ELSEVIER

Tribology International 38 (2005) 578–587

TRIBOLOGY INTERNATIONAL

www.elsevier.com/locate/triboint

# Development of flying type head/slider for optical recording technology

D.E. Kim[a,*], Y.S. Kim[a], K.H. Chung[a], J.K. Lee[b], S.K. Kim[b]

[a]*Department of Mechanical Engineering, Yonsei University, 134 Shinchon-Dong, Seodaemoon-Ku, Seoul 120-749, South Korea*
[b]*Digital Media Laboratory, LG Electronics, Seoul 137-724, South Korea*

Available online 4 March 2005

**Abstract**

Flying-type sliders with the integration of optical components were developed for Near-Field Recording (NFR) and Far-Field Recording (FFR) technologies. The key design issue was the integration of the optical components with the slider. Due to the size of the lenses mounted on it, the slider had to be relatively large, corresponding to the size of a micro-slider. Also, the non-uniform distribution of the slider body density was incorporated in the design. As for the optical disk substrate, a plastic material such as polycarbonate was investigated because of its manufacturing convenience and cost effectiveness. The flying and tribological performance of the prototype optical sliders on various media were assessed. The results showed that the tribological characteristics of the slider/disk interface were sensitive to several factors including the properties of the disk. Adequate flying characteristics of the optical sliders on glass (NFR) and plastic (FFR) disks could be attained by optimizing these parameters.


*Keywords:* Head/slider interface; Optical recording; Plastic disk

## 1. Introduction

One of the issues of the next generation optical storage device is to achieve high recording density while maintaining removability. In the optical storage system the bit size is limited by the spot size of the laser beam which is determined as follows:

$$d \approx \frac{\lambda}{2n\sin\theta} = \frac{\lambda}{2\mathrm{NA}} \quad (1)$$

where $\lambda$ is the wavelength of the laser, $n$ is the refractive index, $\theta$ is the angle between the outermost ray and the optical axis, and NA is the numerical aperture of the lens. In the case of a conventional optical storage device, the wavelength of the laser source is about 650–840 nm and the NA is about 0.45–0.6 nm, which results in the spot size of about 1 μm. In order to decrease the spot size, the wavelength should be reduced and the NA should be increased. However, in the case of Far-Field Recording (FFR) a spot size that is smaller than the wavelength cannot be achieved. In order to overcome the diffraction limit of the light and achieve ultra-high recording density, the Near-Field Recording (NFR) technology was introduced [1,2]. NFR promises ultra-high recording density by exploiting the evanescent wave and overcoming the diffraction limit of the light. In order to obtain a spot size that is smaller than the wavelength of the laser, near-field optics such as the optical fiber probe, Solid Immersion Lens (SIL), and the Super-Resolution Near-Field Structure (super-RENS) have been utilized [3–5]. It has been reported that by using these components the spot size of about 100 nm could be attained [6,7].

As in the case of magnetic recoding, the bit size achieved by NFR is dependent on the gap between the optical head and the recording media [6]. Also, the intensity of the evanescent wave decays drastically with increase in the air gap [8], and therefore, it is crucial to maintain a steady gap between the optical head and the recording media. In the head/disk interface (HDI) systems of conventional FFR devices, the gap between the objective lens and the disk media is controlled by using a focusing actuator. However, since the gap between the optical head and the recording media should be maintained near 100 nm to realize

* Corresponding author. Tel.: +82 2 2123 2822; fax: +82 2 312 2159.
*E-mail address:* kimde@yonsei.ac.kr (D.E. Kim).

0301-679X/$ - see front matter 
doi:10.1016/j.triboint.2005.01.003

the effects of the evanescent wave, a flying-type slider with the integration of the optical head has been proposed for the NFR technology [9,10]. A flying-type slider based on air-bearing lubrication has been widely utilized in hard disk drive (HDD) to achieve flying heights below 10 nm. As the gap between the optical head and the disk media decreases, the probability of contact between the slider and the disk media increases, and therefore, it is necessary to optimize the HDI of the optical recording system with respect to the tribological performance.

In order to utilize a flying-type slider for optical recording systems, an optical lens such as SIL must be adequately integrated with the slider body and the optical processing system. Also, in order to attain stable flyability of the optical slider on the disk media, the disk media should be smooth and possess sufficient rigidity. As for the optical recording media, a plastic material such as polycarbonate (PC) is preferred as the substrate because of its manufacturing convenience and cost effectiveness. However, since the smoothness and stiffness of a plastic media are significantly lower compared with the hard disk, the flyability of the slider will be deteriorated. Therefore, optimization of the tribological characteristics of HDI of optical recording system using a plastic media is a challenging task. An alternative to using a plastic disk is to use a glass disk which offers much higher stiffness and better flatness.

Other important requirements of the next generation information storage devices are miniaturization and removability of the recording media that may be used for portable data storage applications, such as Personal Digital Assistant (PDA), digital camera, and mobile phone. To achieve small form factor of the information storage device, a flying-type slider is also beneficial in reducing the size as well as the complexity of the system. Particularly, the thickness of the device can be reduced by using a flying-type slider/disk system since the conventional optical head/disk system relies on a relatively bulky tracking mechanism.

In this work, flying optical sliders for the NFR device as well as the miniaturized FFR device were developed. Considering the integration with the optical focusing unit and the desired flying height, prototype sliders with optical heads for both near-field and far-field optical recordings were designed and fabricated. The SIL and the super hemispherical lens were utilized as the optical head for NFR and FFR, respectively. The flying performance of the prototype sliders was demonstrated by using both glass and plastic substrates. Also, the tribological issues related to the development of a flying-type slider for optical recording technology were investigated. The flying characteristics of the prototype optical sliders on various disk media substrate were assessed by monitoring the friction and acoustic emission signals during contact–start–stop and flying avalanche tests. The development process for the optical slider and the experimental details are described in the following sections.

## 2. Design of flying optical head and disk media structure

The slider for optical recording consists of optical lenses for focusing of the laser source on the disk media and a magnetic coil for magneto-optical (MO) recording. The general construction of the swing arm section of the optical device and the flying optical slider are shown in Fig. 1. A swing arm structure is preferred for data tracking to achieve high data access rate. The swing arm is actuated by a Voice Coil Motor (VCM). The swing arm is designed to accommodate the optical processing units and the suspension of the slider is attached to the bottom of the arm as shown in Fig. 1(a). When the slider is loaded onto the disk the suspension deflects to accommodate the preload. The optical path of the laser beam from the source to the disk media and backwards is controlled by a set of lenses and mirrors. In order to achieve a small spot size on the disk media, the laser beam must be focused by the lenses integrated with the slider. Also, the MO recording coil is integrated with the slider body as shown in Fig. 1(b).

In order to acquire adequate read/write performance, the distance between the objective lens and the SIL or super hemispherical lens on the slider body had to be fixed. Also, a steady gap between the optical head and the disk media must be maintained during flying. In the case of NFR, the desired gap was about 100 nm and in the case of FFR, the desired gap was about 2 μm. Therefore, the key design issues for the optical slider were the physical integration of the optical unit with the slider and the flyability of the slider. The geometry and size of the flying slider were determined based on the dimensions and locations of the objective lens, SIL or super hemispherical lens, and the MO recording coil. Also, the slider manufacturing process was designed with

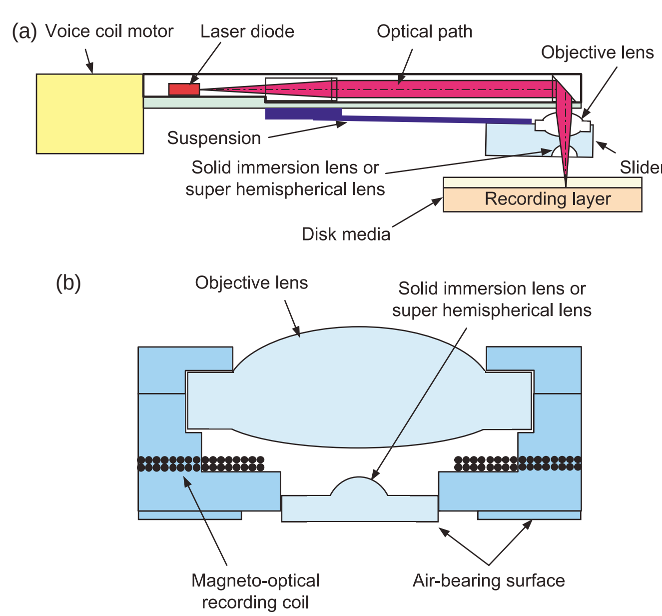


Fig. 1. General construction of (a) the swing arm section of the optical recording device and (b) the flying optical slider integrated with lenses and magnetic coil for magneto-optical recording.