2種のパルス電流を用いた高速スピン軌道トルク磁化反転

Ultrafast spin orbit torque magnetization switching by using two current pulses

京大院工[1] 関大システム理工[2] ○青木 基[1], 本多 周太[2], 大島 諒[1], 重松 英[1],
新庄 輝也[1], 白石 誠司[1], 安藤 裕一郎[1]
Kyoto Univ.[1] Kansai Univ.[2] °Motomi Aoki[1], Syuta Honda[2], Ryo Ohshima[1], Ei Shigematsu[1],
Teruya Shinjo[1], Masashi Shiraishi[1] and Yuichiro Ando[1],
E-mail: aoki.motomi.53r@st.kyoto-u.ac.jp

Magnetization switching induced by spin-orbit torque (SOT) has attracted much interest because it enables the magnetic random-access memory (MRAM) with high durability. For the practical applications, a fast SOT magnetization switching is essential from a view point of fast and low-power operations. Recently, an ultrafast SOT magnetization switching was reported by using a combination of spin transfer torque injected via a magnetic tunnel junction (MTJ) and SOT induced by the spin Hall effect of heavy metals [1]. However, the advantage of SOT-MRAM, i.e., the high durability, was detracted because one of the writing current flows through the tunnel layer of MTJ. In this study, we demonstrated high-speed SOT magnetization switching of a $Ni_{20}Fe_{80}$ (Py) electrode on a platinum (Pt) layer by injecting two types of pulse currents in the Pt layer from different directions. In our method, writing currents only flow in the Pt/Py layers. Therefore, both ultrafast magnetization switching and the high durability of SOT-MRAM were realized simultaneously.

Figure 1 shows a schematic of the fabricated device. Pt/Py/MgO/SiO_2 channel and Ti/Au electrode were fabricated on the MgO substrate. In the demonstration of the SOT magnetization switching, an assist pulse indicated as a red arrow was firstly injected after initializing the magnetization direction along +*y* direction. After a short interval defined as “delay”, a main pulse indicated as a black arrow was injected. Spin current generated by two current pulses gives torque to the magnetization. When the given torque is enough, magnetization switches to -*y* direction. Figure 2 shows a color contour plot of magnetization switching signal as a function of both voltage of the main pulse and “delay”, detected by using low-frequency spin torque ferromagnetic resonance (LFST-FMR) technique [2]. Voltage level of the assist pulse and pulse width of both pulses were fixed to 2 V and 1 ns, respectively. Red area represents successful magnetization switching. The switching voltage was obviously suppressed around “delay” = 0 ns, indicating the realization of ultrafast SOT magnetization switching. In the presentation, we will also explain the physical mechanism of such a significant improvement of the switching properties.

[1] E. Grimaldi *et al*., Nat. Nanotechnol. **15**, 111 (2020).
[2] M. Aoki *et al*., Phys. Rev. B **102**, 174442 (2020).

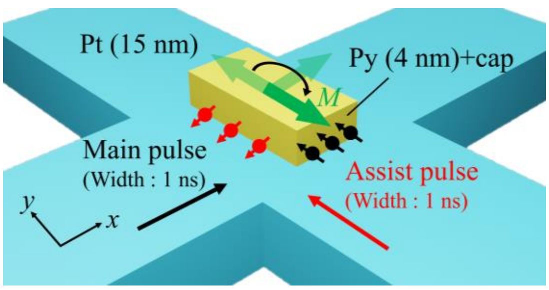

Fig.1. A schematic of device structure for demonstration of SOT magnetization switching.

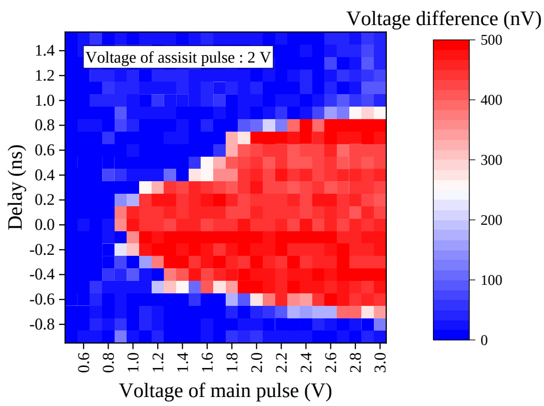

Fig.2. Voltage difference obtained by LFST-FMR as a function of “delay” and voltage level of main pulse.