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Sol–gel synthesis and property studies of layered perovskite bismuth titanate thin films

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Abstract

Layered perovskite bismuth titanate (BTO) thin films were deposited on platinum coated silicon substrates by spin coating. A homogeneous and stable precursor solution was prepared by sol–gel process using bismuth nitrate and titanium(IV) butoxide as starting materials, glacial acetic acid and ethanolamine were selected as solvent and stabilizing agent, respectively. The crystal structure, surface morphology, composition and electrical properties of the films have been investigated. Crystal structure and morphology of the films are strongly influenced by the heat cycle adopted to form crystalline BTO films. Morphology of the films studied by AFM is found to be smooth, dense, and crack free. The deposited films possess good compositional homogeneity and thickness uniformity. The dielectric constant and the dissipation factor measured at 1 kHz at room temperature are found to be 135 and 0.018, respectively, for the films of 0.4-μm thickness annealed at 600 °C for 1 h. The remnant polarization and coercive field values are estimated to be 5 $\mu C\,cm^{-2}$ and 45 $kV\,cm^{-1}$. The films possess good fatigue properties and useful for application in the non-volatile memories.

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Keywords: BTO; Sol–gel process; Ferroelectric thin films

1. Introduction

There have been extensive efforts to enhance the reliability of perovskites based ferroelectric thin films for use in non-volatile ferroelectric random access memory devices [1–3]. Among these ferroelectrics, lead zirconate titanate (PZT) is known to be the most important candidate for NvFRAM applications. However, it shows a serious degradation of ferroelectric properties after being subjected to 10^7 read/write switching cycles [4]. Some layered ferroelectrics such as bismuth titanate (BTO) and strontium bismuth titanate (SBT) showed superior fatigue resistances as compared to Pt/PZT/Pt capacitors. However, the high processing temperature of SBT above 750 °C is an obstacle in integration with silicon devices [5]. Crystallization of BTO at low processing temperatures possibly below 650 °C is of our interest, which is compatible with Si-based integrated circuit. The metal-ferroelectric-insulator-semiconductor (MFIS) hetero-structure with BTO as gate electrode for FE-FET in a non-destructive readout (NDRO) mode has been demonstrated [6] and more recently, the study of photoelectric properties of BTO thin films and hetero-structures has shown that this material possesses good detection properties in UV region [7]. Thin films of BTO have already been prepared by rf sputtering [8], MOCVD [9], PLD [10], MOSD [11] and sol–gel process [12]. Among the various techniques available for the fabrication of BTO thin films, sol–gel processing has been employed in this study which offers excellent uniformity over large area, easy composition control, short fabrication time, as well as low temperature process at comparatively low cost. In sol–gel process the chemical stability of the solution is very important. In our case, the chemical instability of the solution has been overcome by the addition of ethanolamine in the precursor solution and films were prepared by spin-on technique and their structural, morphological, compositional and electrical properties of the BTO thin films were systematically studied.

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