50GB Write-Once Disc with Phase Change Recording Material

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Abstract

We develop phase change type write-once optical disc. The disc has advantages of high-speed and high-density recording because phase change recording material has high recording sensitivity and high C/N. The disc has also long-term data durability due to its write-once function. Write-once function is realized by metal oxide anti-crystallization (AC) layer which is fabricated onto the recording layer. The AC layer decomposes by heat of write process, and affects the crystallization speed of a recording layer. High data transfer rate of 216Mbps is demonstrated. The capacity of 50GB/layer is realized by introducing land/groove format and high linear density write/read technologies.

Keywords: phase change, write-once, anti-crystallization layer, 216Mbps, 50GB/layer

Introduction

In data storage application, optical disc storage system is attractive because of its long-term reliability and data interchangeability. Additionally, write-once (WO) function is very unique characteristics in optical disc. So, the write-once technology can realize data archiving system with huge capacity in which alternation of important original data is never allowed. On the other hand, the data archiving system requires large on-line capacity and high-speed data transfer rate. The WO optical disc for data archiving should archive the performances of high-density recording and high-speed recording. Phase change (PC) material is suitable for these purposes[1)-3)]. Phase change material has high contrast caused by large reflectivity change between amorphous state and crystalline state, and high recording sensitivity even at high recording speed. Land and groove format for high track density recording is applicable. In this paper, we introduce new technology for WO function in phase change optical disc, and study high-speed write/read performance and high-density recording.

Phase Change Type Write-Once Disc Structure

Fig. 1 shows cross sectional view of phase change write-once disc. The phase change material is Ge-Sb-Te based material which is well known as the recording material for rewritable optical disc. That means Ge-Sb-Te based material has reversibility between amorphous state and crystalline state. The reversibility cannot realize real write-once function. In order to realize real write-once function, we introduce anti-crystallization layer (AC layer) into phase change optical disc. The AC layer is metal oxide material and is fabricated onto the Ge-Sb-Te based phase change recording layer. All layers are fabricated by RF-sputtering method.

Test equipment for measuring write and read characteristics has an optical pickup head with a

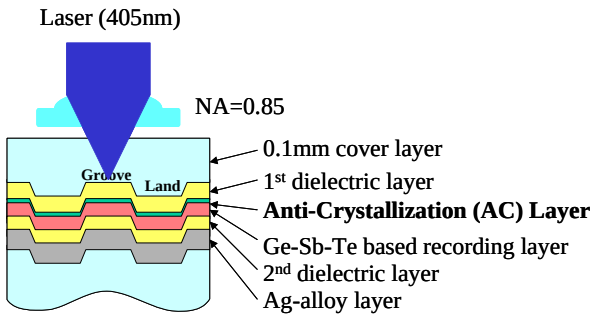

Fig. 1 Cross Sectional View of WO disc

wavelength of 405nm and NA of 0.85. We measure bit error rate by using Partial Response Maximum Likelihood (PRML) method[1), 2)]

Before recording, bulk initialization is performed by irradiation of laser beam with wavelength of 810nm. In the process, phase change recording material is changed to crystalline state in whole disc. Amorphous recording marks are formed onto the crystalline state tracks.

Write-Once Function in Phase Change Optical Disc

Fig. 2 shows jitter value of two kinds of the disc, which are a disc without AC layer and a disc with AC layer. A disc without AC layer is normal rewritable type phase change disc. Disc without AC layer shows good jitter value when new data is written after once or multiple DC erase irradiation. In other words, the disc has good rewritablity. On the other hand, jitter of disc with AC layer increases more than 30% when new data is written even after 5-time DC erase irradiation. The result shows that the AC layer prevents the amorphous mark from crystallization. That means that the disc with AC layer has write-once function.

Fig. 3 shows AC layer thickness dependence of jitter. Solid line shows the case in which AC layer thickness is 1nm, and dotted line shows the case in which AC layer thickness is 3nm. In the figure, but both cases have write-once function, but 1nm case is slightly better. The thickness of 1nm is enough for write-once function. Volume of AC layer is not important.

Fig. 4 shows jitter value of two kinds of discs, which are a disc in which AC layer is located at far side from laser irradiation direction and a disc in which AC layer is located at near side. The case in which AC layer is located at far side has worse jitter than the case in which AC layer is located at near side. Position of AC layer affects rewritability of the phase change material.

In these experiments, random pattern is recorded on groove track with minimum mark length of 0.16μm at linear velocity of 5m/s. Groove pitch of the substrate is 0.32μm.

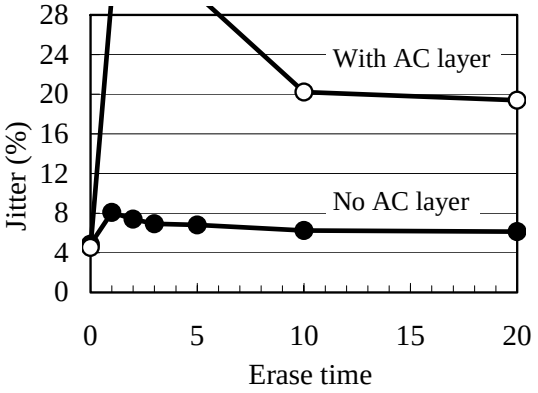

Fig. 2. Jitter of the disc with and without AC layer

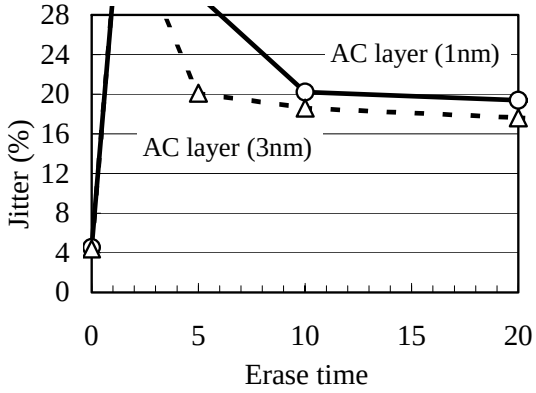

Fig. 3. AC layer thickness dependence of jitter

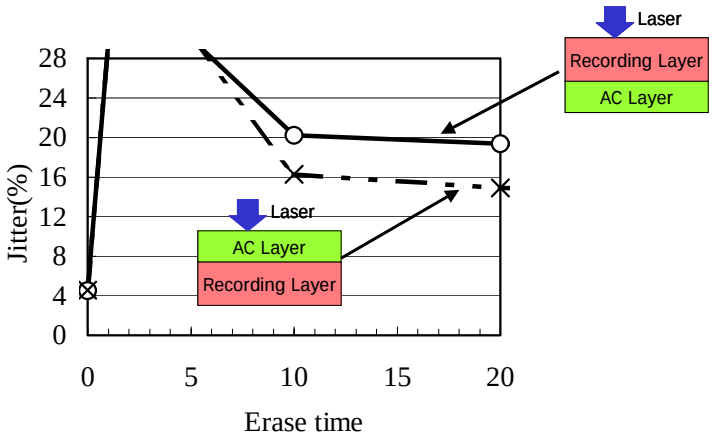

Fig. 4 AC layer location dependence of jitter

For further analysis of the mechanism of the AC layer, X-ray Photoelectron Spectroscopy (XPS) is introduced.

Fig. 5 shows XPS spectrum of Ge, Sb and Te. The figure of Sb spectrum shows that intensity of Sb metal becomes smaller after recording (Table 1). The reduction of Sb metal intensity means that Sb is oxidized during or after recording. The oxygen may come from AC layer by its decomposition during or after recording. As a result that the oxidization of Sb makes crystalline growth rate or nucleation rate lower, the amorphous mark becomes hard to erase.

Table 1 Intensity Ratio

	Ge		Sb	
	Metal	Oxide	Metal	Oxide
Non written	22	78	51	49
Written	20	80	45	55

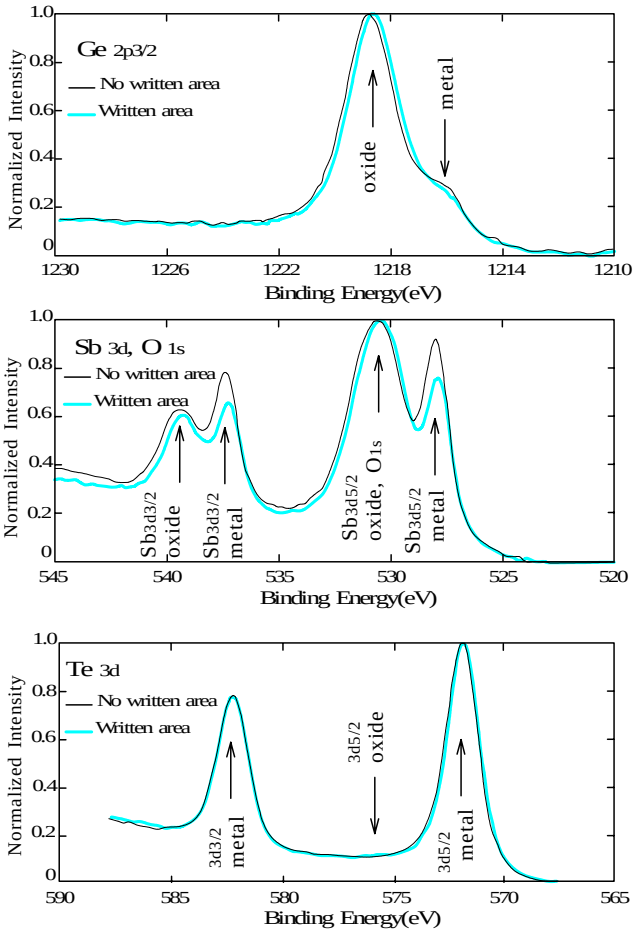

Fig. 5 XPS spectrum of Ge, Sb and Te

High-Density and High-Speed Recording

We investigate high-speed write and read characteristics of the WO disc with AC layer. Fig. 6 shows power margin curve of bit error rate (bER) at 216Mbps speed not only in writing but also in reading by using PRML method. Bottom value of bER reaches to 10^{-6}. Recording power margin of +/-33% is obtained.

Finally we investigated high-density recording of 50GB/layer. Table 2 shows 50GB/layer recording conditions. We choose land and groove format, and its track pitch and bit pitch are 0.24μm and 0.085μm, respectively. Table 3 shows bER with cross-talk in groove recording and land recording. In the condition with cross-talk, bER of 1.6×10^{-4} in groove track and 9.0×10^{-5} in land track are obtained.

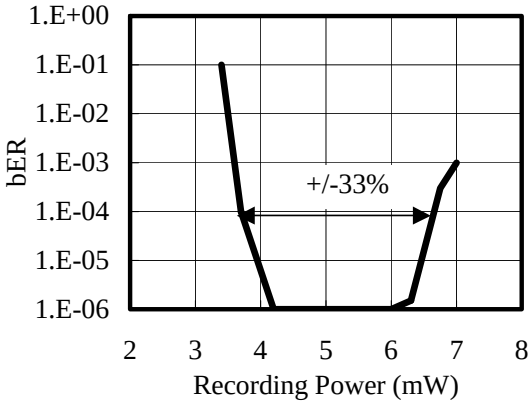

Table 2 Conditions of 50GB/layer

Wavelength	405nm
Objective lens NA	0.85
Linear velocity	3.76m/s
Track pitch	0.24um Land and Groove
Bit pitch	0.085μm
Minimum mark length	0.11μm
Modulation code	(1,7)RRL
Signal processing	Adaptive PRML

Table 3 Bit error rate of 50GB/layer recording

	Groove	Land
Single Track	6.0E-05	3.5E-05
With Cross Talk	1.6E-04	9.0E-05

Summary

We develop phase change write-once disc with metal oxide AC layer, which has high-speed write/read characterisrtic of 216Mbps and high-density recording of 50GB/layer. These high performances of the disc are suitable for data archiving applications.

References

1) H. Minemura, H. Shirai and R. Tamura, ”Study on 200Mbps High Speed Write/Read using a Phase-Change Write-Once Disc”, ODS, MA3, pp.8-9, Vancouver, Canada, May 2003.
2) H. Minemura, T. Kurokawa, H. Shirai and R. Tamura, “New PRML Method for High-Speed and High-Density Recording”, ISOM, Tu-D-01, pp.34-35, Nara, Japan, Nov. 2003.
3) R. Tamura, K. Adachi, H. Shirai and H. Minemura, “216Mbps Write/Read Speed 50GB Phase-Change Write-Once Disc”, ODS, WA4, pp279-280, Montetrey, USA, April 2004.