Two-beam initialization method for a rewritable multi-layer optical disk

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Abstract

The fine feasibility of rewritable triple-layer optical disk with a capacity of 100 GB was previously demonstrated last year (2009). Here, it was an issue that the reflectivity of triple-layer optical disk was extremely lower comparing to the case of dual-layer disk, which made the focusing operation very difficult just merely by utilizing conventional initialization equipment having only one infrared laser beam. We newly developed an initialization-equipment (initializer) providing two laser beams: one is blue for focusing by which a large reflectivity can be obtained from the multi-layer optical disk and the other is infrared for initialization which has sufficiently high output power for initialization at high speed condition. Our prototype triple-layer optical disk having GeTe-Sb_2Te_3 phase-change films for every three layer was successfully initialized after the processes of stacking three recording layers and coating a cover layer.

Key words: rewritable optical disk, multi-layer, initialization, two-beam optical system, GeTe-Sb_2Te_3

1. Introduction

In the manufacturing process of the optical disk, reduction of process number is quite essential for increasing productivity and lowering cost. In the case of multi-layer optical disk, it becomes further important to reduce the process number especially before forming a cover layer, which will enable to reduce the deposition of dusts through long process and accordingly bit error rate. In that meaning, it is highly desirable that initializing process will be performed after completing cover layer. However, we faced a problem that the above manufacturing process directly could not be applied for the rewritable triple-layer Bu-ray Disc by using conventional initialization equipment (initializer) providing just one infrared high power laser. This is because that the reflectivity of rewritable triple-layer optical disk, particularly in the layers of L1 and L2, generally tends to be very small, less than 1%, for the infrared laser, which makes the servo control for focusing very unstable.

Thus, we newly developed an initializer providing two lasers: a blue laser for focus operation, and a high power infrared laser for the initialization. In this paper, the initializer having two-beam optical head, the initializing process for triple-layer optical disk using the initializer, and the test results performed on the sample disk are first described.

2. Experiments

Figure 1 shows a schematic view of the initialization process utilizing the newly developed initialization method. The equipment has an optical head that converges two beams: the preceding infrared laser (λ: 810 nm) with stripe shape (1.5μm x 80μm) for initialization and the following circular blue laser (λ: 405nm) for focusing, through a common objective lens onto the recording layer. Since the initialized area has rather high reflectivity for blue-laser, very stable servo control becomes possible by arranging the blue laser after just behind the infrared laser.

The schematic of this two-beam optical head is shown in Figure 2. The infrared laser beam is collimated, through a polarization beam splitter (PBS), a cold mirror, and converged onto the revolving optical disk by an objective lens, while the blue laser beam is independently collimated, through PBS, reflected by a cold mirror, and also converged on to the disk by the objective lens common for the infrared laser beam. The each reflected laser beam is isolated by the PBS and enters into focus detector that generates focusing signals. Focusing mechanisms are prepared for not only blue laser but also for infrared beam, just in case. For increasing the resolution for “layer isolation,” the numerical aperture (NA) of the objective lens is increased from 0.55 for conventional type to 0.75 at infrared wavelength for new one.

The left hand figure in Figure 3 shows the cross section of one example of our rewritable triple-layer optical disk applied in this experiment[1,2]. In the sample disk, rather GeTe-rich composition in the GeTe-Sb_2Te_3 pseudo binary line is utilized for every layer. The right hand figure in Figure 3 reveals compositional dependences of the crystallization speed (without data) and the variations of optical constants, $|\Delta n|+|\Delta k|$, between in the amorphous and crystalline states on the GeTe-Sb_2Te_3 line, where Δn and Δk respectively denote the variations of refractive indices and extinction coefficients[3]. Each thickness of the GeTe-Sb_2Te_3 film applied to L0, L1and L2 L1 is set to 9.0 nm, 7.5 nm and 5.8 nm, respectively.

2. Results and Discussion

Table I and II show the reflectivity of each information layer measured as the triple-layer structure before and after initialization, respectively. Every value in the tables is determined by calculation based on the reflectivity and transmissivity of each layer that were obtained experimentally using spectroscope. As can be seen from Table I, L0 can be easily pulled in focus position by detecting the reflection of the infrared laser. Thus, the initialization of L0 is first performed. In the case of L1 and L2, some technique is required before starting initialization. As shown in Table I, L1 and L2 show rather low reflectivities both for infrared and blue lasers. Hence, it is necessary at first to make a small crystalline area (trigger area) using infrared laser before pulling in focus. After making the trigger area, the reflectivities of L1 and L2 become large enough (1.9% and 2.6%, respectively) at blue wavelength for focusing. Figure 4 shows the focus error signal from every layer of L0, L1 and L2 for infrared and blue lasers. As shown in the figure, large and clear “S” signal can be obtained for ever layer for the blue laser. Thus, initialization of L1 and L2 can be successively carried out and finally the initialization of the triple-layer optical disk is completed.

The recording properties of the sample disk were evaluated based on the BDXL standard[4], where the laser wavelength is 405 nm, the NA of objective lens is 0.85, the shortest mark length is 0.112 μm, and the linear velocity is 7.36 m/s, assuming 33.4 GB/layer of the recording capacity and 72 Mbps for the recording data-rate[5]. Figures 5 show the dependences of i-MLSE (Integrated Maximum Likelihood Sequence Estimation) and SER (Symbol Error Rate) on write power for each layer[6]. The bottom i-MLSE of 10.5 % (L0), 11.2 % (L1), and 11.5 % (L2) successfully clear the criterions of 12% and SER clear the criterions of $2x10^{-4}$.

4. Conclusions

This study was achieved by co-works of Panasonic Corp. and Hitachi Computer Peripherals Co.. Initialization of triple-layer BD-RE can be carried out after a process of deposition of three recording layers and coating cover layer. The newly developed Hitachi-Computer made initializer (Figure 6) provides two-beam optical head (blue laser for focusing, infrared for initialization and an objective lens of NA:0.75). A sample disk (Panasonic) having GeTe-Sb_2Te_3 phase change material films of rather GeTe-rich composition for every layer shows good signal quality that successfully clears BD-XL standard.

References

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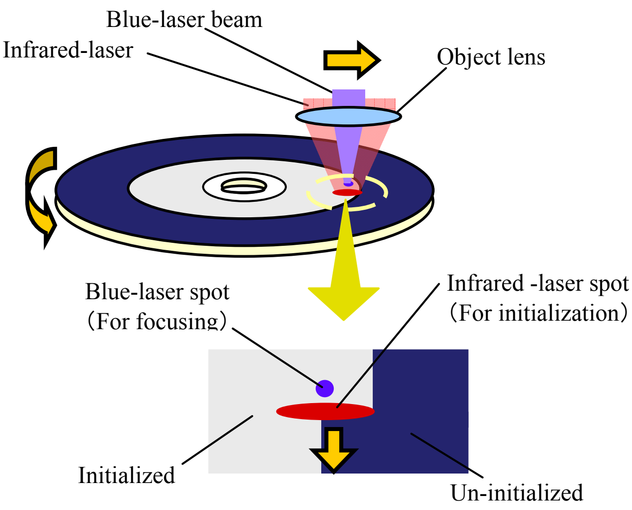

Fig.1. External and movement of initialization equipment for BDXL

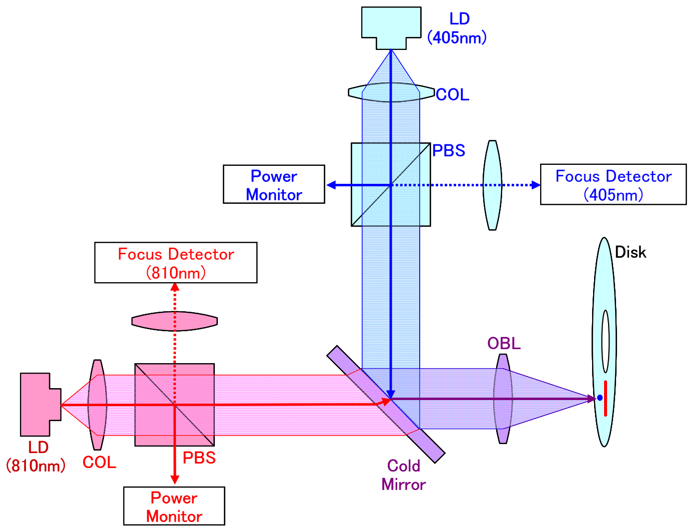

Fig.2. Two-beam optical system

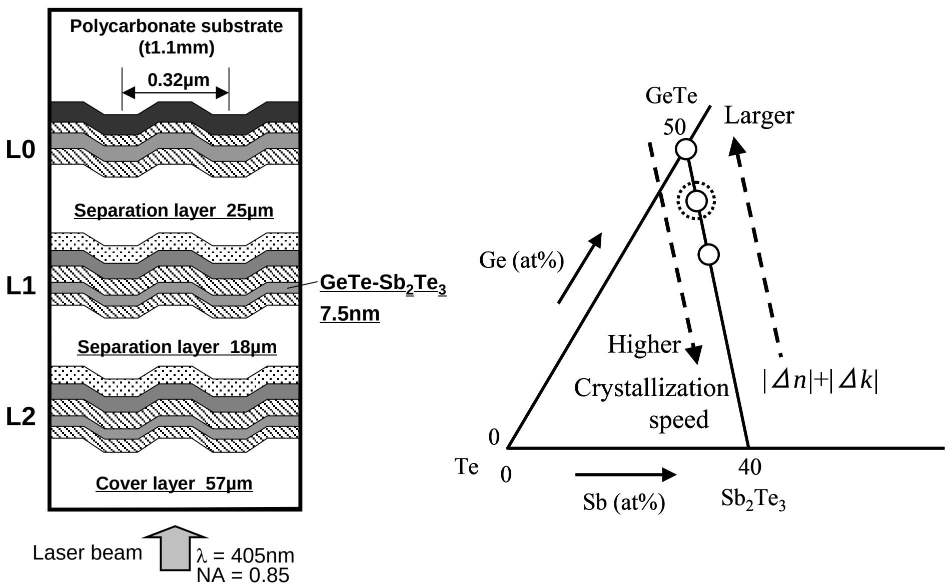

Fig.3. Cross section of triple-layer disk (left) and GeSbTe phase change film applied in it.

Table Ⅰ. Reflectivity of the uninitialized sate

layer	810nm	405nm
L0	4.5%	0.2%
L1	0.8%	0.3%
L2	0.7%	0.3%

Table Ⅱ. Reflectivity of the initialized sate

layer	810nm	405nm
L0	0.1%	1.7%
L1	0.7%	1.9%
L2	4.4%	2.6%

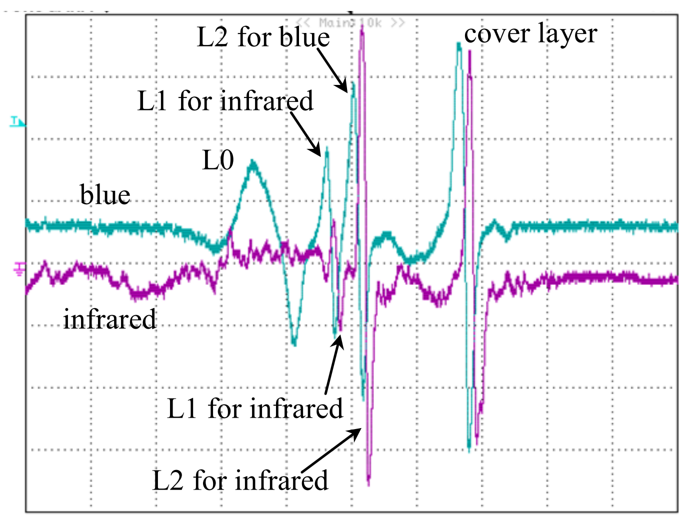

Fig.4. Focus error signals for the infrared and blue laser of every initialized layer(trigger area). Although "S" signal of L1 for infrared is very small, that for blue is large and clear.

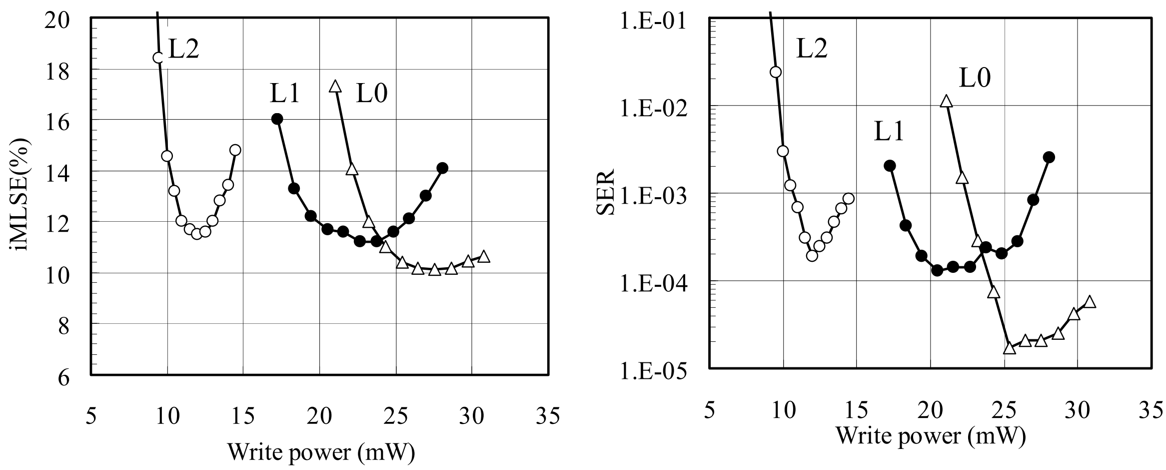

Fig.5. Recording properties of the sample disk; the left and right figures show the dependences of i-MLSE and SER on write power.

Fig.6. View of the developed Initializer