Design and fabrication of an integrated optical flying head for near-field recording system

Yanyang Zi* a, Zhengjia He a, Dapeng Zhao b, Qingxiang Li b

a School of Mechanical Engineering, Xi’an Jiaotong University, Xi’an 710049, China
b Dept. of Precision Instrument and Mechanology, Tsinghua University, Beijing 100084, China

ABSTRACT

To achieve 50nm flying height and accuracy tracking motion, it is essential to reduce the whole size of optical flying head (OFH) to improve mechanical and optical performance. With a view to the practical applicability, a novel integrated OFH based on the combination of SIL and objective lens (OL) is proposed, which possesses both high optical performance and reasonable tolerance in assembly. In addition, the fabrication process of this OFH is illustrated in detail. Finally, the main parameters of ABS for OFH slider are presented by means of numerical simulation. The simulation result demonstrates that the flying height of the integrated OFH slider can keep stable from 43nm to 44nm at different radium of optical disk, which can yield high signal/noise ratio optical signal during the read/write motion in near field recording (NFR) system.

Keywords: Near field recording, solid immersion lens, integrated optical flying head, fabrication process

1. INTRODUCTION

In a near field recording (NFR) system based on solid immersion lens (SIL), the SIL is mounted in a slider that is similar to those used with magnetic hard drives, as shown in Fig.1. Light is focused into the SIL from an objective lens (OL). The motion of the disk under the SIL cause an air bearing of gap \( h \) that separates the SIL from the recording layers. When the air gap \( h \) is far less than the wavelength of light, i.e. \( h=50 \) nm, it possible to overcome the diffraction limit of laser beam and create the ultra-submicron spot on the surface of recording layers by means of evanescent energy coupling between the SIL and the recording layer \[1\]. Because of the small spot size, NFR system based on SIL shows good promise of achieving densities of more than 150Gb/in\(^2\) \[2\].

Fig. 1. SIL slider of NFR

The optical flying head (OFH) is important for the construction of a SIL based NFR system with small head-disk gap size and high data transfer rate. The OFH is very similar to the slider of a hard disk drive (HDD), but it has an optical unit on upper side to transmit light from the laser diode to disk or from the disk to photodiode. Therefore, the OFH should have both mechanical and optical performance to yield stable flying height during the read/write motion. More over, the mass of the optics mounted on the flying head is still significantly heavier than the magnetic read/write

* ziyy@mail.xjtu.edu.cn; phone +86 29 82663689; fax +86 29 82663689
elements on the flying head of HDD. Therefore, the OFH should be effectively designed to enable loading of heavy optical components onto the slider without flying instability during various seeking motions\cite{3}. Recently, extensive effort has been made to design and fabricate an effective OFH integrated with OL and a SIL. Several models of OFH have been proposed for NFR\cite{3-6}.

In order to realize practical applicability and high productivity, we propose here a novel integrated OFH structure based on the combination of SIL and OL. Also, the fabrication process is illustrated in detail.

2. NEAR-FIELD RECORDING OPTICAL SYSTEM

Fig.2 shows the optical configuration of our NFR system. A GaN laser diode ($\lambda=405\text{nm}$) is used for the light source. The micro optical head (Micro-OH) unit consists of a OL, a high NA super hemisphere SIL and a Mirror. The incident polarization is changed from circular to linear by means of HWP1. Hence, part of the incident beam is reflected by PBS1 and reaches a monitor photo detector (Monitor-PD) to observe the quality of incident beam. Owing to combination of QWP, PBS1, PBS2, PBS3, HWP2 and HWP3, the reflected beam from the optical disk surface is lead into a RF-PD, CCD and Servo-PD respectively. The Servo-PD can provide focusing error signal (FES) and tracking error signal (TES), which are used to servo control of tracking and read/write motion for Micro-OH.

![Fig. 2. Optical Path of NFR](image)

3. DESIGN OF INTEGRATED OFH STRUCTURES

In Fig.2, the micro-OH plays an important role to a NFR system. To achieve 50nm flying height and excellently tracking performance, it is essential to reduce the whole size of micro-OH, including optical flying head (OFH). With a view to the practical applicability, a novel integrated OFH based on the combination of SIL and objective lens (OL) is proposed, which possesses both high optical performance and reasonable tolerance in assembly. The structure of integrated OFH is illustrated in Fig.3.

In Fig.3, a SIL and a OL are embedded in a through-counterbore of a SIL binding block. When the manufacturing accuracy of SIL, OL and through-counterbore is high, the new structure can remarkably reduce the alignment error, tilt error and defocus error between SIL and OL.

Fig. 4 shows the schematic structure of micro-OH, including OFH. The OFH is cemented on the bottom of dolly car that possesses tracking motion (TM) along the radium of optical disk. The rotating motion (RT) of the disk under the OFH slider causes an air gap that separates the SIL from the recording layers of disk, i.e. the focusing motion of OFH. The free space propagation of light beam is employed to optically connect the fixed main optical unit (including light source, signal detection unit and so on) with the micro-OH.
1- Slider; 2- Cemented surface; 3- Dolly car; 4- Suspension; 5- Gimbal joint; 6- OL; 7- SIL; 8- SIL binding block

Fig. 3. Structure of integrated OFH

1- Optical disk; 2- SIL; 3- Slider; 4- OL; 5- Mirror; 6- Dolly car; 7- Main optical unit; 8- Suspension; 9- Guide rail; 10- Bracket

Fig. 4. The schematic structure of micro-OH, including OFH

4. FABRICATION PROCESS OF OFH

Fig. 5 shows the process flow chart of this OFH slider. It consists of five main procedures.
5. NUMERICAL SIMULATION OF FLYING CHARACTERISTICS

The main ABS parameters that effect flying altitudes, such as ramp, recess, crown and camber, are studied using the numerical simulator developed by CML Air Bearing Design Program (CMLAir32, Version 5). The main parameters of ABS and the flying attitude of OFH at different radius of disk are illustrated in Table 1 and Table 2 respectively. The results demonstrate that the slider possesses stable flying attitudes as well as the flying height keeps nearly constant between 43nm to 44nm, which satisfy the need of near-field optical storage.

Table 1. Main parameters of ABS

<table>
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<tr>
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<tr>
<td>Recess</td>
<td>60 μm</td>
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<tr>
<td>Ramp-in</td>
<td>5.24nm</td>
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<tr>
<td>Ramp-out</td>
<td>1.22nm</td>
</tr>
<tr>
<td>Crown</td>
<td>10nm</td>
</tr>
<tr>
<td>Camber</td>
<td>2nm</td>
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Table 2. Flying attitude of OFH at different radius of disk

<table>
<thead>
<tr>
<th>r/mm</th>
<th>FH/nm</th>
<th>Pitch/μrad</th>
<th>Roll/μrad</th>
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<tbody>
<tr>
<td>25.00</td>
<td>43.09</td>
<td>3.57</td>
<td>-0.40</td>
</tr>
<tr>
<td>35.00</td>
<td>43.85</td>
<td>2.71</td>
<td>-0.22</td>
</tr>
<tr>
<td>45.00</td>
<td>43.84</td>
<td>2.08</td>
<td>-0.14</td>
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<td>55.00</td>
<td>43.51</td>
<td>1.58</td>
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</table>

5. CONCLUSION

The OFH plays an important role to a NFR system. To achieve 50nm flying height and excellently tracking performance, it is essential to reduce the size of OFH as well as micro-OH. With a view to the practical applicability, a novel integrated OFH based on the combination of SIL and objective lens (OL) is proposed, which possesses both high optical performance and reasonable tolerance in assembly. Also, the fabrication process of this OFH is discussed and the main parameters of ABS for OFH slider are presented by means of numerical simulation. The simulation result demonstrates that the flying height of the integrated OFH slider can keep stable from 43nm to 44nm at different radium of optical disk, which can yield high signal/noise ratio optical signal during the read/write motion in near field recording (NFR) system.

A primary experimental system of near-field optical storage is constructed. It possesses nicer performances of anti-jamming and shock absorption.
6. ACKNOWLEDGEMENT

We gratefully acknowledge the support of the National Natural Science Foundation of China (No. 50305012). Also, we would like to thank SAE Magnetics (HK) Ltd. for the manufacturing our experimental equipments.

REFERENCES