetric analysis/differential thermal analysis (TGA/DTA) and x-ray diffraction analysis (XRD) techniques. The precursors showed amorphous structure up to the calcination temperature of 500°C where perovskite PZT started to form. Scanning electron microscopy analysis (SEM) showed that PZT powder with various particle sizes in the range of nanometer could be obtained.

Key words: Lead zirconate titanate (PZT), Sol-gel processing, Nanopowder, Phase, Micro-structure

INTRODUCTION

Lead zirconate titanate (PZT) material, having a perovskite-type ABO3 formula, is an important ferroelectric material which has good piezoelectric and pyroelectric properties, relatively high Curie temperature and relatively low sintering temperatures (Haertling, 1999; Moulson and Herbert, 1999). PZT was found to be very suitable and useful for many industrial applications such as transducers, computer memory, pyroelectric sensors, electro-optical modulators, etc., (Nagao et al., 1999; Kim and Song, 2003). There are various methods that have been successfully employed for the preparation of PZT powders, for examples, mixed-oxide, hydrothermal, sputtering, spray drying and sol-gel processing (Hammer and Hoffman, 1998; Milne et al., 1999; Chen et al., 2002; Seifert et al., 2004). Among them, the sol-gel processing method has received particular interest because of its considerable advantages in producing high-purity ultrafine nanoparticle over other processing methods. The sol-gel method can produce rather reactive PZT nanopowders which gives rise to the PZT ceramics with good compositional and structural homogeneity (Xu et al., 2004). The most common method for sol-gel synthesis involves hydrolysis and condensation of metal alkoxides with different modifiers including methoxylethanol (Budd et al., 1985), acetic acid (Yi and Sayer, 1996) and acetlyacetone (Tu et al., 1996). The modifiers were used to stabilize titanium and zirconium alkoxides against hydrolysis caused by moisture in air. Recently, two different sol processing routes have been developed. The first one is known as a diol route while the other is named a triol route (Kurchania and Milne, 1998; Nakasata and Milne, 2001). The triol route used a triol, 1,1,1- tris (hydroxymethyl) $CH_3C(CH_2OH)_3$, which undergoes ligand-exchange reaction with propoxy and pentanedione groups on the Ti and Zr