Current induced magnetization switching of W/CoFeB/MgO-based three terminal magnetic tunnel junctions via spin orbit torque

NIMS[1], TDK[2], AIST[3], Univ. of Tokyo[4].

°Shinji Isogami[1], Youhei Shiokawa[2], Atsushi Tsumita[2], Tomohiro Taniguchi[3], Seiji Mitani[1], Tomoyuki Sasaki[2] and Masamitsu Hayashi[1,4]

E-mail: isogami.shinji@nims.go.jp

Spin-orbit torque (SOT) induced magnetization switching in three-terminal magnetic tunnel junctions (MTJs)[1-4] is attracting great interest owing to its potential application for magnetic random access memories. Although there are similarities in the device structure between SOT-MRAM and the conventional spin transfer torque (STT)-MRAM, there remains many issues to be addressed in order for the SOT-based devices to compete with other technologies. We have studied the thermal stability factor (Δ) of three terminal MTJs using current and magnetic field induced magnetization switching. The Δ estimated from current (SOT) induced magnetization switching is studied as a function external bias field (H), duration and amplitude of the current pulse.

The inset of Fig. 1(a) shows the device structure. We use in-plane magnetized magnetic tunnel junctions: the magnetic easy axis is orthogonal to the current flow direction (the SOT switching scheme is referred to as type-Y in ref. [3]). Figure 1(a) shows the easy axis magnetization hysteresis loop. An easy-axis offset field of +50 Oe, due to the dipolar field from the MTJ reference layer, was found. Figure 1(b) shows the MR curve when current pulses with length of 50 ns and amplitude of V_{pulse} is applied to the W channel. H_{y} ~ +50 Oe was applied to compensate the dipolar magnetic field. We find symmetric switching for both positive and negative V_{pulse}. Figure 1(c) shows the switching probability with an easy axis bias field of H_{y} ~ -50 Oe, which favors antiparallel magnetic configuration. The switching probability is fitted using the thermally activated spin-transfer torque (STT) switching model with Δ and an intrinsic threshold current I_{c0} as the fitting parameters[5]. We find Δ for positive V_{pulse} is larger than that for negative V_{pulse}. The asymmetric Δ (against the current flow direction) is one of the characteristics we find for the SOT-induced magnetization switching.

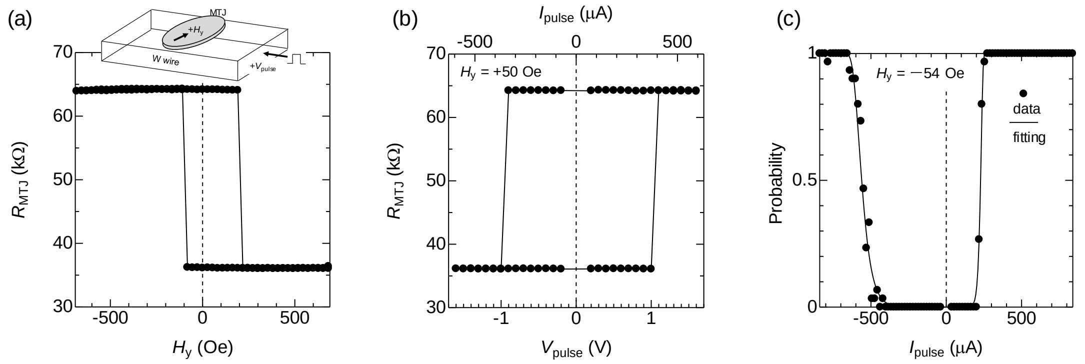

Fig. 1 (a, b) Tunnel junction resistance plotted as a function of the magnetic field (H_{y}) (a) and current pulse amplitude passed along the W channel (b). The pulse length is 50 ns, the H_{y} is +50 Oe. The inset represents schematic illustration of the three-terminal MTJ. (c) Switching probability as a function of current pulse amplitude (I_{pulse}) with H_{y} = -54 Oe. Solid lines represent fitting results.

References:

[1] I. M. Miron, et al., *Nature* 476, 189 (2011). [2] L. Liu, et al., *Science* 336, 555 (2012).
[3] S. Fukami, et al., *Nature nanotech*. 11, 621 (2016). [4] H. Sato, et al., *IEEE Magn. Lett.* 3, 3000204 (2012).
[5] M. Pakala, et al., *J. Appl. Phys.* 98, 056107 (2005).