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Domain nucleation behavior in ferroelectric films with thin and ultrathin top electrodes versus insulating top layers

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The effect of varying the thickness of Pt top electrodes made by the electron beam induced deposition technique on the domain nucleation characteristics of $Pb(Zr,Ti)O_3$ films has been investigated by piezoresponse force microscopy. The advantage of this experimental setup is that the nucleation position can be precisely controlled allowing comparison between two capacitor structures with different top electrode thicknesses and negating the role of defect-induced polarization switching scenarios. In the ultrathin limit (<5 nm), the coercive biases of polarization switching change substantially relative to thicker electrodes, from -4.6 to -2.6 V and from +3.5 to 5.5 V respectively, which we link to a work function size effect. The evolution of the piezoresponse and coercive biases as a function of hysteresis loop cycling is presented and contrasted with that obtained on the bare film surface with no top electrode. To provide a counterpoint to the observed effects with top electrodes, we have demonstrated the variation in switching due to a top silicon oxide insulating layer. This work has revealed a method which could be used to control nucleation bias in ferroelectric thin film systems.

Keywords: nanotechnology, ferroelectric, domain walls, thin films, scanning probe microscopy, hysteresis, polarization switching, piezoresponse force microscopy