Abstract

In current scenario, the communication system demands compact size of components with multiple functionality. To meet these requirements, there has been rapid growth in tunable RF and microwave components of communication systems for voltage tunable applications. Voltage dependent permittivity and lower dielectric loss are the desirable characteristics for the current and next generation tunable microwave applications. Perovskite oxides such as $(Ba,Sr)TiO_3$ (BST) and $Pb(Zr,Ti)O_3$ (PZT) have considered a promising material for applications in tunable microwave devices with their voltage dependent dielectric permittivity and high dielectric constant. Communicaton satellite and nuclear industry applications include communication frequency filter where the devices are exposed to high energy radiations. The goal of the undertaking this work was to fabricate tunable components and study the changes in the electrial and material properties of BST and PZT, exposed to high energy radiation. In the present study, radiation dependence of dielectric capacitance and tunability in the perovskite oxides thin films have been explored.

BST thin films were deposited on sapphire substrate by RF magnetron sputtering technique and interdigitated capacitor (IDC) structures were fabricated using photolithography. Gamma and neutron irradiation induced changes of the BST based tunable capacitor have been investigated and it was found that capacitance of the IDC devices decreased with increasing radiation doses up to a certain level and subsequently with higher radiation level capacitance gradually increases. The observed tunability (~25%) of the un-irradiated BST device was observed nearly constant with irradiation doses and found higher radiation tolerance for its use in space and nuclear application. The surface morphologies and leakage current of these films were also investigated as a function of radiation doses. X-ray photoelectron spectroscopy was used to investigate the surface chemical states of gamma irradiated BST thin films and core level shift was observed towards higher binding energy with increasing gamma doses. Further, Epitaxial heterostructure of ferroelectric $PbZrTiO_3/SrRuO_3$ (SRO) were grown on single crystal $SrTiO_3$ (001) substrates by pulsed laser deposition technique and platinum electrodes were deposited on top of PZT film. The tunability of the PZT varactor devices strongly dependent on bias voltage and exhibited dielectric tunability of 55% at 100 kHz and 10 V. The dielectric capacitance was found to decrease with enhancing gamma irradiation doses, accompanying chnages in the loss tangent values. The tunability of the epitaxial PZT thin film capacitors observed to decrease linearly up to 25% with increasing gamma dose at 400 kGy dose. Moreover, surface chemical states of epitaxial PZT films were investigated by X-ray photoelectron spectroscopy as a function of gamma doses. An anomalous behavior was observed in Pb4*f* states and core level of Pb4*f* state shifted towards lower binding energy due to reduction of PbO to metallic Pb with increasing gamma doses. Higher current and disappearance of Negative differential resistance characteristics were found in higher gamma dose which confirms the presence of metallic Pb. The results achieved from this study would be highly valuable in order to predict operational performance of such devices in radiation environment.