Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary Materials

Conduction Control at Ferroic Domain Walls via External Stimuli

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The conduction mechanism of the 90° domain walls is explored by executing the temperature dependent measurement of charge transport. Domain wall currents measured at various temperatures and bias voltages are shown in **Fig. S1(a)**, where two different transport regimes, depending on the temperature, are characterized. At temperature above 190 K, current scales exponentially with the increase of temperature at various biases (except V_{sd} = 0 V). Further analysis and data fitting (**Fig. S1(b)**) show that transport in this regime follows the thermal activation model with activation energy of ~0.23 eV. It is noticed that this extracted activation energy is in close agreement with that of the oxygen vacancies extracted in $BiFeO_3$, as reported in earlier studies using the scanning probe microscope technique and magnetotransports[1,2].

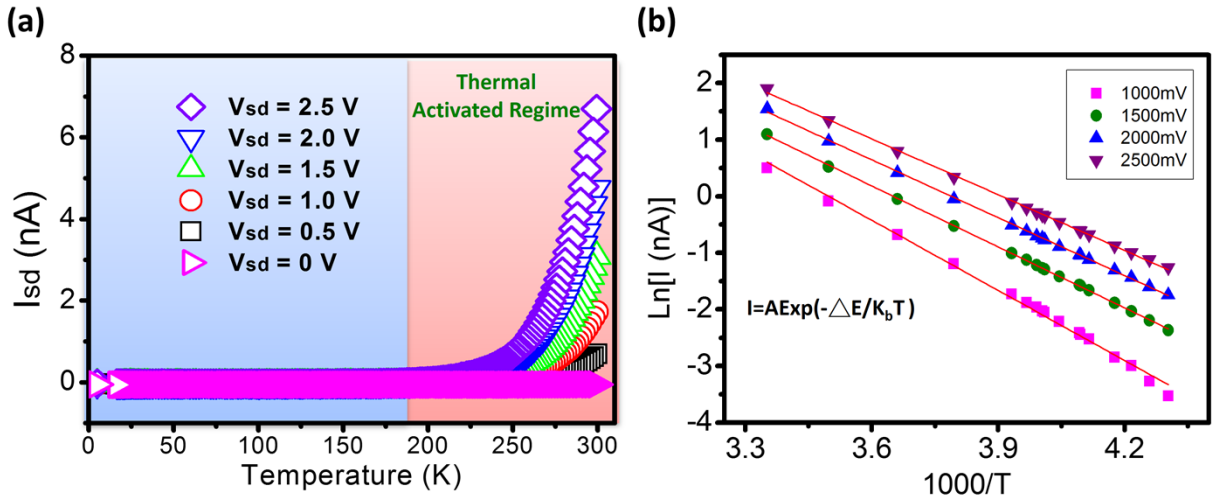

Fig. S1. Temperature dependent study of 90° domain walls. (a) Current-temperature curves as a function of voltage bias, where the characterized thermal activated regime is shown in the pink rectangle. (b) A blowup fitting of the data within high temperature regime (> 190 K), where the temperature axis has been set as 1/T in order to illustrate the exponential fits (red lines) of the current curves.

Reference

1. J. Seidel, P. Maksymovych, Y. Batra, A. Katan, S. –Y. Yang, Q. He, A. P. Baddorf, S. V. Kalinin, C. -H. Yang, J. -C. Yang, Y. -H. Chu, E. K. H. Salje, H. Wormeester, M. Salmeron, R. Ramesh *Phys. Rev. Lett* **2010**, 105, 197603.
2. Q. He, C. H. Yeh, J. C. Yang, G. Singh-Bhalla, C. W. Laing, P. W. Chiu, G. Catalan, L. W. Martin, Y. H. Chu, J. F. Scott, R. Ramesh, *Phys. Rev. Lett* **2012**, 108, 067203.