LIGHT INTENSITY MODULATION TYPE MAGNETIC DOMAIN EXPANSION READOUT MO (*LIM MAMMOS*)

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Abstract -- For high density MO recording, a new method named MAMMOS using a magnetic domain expansion effect has been proposed[1]. In the readout process, recording domains marked in the recording layer are copied into the readout layer, and expanded to obtain a higher signal level. At first, this effect was confirmed by the magnetic field modulation (MFM) readout method[1]. Herein, however, we propose another scheme using a light intensity modulation (LIM) readout method, with which the readout laser power is modulated to control the expansion process. In a disk with an in-plane magnetizing film for the readout layer, the fundamental function of this LIM MAMMOS has been experimentally confirmed. **KEYWORDS** : MAGNETIC DOMAIN EXPANSION READOUT, LIGHT INTENSITY MODULATION

INTRODUCTION

To increase the recording density of MO media, several techniques have been developed. One of the most promising schemes is the magnetic super resolution method (MSR), with which a fine aperture smaller than a laser spot is formed so as to resolve tiny recording domains. As a next breakthrough, the magnetic domain expansion readout method, named MAMMOS (Magnetic Amplifying MO System), was proposed[1].

In this method, three steps are necessary for each readout point. First, the domains recorded in the recording layer are copied into the readout layer one by one, and expanded to obtain a larger signal. Then each domain is collapsed before proceeding to the next position readout. To control such a cycle in the readout process, the first MAMMOS was realized by applying a magnetic field modulation type readout method (so to speak, MFM MAMMOS). Here we introduce a new scheme, a light intensity modulation type readout method (LIM MAMMOS). In this method, the

Fig.1. Magnetic domain expansion readout
using a light intensity modulation method.

readout process is controlled by the modulation of the laser beam intensity. This method should prove suitable for very high speed readout, since laser power lends itself to modulation much faster than magnetic fields.

EXPERIMENTAL

Media

In this study, a disk with an in-plane magnetizing film for a readout layer is used. This film changes to perpendicular magnetization in a high temperature region. The layer structure is schematically illustrated in Fig.2. TbFeCo is the recording layer and GdFeCo the readout layer.

Fig.2 Disk layer structure for light intensity modulation type magnetic domain expansion readout MO.

These layers are magneto-statically coupled with a non-magnetic layer inserted between them. The readout layer changes to perpendicular magnetization at a temperature higher than the critical temperature (T_{cr}) from the in-plane. In this study, the T_{cr} is about 175°C. The compensation temperature (T_{comp}) of the readout layer is 240°C, The Curie temperature (T_c) is higher than 300°C. The composition of the recording layer is transition metal (TM) rich, and the T_c is 270°C. The T_{comp} of the readout layer exists between the T_{cr} of the readout layer and the T_c of the recording layer. Such ordering is essential for this LIM MAMMOS media.

Write/Read Estimation

For the write/ read experiment in this scheme, an optical head with a 680nm wavelength laser and a 0.55 numerical aperture lens was utilized. The linear velocity was 5m/s throughout this test.

For recording, the light intensity modulation method was used. 0.8 μ m marks were recorded with the same length 0.8 μ m for the spaces. The recording laser power (P_w) was 6.3mW, the recording period; 320ns, the pulse width ; 53.3ns and the recording field (H_w) ; 500Oe.

Here, also for the readout, the light intensity modulation type method was applied. The laser power was oscillated between two levels during the readout so as to control the expansion process. The lower power level was 1.5mW, and the higher level 3.5mW. The modulation period, i.e. that which corresponds to each mark and each space period was 160ns. The lower power was irradiated for 150ns and the higher power for 10ns. A constant external field of 80Oe was applied during this readout. The condition is as illustrated in Fig.3.

A conventional readout method was also carried out on the same disk for comparison purposes. A constant laser power was irradiated without an external field.

RESULTS & DISCUSSIONS

Fig.3(a) shows a readout signal with the LIM MAMMOS. During the lower power irradiation, the signal level increases steeply, and at the higher level, it goes down rapidly. That is, with the lower level irradiation, the domain in the recording layer is copied and expanded in the readout layer. Next, at the higher level irradiation, the domain is shrunk and finally collapses to nothing.

Here it is important that the signal increases remarkably only at the place where the mark exists. On the contrary, where there is no mark, the signal level does not show a response. This means the domain was expanded in the readout layer only at the point where the recording domain exists. Such distinction of the recorded pattern is the basic function for this expansion readout scheme.

Fig.3(b) shows a readout signal with a constant laser power, which is a typical waveform of the center aperture detection type magnetic super resolution. Comparing the two, the amplitude of the LIM MAMMOS signal becomes about two times as large as that of the constant one.

Furthermore, the waveform shows a very sharp response with this LIM MAMMOS readout.

Fig.3(a) Expansion readout signal using laser power modulation.

Fig.3(b) Readout signal using constant laser power.

As for the magnetic condition of this phenomena, we have drawn an inference as follows.

First, we assume this LIM MAMMOS is based on the double mask condition. Fig.4 shows readout signals of $1.6 \mu\text{m}$ marks with the same length spaces on the media, irradiating a constant laser power with a constant external field of 80Oe. Fig.4 (a) is the signal for readout power (P_r) ; 1.4mW, and Fig.4(b) is for 2.5mW at the same position. With the lower P_r , the signal shows a symmetrical waveform, which represents the center aperture type readout condition, as mentioned in Fig.3(b). And with the relatively higher P_r , the rear part of the readout signal goes down steeply, which represents the appearance of the rear mask, that is,

the double mask condition. Our assumption is that expansion is induced during the modulation of this double mask condition.

(a) Center aperture type. (P_r ; 1.4mW)

(b) Double mask type. (P_r ; 2.5mW)

Fig.4 Readout waveforms with constant laser powers.

The readout laser power is modulated as Fig.5(1). In this modulation, so to speak "read strategy", the temperature of a point on the film should change as in Fig.5(2). In accordance with this, the magnetic condition changes as in the schematically drawn Figs.5(a)-(c). The figures on the left show sectional drawings in the track cross direction. The ones on the right show plane figures. When the temperature goes to just above the T_{cr} as in (a), the leakage field from the recording layer is relatively strong, so the shape of the recording domain is strictly copied into the readout layer as it is. When the temperature becomes much higher as in (b), the leakage field becomes weaker in accordance with the magnetization of the recording layer decreasing. In such a condition, the force which maintains the edge of the copied domain becomes weaker. Consequently, the domain easily expands with the help of the external field. Enhancement of the signal amplitude is caused by this expansion effect. Also when the temperature becomes higher than T_{comp} as in (c), the magnetic condition changes to TM rich. At this time, when the magnetization turns in the external field direction, the polarity of the Kerr rotation angle becomes the erase condition. This corresponds to initialization.

Fig.5 Aperture movement model for the LIM MAMMOS readout condition.

As the plane figures show, this magnetic condition has a two dimensional distribution on the actual readout condition. The line (A) shows the contour line of the T_{cr} . Outside this line is the in-plane magnetizing area, which forms a front mask, while inside it becomes the aperture where the domain expansion occurs. The inner line (B) shows the contour line of the T_{comp} . The area inside this line forms a rear mask. This represents the double mask condition. The low power condition has a

large aperture holding an expanded domain, while the high power condition has a narrow aperture in accordance with the rear mask expansion, which acts as the initialization collapsing the copied domain. Such aperture movement is essential for the LIM MAMMOS. With this dynamic readout process, the very sharp response is realized.

CONCLUSION

A light intensity modulation method has been introduced for the first time in a magnetic domain expansion readout (LIM MAMMOS) aiming at high density MO recording. Using a disk with an in-plane magnetizing film for the readout layer, the fundamental function of LIM MAMMOS has been confirmed. Readout signals are amplified with very sharp responses. This phenomena can be explained with the aperture movement model.

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