Quantitative analysis for the low-frequency noise in magnetic tunnel junctions

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MgO-based magnetic tunnel junctions (MTJs) are utilized for information readouts in hard disk drives, magnetic random access memories, magnetic field sensors and microwave detectors. For the applications, the noise generated in the MTJs is a crucial factor, which limits their maximal performance. The low-frequency magnetic noise is one of the most important noises and often appears as $1/f$ noise. In the previous studies, the noise is identified as the thermally excited magnetic- domain hopping is the main cause [1], thus is difficult to be understood *quantitatively*. In this study, we develop a theory for the low-frequency noise, in which the macro-spin model with asymmetric potential in the magnetic free layer is introduced.

MTJs with CoFeB/MgO/FeB structure are made by sputtering methods. The resistance in the parallel magnetization configuration and resistance-area product are 215 Ω and 2.5 Ωμm^2, respectively. The designed junction size is 100 nm in diameter, and the magnetoresistance ration is 90%. The DC bias current is applied to the MTJs, and the noise is measured by spectrum analyzer. We applied the magnetic field of 1.1 kOe tilted from the film normal. Figure 1(a) shows the typical low-frequency noise in the MTJs. Figure 1(b) shows the DC bias dependence of the peak amplitude of the noise. Note that a spectral distribution of the low-frequency noise has a Lorentzian form and is quantitatively reproduced by a theory incorporating nonlinear ferromagnetic resonance which is attributed to the asymmetry in the magnetic potential.

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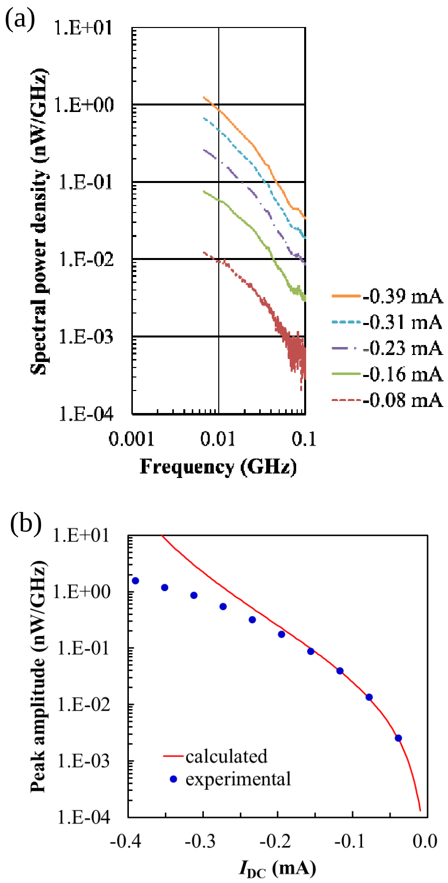

Fig. 1 magnetic noise spectra