

Simulation of microwave excitation in micro strip line induced by radio-frequency signal amplification using magnetic tunnel junctions

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Magnetic tunnel junctions (MTJs) is promising for radio-frequency (rf) device in spintronics, such as spin-torque diode effect, spin-torque oscillator, and rf amplifier. The rf amplifier have been attempted by ferromagnetic resonance (FMR) in MTJ system with direct current application. Recently, our group succeeded to amplify the rf signal measured by S_{11} signal [1]. The rf-signal can be enhanced by mutual phase-locking [2] between MTJ and external resonator such as micro strip line.

In this study, we investigated enhancement of microwave in micro strip line induced by rf-amplification of MTJ. Figure 1 shows the experimental results of mapping of S_{11} signal as functions of in-plane magnetic field. We observed the S_{11} signal higher than 1 in the red region. By using the experimental parameters of the MTJ, we calculated the free layer magnetization dynamics of MTJ and voltage in micro strip line with the dc current and thermal fluctuation by 4th order Runge-Kutta method. Figure 2 shows the temporal variation of voltage in the micro strip line with a length of 0.375 m. The vertical and horizontal axis is position and time, respectively. The color is the magnitude of voltage oscillation. We observed the standing wave of voltage whose amplitude is 0.06 V under the dc voltage of 0.32 V. The rf-signal is enhanced by phase-locking due to the voltage standing wave. This study is supported by two countries collaborative investigation, MIC, ImpACT program, and JSPS KAKENHI (Grant No. JP16H03850).

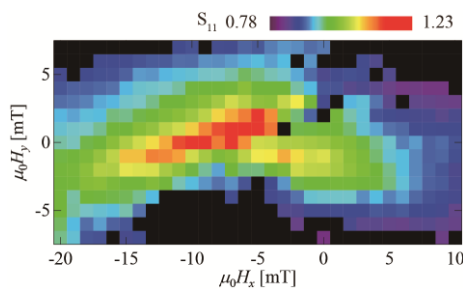


Fig. 1 S_{11} intensity as functions of in-plane field

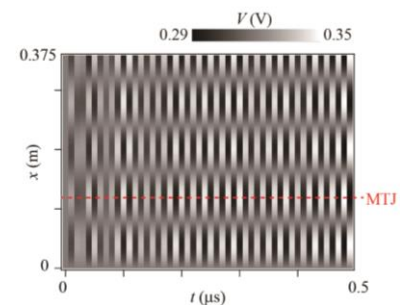


Fig. 2 Temporal voltage change in micro strip line

[1] M. Goto *et al.*, the 62th MMM conference, CI-06, (2017) [2] S. Kaka, *et al.*, Nature, **437**, 389 (2005)