Effect of Magnetic Domain Structure on Noise Property in Magnetic Tunnel Junction Based Sensor

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Measurements of cardiac and cerebral magnetic fields were demonstrated by using magnetic tunnel junction (MTJ) based sensor at room temperature [1]. However, for actual medical applications, it is necessary to improve the signal-to-noise ratio in MTJ-based sensors. Especially, 1/*f* noise in the low frequency range is a serious problem for bio-magnetic field detection [2], but the origin of the noise in MTJs is still not clear. A possible origin of the noise is fluctuation of magnetic domain in the free layer of MTJs [3]. In this study, we fabricated MTJs with free layers which have various thicknesses and shapes, and investigated their domain structure by magneto-optical Kerr effect to clarify influence of magnetic domain structure on the 1/*f* noise in MTJ-based sensor.

The structure of prepared MTJ multilayer is Ta(5 nm)/Ru(10 nm)/Ta(5 nm)/NiFe(*d* nm)/Ru(0.9 nm)/CoFeB(3 nm)/MgO(1.6 nm)/CoFeB(3 nm)/Ru(0.9nm)/CoFe(5 nm)/IrMn(10 nm)/Ta(5 nm)/Ru(3 nm). MTJs were micro-fabricated in various shapes by photolithography and Ar ion milling. After the microfabrication, MTJ devices were annealed at 325°C applying magnetic field of 10 kOe for crystallization of CoFeB layers, and were subsequently annealed at 300°C rotating magnetic field direction of 90 degree to make orthogonal easy axes alignment of free and pinned layers. Noise measurement was carried out by network-analyzer applying bias voltage of 10 mV.

Fabricated MTJs showed large TMR ratio of 93.2% at room temperature regardless of shape and thickness for free layers. Fig. 1 shows observed images of magnetic domain and noise spectra for each MTJ device. MTJ devices with complicated magnetic domain structure in the free layer showed larger noise than those for MTJs with simple domain structure. We found that the domain structure strongly influence 1/*f* noise in MTJ-based sensors.

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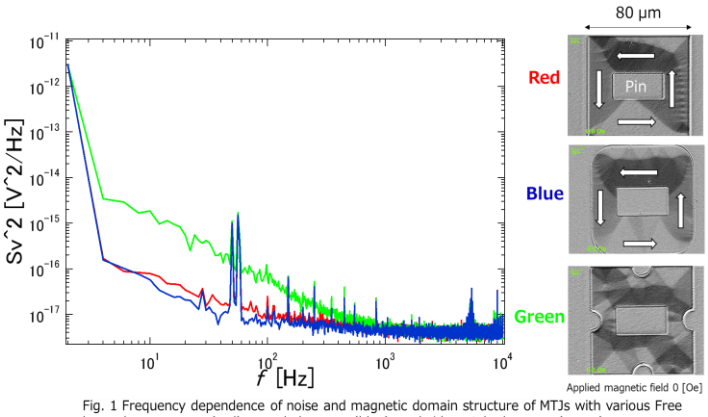

Fig. 1 Frequency dependence of noise and magnetic domain structure of MTJs with various Free layer shape: square (red), rounded square (blue), and side-notched square (green)