In-situ X-ray Diffraction Study of Gamma Irradiation Effects on Ferroelectric Thin Films

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Ferroelectrics have been widely used in a variety of applications, including sensors, actuators transducers, and microelectromechanical systems (MEMS). $Pb(Zr_xTi_{1-x})O_3$ (PZT) ferroelectric thin films have been largely studied for applications to MEMS (so-called PiezoMEMS applications) due to their extraordinary piezoelectric and electromechanical coupling coefficients and high remanent polarization. One example of PZT used as MEMS is logic switches. The switches utilize a converse piezoelectric effect driven unimorph actuator, enabled by two metallic electrodes that provide an electric field across the ferroelectric PZT thin-film layer, to generate movement, thus opening or closing the switch.

Previous research studied the radiation-induced effects of ferroelectric thin film material by measuring hysteresis loop with increasing radiation dose. The results display degradation in the dielectric and polarization responses that is characteristic of domain wall pinning. In the present work, the goal is to further study the effect of radiation exposure on the ferroelectric logic switch materials' performance and structure. A mechanism is proposed based on domain wall motion and pinning sites. Specifically, charged defects will form through ionization during irradiation and will drift to the domain walls. Upon reaching the domain wall, the extra charges will aid in the formation of new pinning sites and therefore, the domain wall motion is constrained. To accomplish the goal, we performed *in-situ* X-ray diffraction (XRD) on ferroelectric PZT(30/70) thin films deposited on platinized silicon wafers, with IrO_2 or Pt top electrodes, to study both intrinsic (lattice strain) and extrinsic (domain switching) contribution to the dielectric and piezoelectric responses. Half of the samples were irradiated at the Naval Research Laboratory to 10 Mrad(Si) using their ^{60}Co gamma irradiation facilities.

The experimental data shows that there were negligible differences in the electromechanical phenomena between non-irradiated and gamma-irradiated samples, suggesting that the ferroelectric materials are radiation tolerant. Furthermore, this improved knowledge will lead to the development of improved materials for application used in radiation environments.