# Sub-nanosecond magnetization switching in a magnetic tunnel junction with thermal isolation

Osaka Univ. [1], CSRN-Osaka [2]
°Y. Kaneda [1], M. Goto [1,2], H. Nomura [1,2], and Y. Suzuki [1,2]
Email: kaneda@spin.mp.es.osaka-u.ac.jp

Magnetoresistive random access memory (MRAM) has attracted attention as a next generation memory device because of its high speed and low power consumption properties. Electric magnetization reversal is important for writing a memory. Existing magnetization control technologies such as spin transfer torque [1] can control the magnetization direction more efficiently in a thin film of around 1 nm, however, influence of noise and device variation increase in such the condition. Recently, Joule heat-induced magnetic anisotropy change of a free layer in a magnetic tunnel junction (MTJ) with thermal isolation was reported [2], which has been expected to be able to control the magnetization direction efficiently even in a thick film. The magnetization switching by this effect is one of the attractive techniques for controlling MRAM, however, high speed magnetization switching by heating has not been observed in such an effectively heat-insulated system. In this study, we researched magnetization switching of a free layer in an MTJ with the thermal isolation.

Film structure is buffer layer | IrMn | CoFe | Ru | CoFeB pinned layer | MgO barrier (1 nm) | FeB free layer (2 nm) | MgO (0.3 nm) | W (2 nm) | MgO (0.4 nm) capping layer | metal electrode. Figure 1 shows the measurement set-up. A voltage pulse was applied by a pulse generator to the MTJ under a tilted external DC magnetic field. The pulse width and the pulse height are 0.5 ns and 299 mV respectively. After that, the magnetization direction of the free layer was detected by measuring voltage $V_{\text{lock-in}}$ using a lock-in amplifier. These measurements were repeated 100 times. Figure 2 is the result of $V_{\text{lock-in}}$ with 100 repetitive pulse voltage applications under various external DC magnetic fields. We observed that the magnetization switching of the free layer with thermal isolation occurred when external DC magnetic fields was 15 mT or 20 mT.

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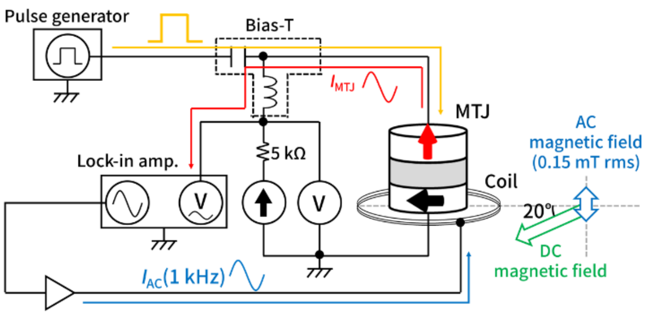


Fig. 1, Schematic of measurement set-up

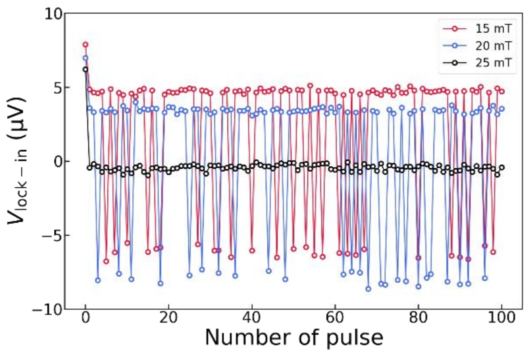


Fig. 2, $V_{\text{lock-in}}$ with 100 repetitive pulse voltages under various DC magnetic fields

[1] E. B. Myers *et al.*, Science **285** 867 (1999) [2] M. Goto *et al.*, Nat. Nanotechnol. **14** 40 (2019)