Synthesis and Characterization of Ferroelectric (1-x)$SrBi_2Ta_2O_9$-xBi_3TaTiO_9 Thin Films for Non-volatile Memory Applications

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(ABSTRACT)

The (1-x)$SrBi_2Ta_2O_9$-xBi_3TaTiO_9 thin films fabricated by modified metalorganic solution deposition technique showed much improved properties compared to $SrBi_2Ta_2O_9$: a leading candidate material for memory applications. A pyrochlore free crystalline phase was obtained at a low annealing temperature of 600 ^oC and grain size was found to be considerably increased for the (1-x)$SrBi_2Ta_2O_9$-xBi_3TaTiO_9 compositions. The film properties were found to be strongly dependent on the composition and annealing temperatures. The measured dielectric constant of the thin films was in the range 180-225 for films with 10-50 mol % of Bi_3TaTiO_9 content in the solid solution. Ferroelectric properties of (1-x)$SrBi_2Ta_2O_9$-xBi_3TaTiO_9 thin films were significantly improved compared to $SrBi_2Ta_2O_9$. For example, the observed $2P_r$ and E_c values for films with 0.7$SrBi_2Ta_2O_9$-0.3Bi_3TaTiO_9 composition, annealed at 650 ^oC, were 12.4 $\mu C/cm^2$ and 80 kV/cm, respectively. The solid solution thin films showed less than 5 % decay of the polarization charge after 10^{10} switching cycles and good memory retention characteristics after about 10^6 s of memory retention.

The size and temperature effect of 0.7$SrBi_2Ta_2O_9$-0.3Bi_3TaTiO_9 thin films were studied by determining how the ferroelectric properties vary with film thickness and temperature. It was found that the ferroelectric properties were determined by the grain size, and not by the thickness of the film in our studied thickness range of 80-350 nm. A 80 nm thick film showed good ferroelectric properties similar to the 350 nm thick film. Thermal stability of the 0.7$SrBi_2Ta_2O_9$-0.3Bi_3TaTiO_9 thin film was found to be much better compared to the $SrBi_2Ta_2O_9$ and Pb(Zr,Ti)O_9 thin films due to its higher Curie temperature and lower Schottky activation energy according to temperature changes. Also, 0.7$SrBi_2Ta_2O_9$-0.3Bi_3TaTiO_9 thin films has shown good ferroelectric properties on multilayer system such as PtRh/$PtRhO_x$/poly-Si suggest their suitability for high density FRAM applications.