Magnetization dynamics at high S_{21} condition in magnetic tunnel junction

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Various radio-frequency(RF) devices, using a Magnetic tunnel junction (MTJ), have been developed including spin-torque oscillator and spin-torque diode. In addition to these devices, MTJ can be used as amplifier of RF signals. The amplification is excited by ferromagnetic resonance (FMR) with a direct current applying to MTJ. Recently, it is reported that the RF transport signal (S_{11}) from MTJ could be amplified by RF external magnetic field [1].

In this study, we demonstrate the high S_{21} value using MTJ and its physical mechanism. The film structure is Ru(7 nm)/Ta(3 nm)/MgO(0.3~0.5 nm)/FeB(2 nm)/MgO(1 nm)/CoFeB/Ru/CoFe/IrMn(7 nm)/Ta/Ru. Figure 1 shows the spectrum at highest S_{21} value when we applied magnetic field and dc current to MTJ. The $S_{21} > 0$ dB was observed, which means that the input signal was amplified. To understand the origin of torque (excited by magnetic anisotropy change, spin-transfer or nonlinear effect, etc.) at high S_{21} condition, we measured the diode spectrum [2]. Figure 2 shows the perpendicular magnetic anisotropy change as a function of applying voltage. We observed large anisotropy change 850 $\mu J/m^2V$. We also observed the parabolic anisotropy change. This result suggested that the torque at high S_{21} condition is excited by the anisotropy change coming from Joule-heating.

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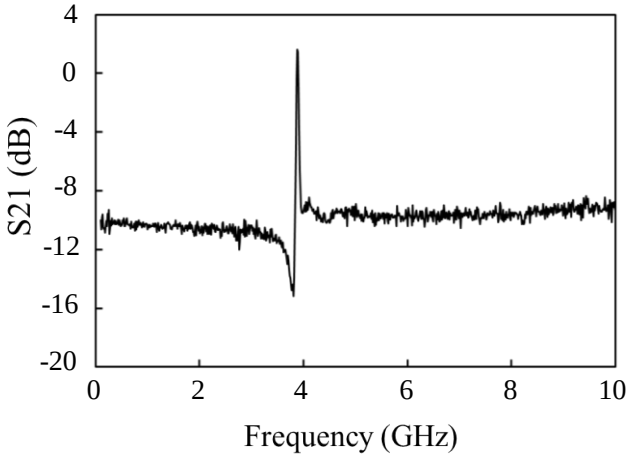

Fig.1: The S_{21} spectrum at its highest condition

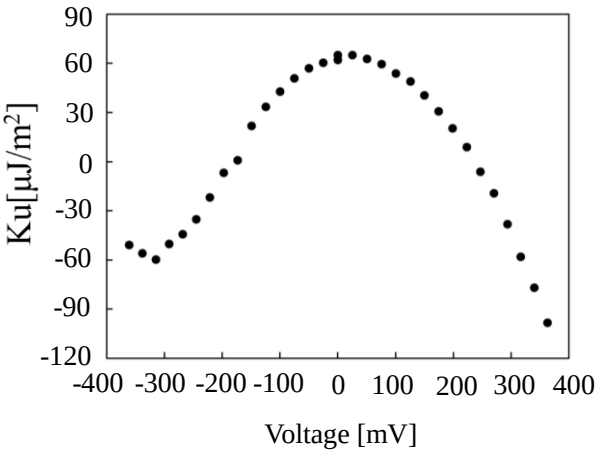

Fig.2: Perpendicular magnetic anisotropy changed by voltage

[1] K. Konishi *et al.*, Appl. Phys. Lett. **102**, 162409 (2013)

[2] A. Turapurkar *et al.*, Nature. **438**,339 (2005)