Simulation of Wall Motion in Displacement Layer with Reduced Exchange Energy on DWDD Media

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Abstract- Simulation of the wall motion in Domain Wall Displacement Detection media has been carried out for the two kinds of the displacement layers. It has been found that the wall motion in the displacement layer with the reduced exchange energy has to be treated as the physical phenomenon which is different from that in the ordinary displacement layer. The improvement of the wall motion in the displacement layer with the reduced exchange energy depends on the clever control of the stray field.

Key words: Domain Wall Displacement Detection, exchange energy, displacement layer, wall velocity, stray field

1. Introduction

Domain Wall Displacement Detection (DWDD) 1) is a very promising method for achieving an ultra high-density magneto-optical disk. In order to improve the readout characteristics on DWDD media, it is desired to decrease the space-dependent jitter which is attributed to the fluctuation of timing of the wall displacement and the velocity of the wall motion. Since the applying of the magnetic field is effective to suppress the jitter in DWDD, it is expected that the space-dependent jitter can be decreased by the improvement of the wall motion. In the present study, therefore, the wall motion in the displacement layer of triple-layered DWDD media has been simulated for the different exchange integral $J_{ex, TM}$ in the Gd-TM (transition metal) films. The reduction of the exchange energy between Gd and TM pair atoms owing to the reduction of the $J_{ex, TM}$ is realized by adding a small amount of Bi to the Gd-Fe-Co film 2). The simulation parameters used in the calculation of mean field theory are due to our previous study on Gd-Fe and Tb-Fe films 2,3). Thickness and Curie temperature of each layer are due to the calculation condition for the triple-layered disk in Ref. 4.

2. Results and Discussions

2.1 Timing of the wall displacement

The wall displacement in the front process 4) occurs under the condition of

$$\frac{\partial \sigma_D}{\partial x} > 2M_sH_w + \sigma_w t$$

(1)

where $\sigma_D$, $M_s$, $H_w$, $t$ and $\sigma_w$ are the domain wall energy, the magnetization, the wall coercivity, the thickness of the displacement layer and the interface wall energy, respectively. Figure 1 shows the relationship of Eq. (1) for the two kinds of displacement layers; (a) the ordinary displacement layer and (b) the displacement layer with the reduced exchange energy. Position $x = 0$ indicates the center of light beam. The cross point of $\partial \sigma_D/\partial x$ and $2M_sH_w + \sigma_w/t$ is the start point of the wall displacement. In comparing Figs. 1 (a) and (b), $\partial \sigma_D/\partial x$ as the driving force of wall in (b) is larger than that in (a) around the start point of the wall displacement, and $2M_sH_w + \sigma_w/t$ as the suppression force of wall motion in (b) decreases more rapidly than that in (a). These differences seem to make the start of wall motion in (b) quicker than that in (a).

Figures 2 and 3 show the temperature dependence of the magnetization and the perpendicular anisotropy constants for the two kinds of displacement layers, respectively. In Fig. 3 the effective anisotropy constant of (b) decreases more rapidly with increasing temperature than that of (a) around the temperature range from 450K to 500K where the wall motion will occur. Hence, in the displacement layer with the reduced exchange energy, the driving force of wall can be larger and the suppression force of wall motion can be smaller as compared with those in the ordinary displacement layer. In Fig. 2, the magnetization of (b) around the temperature range from 450K to 500K shows about ten times as large as that of (a). This fact indicates that the wall motion in the displacement layer with the reduced exchange energy has to be treated as the physical phenomenon which...
2.2 Velocity of the wall motion

The velocity of the wall motion during the front process has been calculated for the two kinds of displacement layers by the approximate estimate from the Landau-Lifshitz-Gilbert equation. The linear velocity of medium is 3 m/sec. The results are shown in Figs. 4 (a) and (b). Here, the optimum composition of Gd for each displacement layer is chosen to complete the whole wall motion in the shortest period. The velocity of the wall motion in Fig. 4(b) is larger than that in Fig. 4(a), and then the whole wall motion in Fig. 4(b) has been completed faster than that in Fig. 4(a).

2.3 Influence of the stray field upon wall displacement

The simulation of the wall motion mentioned above are carried out without taking account of the stray field. However, it is very important to study the influence of the stray field upon the wall displacement. Then the stray field in the displacement layer itself has been estimated for the displacement layer with the reduced exchange energy and the result is shown in Fig. 5. Since the stray field in Fig. 5 is larger than the Walker breakdown field (62.8 Oe), it is required to suppress the stray field to realize the quick wall motion in Fig. 4(b).

Fig. 2 Temperature dependence of magnetization for (a) the ordinary displacement layer and (b) the displacement layer with the reduced exchange energy.

Fig. 3 Temperature dependence of anisotropy constants for (a) the ordinary displacement layer and (b) the displacement layer with the reduced exchange energy.

is different from that in the ordinary displacement layer. That is, in the case of the displacement layer with the reduced exchange energy, the wall motion occurs under the field in the vicinity of the Walker breakdown field. Whereas in the case of the ordinary displacement layer, the wall motion occurs under much larger field.

Fig. 4 Wall position and velocity with time for (a) the ordinary displacement layer and (b) the displacement layer with the reduced exchange energy.

Fig. 5 Stray field with position in the displacement layer with the reduced exchange energy.

3. Conclusion

In order to improve the wall motion in the DWDD medium, the substitution of displacement layer has been investigated. The reduction of the exchange energy in the displacement layer is effective to realize the quick wall motion in the vicinity of the Walker breakdown field. However, the stray field in the displacement layer with the reduced exchange energy is large. Therefore it is desired to suppress the stray field cleverly to realize the quick wall motion in the displacement layer with the reduced exchange energy.

References