다층 자료 저장 Near Field Optics의 수차 보정

Aberration Compensation in Near Field Optics for Multi-layer Data Recording

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1. Introduction

We can use multi-layer recording in order to record a large amount of data in optical data storage devices such as DVD. Because spherical aberration(SA) is induced by changing the media depth, SA compensation is required. The following is SA value in a single surface system.

$$W_{040} = -\frac{n'(n'-n)}{8n^2}\frac{S'(S'-R)^2[n'S'-(n+n')R]}{R^3L^4}r^4.$$

(n, n' : 1st and 2nd refractive index, R : the radius of curvature,
S' : the value of the image distance, r : the pupil radius,
L : he distance between exit pupil and Gaussian image point)

$W_{040}=0$ when $S'=0$, $S'=R$, $S'=\frac{n+n'}{n'}R$. If R is infinite, then the SA value becomes

$W_{040} = -\frac{n'(n'^2-n^2)}{8n^2S'^3}r^4$, ($L \to S'$). Since $n'\frac{r}{S'} = NA$ and $S'=t$ (media thickness)

$W_{040} = -\frac{(n'^2-n^2)}{8n^2n'^3}NA^4t$. This shows that the SA is linearly proportional to the media depth.

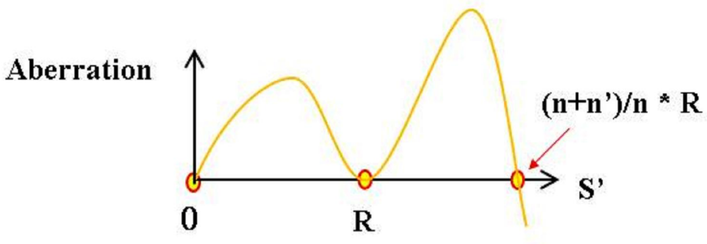

Fig 1. The SA induced by changing S′ in a single surface.

2. SA Compensation

1) Liquid Crystal (LC) plate

We have placed the LC plate in front of the objective lens in order to compensate the wavefront. Through this method we have analyzed the effect of compensation. The maximum area where actual LC plate compensation is possible and the rest of the area which act as the limiting condition led to the discovery of the limit of compensation and the number of step that allows optimized compensation.

2)Keplerian Telescope Type

This compensator relies on the application of the Keplerian type. Same type of lens was conjugated to compose the compensator. Moreover, the system was constructed so that there will be alteration in the length of the entire lens system. The system's NA is higher than 1.8, and the refractive index of the media is around 1.9. The depth of the media is designed to achieve the best focus at middle. Based on this design, we have evaluated the performance while changing the media depth.

3) Compact Combined (Collimator + Objective) System

The Keplerian type system is comprised of a total of 5 lenses when including the collimator. A system which includes many lenses have various disadvantages. Therefore an attempt was made to reduce the number of lenses, and surprisingly it was possible to reduce the number of lenses to 3 in an NA 1.7 system. This result indicates that designing a 3 lens system may be possible in other systems with different limitation conditions. When the refractive index of the media is 1.9, the best focus is achieved at 9 μm and compensation is possible up to 2μm.

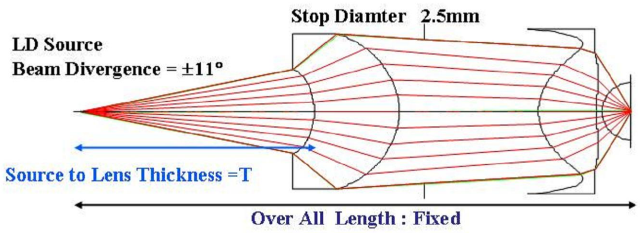

Fig 2. Layout

Media depth	On axis	Field 0.2 degree
-2 μm	5.1 mλ	18.9 mλ
center	20.5 mλ	24.9 mλ
+2μm	7.2 mλ	7.9 mλ

3. Tolerance Analysis for Kepler type and Improvement by Balancing

The tolerance of high NA system is analyzed in six categories. The tilt of the objective lens was especially critical. In order to compensate the tilt, by using the field and the SIL decenter the tolerance of the objective lens could be improved. We could also discovered that the tolerance could be improved by designing the objective lens while taking the SIL decenter into consideration from an early stage. This method is also applicable in an Opti-SIL system which has a relatively lower tolerance that the Hemi-SIL system.

4. References

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