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BARIUM METAPLUMBATE ($Ba_xPb_{1-x}O_3$) ELECTRODES FOR ORIENTED FERROELECTRIC THIN FILMS

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Recently, it has been suggested large strains can be obtained through domain switching of highly-oriented tetragonal ferroelectrics such as $Pb_{1-x}Ba_xTiO_3$ (PBT) [1, 2]. To successfully integrate such films into usable large-strain devices, orientation must be achieved on an electroded substrate. Films deposited on metallic electrodes such as Pt, however, are randomly oriented due to poor lattice matching between the cubic electrode layer and tetragonal perovskite film. It has also been widely shown in literature that Pt electrodes are associated with increased fatigue due to the migration of oxygen vacancies to the film-electrode interface [3, 4]. Conductive oxide electrodes provide an attractive alternative to Pt for use in ferroelectric devices. Though their conductivity is somewhat less than Pt, conductive oxides with perovskite structures and good lattice matching have been shown to enhance ferroelectric properties and improve the fatigue characteristics of perovskite ferroelectrics [5]. It is believed the improved properties result from the ability of the conductive oxide electrodes to serve as a sink for oxygen vacancies which migrate to the film-electrode interface.

Barium metaplumbate ($BaPbO_3$, BPO) is particularly suited for use with $Pb_{1-x}Ba_xTiO_3$ ferroelectrics, as it provides good lattice matching without introducing additional cation species. Several procedures have been reported for producing BPO, but all involve multiple steps, high-vacuum processes, or high processing temperatures [6, 7]. Low temperature and ambient pressure processes are more desirable for facile integration of ferroelectrics into conventional Si-based processing [2]. Here, an economical single-step, single ligand sol-gel process for producing oriented BPO thin films at low temperatures is presented (Fig. 1). Thin film BPO electrodes were produced via spin-coating onto single crystal MgO(100) substrates. BPO powders and thin films were examined by x-ray diffraction (XRD), fourier transform infrared spectroscopy (FTIR), micro-Raman spectroscopy, and simultaneous thermal analysis (STA). STA of dried BPO powder (Fig. 2) together with X-ray analysis of calcined samples shows that BPO forms through an exothermic event at 355^{o}C in an Ar/O_2 atmosphere, which is accompanied by a weight loss of 26%. The orientation of the electrodes was determined via XRD. The effect of deposition parameters, including heat treatment (number of layers, pyrolysis temperature, calcination temperature, heating rate) and Pb:Ba content on resulting conductivity and orientation is discussed. Although the BPO shows almost random orientation, Fig. 3, PBT thin films deposited on these electrodes have 100/001-preferred orientation.

References

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Figures

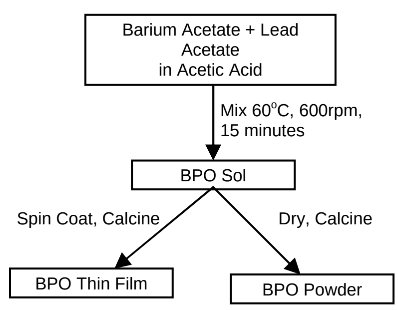

Fig.1. Schematic of sol-gel process for production of BPO powders and thin films

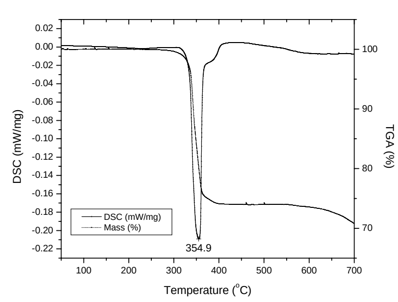

Fig. 2. Simultaneous thermal analysis of $BaPbO_3$ dried powder. (heating rate = 5^{o}C/min, 20%O_2/80%Ar)

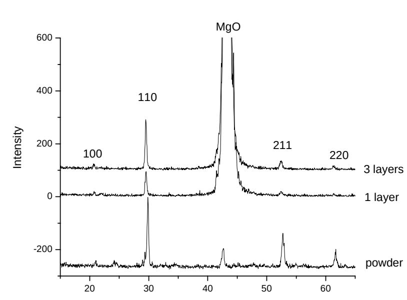

Fig. 3. X-ray diffraction data for powder, single-layer, and three-layer thin film $BaPbO_3$ deposited on single crystal MgO(100) and calcined at 600^{o}C.