Supplementary information of “Visualizing ferromagnetic domain behavior of magnetic topological insulator thin films”

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I. 2D FFT AND FILTERED IMAGE OF ZFC MFM IMAGE

FIG. S1. (a) 5K raw MFM image after ZFC shows relatively poor signal to noise ratio because the magnetic tip moment is not fully aligned. (b) 2D FFT image of the MFM image(a) shows a dark dot in the center. (c) A line profile of 2D FFT image along the radius exhibits a peak around $\lambda = 833\text{ nm}$, which roughly manifests the typical domain size. (d) The filtered MFM image ($\lambda \geq 50\text{ nm}$) shows better signal to noise ratio without changing the domain pattern.
II. HISTOGRAM ANALYSIS OF MFM IMAGES

FIG. S2. (a) 5 K MFM image at 0.05T after ZFC. (b) histogram analysis of MFM image at 5 K, 0.05 T. Bin number is set to be 100 from -0.1 Hz to 0.09 Hz (green bins). The histogram curve is fitted to the sum of two gaussian peaks. The lower frequency one (red: -0.022Hz) corresponds to up domain contribution. The higher frequency (blue: 0.025Hz) one corresponds to down domain contribution. The net magnetization of this domain state $M/M_S$ is estimated to be $(1563 -1416.5)/(1563+1416.5)=0.049$. 
III. DOMAIN BEHAVIOR OF TIME RELAXATION EFFECT AROUND COERCIVE FIELD

FIG. S3. (a) MFM image of Sb$_{1.89}$V$_{0.11}$Te$_3$ thin film at 0.7 T after ZFC. (b) MFM image taken 5 mins after (a) at 0.7 T shows more up domains. (c) Green regions, obtained by subtracting image (b) by (a), represents newly grown domains during relaxation. (d) MFM image of Sb$_{1.89}$V$_{0.11}$Te$_3$ thin film at -0.7 T after the thin film was positively saturated. (e) MFM image taken 5 mins after (d) at -0.7 T shows more down domains. (f) This relaxation process includes both domain nucleation (N) and domain wall propagation (G).
IV. TEMPERATURE DEPENDENCE OF MFM IMAGES

FIG. S4. Zero field (a) topographic and (b)-(e) temperature dependence of MFM images of Sb$_{1.89}$V$_{0.11}$Te$_3$ thin film after ZFC. (d) Weak domain contrast is still visible at 30 K. (e) Domain contrast disappears at 35 K. (f) Temperature dependence of 2-probe resistance $R_{xx}$ shows anomaly at $T_C \approx 32$ K, which is consistent with MFM measurement.