

Microwave emission using two magnetic tunnel junctions with positive gain

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As the next generation microwave signal sources, magnetic tunnel junction (MTJ) is attracting attention. Recently, it was reported that the microwave amplification of reflection signal from MTJ is succeeded by spin-torque due to the heat-induced magnetic anisotropy change [1]. Furthermore, we reported that the transmission signal is amplified with a similar mechanism [2]. These results suggest that, using multiple MTJs which have positive gain at same frequency region, the maser could be excited. In this study, we investigate the microwave emission from magnoise in MTJ, and characterize transmission amplification by using two heat-driven MTJs and feedback loop circuit.

The film structure is buffer layer / IrMn (7 nm) / CoFe / Ru / CoFeB / MgO barrier (1 nm) / FeB (2 nm) / MgO cap ($t_{\text{MgO}}=0.3$ nm, 0.4 nm) / metal cap. Figure 1 shows the set up to measure the magnoise with feedback loop circuit. The DC voltages were applied to the MTJ 1 ($t=0.3$ nm) and MTJ 2 ($t=0.4$ nm) through bias-tee. The microwave signal in the loop circuit is measured through the directional coupler. The directional coupler has 13dB coupling loss. Total gain without sample in loop circuit is adjusted to the negative gain of -0.44 dB by using external amplifier and attenuator. The total cable length in the loop circuit is about 11.5 m. Figure 2 shows the comparison between the spectra applied voltage to only MTJ 1 (green curve) or MTJ 2 (red curve), and the spectra which is measured with applying voltage to both MTJs (blue curve). Resolution bandwidth was 0.1 MHz. The blue curve shows sharp peak at 4.809 GHz. Compared to green curve, the line width reduced, and the peak power spectrum density increased not less than 5 times and 15 times respectively. This result suggests that the microwave amplification by the MTJ could be enhanced by using multiple MTJs.

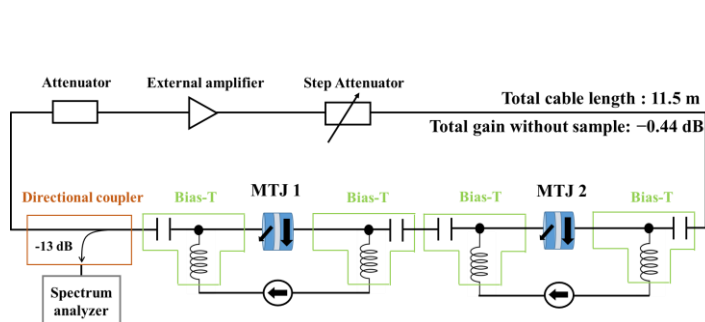


Fig. 2. Set up for magnoise measurement with feedback loop circuit.

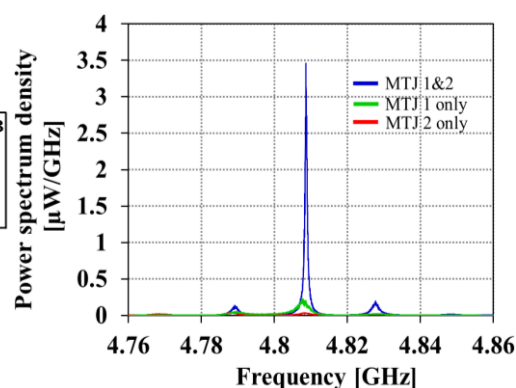


Fig. 2. Magnoise spectrum when one or two MTJs are in the loop circuit.

[1] M. Goto *et al.*, Nat. Nanotechnol. (2019) [2] Y. Yamada *et al.*, JSAP Autumn meeting (2018)