Effect of Mg-doping and Fe-doping in Lead Zirconate Titanate (PZT) Thin Films on Electrical Reliability

D. Koh, S.W. Ko, J.I. Yang, B. Akkopru-Akgun, S. Trolier-McKinstry

Uniformly acceptor doped Pb(Zr0.48Ti0.52)O3 (PZT) films with 2 mol. % Mg or Fe prepared by chemical solution deposition exhibited decreased dielectric constants and remanent polarizations relative to undoped PZT. For highly accelerated lifetime testing (HALT) at 200 °C and an electric field of 300 kV/cm in the field up direction, the HALT lifetimes (t50) for undoped, Mg-doped, and Fe-doped PZT films were shortened from 2.81 ± 0.1 to 0.21 ± 0.1 and 0.54 ± 0.04 h, respectively. Through thermally stimulated depolarization current measurement, significant V†† O electromigration was found in homogeneously Mg-doped PZT thin films, a major factor in their short HALT lifetime. Because the concentration of oxygen vacancies increases with uniform acceptor doping, the lifetime decreases. In contrast, when a thin layer of Mg-doped or Fe-doped PZT was deposited on undoped PZT or Nb-doped PZT (PNZT), the HALT lifetimes were longer than those of pure PZT or PNZT films. This confirms prior work on PNZT films with a Mn-doped top layer, demonstrating that the HALT lifetime increases for composite films when a layer with multivalent acceptors is present near the negative electrode during HALT. In that case, the compensating electrons are trapped, presumably on the multivalent acceptors, thus increasing the lifetime.