Ferroelectric switching kinetics in epitaxial PMN-PT thin films

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Abstract

Ferroelectrics are emerging materials that enable energy-efficient memory and compute devices. To impact microelectronics, however, the speed of ferroelectric operation a device scale (lateral: 10-100s nm, thickness: 10s nm) must be fast, 1-2 ns or preferably better. Here we examine ferroelectric switching in epitaxial PMN-PT ferroelectric thin film capacitors with 15 – 80 nm thickness and 300 nm – 40 microns lateral dimension. We find that the ferroelectric switching behavior obeys the Kolmogorov–Avrami–Ishibashi theory. The switching kinetics is dominated by a mix of 2D and 3D domain growth. As a result, the ferroelectric switching time versus lateral scaling follows Mertz law down to 1 micron diameter capacitors indicating domain growth is the dominant switching mechanism in this range. Switching times are near 1 ns for capacitors in the 1-3 micron diameter range. Piezoresponse force microscopy measurements of 150 nm thick films reveal a clamped piezoresponse for capacitors above 800 nm with relaxed clamping near the perimeter. Capacitors below 400 nm in diameter are relaxed. Our results give a promising outlook for PMN-PT based ferroelectric and multiferroic devices for energy efficient logic and memory.