THE CHARACTERIZATION OF TRACKING SERVO SIGNAL AND CROSS-TALK OF MAGNETO-OPTICAL DISKS WITH Cr GUIDING LAYERS

R. MATSUDA and K. TAKI

Research Laboratory, Brother Industries, Ltd., 15-1 Naeshiro-cho, Mizuho-ku, Nagoya 467, Japan

Abstract—Magneto-optical disks with metal guiding layers have spiral guiding bands which work as slits placed close to recording layers. The divided push-pull signal has been improved by using Cr as guiding layers. The disk noise for the track pitch of 0.85 \( \mu \text{m} \) is lower than that of a pre-grooved glass disk with the track pitch of 1.6 \( \mu \text{m} \). It is confirmed that the disk noise which arises at the edges of the spiral Cr guides is very small. The maximum CNR of 47.3 dB and 54.0 dB were obtained at 3.73 MHz and 1.0 MHz for the track pitch of 0.85 \( \mu \text{m} \). The magnetic domains are restricted in the recording regions because the cross-talk at 1.0 MHz has been suppressed to less than -23.4 dB even though the readout laser spot size is about 1.4 times as large as the track pitch.

KEYWORDS : MAGNETO-OPTICAL DISK, NARROW TRACK PITCH, CROSS-TALK, DISK NOISE, DPP

INTRODUCTION

Magneto-optical disks of the second generation, which begin to circulate in the market, do not yet offer adequate recording capacities and access times to enable to treat a lot of data with a combination of image and graphics. In order to increase bit density, track density as well as linear recording density must be improved by narrowing the track pitch without increasing cross-talk from adjacent tracks [1]-[6].

We have proposed that the magneto-optical disks with Ta guiding layers are useful for reduction of track pitch[7][8]. However, tracking servo signal, that is divided push-pull signal, is too small to achieve stable tracking for a track pitch of less than 1.0 \( \mu \text{m} \). The disk noise which originates in surface roughness of an enhancing layer increases because the SiN enhancing layer under a Ta guiding layer is also etched by CF\(_4\) plasma as soon as a Ta layer is removed.

Higher divided push-pull signal is obtained by increasing reflectivity of a guiding layer. The reflectivity of Cr is higher than that of Ta and Cr is easily dry-etched by CCl\(_4\) plasma which does not etch SiN [9]. In this paper, We report on improvement of divided push-pull (DPP) signal and disk noise by using Cr as a guiding layer. The cross-talk is also investigated for a narrower track pitch up to 0.85 \( \mu \text{m} \).

STRUCTURE

The structure of a magneto-optical disk with a Cr guiding layer is shown in Fig.1. A spiral band of Cr is fabricated on a SiN enhancing layer as a guiding layer. The recorded domains are restricted in the recording regions whose width are \( w_0 \) because the guiding layer works as slits placed close to the recording layer. The push-pull method is used for tracking since the incident laser beam is diffracted by the guiding and recording layer in the same manner as conventional pre-grooved disks. Since the thickness of an interference layer \( d_3 \) corresponds to the groove depth, \( d_3 \) is chosen to be \( \lambda/8n \) in order to obtain the maximum push-pull signal, where \( n \) is the refractive index of the enhancing and interference layers. The Kerr effect enhancement is increased in the same manner as conventional pre-grooved disks by adjusting the total thickness of the enhancing and interference layers \( d_1 + d_3 \) to be \( \lambda/4n \).

In conventional pre-grooved disks, disk noise which arise at side walls of grooves can not be disregarded[10]. However, disks with metal guiding layers has no side walls so that lower disk noise is
realized for narrower track pitch.

The enhancing layer on a glass substrate and the interference layer were prepared by reactive rf magnetron sputtering with Ar + N2 gas. The recording layer was prepared by dc magnetron sputtering from Tb24Fe69Co7 alloy target. The Cr guiding layer of 20 nm thick was prepared by dc magnetron sputtering. In CCl4 + O2 ambient, a Cr film is easily dry-etched without any damage on the surface of a SiN enhancing layer.

DIVIDED PUSH-PULL SIGNAL

The DPP signals were measured with a conventional optical head having an objective lens NA of 0.53 and 780-nm laser. These DPP signals depend on not only track pitch but also recording region width \( w_R \). When the recording region width \( w_R \) becomes wide, the DPP signals decreases while the CNR increases. When CNR have over 45 dB at 3.73 MHz, the DPP signals are shown in Fig.2 for etch track pitch \( w_p \). The DPP signals of the disks with Cr guiding layers are improved by 1.5 times as large as that of the disks with Ta guiding layer because the reflectivity of Cr is higher than that of Ta. For the track-pitch of 0.85 \( \mu \)m, the DPP signal decreased to 0.13. However, the DPP signal would be improved to about 0.3 by narrowing recording region width \( w_R \) as shown later. The decrease in CNR by narrowing recording region width \( w_R \) would be compensated with adoption of the well-known quadri-layer structure.

DISK NOISE

The disk noise which is dominated by the disk structure can be evaluated from the increase in noise level \( \Delta N \) defined as \( \Delta N = N_s - N_r \) where \( N_r \) represents the noise level of the rotating disk and \( N_s \) represents the noise level of the stopping disk measured with an optical head under the control of the focusing and tracking servo. The relative shifts of noise levels by the change in readout power, reflectivity and diffraction are canceled by the noise level of stopping disk \( N_r \).

The disk noise for the track pitch of less than 1.0 \( \mu \)m is shown in Fig. 3 compared with a conventional pre-grooved glass disk with the track pitch of 1.6 \( \mu \)m. Even though the track pitches are narrower, the disk noise of disks with Cr guiding layers is lower than that of a pre-grooved glass disk. The increase in disk noise is less than 1.0 dB when the track pitch to 0.85 \( \mu \)m from 1.0 \( \mu \)m. This result reveals that the disk noise which arises at the edges of the spiral Cr bands is very small.

CNR AND CROSS-TALK

The CNR and the cross-talk for a track pitch of 1.0 \( \mu \)m, 0.90 \( \mu \)m and 0.85 \( \mu \)m were measured at a constant
linear velocity 5.7 m/s with an optical head having an objective lens NA of 0.53 and a 780-nm laser. The laser spot was circular and its diameter was 1.22 μm. The CNR and the cross-talk at 1 MHz and 3.73 MHz are plotted in Fig.4 as a function of track pitch wp. The write power was chosen so as to give minimum second harmonic distortion.

When the track pitch is reduced to 0.85 μm from 1.0 μm, the decrease in CNR is very small at both 1.0 and 3.73 MHz because the recording region width wₐ is almost the same for each track pitch in order to obtain maximum CNR. The maximum CNR of 47.3 dB and 54.0 dB were obtained at 3.73 MHz and 1.0 MHz for the track pitch of 0.85 μm. The cross-talk increases with the decrease in track pitch. The cross-talk for the track pitch of 0.85 μm were -26.6 dB and -23.3 dB at 3.73 MHz and 1.0 MHz, respectively, though the laser spot size is about 1.4 times as large as the track pitch. The readout signals measured for this track pitch of 0.85 μm have satisfied the condition required for digital signals, that is the CNR of more than 45 dB and cross-talk of less than -23 dB.

Since the conventional mastering technique for optical disks is used for the formation of a Cr guiding layer, recording region width wₐ becomes wide as cutting power Pcut rises [7], where cutting power Pcut is exposure power for photoresist on the Cr film.

The cross-talk at 1.0 MHz, CNR at 3.73 MHz and DPP signal for the track pitch of 0.85 μm are shown in Fig.5 as a function of Pcut. The CNR at Pcut=9 mW is large enough but DPP signal is low. Higher DPP signal is obtained at Pcut < 8.3 mW while the CNR is less than 45 dB. By using a conventional quadri-layer structure, the CNR of more than 45 dB and DPP of more than 0.3 would be realized simultaneously for the track pitch of 0.85 μm.

For the track pitch of 0.85 μm, the CNR and cross-talk change with write power as shown in Fig. 6. The CNR and cross-talk at 3.73 MHz were constant at the write power ranging from 4.5 mW to 6.0 mW. The CNR at 1.0 MHz was also constant at write power ranging from 3 mW to 7.5 mW but the cross-talk increased at write power of more than 5.5 mW.

The magnetic domains written at more than 5.5 mW are expand to the adjacent tracks by the thermal diffusion. A typical readout signal spectrum is shown in Fig. 7 for the track pitch of 0.85 μm. The signals of 1.0, 1.3 and 1.6 MHz were recorded on adjacent three tracks and the signal at the middle track was read in order to evaluate the cross-talk. The cross-talk is defined as difference between carrier level at 1.3 MHz and those at 1.0 and 1.5 MHz. Magnetic domains were observed by a polarization microscope through the protective layer, not through the substrate as shown in Fig.8 where the
track pitch was 0.85 μm. These domains were also recorded on the mirror region where the Cr guiding layer is completely removed. When the magnetic domains were recorded at 7.5 mW, increase in cross-talk and a lot of unexpected peaks which do not satisfy the harmonics relation of recorded signals were observed as shown in Fig.7 (b) compared with the spectrum written at 4 mW as shown in Fig.7 (a). These peaks arise due to the interference of domains extended from adjacent tracks. As shown in Fig.8 (b), it was confirmed that the magnetic domains written at 1.0 MHz and 7.5 mW expanded to the adjacent tracks by thermal diffusion. The magnetic domains written at the optimum write power which give minimum second-harmonic distortion is restricted in the recording regions as shown in Fig.8 (a) compared with the expanded domains written on the mirror region. Therefore, the cross-talk is suppressed to less than -23.4 dB even though the readout laser spot size is about 1.4 times as large as the track pitch.

CONCLUSION

The DPP signal of the magneto-optical disks with Cr guiding layers has been improved by 1.5 times as large as that of the disks with Ta guiding layers because the reflectivity of Cr is higher than that of Ta. The DPP signal for the track pitch of 0.85 μm is improved to about 0.3 by narrowing \( w_r \). The decrease in CNR by narrowing \( w_r \) would be compensated with adoption of the well-known quadri-layer structure. The disk noise for the track pitch of 0.85 μm is lower than that of a pre-grooved glass disk with the track pitch of 1.6 μm. It is confirmed that the disk noise which arises at the edges of the spiral Cr bands is very small.

The maximum CNR of 47.3 dB and 54.0 dB were obtained at 3.73 MHz and 1.0 MHz for the track pitch of 0.85 μm. The magnetic domains written at the optimum write power is restricted in the recording regions so that the cross-talk at 1.0 MHz has been suppressed to less than -23.4 dB even though the readout laser spot size is 1.4 times as large as the track pitch. By using an optical head with 670 nm laser, the track pitch would be reduced to less than 0.85 μm with stable tracking and low cross-talk.

ACKNOWLEDGMENTS

The authors wish to thank S. Yamada, K. Makino and T. Tsuji for their continuous encouragement.

REFERENCES


CONCLUSION

The DPP signal of the magneto-optical disks with Cr guiding layers has been improved by 1.5 times as large as that of the disks with Ta guiding layers because the reflectivity of Cr is higher than that of Ta. The DPP signal for the track pitch of 0.85 μm is improved to about 0.3 by narrowing \( w_r \). The decrease in CNR by narrowing \( w_r \) would be compensated with adoption of the well-known quadri-layer structure. The disk noise for the track pitch of 0.85 μm is lower than that of a pre-grooved glass disk with the track pitch of 1.6 μm. It is confirmed that the disk noise which arises at the edges of the spiral Cr bands is very small.

The maximum CNR of 47.3 dB and 54.0 dB were obtained at 3.73 MHz and 1.0 MHz for the track pitch of 0.85 μm. The magnetic domains written at the optimum write power is restricted in the recording regions so that the cross-talk at 1.0 MHz has been suppressed to less than -23.4 dB even though the readout laser spot size is 1.4 times as large as the track pitch. By using an optical head with 670 nm laser, the track pitch would be reduced to less than 0.85 μm with stable tracking and low cross-talk.

ACKNOWLEDGMENTS

The authors wish to thank S. Yamada, K. Makino and T. Tsuji for their continuous encouragement.

REFERENCES


CONCLUSION

The DPP signal of the magneto-optical disks with Cr guiding layers has been improved by 1.5 times as large as that of the disks with Ta guiding layers because the reflectivity of Cr is higher than that of Ta. The DPP signal for the track pitch of 0.85 μm is improved to about 0.3 by narrowing \( w_r \). The decrease in CNR by narrowing \( w_r \) would be compensated with adoption of the well-known quadri-layer structure. The disk noise for the track pitch of 0.85 μm is lower than that of a pre-grooved glass disk with the track pitch of 1.6 μm. It is confirmed that the disk noise which arises at the edges of the spiral Cr bands is very small.

The maximum CNR of 47.3 dB and 54.0 dB were obtained at 3.73 MHz and 1.0 MHz for the track pitch of 0.85 μm. The magnetic domains written at the optimum write power is restricted in the recording regions so that the cross-talk at 1.0 MHz has been suppressed to less than -23.4 dB even though the readout laser spot size is 1.4 times as large as the track pitch. By using an optical head with 670 nm laser, the track pitch would be reduced to less than 0.85 μm with stable tracking and low cross-talk.

ACKNOWLEDGMENTS

The authors wish to thank S. Yamada, K. Makino and T. Tsuji for their continuous encouragement.

REFERENCES