Optimum SIL System Design with High NA and Large Tolerance

Kitak Won, Narak Choi, Jaisoon Kim, Jiyeon Lee*, Kyungeon Lee*, Yunsup Shin*

School of Physics and Astronomy, Seoul National University,
Digital Storage Research Lab., LG Electronics*

jskim@phya.snu.ac.kr

Abstract

Even though high NA, Hyper SIL system easily decline the optical performance even a little alignment error. Not only to overcome this instability but to maintain the high NA gain, we suggest a new system (Optimum SIL) which is a combination of each advantage of Hyper SIL and Hemi SIL. Simulation results shows that Optimum SIL system has much higher tolerance to various performance-lowering factors than Hyper SIL system even with a relatively small NA resignation.

1. Introduction

To achieve high data capacity, a number of methods are suggested in optical data storage. The solid Immersion Lens (SIL) technology as the method which increases the store dosage of existing a lot a breadth even from lithography field the attention is receiving, from only data storage field the bay it knows it reduces and as the next generation technique for the many research is become accomplished.[1-4] For use with SIL technology, commonly two systems are considered Hemi SIL and Hyper SIL. In Hemi SIL system, hemisphere is used as a SIL lens element, otherwise aplanatic hyper hemisphere is used in Hyper SIL system. Currently, because of the high NA gain, Hyper SIL is more investigated than the other. However, due to the sensitivity of Hyper SIL, a small position error makes large aberration, it is difficult to put the Hyper SIL system to practical use. In this paper, we suggest an idea improving the tolerance of optical system with minimized NA resignation.

2. Characteristics of Optimum SIL

Figure 1 shows spherical aberration due to the distance from the input surface to focus point inside the SIL lens.[5,6] There are four specific points one is stable and aberration free(A), another is also aberration free but not stable(B), and the others are not zero aberration but stable(C,D). The two prior points are used in Hemi SIL(A) and Hyper SIL(B) each other. Yet the other points did not be considered specially. In general, curve stability means tolerance and object distance related NA. Hyper SIL has high NA gain, If the objective lens, which is conjugated to SIL position C has some proper aberration that can just compensate the SIL position-induced aberration, we can make a system which has a good tolerance and high NA at once (Optimum SIL).

3. Tolerance Analysis with each other different SIL System

Optimum SIL point basically has residual spherical aberration. So it is necessary to design object lens which can compensate the aberration. More over, considering of possible mass manufacturing, the optical system also has enough tolerance to some performance lowering factors such as axial displacements, tilt, decenter, lens

thickness error, etc.

For production process, we work out a design for one aspherical object lens with PMMA, SIL with LASF35. System NA is 1.8 with 405nm source. Hyper SIL system has high NA gain but lower tolerance. On the other hand, Optimum SIL system satisfies most requirements for mass manufacturing with keeping relative high NA. Comparing with Hyper SIL system, we can verify that Opti SIL has good tolerance of axial displacements, tilt, decenter, lens thickness error and decenter.

4. Results

Optimum SIL system has high NA as well as good tolerance of axial displacements, tilt, decenter, lens thickness error and decenter. It can be alternative system to overcome Hyper SIL system which has high sensibility.

References

[1] I. Ichimura, S. Hayashi and G. S. Kino: Appl. Opt. 36 (1997) 4339

[2] T. D. Milster, R. S. Upton and H. Luo: Opt. Eng. 38 (1999) 295.

[3] Y. Zhang, T. D. Milster, J. Kim and S. Park, "Advanced Lens Design for Bit-Wise Volumetric Optical Data Storage", JJAP, Vol. 43, No 7B, 2004

[4] B. D. Terris, H. J. Mamin, and D. Rugar: Appl. Phy. Lett. 68 (1996) 141-143.

[5] F. A. Jenkins and H. E. White, Fundamentals of Optics, pp.166-167, McGraw-Hill, Inc., Tokyo, 4th edition, 1965

[6] R. Kingslake, Lens design fundamentals, pp.101-107, Academic Press, New York, United Kingdom Edition, 1978

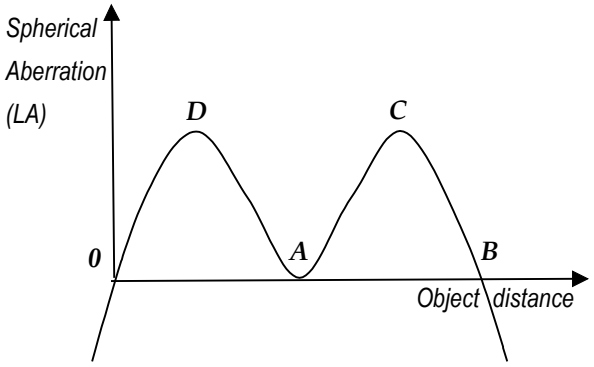

Fig.1. A:Hemi SIL, B:Hyper SIL, C:Opti SIL