Polarization Scaling in Ultra-thin Epitaxial Ferroelectric Heterostructures: Experimental Results

R. RAMESH, Dept of Materials Science and Physics, University of California, Berkeley CA 94720, V. NAGARAJAN, J.Q. HE, C. JIA, H. KOHLSTEDT, R. WASER, Center of Nanoelectronic Systems for Information Technology, Dept IFF, FZ- Juelich D52425, S. PRASERTCHOUNG, T. ZHAO, Dept of Materials Science and Dept of Physics, University of California, Berkeley CA 94720, K. LEE, Y.K. KIM, S. BAIK, Dept. Materials Science and Engineering, Pohang University of Science and Technology, Pohang 790-7 — Scaling of the structural order parameter and the polarization was investigated in ultra-thin epitaxial PbZr$_{0.2}$Ti$_{0.8}$O$_3$/SrRuO$_3$/SrTiO$_3$ model ferroelectric heterostructures. High Resolution Electron Microscopy and Synchrotron X-Ray studies show that a high tetragonality (c/a≈1.06) is maintained down to 40 Å thick films, suggesting indirectly that ferroelectricity is fully preserved at such ultrathin thicknesses. However, measurement of the switchable polarization (∆P) using a novel pulsed probe setup revealed a systematic drop from ~ 140 µC/cm$^2$ for a 150 Å thick film to 11 µC/cm$^2$ for a 40 Å thick film. This contradiction between the structural measurements and the measured switchable polarization is explained by an increasing presence of a strong depolarization field, which creates a pinned 180° polydomain state for the thinnest films. This work was supported by MRSEC Grant # 00-8008, DOE Grant DE-FG02-01ER45937 and NSF-DFG Grant 02-44288.

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