ABSTRACT

Key Words : Ferroelectric films, DRAM capacitor, Perovskite ceramics, High-permittivity dielectric, PLZT, BST, E-beam evaporation, rf sputtering, Plasma diagnostics, Langmuir probe

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The present research elucidates the processing and characterization of lead-lanthanum-zirconate-titanate (PLZT) and barium-strontium-titanate (BST) thin films for silicon based devices applications.

PLZT and BST powder materials have been synthesized using water soluble salts by coprecipitation techniques. The powders have been compressed, pelletized and sintered at between 1100-1300°C to use as sources and targets for film deposition.

A single-source electron-beam evaporation technique has been used for the deposition of PLZT thin films on silicon based substrates. An optimized annealing condition has been established for the formation of crystalline perovskite phases. The effect of bottom electrodes and barrier layers on the growth of the PLZT films have been studied. PLZT films with good optical and electrical properties have been obtained under optimized conditions. Optical band gap has been found to be 3.8 eV. Electrical properties of the films have been evaluated using metal-insulator-semiconductor (MIS) and metal-insulator-metal (MIM) structure. A moderately low interface trap density has been observed at the silicon mid-gap. Leakage current characteristics show a strong dependence on the processing temperature of the bottom electrode. A drop in leakage current by about five orders of magnitude has been observed for capacitor with platinum electrode deposited at room temperature compared to that deposited at higher temperature. A correlation between the microstructure of the bottom electrode, space charge layer at PLZT/Pt interface, and the nucleation of PLZT has been suggested to explain this observation.

Rf magnetron sputtered $Ba_xSr_{1-x}TiO_3$ thin films have been deposited on silicon and platinum coated silicon (with different buffer and barrier layers) substrates. The analysis of plasma discharge has been carried out using Langmuir probe diagnostic technique. Both the pressure and power have been found to influence the ion density

and self bias of the target. Introduction of oxygen into the discharge effectively decreases the ion density. The structural and compositional properties have been investigated using x-ray diffraction, atomic force microscopy, x-ray photoelectron spectroscopy and Rutherford back scattering. The growth and orientation of the films have been found to depend upon the type of substrates and deposition temperatures. The (100) texture in the film is promoted at a pressure 0.25 torr with a moderately high value of ion density and low ion bombardment energy. The crystallinity of the BST films has been found to be superior on platinum coated substrates. The quantitative composition of the BST films have been found to be in close match with the target composition.

Electrical properties of the BST films have been evaluated using both MIS and MIM structures. The formation of parasitic interfacial capacitance in series with the BST film on bare Si could be prevented by using platinum coated silicon substrates with different buffer and barrier layers. The dielectric constant of BST films increases with increasing barium concentration in the film. Polarization characteristics of $Ba_{0.95}Sr_{0.05}TiO_3$ [BST (95/5)] film has been studied at 50 Hz. Current-voltage behavior have indicated an ohmic nature at lower voltages and Poole-Frenkel conduction at higher voltages. The films have shown an excellent time dependent dielectric breakdown under constant current stressing.

The optical parameters of BST film have been evaluated both from transmission spectra and ellipsometric measurements. The dispersion data of refractive index have shown that the interband transition region follows a single electronic oscillator model. Both refractive index and band gap of BST films have been found to depend on the composition.