The Formation and Morphology of Magnetic Domains on Trampoline-Shaped $La_{0.7}Sr_{0.3}MnO_3$ Microstructures Grown on $SrTiO_3(110)$

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In recent developments, it has become possible to pattern oxide-based M/NEMS (micro- and nano-electromechanical systems) structures using etching techniques comparable to those employed in silicon technology [1]. Oxides are particularly promising, because they offer potential for additional functionalities owing to their intricate phase diagrams, which can include various magnetic phases in compounds such as $La_{1-x}Sr_xMnO_3$. This advancement enables the realization of fully integrated, monolithic, all-oxide magnetically sensitive M/NEMS, eliminating the need for external magnetic layers required in silicon-based devices (see, e.g., Ref. [2]).
Here, we examine trampoline-shaped $La_{0.7}Sr_{0.3}MnO_3$ thin film elements, with a rectangular central pad (see Fig. **1a**) deposited on $SrTiO_3(110)$. When such structures are released from the substrate, they could serve as magnetically sensitive resonators in innovative magnetic field sensing applications [3]. The performance of these devices critically depends on their micromagnetic domain structure.
To visualize the micromagnetic domain configuration, we employed a Magnetic Force Microscopy (MFM) setup capable of applying in-plane magnetic fields up to $\mu_0 H = \pm 26.7$ mT. The $SrTiO_3(110)$ substrate induces an in-plane uniaxial magnetic anisotropy with an easy axis aligned along the [1-10] direction, while the rectangular central pad introduces a shape anisotropy favoring magnetization along its longer side. Figure **1b** depicts the domain structure of such an element in remanence ($\mu_0 H = 0.0$ mT) after saturation in a magnetic field of $\mu_0 H = +26.7$ mT aligned along the [001] direction. Dark lines indicate Bloch-type domain walls, which enclose spike domains that initiate the magnetization reversal process. Surprisingly, we find that all Bloch walls in our images point in the same direction. Additionally, the transition into the single domain state does not simply occur via domain wall propagation. Instead, incoherent rotation seems to be relevant as well. To explore the evolution of the micromagnet structure and to reveal the underlying processes, we studied four principal configurations in which the directions of the uniaxial anisotropy, shape anisotropy, and magnetic field are parallel or perpendicular aligned with respect to each other.

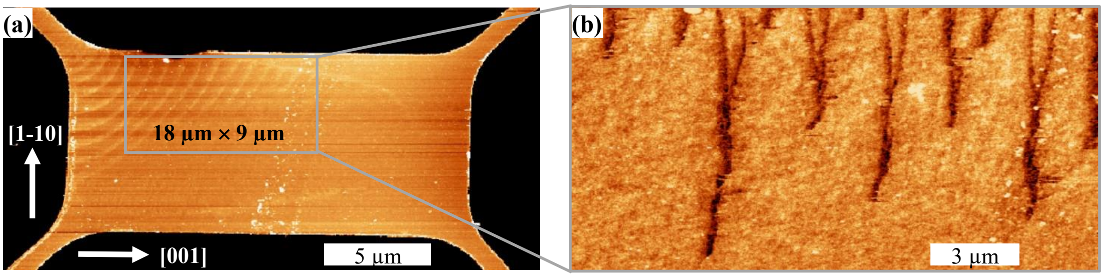

Figure 1:Trampoline-shaped $La_{0.7}Sr_{0.3}MnO_3$ thin film grown on $SrTiO_3(110)$. **a** Topography of the rectangular central pad. **b** MFM image of the micromagnetic configuration in remanence.

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[3] L. Pellegrino et al., IEEE NMDC 2023; doi:10.1109/NMDC57951.2023.10344075