バイアス電圧チョップ法を用いた、磁気トンネル接合スピントルク発振素子中に励起されたマグノイズの高感度測定

High Sensitivity Magnoise Measurement on a Magnetic Tunnel Junction Based Spin Torque Oscillator Using Bias Voltage Chopping Technique

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Magnoise is a powerful probe for characterizing a magnetic tunnel junction (MTJ) based devices, as it gives thermally excited ferromagnetic resonance (FMR) signals whose frequency is dependent on the effective magnetic field. In order to measure magnoise on nano-scale MTJ devices, we have developed a highly sensitive magnoise measurement system using a bias voltage (V_B) chopping and synchronous data acquisition technique. As shown in Fig. 1, a MTJ device is biased by a chopped voltage source, and a spectrum analyzer (SA) acquires the noise power in synchronization with the chopped V_B. Then the odd and even indexed data points are separately averaged and the difference between them is numerically calculated. This is equivalent to the lock-in detection, but with less hardware components needed.

Fig. 2 shows the magnoise spectrum measured on a MTJ based spin torque oscillator (STO) having an in-plane magnetized free layer and out-of-plane magnetized reference layer under the application of V_B = -100 mV and out-of-plane bias field (H_B). The diameter of this STO is estimated to be 21 nm from the resistance-area product and the device resistance. It clearly shows FMR signals from both the free and reference layers, which show different dependencies on H_B reflecting the magnetic states of these layers. When H_B < -300 mT, the free layer is fully perpendicularly saturated, thus the FMR frequency is proportional to H_B. When -300 < H_B < 700 mT, the FMR signal from the free layer shows a convex dependence typical for in-plane magnetized layers, while the FMR signal from the reference layer shows a linear dependence as it is perpendicularly magnetized.

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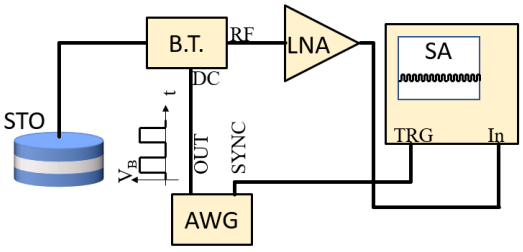

Fig. 1, Block diagram of high sensitivity magnoise measurement setup.

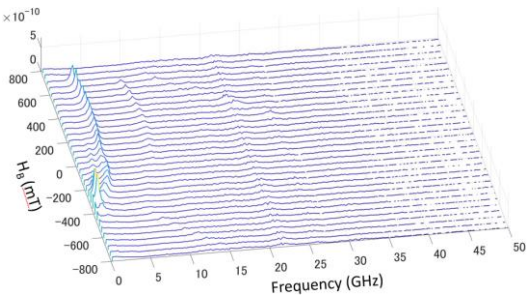

Fig. 2, Magnoise spectrum of a MTJ based STO as a function of H_B.