MAGNETO-OPTICAL DISK WITH EXCHANGE-COUPLED DOUBLE-LAYER AND HEAT-SINK LAYER FOR RED LASER

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Abstract-Relationships between noise level and writing layer thickness for the exchange-coupled double-layer magneto-optical (MO) disk were investigated. Using the inverse magnetization direction copying mode is effective in reducing the writing layer thickness without increasing the noise level. Due to reducing the magnetic layer thickness to 60 nm in the novel MO disk, \( \theta_k \) enhancement by heat-sink layer is achieved. Read/write characteristics for a novel MO disk with exchange-coupled double-layer were compared with those for a conventional quadrilayer MO disk at 690 nm wavelength. C/N ratio for this MO disk shows a 1.5 dB improvement over that for a conventional one in all the frequency range. Leading edge jitter for this MO disk is lower than that for the quadrilayer MO disk, because of its higher C/N ratio and suppressed thermal interference.

KEYWORDS: EXCHANGE-COUPLED DOUBLE LAYER, MAGNETIZATION DIRECTION COPYING, HEAT-SINK LAYER

INTRODUCTION

An exchange-coupled double-layer, which consists of a GdFeCo readout layer and a writing layer, has larger Kerr rotation angle(\( \theta_k \)) than conventional TbFeCo. This property is suitable for high density recording and high C/N readout. However, mark-edge shift is caused by thermal interference in MO disks with an exchange-coupled double-layer which is over 100 nm thick. To realize high density recording, suppression of thermal interference is indispensable. In order to suppress the thermal interference, the write compensation method was used for a direct overwrite MO disk with exchange-coupled multilayers[1]. To reduce the thermal interference in exchange-coupled multilayers, thinning the magnetic layer and a heat-sink layer are effective. Further, an optimum disk structure is also required to obtain a high performance MO disk. The authors have proposed a novel MO disk with a 60 nm thick exchange-coupled double-layer and a heat-sink layer[2].

In this paper, relationships between noise level, magnetization direction copying mode and writing layer thickness for exchange-coupled double-layer MO disk are reported. Furthermore, read/write characteristics for this novel MO disk at 690 nm wavelength were compared with those for a conventional quadrilayer MO disk, to clarify the advantages of the novel MO disk.

EXPERIMENT

Two types of samples were prepared by magnetron sputtering onto polycarbonate (PC) substrates 130 mm in diameter. The disk structure is shown in Fig. 1.

![Figure 1 Novel MO disk diagram.](image)

The dielectric layer(SIN\(_x\)) was deposited by r.f. magnetron reactive sputtering with a pure Si target and Ar and N\(_2\) mixture gas. Magnetic layers were
deposited by r.f. magnetron sputtering with a transition metal target (Fe or FeCo alloy) and rare earth chips (Tb or Gd). An AITi metallic heat-sink layer was deposited from the AITi target. The virtual optical constant method [3] was used to design the disk structure. Read/write characteristics were measured with a read/write tester with an optical head using a 690 nm wavelength laser and an objective lens with N.A.=0.55. Testing conditions were as follows: linear velocity was 9.4 m/s, readout laser power was fixed at 1 mW, magnetic bias field was over ±350 Oe. The reproduced pulse was detected by the 2nd-order differential detection method [4].

RESULT AND DISCUSSION

1. Magnetization copying mode

Kerr hysteresis loops for the exchange-coupled GdFeCo/TbFe on PC substrates at room temperature are shown in Fig. 2. To observe the Kerr loop from the film side, the metallic heat-sink layer was not deposited.

![Writing layer](image1)

![Readout layer](image2)

Figure 2 Kerr hysteresis loops.

The magnetization direction of the TbFe writing layer is not reversed, up to 20 kOe. On the other hand, the magnetization direction of the GdFeCo readout layer gradually reversed with increasing magnetic field. Finally, it turned back to the initial direction. These results indicate that the magnetization direction copying from the TbFe writing layer to the GdFeCo readout layer, called inverse magnetization direction copying mode [5], occurs. For the disk with regular magnetization direction copying mode, the magnetization direction of the TbFe writing layer and the GdFeCo readout layer reversed at the same time, and no minor loop was observed.

Hasegawa et al. reported [6] that the interface magnetic wall behavior near a layer boundary in an exchange-coupled double-layer is strongly influenced by the magnetic properties of the readout layer and the writing layer, especially the ratio of magnetic wall energy density \( \sigma_{W-RO}/\sigma_{W-W} \) for the temperature range of interest, where \( \sigma_{W-RO} \) and \( \sigma_{W-W} \) are the magnetic wall energy density for the readout layer and the writing layer, respectively.

When \( \sigma_{W-RO}/\sigma_{W-W} \) is small, it is easier for the interface wall to move to readout layer. It is considered that \( \sigma_{W-W} \) is at least greater than that of the readout layer \( \sigma_{W-RO} \) at room temperature for an inverse copying mode disk.

2. Noise level and magnetization copying mode

Noise increase (\( \Delta N \)) values, as a function of the TbFe writing layer thickness as in regular and inverse magnetization direction copying mode disks, are shown in Fig. 3. The \( \Delta N \) value was defined as the difference between noise levels for each disk and the standard noise level, which corresponds to the lowest noise level for these disks.

![Noise increase (\( \Delta N \)) as a function of TbFe writing layer thickness](image3)
The \( \Delta N \) value for GdFeCo/TbFe with regular copying mode gradually increased with reducing TbFe layer thickness. However, the \( \Delta N \) value for GdFeCo/TbFe with the inverse copying mode remained constant. This shows that the inverse magnetization direction copying mode is effective in reducing the writing layer thickness, without increasing the noise level.

3. Disk structure optimization

Disk structure was optimized in order to obtain high read/write performance at 690 nm wavelength. The 2nd dielectric layer thickness dependence of \( \theta_k \) and reflectivity are shown in Fig. 4. \( \theta_k \) gradually changed and attained a maximum at about 124 nm. This indicates that the optical interference takes place between the light reflected from the magnetic layer and that reflected from the heat-sink layer. In short, the heat-sink layer functions as a reflective layer. Due to the reduction in the magnetic layer thickness to 60 nm in the novel MO disk, \( \theta_k \) enhancement by a heat-sink layer is achieved.

![Figure 4]

Figure 4 Kerr rotation angle and reflectivity as a function of 2nd dielectric layer thickness.

4. Disk performance

Read/write characteristics comparison was carried out between the novel MO disk with the exchange-coupled GdFeCo/TbFeCo and the heat-sink layer and a conventional quadrilayer MO disk. The write compensation method was not applied. Disk structures for each of the MO disks were designed to achieve the maximum figure of merit at 690 nm wavelength. Frequency dependence of C/N ratio and leading edge jitter for both MO disks are shown in Fig. 5. C/N ratio for the novel MO disk is higher than that for the quadrilayer MO disk in all the frequency range, since the novel MO disk has a larger \( \theta_k \) value than the quadrilayer MO disk and the same reflectivity. Leading edge jitter for this MO disk is lower than that for the quadrilayer MO disk, because of its higher C/N ratio and suppressed thermal interference.

A novel MO disk, with an exchange-coupled double-layer(GdFeCo 30 nm/TbFeCo 30 nm) and the heat-sink layer, is suitable for use as a high performance media.

![Figure 5]

Figure 5 C/N ratio and leading edge jitter as a function of recording frequency. Leading edge jitter correspond to the standard deviation for the histogram of the time-interval analysis. Writing laser power for a conventional MO disk and for the novel MO disk are 5.5 mW and 6.0 mW, respectively.

**SUMMARY**

Relationships between noise level and writing layer thickness, and read/write characteristics comparison at 690 nm wavelength between a novel MO disk with an exchange-coupled double-layer and
heat-sink layer and conventional quadrilayer MO disk were studied. It was found that the inverse magnetization direction copying mode is effective to reduce the writing layer thickness, without increasing the noise level. This novel MO disk shows higher C/N ratio and lower jitter than the conventional quadrilayer MO disk in all the frequency range.

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