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Structural, ferroelectric and photocatalytic performance of $Ba_{1-x}Ca_xTiO_3$ ceramics

P. Suresh, P. Mathiyalagan, and K. S. Srikanth

School of Mechanical Engineering, Galgotias University, Greater Noida, Uttar Pradesh, India

ABSTRACT

$Ba_{1-x}Ca_xTiO_3$ (Ca added $BaTiO_3$; x = 0–0.3) ceramics is used as a target catalyst to probe the influence of ferro-electricity on the de-colorization of a typical dye molecule Methyl orange under visible light irradiation. The results indicated that there is a two fold increase in the de-colorization rate using $Ba_{0.7}Ca_{0.3}TiO_3$ in around 180 min. This is ascribed to the ferro-electricity of the tetragonal phase. To probe the ferro-electricity in the catalyst, the P-E hysteresis loops show high polarization of 17.50 μC/cm^2 in x = 0.3 compared to 10 μC/cm^2 for x = 0 at 303 K. The high value of polarization in Ca added $BaTiO_3$ enhances ferro-electricity and ensures a tightly bound layer of dye molecule and also acts to separate the photo-excited carriers due to the internal space charge layer. Both these features act to enhance the catalytic performance. Further, we studied the temperature dependence of dielectric study and it was found that dielectric constant increased and undergoes a maximum corresponding to a phase transition (330 K for x = 0.3) and thereafter decreased. The Ca substitution diffused the phase transition of $BaTiO_3$ and resulted in shift of transition temperature towards room temperature with increase in content of Ca which is useful for many dielectric applications.

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1. Introduction

Interest in lead-free ferroelectric ceramics has emerged over the decade of time owing to suitable replacement of lead based substances namely lead zirconate titanate $(Pb(Zr,Ti)O_3)$. Lead zirconate titanate contains approximately 60 wt.% of lead which is harmful to the nature. In this context, as a replacement material the three well known ferroelectrics namely $BaTiO_3$ [1, 2], $KNbO_3$ [3] and $Na_{1/2}Bi_{1/2}TiO_3$ [3–5] in pure and modified forms have been investigated with renewed interest. A perusal of literature [6–8] suggests that Zr, Sn, and Hf addition in $BaTiO_3$ would chemically tune the orthorhombic-tetragonal and rhombohedral-orthorhombic phase transitions near to room temperature which results in enhanced piezoelectric properties. Yao et.al achieved the enhanced piezoelectric properties in $BaTiO_3$-11$BaSnO_3$ with a giant piezoelectric coefficient (d_{33}) of 697 pC/N. This is the highest reported piezoelectric coefficient till date [6]. As part of the ongoing research on lead-free ceramics, it is pivotal to develop further the various types of cations which substitutes in Ba and/or Ti sites. This cations

CONTACT P. Suresh psuresh2730@gmail.com