Fatigue properties of PZT ferroelectric thin films

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Abstract

250 nm-thick PZT thin films with Zr/Ti ratio of 60/40 were deposited in situ at 500°C using a multi-target R.F. sputtering. The films were (100) or (111) oriented when grown on Pt/TiO2/SiO2/Si and exhibited c-axis epitaxial microstructure when deposited on Pt/MgO. Electrical measurements were performed in order to investigate the fatigue properties of the films. It was found that fatigue characteristics of the Pt/PZT/Pt capacitors are strongly dependent on their crystalline orientation. The (111)-oriented films were found to be very prone to fatigue : a reduction of 80 % of the remnant polarization was obtained after 10e6 cycles at 100 kHz. C-axis epitaxial films also exhibited poor fatigue endurance as they lost more than 50 % of the initial polarization after bipolar switching at around 10e10 cycles. In contrast, the (100)-oriented films did not show any noticeable fatigue up to 10e9 cycles under similar stress conditions. In order to understand the origin of the fatigue phenomenon, we have studied the effect of several parameters (electric field amplitude, pulse shape,) on the polarization fatigue of the (111)-oriented films. One of the important results is that degradation of polarization is frequency dependent. The loss of polarization follows a scaling behavior giving by N/(sqrtF), where N is the number of switching cycles and F the frequency. Lastly, partial recovery of polarization was generally observed during cycling (self-recovery). It is known that the ferroelectric properties of a fatigued ferroelectric capacitor can be restored by application of an external voltage (d.c. or a.c.). In our case, we have found that the same recovery can be obtained without applying any external voltage to the capacitor (spontaneous recovery).