Resistive Switching Characteristics in Interface-Engineered Ferroelectric Tunnel Junctions

○Akihito Sawa[1], Yoshikiyo Toyosaki[1], and Hiroyuki Yamada[1,2]

National Institute of Advanced Industrial Science and Technology (AIST)[1], JST PRESTO[2]

E-mail: a.sawa@aist.go.jp

Ferroelectric resistive switching (RS) observed in ferroelectric junctions has recently attracted considerable attention because of its potential application to nonvolatile memories with low power consumption and high scalability. For ferroelectric tunnel junctions (FTJs) consisting of an ultrathin ferroelectric barrier, reversal of its ferroelectric polarization induces a change in the tunneling barrier height. The barrier height modification due to polarization reversal requires an asymmetric potential distribution in the ferroelectric barrier. Such an asymmetric potential distribution can be caused by different top and bottom electrode metals having different screening lengths. Another possible origin of the asymmetric potential distribution is the existence of an ultrathin dielectric layer, i.e., dead layer, at the interface between an electrode and a ferroelectric layer. Although the ferroelectric RS in FTJs has been extensively studied, both experimentally and theoretically, the fundamental understanding about the mechanism is still lacking.

In this study, we found that the RS characteristics in $BaTiO_3$ (BTO)-based FTJs strongly depend on the surface-termination of BTO in contact with a simple-metal electrode of Co or Pt.[1] FTJs consisting of BTO barrier layers with BaO or TiO_2 terminations show “eight-wise” or “counter-eight-wise” switching, respectively, suggesting opposing relationships between the polarization direction and the resistance state. The resistance-switching ratio in the junctions can be remarkably enhanced up to 1000, by artificially controlling the fraction of BaO termination. These results are explained in terms of the termination dependence of the depolarization field, i.e., the asymmetric potential distribution, that is generated by a dead layer and imperfect charge screening at the interfaces. Moreover, we demonstrated epitaxial BTO-based FTJs on Si substrates by employing a newly-developed layered oxide buffer of $SrTiO_3/SrO_x$/yttria-stabilized ZrO_2 (YSZ).[2] The layered oxide buffer drastically improved flatness of the interface between the BTO barrier and the $(La,Sr)MnO_3$ (LSMO) bottom electrode. We achieved reversible RS in the FTJs by applying pulsed voltage stresses, which demonstrates the feasibility of the nonvolatile ferroelectric resistive switching memories on Si.

We thank M. Kobayashi, H. Kumigashira, and T. Nagai for XPS and TEM studies. Part of this work was financially supported by the JSPS KAKENHI (Grant No. 26286055).

[1] H. Yamada *et al*., Adv. Funct. Mater. 25, 2708 (2015).

[2] H. Yamada, Y. Toyosaki, and A. Sawa, Adv. Electron. Mater. 2, 1500334 (2016).