# One SIL Head Recording/Reading on a Rewritable Dual-Layer Optical Disk Having High-index Cover and Separation layers

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## Abstract

We first demonstrated the dual-layer rewritable recording with single SIL (Solid Immersion Lens) head that can access both layers. Newly developed optical disk has cover and separation layers having the refractive index of 1.8, which thickness are 3.0 µm and 3.5 µm respectively, and two phase-change recording layers, L0 and L1. The SIL head is designed to focus the laser beam on both of L0 and L1 by beam expander. The recording capacity confirmed on the system corresponds to 150 GB.

**Keywords:** near-field recording, dual-layer, SIL, rewritable, high refractive index

## Introduction

Near-filed recording utilizing a SIL (Solid Immersion Lens) optical system has been developed since 1990s as a possible candidate for the next generation optical disks [1]. It enables a high density recording even using the basically similar recording media as Blu-ray disks except for the very thin cover and separation layers [2].

In 2008, we first demonstrated the recording onto a dual-layer rewritable disk with SIL optical systems. On the experiment, we used two optical heads respectively mounting a different shaped SIL and individually recorded and read on the two layers. In addition, we used the conventional UV resins with the refractive index 1.5 for the cover and separation layers, so it limited the effective NA (numerical aperture) and the recording capacity was 135 GB.

After that, we investigated to form very thin cover and separation layer with the higher refractive index. In parallel, we developed an evolved optical head that can access both layers with single SIL. In this paper, we present structure of the new optical disk and configuration of the new SIL optical system, and overwrite experimental results using them.

## Dual-layer disk and SIL optical system

Figure 1 shows the stack structure of the optical disk. A GeSbTe-based phase-change material film is formed as each recording layer for L0 and L1, which are developed based on Blu-ray Disk Rewritable (BD-RE) recording films. The cover layer and the separation layer are formed by spin coating process, and these layers have a refractive index of 1.8 (@ 405 nm in wavelength). The refractive index is rather larger comparing to that of conventional UV-resin, 1.5, for example used in BD-RE. Thickness of the cover layer and the separation layer are set to 3.0µm and 3.5µm respectively.

Figure 2 is the schematic diagram of recording and readout optics of our SIL optical system. The refractive index of the SIL (Lens 1) is 2.068. In the previous report in 2008, we adjusted thickness of the SIL and distance between the SIL and the objective lens (Lens 2) to minimize spherical aberration for a dual-layer disc by using two optical heads as mentioned above [3]. In the present optical system, we have used newly developed beam expander composed of three lenses (Lens 3, 4, and 5) as shown in Figure 3. This beam expander is designed to focus the laser beam on both of L0 and L1 with compensating the spherical aberration by only moving one lens (Lens 5) and fixing the shape of the SIL and the distance between the SIL and the objective lens. This optical system focuses the laser beam 0 – 8 µm depth from cover layer surface. For the gap servo, an additional optics with 650 nm red laser is used simultaneously.

## Experiments & Results

The total experimental setup was prepared by changing the optical system and adding the gap servo circuit based on the commercial Blu-ray drive. For evaluating the disk, (1-7) pp modulation code was adopted and the channel clock frequency was set to 66 MHz. Gap length was set to 20 nm. Using this setup, recording/reading for both L0 and L1 of the disk was confirmed by moving Lens 5.

Table 1 Recording conditions

| | SIL | | Blu-ray Disc |
|---|---|---|---|
| Bit Length | 64.5nm/bit | 70nm/bit | 110nm/bit |
| Minimum Mark Length | 86.1nm | 93.1nm | 149nm |
| Linear Velosity | 2.84m/s | 3.08m/s | 4.92m/s |
| Estimated Recording Capasity (Dual-layer) | 150GB | 128GB | 50GB |

Figures 4 (a) and (b) show dependence of TE signal amplitude on Lens 5 position. The laser focuses on both L0 and L1 by only adjusting the position of Lens 5.

Figures 5 (a) and (b) show dependence of 9T CNR (carrier to noise ratio) on write power for L0 and L1, respectively, at the bit length of 70.0 nm (i.e. minimum mark length was 93.1 nm and linear velocity was 3.08 m/s). Over 50 dB of CNR was obtained. It means the disk noise is sufficiently low for both L0 and L1.

Figure 6 (a) and (b) show eye patterns for L0 and L1 at the bit length of 64.5 nm, where the write, erase, cooling and readout powers were respectively set to 19.0 mW, 8.0 mW, 0.1 mW and 1.2 mW for L0 and 16.0 mW, 4.7 mW, 0.1 mW and 1.2 mW for L1. The measured jitter values through the limit equalizer are 11.0 % for L0 and 11.2 % for L1.

## Conclusion

We have developed a dual-layer rewritable optical disk with high-index (n=1.8) thin cover and separation layers and a new SIL optical head system enabling to access the both layers with single SIL. The recording capacity confirmed on the system will correspond to 150 GB.

It is possible to reduce the bit length if PRML (Partial Response Maximum Likelihood) and much higher index resin are adopted. We will develop a disk with much larger capacity, which will be close to half terabyte.

## References


[1] S. M. Mansfield et al.: Opt. Lett. 18, (1993) 305.
[2] T. Ishimoto et al.: Jpn. J. Appl. Phys. 48, (2009) 03A015.
[3] M. Birukawa et al.: Technical digest of ISOM/ODS (2008), TD05-152

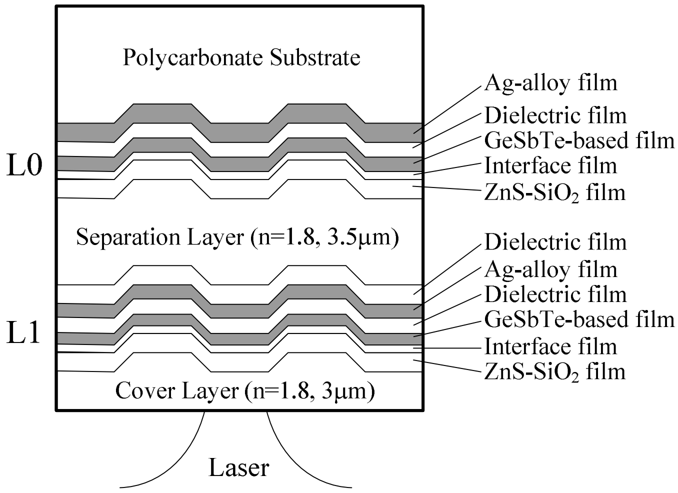



Fig.1 Layer structure of the dual-layer disk.

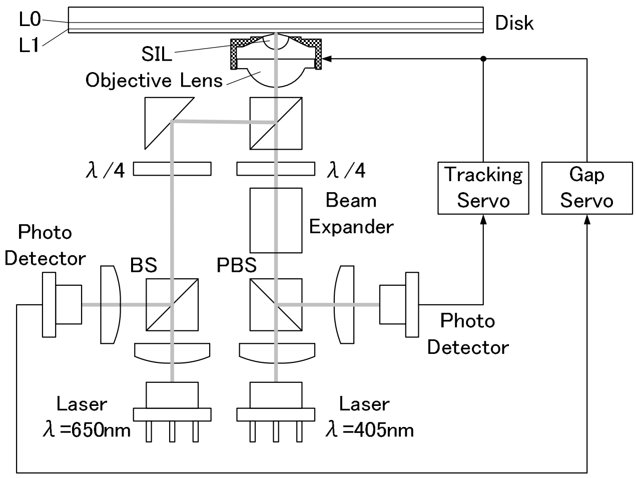



Fig.2 Schematic of the SIL optics and servo system.

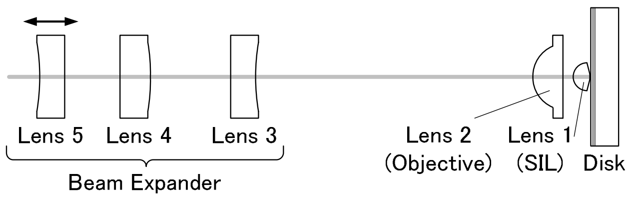



Fig.3 Configuration of beam expander, objective lens and SIL.

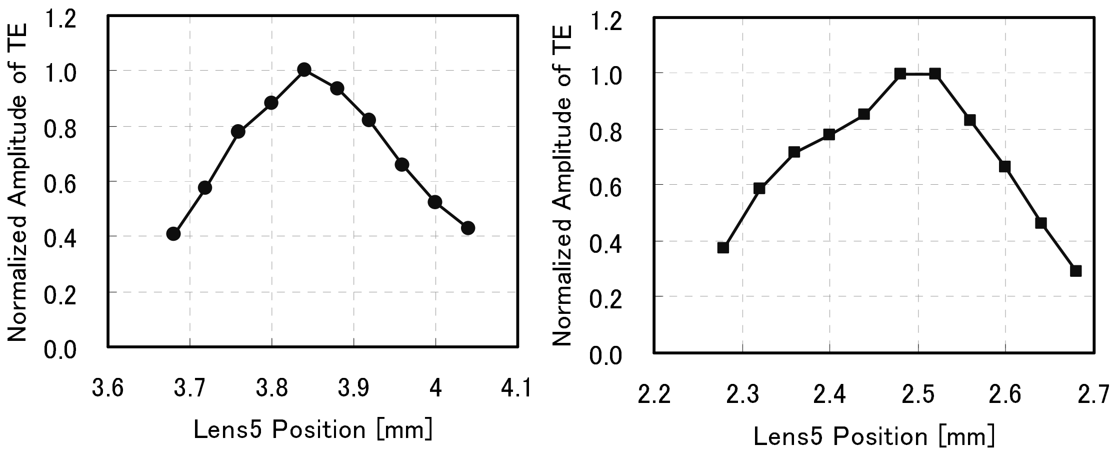
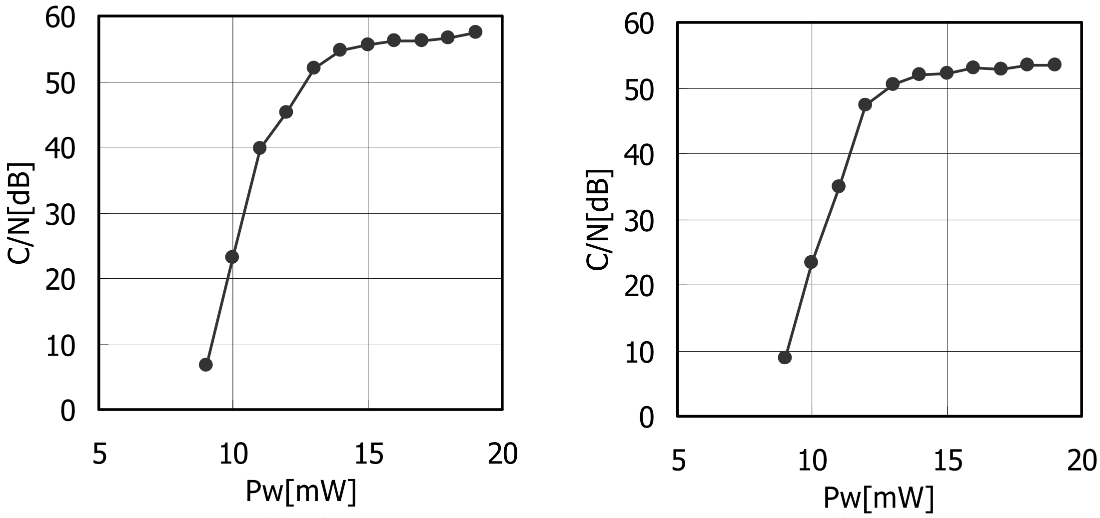
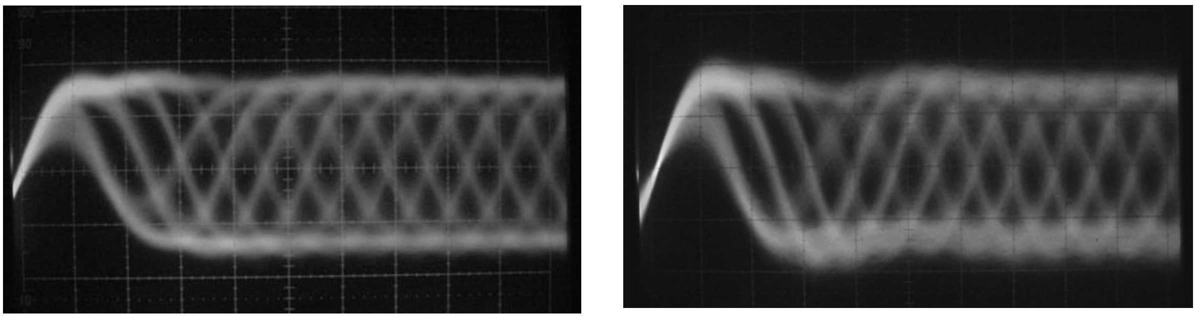



Fig.4 Dependence of TE signal amplitude on Lens 5 position




(a) L0 (b) L1

Fig.5. Dependence of 9T C/N on write power at the bit length of 70.0nm



(a) L0 (b) L1

Fig.6 Eye pattern of (1-7)pp random signal at the bit length of 64.5nm