Ferroelectric PSTO and Mn: BSTO Thin Films for Wireless Microwave Elements

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Ferroelectric thin films have broad applications in electronic, optoelectronic, optical, acoustic and microwave devices areas. Especially, there has been a significant increasing need of films in wireless microwave communications, such as microwave phase shifters, filters, and oscillators. Currently, ferroelectric BSTO and PSTO thin films are considered to be very promising candidates for room temperature tunable microwave elements because of their high dielectric tunability and relative low dielectric loss.

Recently, we have focused on the improvement of dielectric properties of the highly epitaxial ferroelectric thin films. A novel method of 2% Mn additional-doping technique was adapted to the pure BSTO/MgO films. The as-growth films were characterized by x-ray diffraction and transmission electron microscopy to understand the microstructure, crystallinity, epitaxy behaviors. The microstructural studies reveal that both BSTO and PBCO thin films are c-axis oriented with excellent single crystalline and excellent epitaxial behavior although both BSTO and PBCO film have large lattice mismatch with (001)MgO substrate at about 6% and 7.5%, respectively. The epitaxial relationships were found to be $(001)_{\text{films}}//(001)_{\text{MgO}}$ and $[100]_{\text{film}}//[100]_{\text{MgO}}$.

To understand the dielectric properties of the as-grown PSTO and Mn:BSTO films, high frequency dielectric measurements were employed to analyze the dielectric properties of Mn: BSTO and PSTO thin films. A significant improvement of dielectric property of the as-grown Mn: BSTO films was achieved with large tenability of 80% at 40 KV/cm, very large dielectric constant value of 3800 and extra low dielectric loss of only 0.001 at 1 MHz measuring frequency and room temperature. The mechanisms responsible for this improvement concern the fact that the acceptor dopants Mn^{2+} can compensate for the electrons generated form the oxygen vacancies, whose hopping between different titanium ions will induce the dielectric loss. The high frequency (10-30 GHz) dielectric measurements demonstrate that the Mn: BSTO films are excellent in both dielectric property and very low insertion loss values of only 0.2 dB at 10 GHz and more than 1.5 dB at 30 GHz. On the other hand, the high frequency dielectric property measurementson the as-grown PSTO/MgO thin films exhibit a high dielectric constant value of 1420 at zero-bias and a very large tunability at 34% under bias field 40 Kv/cm up to 20 GHz. In summary, these results indicate that highly epitaxial Mn: BSTO and PSTO thin films are good candidates for developing the high-frequency, room-temperature tunable microwave.