Reliability in Patterned PZT Films for MEMS Applications

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Lead zirconate titanate, PZT (52/48) thin films were patterned into features of different widths, including various sizes of squares and 10 μm, 8 μm and 5 μm antenna designs to study the relative importance of damage produced at the perimeter of the features on the reliability of the PZT. 600nm thick PZT (52/48) thin films were deposited on platinized Si substrate by chemical solution deposition. Following the PZT deposition, a 1000 Å thick platinum layer was deposited onto the crystallized PZT as the top electrode and TiW was deposited on the top Pt layer as an adhesion layer for the Ni mask using RF sputtering**.** After the film deposition process, patterning was done by lithography, electroplating of a Ni hard mask and a reactive ion etch process with a substantial bombardment component. HALT measurements were made at temperatures ranging from 120 ºC to 180 ºC and electric fields ranging from 100 kV/cm to 225 kV/cm. The characteristic time to failure t_{50} increased with decreasing feature size. The activation energy for all feature sizes were 0.82eV ~ 1.1eV; the range of voltage acceleration factors for all feature sizes was 3.4 ~ 5.2. It is hypothesized that the sidewall and the bulk of the film both contribute to the observed feature size dependence of the median time to failure and activation energy in patterned PZT thin film. HfO_2 was deposited using ALD to minimize sidewall damage such as dangling bonds on the etched surfaces. After ALD coating, the lifetime of all features sizes increases because the sidewall damage is partially recovered without significant changes in the activation energies.