DURABILITY OF MARK-EDGE RECORDING MO MEDIA

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Abstract-Durability of mark-edge recording magneto-optical disk is studied. Rare-earth rich TbFeCo film shows a very good write/erase cyclability more than $10^6$ repetition in a jitter bucket curve test. By applying a novel protective overcoat resin and a high grade poly-carbonate substrate, there shows no degradation after 1000 hours 80°C, 90%RH accelerating test.

KEYWORDS: MARK-EDGE RECORDING, MO DISK, CYCLABILITY, DURABILITY

INTRODUCTION

Mark edge recording method is the key issue to increase both linear bit density and data transfer rate for Magneto-optical disks. To realize those disks, very accurate domain edge control is required [1]. At the same time, very reliable, durable disk is also necessary. The second generation 5.25 inch size MO disk with 2GByte memory capacity was developed under those concepts [2]. Here, we report the disk design to establish highly reliable memory focusing write/erase cycle repeatability and high temperature/high humidity durability.

DISK LAYER STRUCTURE AND DIVIDED PULSE FOR MARK EDGE RECORDING

The second generation 5.25 inch MO has a three times capacity (2GB) comparing with the first generation disk, employing narrow track width (1.34 μm), mark length modulation/mark edge detection scheme and zoned constant angular velocity format. As shown in Fig. 1, the minimum domain length is 0.75 μm, the maximum is 3 μm under (1-7) Run Length Limited code [2]. Window length $T_w$ for one bit detection is only 0.38 μm and every domain edge should be controlled within the accuracy of ±0.02 μm.

The disk layer structure is so called quadri layer structure as shown in Fig. 2, which is almost similar to the first generation one. We can expect the cost effective production using the same processing line.
Devided pulse laser beam is irradiated to control precise domain edges. Fig. 3 shows a typical pulse patterns. Pa is a power level for pre-heating, Pw1 for nucleate the minimum size domain and Pw2 for keeping the constant domain width. Every typical values at a linear velocity 9.4m/s are as follows, Pa : 3.5mW, Pw1 : 5.45mW 60ns, Pw2 : 5.7mW 20ns.

Fig. 3 Divided pulse laser beam is irradiated to record precise marks (domains) within the edge accuracy ±0.02μm.

Fig. 4 Temperature dependence of the coercive force for RE rich disk (Tb26Fe62Co12) and TM rich one (Tb23Fe65Co12). Rectangular points shows Hc after 300°C, 5 minutes thermal damage test.
WRITE / ERASE CYCLABILITY

It is well known that by the write / erase repetition cycle there causes a thermal damage to TbFeCo film and brings a position change of written domain edge and finally gives serious jitter error. Such phenomena may depend on the TbFeCo composition. Here we compared typical two compositions, one is Tb\(_{2/3}\)Fe\(_{6/2}\)Co\(_{12}\) (RE rich) another is Tb\(_{2/3}\)Fe\(_{6/2}\)Co\(_{12}\) (TM rich). The coercive force Hc of RE rich disk is very large at a recording temperature region (150–180°C) as shown by open circles in Fig. 4, while Hc of TM rich one is smaller (black dots). Those two disks has the same layer structure and thickness. Curie temperatures are tuned each other to have the same laser power writing sensitivity.

Carrier and Noise degradations by the repetition of an accelerated erase power (11.0mW) is shown in Fig. 5 (nominal power is only 6.5mW). RE rich disk shows no degradation after 10\(^6\) times (corresponding to 10\(^7\) times at nominal power condition), while TM-rich one gives serious change after 10\(^6\) times. It should be noted that RE-rich one is durable for cyclability test. Such situation is checked again using the actual write / erase conditions using the drive OD152 [2]. We can see the total jitter bucket curve against a relative write power change in Fig. 6. Every point shows a percentage of total jitter per window of 10\(^4\) random patterns. We kept the ratio Pw1 / Pa, Pw2 / Pa constant respectively and changed the relative power. Comparing with results for RE rich and TM rich disk, the bucket curve change after 10\(^6\) times repetition is serious for TM rich one. Especially, at a high relative power side, TM rich disk shows a rapid jitter increase due to a blooming of recorded domains.

The reason why TM rich disk is inferior to RE rich disk is simply explained by the coercive force degradation due to thermal damage. Both disks are annealed at 300°C, 5 minutes. In Fig. 4, Hc of RE rich disk (open rectangular) shows no change after such serious condition, while TM rich one decreases remarkably. The recording temperature is almost defined by the cross section between Hc and total magnetic

![Fig. 5 Accelerated write / erase cycle test for RE rich disk and TM rich one. Erase power Pe is 11mW, which is very larger than nominal power of 6.5mW. RE rich disk is very reliable than TM rich one.]

![Fig. 6 Percentage of total jitter per window for 10\(^4\) random pattern samples. The jitter bucket curve of TM rich disk moves to low power side after 10\(^6\) write / erase repetition, while RE rich one moves a little.]

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field including external applied field \[3\], so it should be noted that the recording temperature of TM rich disk decreases drastically by the thermal damage, which brings the jitter bucket curve slide toward relatively low power side as shown in Fig. 6 by full dots. Detailed discussions of domain formation model are described in the reference \[4\].

HIGH TEMPERATURE / HIGH HUMIDITY DURABILITY

The domain edge should be controlled within the accuracy \(\pm 0.02 \mu \text{m}\). This requirement may restrict the disk life, so the jitter bucket curve change was checked in \(80^\circ \text{C}, 90\% \text{RH}\) environment for RE rich disk. The most effective approach to elongate the life of MO disk is a selection of resin materials such as substrate material and protective overcoat one. Polycarbonate resin is carefully selected as a MO grade substrate, which eliminates lower molecular component and some active impurities such as chlorine \[5\]. Very purified ultra-violet cured resin is used as a protective overcoat on the top of Al-alloy reflective layer. The result in jitter bucket curve of \(10^6\) random patterns is shown in Fig. 7. In spite of such a serious environment of \(80^\circ \text{C}, 90\% \text{RH}\), there occurs no change in bucket curve after 1000 hours. In \(60^\circ \text{C}, 90\% \text{RH}\) conditions, the test continues beyond 3000 hours without any jitter change. Disk life is estimated to be very longer than 10 years.

![Graph](image)

Fig. 7 Jitter bucket curve shows no degradation after 1000 hours in \(80^\circ \text{C}, 90\% \text{RH}\) condition.

CONCLUSION

Reliability of mark edge recording MO is studied on a 5.25 inch diameter double sided disk with 2GByte memory capacity.

(1) RE rich TbFeCo is compared with TM rich TbFeCo from a viewpoint of write/erase cyclability. The jitter bucket curve shows little degradation after \(10^6\) cycle in RE rich TbFeCo, while TM rich one's bucket curve moves to relatively low power side due to thermal degradation.

(2) Disk life is elongated by a MO grade poly carbonate substrate and purified overcoat UV resin. There appears no change in the jitter bucket curve after 1000 hours in \(80^\circ \text{C}, 90\% \text{RH}\) accelerated environment.

REFERENCES