Detection of the weak magnetic field by serial MTJs with various aspect ratio free layers

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Introduction

Since large tunnel magnetoresistance (TMR) effect was discovered in MgO based magnetic tunnel junctions (MTJ) at room temperature, the sensors based on MTJs have been attracted much attention for magnetic field sensing. In particular, integrating MTJs in series is a feasible way to offer high field sensitivity, therefore the serial MTJs enable us to design magnetic sensors for sensing biomagnetic field. Considering that sensitivity is directly affected by magnetic shape anisotropy in the free layer of MTJ, changing the aspect ratio of the free layer in MTJ can lead to different detectivity [1]. Therefore, the sensors based on 20 serial MTJs with various free layers of aspect ratio (A = width: length) were fabricated, and their abilities of sensing magnetic field were investigated.

Experiments

The magnetic films were prepared by magnetron sputtering system and their stacking structure was SiO_2-sub./Ta(5)/Ru(10)/Ta(5)/$Ni_{80}Fe_{20}$(70)/Ru(0.9)/$Co_{40}Fe_{40}B_{20}$(3)/MgO(2.5)/$Co_{40}Fe_{40}B_{20}$(3)/Ru(0.9)/$Co_{75}Fe_{25}$(5)/$Ir_{22}Mn_{78}$(10)/Ta(8)(in nm). The free layers of fabricated MTJs have the same area (2500 μm^2) but different aspect ratios A (1, 2, 3 and 4). After microfabrication, sensor performance was investigated for sensing AC magnetic field. An alternating current of a 10 Hz sine wave was offered for the coil and a homogeneous field of 0.35 Oe was applied to the sensor. The output signal was digitized by using an FFT spectrum analyzer.

Result

Experimental result differentiated abilities of sensors for sensing fields. The obvious peak of the output signal can be observed. The summary result clearly showed the bias dependence of output peak on different sensors. The high output peaks can be observed for sensors A = 2, 3, and 4. Furthermore, noise property of each sensor indicated that free layer shape had strong effects on MTJ sensors. Therefore, it can be expected that the serial MTJ sensor with optimized shape can offer excellent detectivity for sensing weak magnetic field.

Reference

[1] K. Fujiwara, M. Oogane, F. Kou, D. Watanabe, H. Naganuma, and Y.Ando, Jpn. J. Appl. Phys. 50, 013001 (2011).

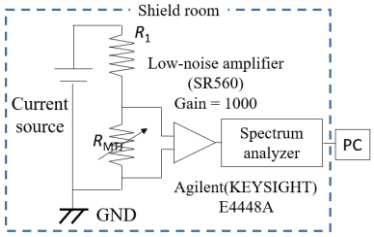

Fig.1 Schematic diagram of the experimental setup

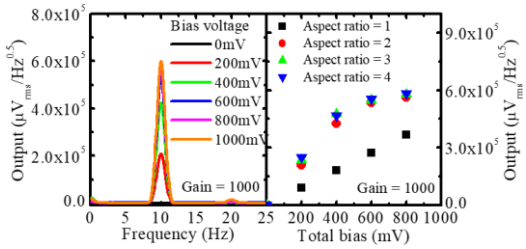

Fig.2 Output signal from the sensors with various free layer aspect ratios at various applied magnetic field.