Random Signal Improvement of Super-RENS WORM Disk

Jooho Kim[1], Inoh Hwang[1], Jaecheol Bae[1], Jinkyung Lee[1], Hyunsoo Park[1] and Insik Park[1]
[1]Digital Media R&D Center
SAMSUNG ELECTRONICS CO., LTD, Yeongtong-Gu, Suwon, 442-742, Korea
Tel: 82-31-200-4249, Fax: 81-31-200-3160, E-mail: jooho1.kim@samsung.com

Takahashi Kikukawa [2], Narutoshi Fukuzawa [2], Tatsuhiro Kobayashi [2]
[2]Advanced Storage Technology Group, Devices Development Center
TDK Corporation, 462-1, Otai, Saku, Nagano, 385-0009, Japan

Junji Tominaga[3]
[3]Center for Applied Near-Field Optics Research
National Institute of Advanced Industrial Science and Technology (AIST), 305-8563, Japan

Abstract: We firstly report the bER characteristics of super-resolution near field structure (Super-RENS) write-once read-many (WORM) disk at a blue laser optical system. (Laser wavelength 405nm, numerical aperture 0.85) We used a disk of which carrier-to-noise ratio (CNR) of 75nm is 47dB. We controlled the equalization (EQ) characteristics and used advanced partial-response maximum likelihood (PRML) technique. We obtained bit error rate (bER) of 10-2 level at 50GB and 10-3 level at 40GB with new signal processing techniques. This result shows high feasibility of super-RENS technology for practical use.

1. Introduction

Super-RENS is one of the promising technologies to overcome the resolution limit and to achieve high capacity optical storage. The signal characteristics (CNR) of the super-RENS disk has been achieved from 300nm mark to 37.5nm signals by using a Sb type to a PtOx type during the last 6 years.[1-5] The recording mechanism was approved as a rigid bubble formation by the decomposition of PtOx into Pt nano-particle and oxygen gas through the TEM cross sectional image observation.[3,6] The readout mechanism of super-RENS disk is not clear at the moment although there are some proposals that super-resolution effect may comes from a phase change layer, recently.[7-8] The issue of super-RENS has been changed from CNR of single frequency pattern to signal characteristics of random pattern.[9-10] In this study, we will firstly report the bER characteristics of super-RENS WORM disc at a blue laser optical system.

Table. 1. Experimental conditions

Item	Value
Wavelength	405 nm
Numerical aperture	0.85
Linear velocity	2.5m/s ~ 3.6m/s
Modulation code	RLL (1,7)
Minimum mark length	107nm(35GB) 94nm(40GB) 75nm (50GB)
Pattern Signal	[2T/20ea-3T/20ea]-[2T/20ea-4T/20ea].... [2T/20ea-8T/20ea] – [2T/20ea-9T/20ea]

2. Experimental Procedure

We used a super-RENS WORM disk using PtOx and phase change material. The thicknesses of substrate and cover layer are 1.1mm and 0.1mm, respectively. The experiment conditions are depicted in Table 1. In order to examine recording and readout characteristics, an optical disk drive tester (a Pulstec DDU-1000, a laser wavelength (λ) = 405 nm and a lens numerical aperture (N.A.) = 0.85) was used. The CNR characteristics were analyzed with a spectrum analyzer, and a resolution bandwidth (RBW) was 30kHz. RLL (1,7) code was used for random pattern. We controlled EQ profile characteristics and used advanced PRML technique in order to improve the bER characteristics.

3. Results and discussion

The writing and readout conditions of each T (2T~9T) were controlled to get both high CNR and good symmetry condition. Fig. 1 shows the CNR characteristics with respect to mark length. The CNR of 75nm (2T) was 47dB, and the capacity is 50GB. The pattern signal (2T-3T-2T-4T-2T-5T-2T-6T-2T-7T-2T-8T-2T-9T, the numbers of each T is 20.) was used to check a symmetry condition. A good symmetry was obtained as shown in Fig.2, and an eye pattern using limit EQ is shown in Fig.3.

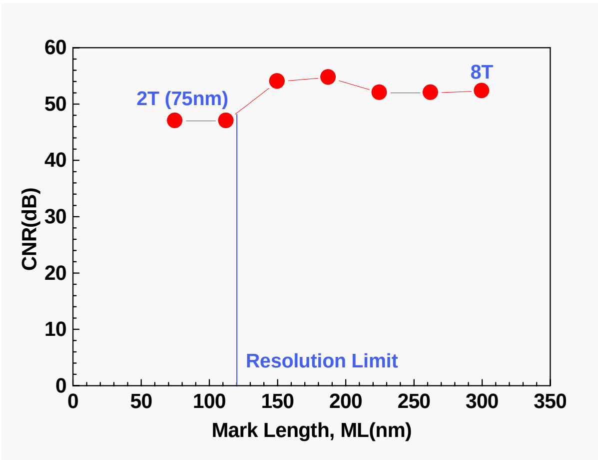

Fig. 1 the CNR characteristics as a function of mark length.

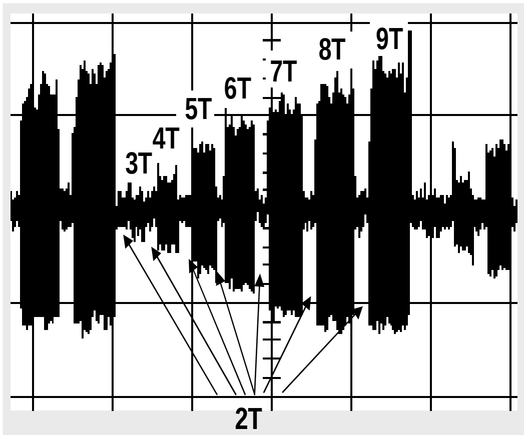

Fig. 2 Symmetry state of the pattern signal.

As compared with the previous report, the eyes are completely opened. Fig.4 shows the eye pattern of 40GB random pattern signal using limit EQ and a completely boosted 2T signal can be seen. In order to investigate bER characteristics with respect to readout power, bER was measured using controlled EQ and advanced PRML technology and the results were shown in Fig. 5. As shown in Fig. 5, bER remarkably decreases in the vicinity of readout power of 2.0mW, which corresponds to the threshold power of CNR at 75nm of minimum mark length. This reveals that there is also threshold phenomenon at random pattern signal. From these results, super-resolution effect in super-RENS system is effective on not only a single pattern but also a random pattern. The bER change according to capacity was also investigated as shown in Fig.6. The bER at 40GB and 50GB are 10^{-3} level and 10^{-2} level. This result would be the first meaningful result with respect to a random pattern signal using super-RENS technology.

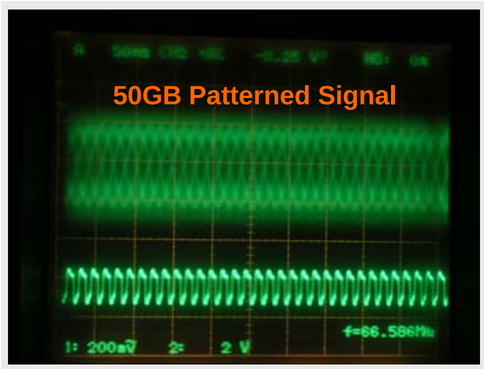

Fig. 3 Eye-Pattern of the 50GB pattern signal

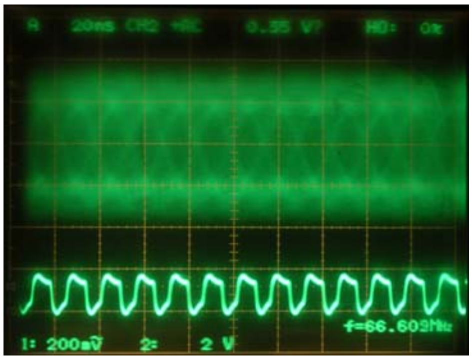

Fig. 4 Eye-Pattern of the 40GB random signal

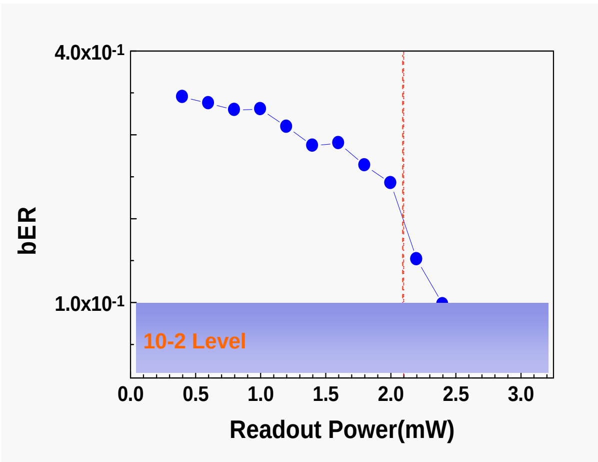

Fig.5 bER characteristics as a function of readout power showing threshold phenomenon.

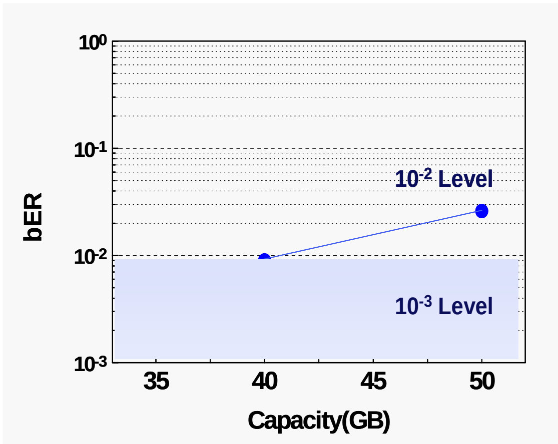

Fig. 6 bER characteristics as a function of disc capacity.

4. Conclusion

With optimized writing condition, high CNR and good symmetry were obtained simultaneously. We confirmed the threshold phenomena of bER with random pattern signal for the first time. This result shows that the super-resolution effect in super-RENS system plays a role not only on single pattern signal but also on random pattern signal. We have achieved the 10^{-3} level bER at 40GB and the 10^{-2} level bER at 50GB using controllable EQ and advanced PRML techniques. We think these results show the feasibility of super-RENS technology for practical use.

References

1. J. Tominaga, T. Nakano, and N. Atoda, Appl. Phys. Lett. **73**, 2078 (1998).
2. H. Fuji, J. Tominaga, L. Men, T. Nakano, H. Katayama and N. Atoda, Jpn. J. Appl. Phys., Part 1 **39**, 980 (2000).
3. T. Kikukawa, T. Nakano, T. Shima and J. Tominaga, Appl. Phys. Lett. **81**, 4697 (2002).
4. J. Kim, I. Hwang, H. Kim, D. Yoon, I. Park, D. Shin, Y. Park and J. Tominaga, Jpn. J. Appl. Phys., Part 1 **43**, 4921 (2003).
5. T. Kikukawa, N. Fukuzawa and T.Kobayashi, Technical Digest of ISOM 2004, Fr-PO-02, 262 (2004).
6. J.H. Kim, I. Hwang, D. Yoon, I. Park, D. Shin, T. Kikukawa and J. Tominaga, Appl. Phys. Lett. **83**, 1701 (2003).
7. J. Tominaga, T. Shima, M. Kuwahara, T. Fukuya, A. Kobolov and T. Nakano, Nanotechnology **15** 411 (2004).
8. I. Hwang, J. Kim, H. Kim, I. Park and D. Shin, Asian-Pacific Data Storage Conference Digest 70 (2004).
9. J. Kim, I. Hwang, H. Kim, D. Yoon, H. Park, K. Jung, I. Park and J. Tominaga, SPIE Proceeding **5380** 336 (2004).
10. J. Kim, I. Hwang, H. Kim, I. Park and J. Tominaga, Technical Digest of ISOM 2004, Th-H-01, 140 (2004).