INFLUENCE OF COMPOSITION IN DOUBLE LAYER FILMS FOR SUPER RESOLUTION

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Abstract — Composition and thickness dependence of GdFeCo/TbFeCo double layer films for magnetically induced super resolution were studied. The resolution depends on the composition and thickness of the GdFeCo readout layer in particular. Varying Fe-Co ratio and the thickness of GdFeCo, sensitivity to recording magnetic field was investigated. Cross-talk of 100 nm readout layer was 12 dB less than a conventional disk.

KEYWORDS: SUPER RESOLUTION, DOUBLE LAYER, GdFeCo/TbFeCo, CROSS-TALK

INTRODUCTION

Exchange coupled double layer film was reported for magnetically induced super resolution (MSR) recently [1]. Figure 1 illustrates a schematic view of readout process for a double layer. The direction of magnetic moments of the readout layer changes from in-plane to perpendicular to the film plane for the region raised up to high temperature. The region works as an aperture of MSR. Therefore rapid change of the direction of magnetic moment with increasing temperature is necessary to enhance resolution. Higher resolution can be obtained by controlling the composition and thickness of the readout layer. Hirokane et al. reported that insertion of an intermediate layer into the double layer could decrease recording magnetic field because exchange coupling disappears at around its Curie temperature which is lower than that of the recording layer [2].

In this paper, we investigated the contribution of composition of the readout layer. Composition and thickness of GdFeCo readout layer were varied to investigate the magnetic and disk properties of GdFeCo/TbFeCo double layer films. We obtained considerably high carrier to noise ratio (CNR) for 0.5 \( \mu m \) mark length.

EXPERIMENTS

Samples were deposited by sputtering onto glass substrates and polycarbonate disk substrates with grooves of 1.6 \( \mu m \) track pitch and 1.15 \( \mu m \) pitch to examine cross-talk. Typical sample structure is: PC/SiN(80 nm)/GdFeCo/TbFeCo/SiN(80 nm)/Al(20 nm).

Contents in the readout layer were varied, which was expressed as Gd\(_x\)(Fe\(_{100-x}\)Co\(_y\))\(_{100-x}\). Terbium content in the recording layer was 19 at%. Thickness of the readout layer was varied from 60 to 120 nm, and one of the recording layer was 50 nm. Each disk has an Al layer to obtain suitable write laser power.

Read and write characteristics of disk samples were obtained using a laser with wave length of 780 nm and an objective lens with numerical aperture of 0.53. Typical linear velocity was 5.7 m/sec.

RESULTS

Magneto Optic Behavior

Figure 2 shows typical Kerr hysteresis minor loops of a GdFeCo readout layer at room temperature, 100 °C and 200 °C. Kerr rotation angle is very low at room temperature in zero field. It should be noted that the loop at room temperature has an asymmetrical shape with different behavior in saturation. With increasing temperature the loop gets close to rectangular and shifts from zero field. Namely, Kerr rotation in zero field
saturates at a certain temperature. Magnetic moments in the readout layer are perpendicular to the film plane at above 140°C in the case of Fig. 2.

Gd Content and Thickness of the Readout Layer

The content of Gd and thickness of the readout layer were varied. Curie temperature of the recording layer was 280°C which was settled so that the contribution of the magnetic properties of the readout layer could be estimated at higher temperature.

Figure 3 shows temperature dependence of Kerr rotation angle for the samples on glass substrates in zero field. Kerr rotation angle of every sample is very low at lower temperature and increases with temperature. Kerr rotation becomes saturated value at a certain temperature, which becomes higher with Gd content.

Readout laser power dependence of CNR for 0.4 μm mark is shown in Fig. 4. The sample of x=27 shows relatively high CNR value and wider readout laser power margin. The CNR increases at above a threshold readout power, which become larger with Gd content. It is similar to the saturation of Kerr rotation.

Higher CNR was obtained for thicker readout layer (Fig. 5). For other Fe-Co ratio, the Gd content was varied in the same way and the change of the curve with the readout layer thickness was remarkable for Fe-Co ratio of y=50.

Recording Magnetic Field Dependence of CNR on the Readout Layer

Recording magnetic field dependence of the CNR is shown in Fig. 6. Thinner readout layer enables smaller record-
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Fig. 6 Recording magnetic field dependence of the CNR for some readout layer thicknesses. Recorded mark is 0.76 μm long.

Fig. 7 Recording field dependence of CNR for different Fe-Co ratio. Recording mark is 0.76 μm long (1.52 μm pitch).

Composition of GdFeCo (x and y) in the readout layer was varied to estimate the contribution of the Fe-Co ratio. Here, Curie temperature of the recording layer was 220 °C. Figure 7 shows recording magnetic field dependence of CNR for different y, where the thickness of the readout layer is 80 nm and x is optimized for each y. The CNR for y=50 changes most steeply. Slower change occurs for smaller y.

Cross-talk

Cross-talk of disks with 1.15 μm track pitch was measured as shown in Fig. 8, which include a conventional disk with a TbFeCo layer for comparison. Smaller cross-talk was obtained for thicker readout layer. It is 12 dB less for 100 nm readout layer than for the conventional disk.

Fig. 8 Cross-talk for the disks of different readout layer thicknesses with 1.15 μm track pitch substrate. Mark length is 0.76 μm and linear velocity is 7.54 m/sec.

Fig. 9 Mark length vs. CNR for Gd27(Fe50Co50)73(80nm)/TbFeCo(50nm). Linear velocity is 7.54 m/sec.

Fig. 10 shows mark length vs. CNR for Gd27(Fe50Co50)73(80nm)/TbFeCo(50nm). The CNR for 0.5 μm mark is more than 45 dB for linear velocity of 7.54 m/sec.

DISCUSSION

When perpendicular magnetic anisotropy constant Ku of a thin film is low as Ku<2πMs², where Ms is saturation magnetization, magnetization of film is in-plane. In the case of GdFeCo, enrich of Co content decrease Ku (Fig. 10). Accordingly, magnetization can be in-plane for lower Ms. Figure 10 shows x with maximum CNR value for each y and compensation composition of GdFeCo at room temperature. Optimum Gd content gets close to the compensation content with increasing y. It enables lower compensation temperature of the
readout layer, which means that Ms reduces rapidly and the magnetic moments change their direction quickly with temperature. Hence, higher resolution was obtained for \( y = 50 \) sample. The compensation temperature of \( \text{Gd}_{27}(\text{Fe}_{50}\text{Co}_{50})_{73} \) was measured as 250°C.

The CNR for \( y = 50 \) sample steeply changes with recording field (Fig. 7). This is because Ms and Ku of the readout layer of \( y = 50 \) are close to zero at near Curie temperature of the recording layer. Then the readout layer does not affect recording process so much.

Figure 11 shows the direction of the magnetic moments of transition metal in the double layer film calculated to minimize total magnetic energy [3]. Some results are shown for different thickness of the readout layer. The moments slowly change their direction with distance from the interface. A certain thickness of the readout layer is necessary to get lower Kerr rotation from substrate at room temperature. On the other hand, thinner readout layer is better so that the moments are perpendicular to the film plane in the readout process.

The CNR of 120 nm readout layer is lower than those of 80 and 100 nm (Fig. 5). Thicker readout layer shows smaller shift of Kerr loop at high temperature. The CNR changes with magnetic field in readout process as shown in Fig. 12. Disk with thinner readout layer showed wider range of high CNR. This indicates that too thick readout layer does not have enough stability of perpendicular area in readout process by small loop shift.

CONCLUSION

Composition and thickness contributions in double layer films for super resolution were investigated. High resolution and low cross-talk were obtained for Fe-Co ratio of 1:1 and 80 to 100 nm thick readout layer. Sensitivity to recording magnetic field was also improved by optimizing Co content and thickness of the readout layer.

REFERENCES