CROSSTALK EVALUATION IN LASER-ASSISTED MAGNETIC RECORDING USING A BLUE LASER

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Abstract- Laser-assisted magnetic recording is an interesting method for narrowing a track pitch; in particular, crosstalk canceling in laser-assisted magnetic readout has a unique feature that it enables us to reproduce a narrower track than an assisting laser spot size. Shorter wavelength of the assisting laser promises the higher track density, accordingly. In this paper, we have demonstrated the crosstalk evaluation by using a blue laser for the assisting beam and obtained as high track density as 85ktpi.

Key words: laser-assisted, perpendicular magnetic recording, crosstalk canceling, thermally-assisted

1. Introduction

There have been proposed various types of optically-assisted, which is functionally equivalent to thermally-assisted, magnetic recording that combines magnetic and optical recording technologies^{1) - 3)}. Other combining magnetic recording methods than our proposed one, which is called laser-assisted magnetic recording²⁾, utilize optical-assist only for write function to make a recorded track narrower; however, in order to reproduce it, microfabrication of a readout head element remains to be a crucial issue. On the other hand, the laser-assisted magnetic recording has a function of thermally-assisted magnetic readout to read a narrow track independently of a readout head width; it will be a solution to the above issue.

Besides, by using the temperature dependence of magnetization of a ferri-magnetic alloy with a magnetic compensation temperature (Tcomp) higher than room temperature (RT), laser-assisted magnetic readout enables to suppress crosstalk from adjacent tracks effectively⁴⁾. The laser-assisting during readout is designed so that the Tcomp is reached in the middle of each adjacent track at a thermal profile; hence, the adjacent track has regions with magnetic polarity different from each other and the sum of the leakage flux from the adjacent track, which is the source of crosstalk, is decreased.

Also in laser-assisted magnetic recording, shortening the wavelength of an assisting laser is a direct and effective way to increase the areal density. Now that a blue laser is practically available, we have applied it to laser-assisted magnetic recording and confirmed that it works well, especially from the view point of crosstalk canceling.

2. Experiments

The recording medium consisted of a Tb₂₂Fe₆₂Co₁₆ magnetic recording film with 50 nm thick and a amorphous carbon film with 20 nm thick sputtered onto a glass disk substrate of 2.5 inch in diameter and 0.635 mm thickness. A liquid perfluoropolyether (PFPE) film was applied on top of the a-C film for lubrication. Magnetic properties were measured by using a vibrating sample magnetometer (VSM).

In this study, we utilized two kinds of test stands; one was equipped with a red laser for an assisting light source and the other with a blue laser. They used air-bearing spindles. Conventional GMR heads with the same specifications were applied to both test stands. The magnetic head and the optical head for laser-assisting were placed opposite sides of a magnetic disk²⁾. An assist laser beam irradiated the recording medium through the glass disk substrate. Major specifications of optical heads for laser-assisting and of a magnetic head are listed in Table 1.

Cross-talk relevant measurements were performed at a linear velocity of 11m/s. Test tracks were 0.3 μ m in width recorded at a frequency of 5 MHz with a write assist laser power of 2.4 mW by using the spin stand equipped with

Table 1 Specifications for the magnetic head and the optical head used in this study.

Magnetic head		
Write gap length	0.273 μm	
Write track width	1.06 μm	
(from microtrack)		
Read gap length	0.156 μm	
Read track width	0.71 μm	
(from microtrack)		
Optical head	Red	Blue
Wavelength	650nm	402 nm
N.A.	0.6	0.65
Spot diameter (1/e ²)	1.07 μm	0.575 μm

Fig.1 Remanent magnetization as a function of temperature.

the blue laser. The flying height of the magnetic head was about 30 nm. The laser-offtrack measurement was used for estimating magnetization distribution in the recording medium due to the temperature profile during laser-assisted readout⁴⁾. In this measurement, after a single track was recorded, only the assisting laser spot was shifted with a certain distance from the center of the track while fixing the magnetic head on the track. Then the signal level shows the induced magnetization in proportion to the temperature profile in the laser-assisted area. Also off-track measurement where both the magnetic head and the assisting laser spot are shifted simultaneously, which is equivalent to a track profile in the conventional magnetic recording, and multi-track recording were performed to evaluate a crosstalk performance.

3. Results and discussion

3.1 T_{comp} relevant issues

Figure 1 shows the temperature dependence of the remanent magnetization of the recording medium. The T_{comp} was found to be about 68 °C, where the polarity of the magnetization was changed.

Laser-assisted readout signals as a function of the read assist laser power are shown in Fig.2, which were measured on the same track by using the spin stand equipped with a blue laser and the other one with a red laser. The dips in signal levels were obtained at read assist powers of 1.1 mW for the red laser assisting and 0.75 mW

Fig.2 Dependence of the signal levels on the read assist laser power by using a blue laser and a red laser.

Table 2 Volume specific heat (ρC) and thermal conductivity of materials composing the recording medium.

Material	ρC [J/(deg cm ³)]	k [J/(cm deg sec)]
Air	0.0013	0.00026
a-C	1.06	0.643
TbFeCo	3.7	0.2
glass	1.73	0.013

Fig.3 Calculated thermal distribution.

for the blue laser assisting; the average temperature in the readout track area was thought to reach T_{comp} at each assisting power.

The temperature profiles during laser-assisted readout were simulated; thermal parameters of constituent materials of the medium are listed at Table 2. Absorbance of the medium was 0.57 at a wavelength of 405 nm (a blue laser) and 0.49 at a wavelength of 650 nm (a red laser). Figure 3 shows the numerical results of the temperature distribution, which are expressed by open symbols, both for the blue laser and the red one at the assisting power where the signal level exhibited a minimum. Supposing that the track width was 0.3 μm, an average temperature in the track would be about 65 °C and 70 °C for the red laser assisting and the blue one, respectively; these values were in agreement with T_{comp} measured by VSM. Accordingly, the temperature profile is found to be a major determinant for laser-assisted readout and the thermal simulation gives us a good estimation.

3.2 Off-track analysis

The laser-offtrack and offtrack measurements were used for evaluating the improvement of track density by employing a shorter wavelength laser for assisting. In order to compare the differences in temperature profiles which are caused by different laser spot sizes exactly, the same peak temperatures would be required. Considering the numerical result, we set a read assist power to be 2.35 mW for the red laser and 1.4 mW for the blue laser; then, the peak temperature would become about 113°C for both

Fig.4 Carrier level as a function of laser offtrack.

cases. The simulated results of temperature profiles under these conditions are shown as closed symbols in Fig.3.

At the above read assist powers, the laser-offtrack plots were obtained as shown in Fig.4. The reproduced carrier levels decreased with the increase of laser beam displacement (offtrack distance) and exhibited a minimum. Then they increased again, approaching the values at room temperature. As mentioned above, canceling of leakage flux from induced magnetization in the written track was occurred around the offtrack distance where the signal showed a minimum. This means that crosstalk from an adjacent track located at this position is lowered. The offtrack positions for minimum signals were $0.5 \mu\text{m}$ for the red laser and $0.3 \mu\text{m}$ for the blue laser. The ratio between these values corresponded to that between spot sizes of two lasers. Hence, also in the blue laser assisting system, crosstalk canceling for laser-assisted magnetic recording was found to work well.

Figure 5 shows the dependence of the reproduced signal on the offtrack position of the readout system consisting of the magnetic head and the optical head. A drop in the signal level around $0.6 \mu\text{m}$ offtrack for non-laser-assisting was due to the sensitivity change of the GMR head itself. In order to lower the crosstalk level to less than -20 dB , it was found that a track pitch cannot be

Fig.5 Carrier level as a function of readout system offtrack.

Fig.6 Crosstalk evaluation for multi-track readout.

less than $0.5 \mu\text{m}$ for non-laser-assisting; however, it can be narrowed to $0.3 \mu\text{m}$ by blue laser-assisted readout.

On the basis of these results, the crosstalk in multi-track recording was evaluated at the estimated track pitch of $0.3 \mu\text{m}$ by using the spin stand with the blue laser. Three tracks were recorded at a frequency of 4.5 MHz ($1.2 \mu\text{m}$ long mark), 5 MHz ($1.1 \mu\text{m}$ long mark), and 5.5 MHz ($1.0 \mu\text{m}$ long mark), respectively at the above track pitch. Then we observed the differences among these carrier levels with a spectrum analyzer while reading the center track. Figure 6 shows the spectra of both the laser-assisted readout with a laser power of 1.4 mW and the non-assisted readout. The read track width of the magnetic head was $0.71 \mu\text{m}$, which was larger than the track pitch. Thus, the crosstalk, which is difference between the signal from the center track and that from the adjacent track, was rather large and reached -4 to -5 dB . On the other hand, that was reduced to -15 dB in laser-assisted readout. This obtained crosstalk value was not good enough for a system design; but some of the relatively large crosstalk is attributed to non-positional servo in our experimental setup which is easily influenced by external disturbances. These disturbances likely cause variations in track pitch for multi-track recording; thereby the crosstalk canceling for multi-track readout was smaller than that in the single track readout estimated from the off-track measurement. Therefore, the actual crosstalk could be smaller with a positional servo.

4. Summary

Crosstalk canceling method works well in a laser-assisted magnetic readout system using a blue laser in the same way as the red laser-assisted system. The temperature profile in the magnetic recording media is crucial for the basic performance of crosstalk canceling; hence, the track pitch can be narrowed by a smaller laser spot size accordingly. A track pitch of $0.3 \mu\text{m}$, which corresponds to 85 ktpi , is found to be accessible in laser-assisted magnetic recording using a GMR head of $1.06 \mu\text{m}$

m write track width and a blue laser assisting beam of $0.57\text{ }\mu\text{ m}$ in diameter.

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