High Frequency Magnetization Response of Perpendicular Double-Layer Media

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Abstract — The magnetization reversal of the perpendicular double-layer medium at high frequencies is investigated by using the dynamic micro-magnetic simulation. The magnetization in the recording layer is hard to reverse sufficiently in the case of high frequency recording. The medium with high saturation and high anisotropic field, such as CoCrPt is desirable for the high frequency recording. The high saturation increases the torque of the recorded magnetization and high anisotropic field suppresses the natural resonance.

I. INTRODUCTION

Perpendicular magnetic recording has been used for the high density magnetic recording[1]. It has been expected to realize a recording density of 1 Tb/in^2 in research for perpendicular recording. Perpendicular double-layer media is a popular medium for perpendicular magnetic recording. It takes a structure that a soft magnetic underlayer is attached under the recording layer. With such an increase of recording density, it comes to be demanded that recording is more quickly. Therefore it is necessary to record by high frequency magnetic recording field at giga Hz order. In the case of high frequency recording, there is a problem. The following capability of magnetization reversal to high frequency field is not come out. In this paper, high frequency magnetization response in double-layer medium is simulated.

II. CALCULATION PROCEDURE

A simulation model of perpendicular double-layer medium is shown in Fig.1. A calculated region of double-layer medium is 200 x 200 x 110 nm^3. In z (perpendicular) direction, there are 10 nm thick recording layer and 100nm thick underlayer. The medium is divided into 100 x 100 x 3 divisions. An individual cell size is 2 x 2 x 10 nm^3 in recording layer and is 2 x 2 x 50 nm^3 in underlayer. Time step is 10^{-14} s.

TABLE1 lists medium parameters. Co-Cr alloys and Co-Zr-Nb are supposed as the recording layer and the underlayer, respectively. Damping factor is assumed to be 0.03, although it is unknown.

The magnetization in each cell is calculated by Landau-Lifshitz-Gilbert equation[2] with the eddy current field. The influence of the eddy current field can be calculated by adding the eddy current field to an effective field[3]. Next, eddy current field generated at center of the cell is calculated from the eddy current by Biot-Savart Law. The exchange field between the recording layer and underlayer is not considered, assuming that there is an intermediate layer between layers.

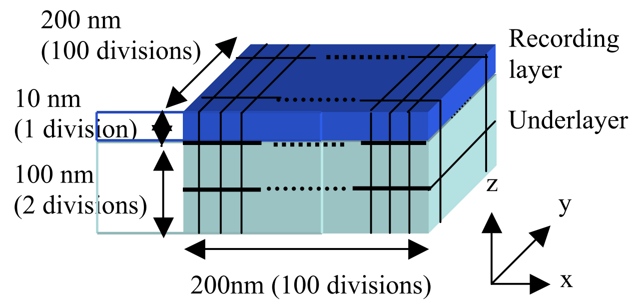


Fig.1 Perpendicular double-layer medium model

TABLE1
SIMULATION PARAMETRES

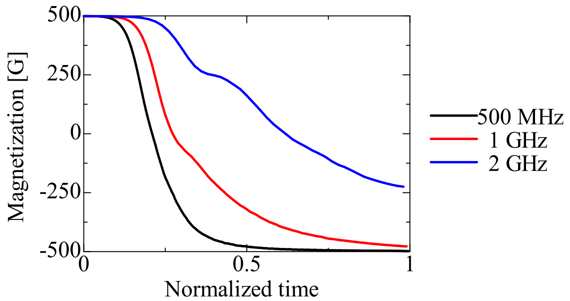
	Recording layer		Underlayer
	CoCrPt	CoCrTa	CoZrNb
Saturation magnetization (emu/cc)	500	300	1000
Anisotropy field (Oe)	10000 z-direction	5000 z-direction	10 x-direction
Exchange stiffness (erg/cm)	3.0×10^{-8}	1.0×10^{-8}	1.0×10^{-6}
Resistivity (Ωcm)	80	80	80 μ
Damping factor	0.03	0.03	0.03

To begin with, initial magnetization of +z direction is set to the recording layer, and +x direction is set to the underlayer. After the calculation converged, a sinusoidal external magnetic field is applied to the central area of 120 x 60 nm^2 in the –z-direction. Frequencies of the external magnetic field are at 100, 200, 500, 1000, 2000 MHz, and the maximum strength is 10000 Oe.

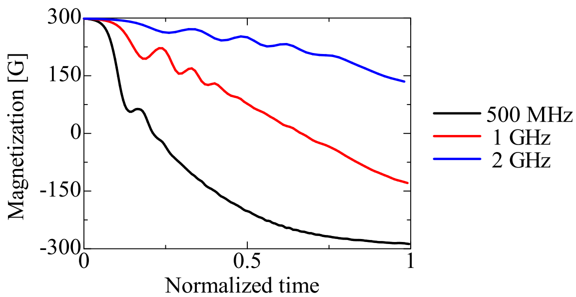
III. RESULTS AND DISCUSSION

Figure 2 shows the average magnetization response of the recording layer. Here, the elapsed time is normalized by the half period of the driven external magnetic field at various frequencies. Magnetization reverses completely at frequencies less than 500 MHz. As the frequency becomes high, magnetization reversal reduces heavily. These reductions are not caused by the eddy current loss because the eddy current field is small very much relative to the other effective field[4]. Recording material with high saturation and high anisotropic field, such as CoCrPt is easy to reverse at high frequencies.

Figure 3 shows magnetization responses in a typical cell. The magnetization in the CoCrTa oscillates because of the small anisotropic field. It leads to a long time transition. So the magnetization cannot be reversed in a short period. On the other hand, a large anisotropic field of the CoCrPt suppresses the natural resonance and changes the magnetization smoothly.



(a) CoCrPt



(b) CoCrTa

Fig.2 Average magnetization response at various frequencies

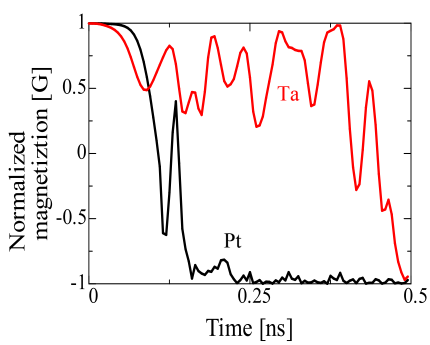
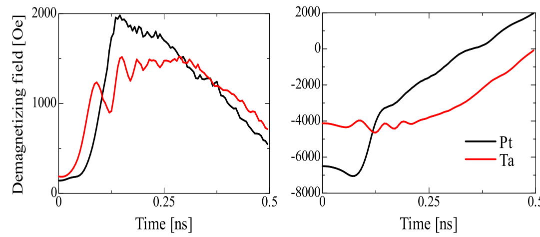


Fig.3 Magnetization response at 1 GHz in one cell.



(a) x-direction (b) z-direction

Fig.4 Change of demagnetization field at 1GHz in the recording layer

Furthermore, the large saturation assists the magnetization reversal at high frequencies. Changes of demagnetizing field at 1 GHz in the recording layer are shown in Fig.4. At initial stage of the reversal, -z component of the demagnetizing field is large in the CoCrPt. And the x component of the demagnetizing field, which gives a torque to the z-direction magnetization, is large at middle of the period. These behaviors assist the magnetization reversal in the CoCrPt.

IV. CONCLUSIONS

This paper investigated the magnetization reversal of the perpendicular double-layer medium at high frequencies. The magnetization in the recording layer is not reversed sufficiently in the case of high frequency recording. The medium with high saturation and high anisotropic field, such as CoCrPt is desirable for the high frequency recording. The high saturation increases the torque of the recorded magnetization and high anisotropic field suppresses the natural resonance.

V. REFERENCES

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