Magnoise and 1/f noise of magnetic vortex states in magnetic tunnel junctions

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The knowledge of magnetic noise in devices is important for realizing highly sensitive magnetic field sensors. In these several decades, magnetic noise such as magnoise [1], nonlinear magnoise [2], and 1/f noise [3] has been reported in magnetic tunnel junctions (MTJs) with single domain states. Moreover, the low frequency noise has been studied in a MTJ with the magnetic vortex state which is the candidate for a highly sensitive sensor with wide dynamic range because of its negligible hysteresis and high saturation field [4]. However, the magnetic noise of the magnetic vortex state is not studied in wide frequency range. In particular, 1/f noise mainly limits the sensitivity of sensors, therefore, to clarify the mechanism of the magnetic 1/f noise in the magnetic vortex is an important subject. In this study, we investigate the magnetic noise in the MTJ with a magnetic vortex state in the free layer (FL).

The film structure is Buffer/ IrMn(6)/ CoFe(2.5)/ Ru(0.85)/ CoFeB(2.1) and CoFe(0.4) pinned layer/ MgO(1.1)/ FeB(5) magnetic vortex FL/ MgO(1.1)/ Ta(5)/ Ru(5) (nm in thickness). Figure 1 shows the magnetoresistance (MR) curve of the MTJ. The magnetic vortex structure forms in the magnetic field range shown as the bold line in Fig. 1. The inset of Fig. 2 is the noise power spectrum of the magnetic vortex at zero magnetic field. The peak intensity of magnoise is proportional to the square of the voltage as shown in Fig. 2. The result is consistent to the behavior of the power spectrum induced by vortex-core dynamics due to the thermal fluctuation. Furthermore, 1/f magnetic noise of the magnetic vortex is observed in the MHz frequency range. Our results provide the fundamental knowledge to discuss the feasibility of the magnetic field sensor using the magnetic vortex.

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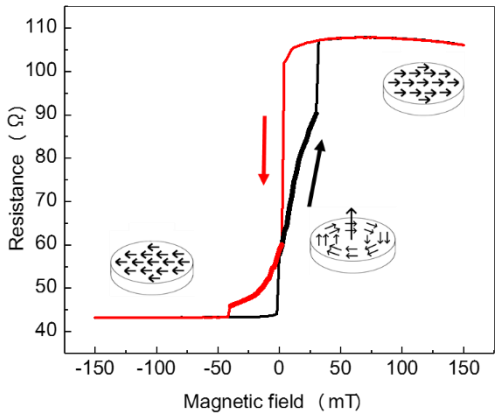

Fig. 1 MR curve

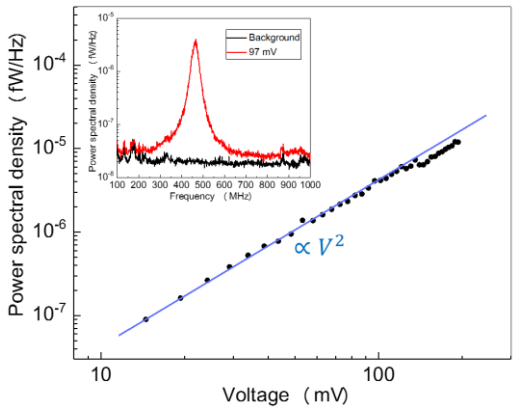

Fig. 2 Voltage dependence of the magnoise peak

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