

Large spin torque diode voltage by resonant expulsion of vortex core

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Magneto resistive devices are known as the devices which can rectify radio-frequency (rf) signal by spin torque diode (STD) effect.¹⁻³⁾ In the STD, the rectified voltage is roughly proportional to the input rf power because the rectification originates from the spin dynamics generated by rf input. Most recently, a new STD effect was discovered in the magnetic tunnel junction (MTJ) having a vortex remanent state where the vortex core is eventually expelled by the rf input.⁴⁾ The new STD effect uses the change of the magnetic state in the MTJ, therefore the rectified voltage does not depend on the input rf power but on the magneto-resistance (MR) ratio. In the previous work⁴⁾, NiFe was used for the magnetic free layer which resulted in small MR ratio of 10 % and small rectified voltage of 1 mV.⁴⁾ In this work, we used FeB as the free layer which will enhance MR ratio over 100 %^{5,6)}.

We prepared a circular shaped MTJs having the structure of sub/buffer/PtMn(15)/CoFe(2.5)/Ru(0.98)/CoFeB(3.0)/MgO(1.0)/FeB(3.0)/MgO(1.0)/Ta/Ru with ϕ 450 nm. The MR ratio was 120% at the bias voltage of 30 mV and the resistance and area product value was $3 \Omega \mu\text{m}^2$. Figure 1 shows the setup for the measurement of the STD effect, where the signal generator (Keysight N5182), bias tee (Keysight 11612A), and source measuring unit (Keysight B2912A) are equipped. We measured STD effect by sweeping rf frequency under the external magnetic field of 4.7 kOe, the constant current of 2.4 mA, and the rf power of $0.31 \mu\text{W}$ (-35 dBm). The external field was applied in the direction of 88.5 degrees out of the MTJ film plane. Figure 2 shows the voltage change by the STD effect. The large voltage change (25 mV) was observed from 440 MHz to 450 MHz, which is the highest value reported to date under the input rf power of sub- μW range. The frequency range corresponded to the precession frequency of the vortex core precession, suggesting the fact that the voltage change is likely to be caused by the vortex-core expulsion.

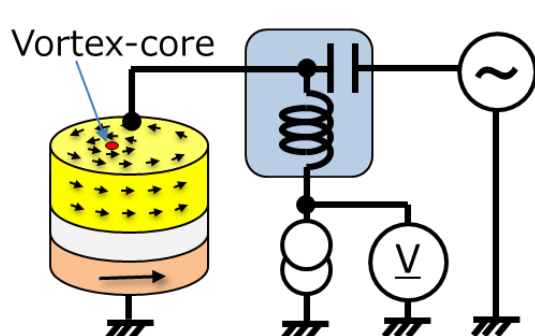


Fig. 1 Measurement setup of STD effect
<Reference>

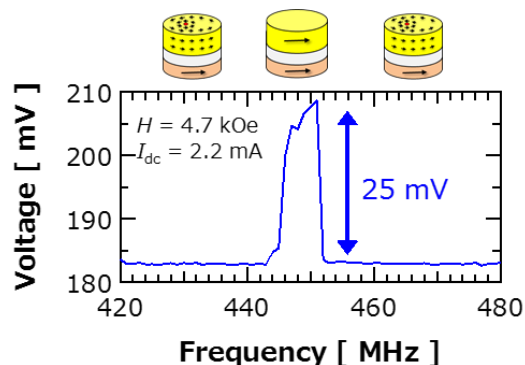


Fig. 2 Result of STD effect.

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