Structural and dielectric studies of $Ba_{0.48}Sr_{0.52}TiO_3/LaNiO_3$ artificial superlattices prepared by rf magnetron sputtering

H. Y. Lee[1*], H. J. Liu[1], K. F. Wu[2], C. H. Lee[2]

[1]*National Synchrotron Radiation Research Center, Hsinchu, Taiwan*

[2]*National Tsing Hua University, Hsinchu, Taiwan*

Introduction

Recently, there is a great interest in the growth of artificial superlattice of ferroelectric oxides for its ability of improving the property of materials through structure modification. Among various oxide materials, $(Ba,Sr)TiO_3$, a perovskite material, is a promising material with a large dielectric constant for future generations of dynamic random access memories (DRAMs) because its combination of large dielectric constant, small dielectric loss, small density of leakage current and satisfactory thermal stability is unique[1]. In the superlattice system, the composite effect from individual sublayers and their interface usually determines the material property. Because the characteristics of superlattice largely depend on the multilayerd film thickness, density, surface and interface roughness, the method of characterizing thin film structure is critical for control of the conditions of film processing. An investigation of film structure on a microscopic scale is thus of great significance for the fabrication of materials in this new class.

In this work, we studies the structure and dielectric properties of $Ba_{0.48}Sr_{0..52}TiO_3/LaNiO_3$(BST/LNO) superlattice grown on $SrTiO_3$(STO) by rf sputtering.

Methods and Materials

The BST/LNO superlattice was grown on a conductive Nb-doped single-crystal STO (001) substrate with a triple-gun rf magnetron sputtering system with computer control of shutter opening. Thereby we control precisely the duration of deposition of each layer during the deposition of a superlattice. The sputtering was performed with a power density 2.5 W/cm^2 for BST and 1.5 W/cm^2 for LNO with a highly purified gas (25 % O_2 + 75 % Ar) at a working pressure 1 Pa. The superlattice contains 10 periods of BST/LNO with sublayer 30 nm thick deposited at temperature ranging from 400-600^{o}C. X-ray scattering measurements were performed at wiggler beamline BL-17B1 of National Synchrotron Radiation Research Center (NSRRC), Hsinchu, Taiwan.

Results and Discussion

Figure 1 (a) shows a set of the reflectivity curve of the BST/LNO superlattice films deposited at different substrate temperatures and their best fitted results. The presence of the clear oscillations indicates that both the surface and the interface correlate well with each other and are smooth enough to produce the oscillations. From the fitted data, it show that the density of the BST and LNO sublayers are slightly lower than that of the bulk values, which most likely resulted from the increase of defect density in high temperature thin film deposition. The interface roughness values of superlattices remains nearly constant at value of 0.77 – 0.82 nm. Figure 1 (b) shows crystal-truncation-rod (CTR) spectrum along the [0 0 *L*] direction of BST/LNO superlattice film deposited at different substrate temperature. The main peak (as indicated by arrows) and satellite peaks that are accompanied with clearly discernible pendellösung fringes on both sides of the main peak indicate the high quality of the BST/LNO artificial superlattice structure formed on STO substrate with RF sputtering.

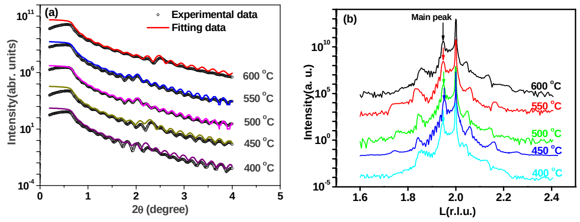

Figure 1 (a). Reflectivity curves and their best fitted results (b) Intensity distribution of (002) crystal-truncation-rod spectrm.

Figure 2 (a) shows the dielectric properties of BST/LNO superlattice films were measured at a frequency 10 kHz as a function of deposition temperature. The dielectric constant value, 385-426, is three times as large as that of BST single-phase films, with ~110, prepared under the same conditions. Figure 2 (b) show a set of dielectric constant as a function of measured frequency for the superlattice films deposited at 450℃ and 550℃. The dielectric constants of all superlattices films decreased gradually with increasing applied frequency at evaluated deposited temperature. It is considered that the dipole moment consists of the oriented, ionic and electric polarization above the frequency of 1 kHz [2].

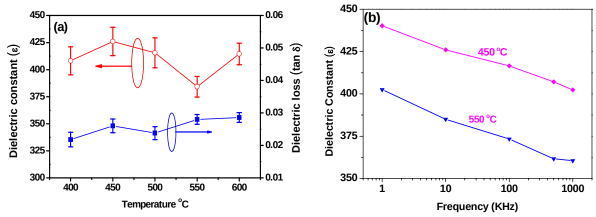

Figure 2 (a). Dielectric constant and dielectric loss of the supperlattice deposited at different substrate temperatures (b). Dielectric constant measured at different frequency.

In summary, high crystalline quality of BST/LNO superlattices were successfully fabricated on a STO substrate through rf magnetron sputtering. These BST/LNO artificial superlattices show a significant enhancement of dielectric constant with small dielectric loss relative to BST single layers of the same thickness.

Acknowledgments

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Reference

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