Dual focus optical head for 0.6mm and 1.2mm disks

Yoshiaki Komma, Kenichi Kasazumi, Seiji Nishino and Sadao Mizuno

Materials and Devices Lab., Matsushita Electric Industrial Co., Ltd.
1006 Kadoma, Kadoma-shi, Osaka 571, Japan
Telephone:+81-6-906-4396 Facsimile:+81-6-906-5693.

Yoshihiro Kanda

Disc Engineering Dep't
1-4 Matsuo-cho, Kadoma-shi, Osaka 571, Japan

Hideki Hayashi

Audio Video Information Technology Lab.
1006 Kadoma, Kadoma-shi, Osaka 571, Japan

ABSTRACT

We propose a dual focus optical head with a holographic optical element (HOE) which compensates for spherical aberration, allowing it to read both 0.6mm disks and 1.2mm disks. The thin disk is read using transmitted light and the thick disk is read using +1st order diffracted light of the blazed HOE. The characteristics of the focused spot, the servo signal detection and the signal of the Compact Disc indicate that both disks can be read by the dual focus optical head.

1. INTRODUCTION

Shorter light source wavelength and larger numerical aperture (NA) are important optical factors in optical pickup heads for realizing high density optical storage.[1]

Laser diodes (LDs) with wavelengths in the 680nm range are now commercially available. Optical disk systems using a 680nm LD and a large NA lens have recently been the focus of considerable research activity. Large NA lenses, however, are extremely sensitive to aberrations in the disk substrate when the disk tilts. Accordingly, a thin (0.6mm) substrate is preferable[1] for reading high density optical disks with a large NA (=0.6) lens from the viewpoint of

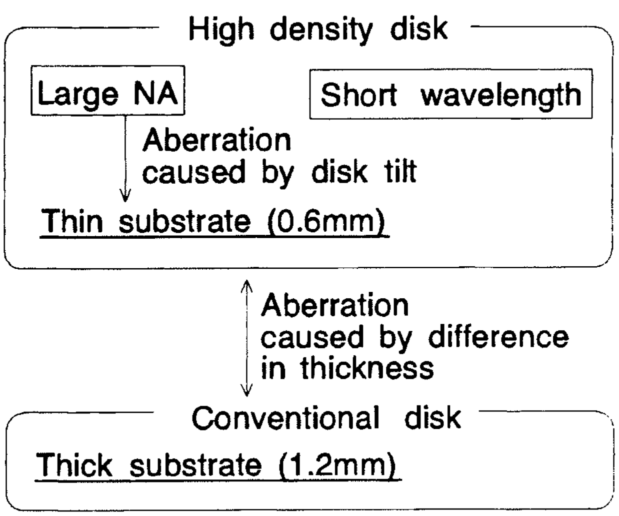

Fig.1. Background of the dual focus optical head.

LG Electronics, Inc. et al.
EXHIBIT 1005

0-8194-1671-1/94/$6.00

tolerance to disk tilt (Fig.1).

Before reading conventional 1.2mm disks using the same optical head, spherical aberration, which is caused by disk thickness difference, must be corrected.

We propose a dual focus optical head with a holographic optical element (HOE) which compensates for spherical aberration, allowing the reading of both 0.6mm disks and 1.2mm disks.

2. THE OPTICS OF THE DUAL FOCUS OPTICAL HEAD

2.1. The functions of the HOE

Figure 2 shows the functions of the HOE in the dual focus optical head.

The thin disk is read using the HOE's transmitted zero order light and the thick disk is read using +1st order diffracted light.

(a) For 0.6mm disks, the zero order diffraction (=transmittance) is utilized on both the outgoing and the incoming path. Returning light from the disk is also a plane wave when the transmitted light is focused on the 0.6mm disk. In this case the HOE simply plays the role of a parallel plate. The characteristics of the signal being read from high density thin disks are unaffected by misalignment of the HOE or deviation of the wavelength from the set value.

(b) For 1.2mm disks, the +1st order diffracted light is converged and reflected on the disk, and the +1st order diffracted light on the incoming path is utilized to obtain signals. The light beam is a plane wave when the +1st order diffracted light on the outgoing path is focused on the 1.2mm disk. In this case, the HOE functions as a lens in combination with the objective lens.

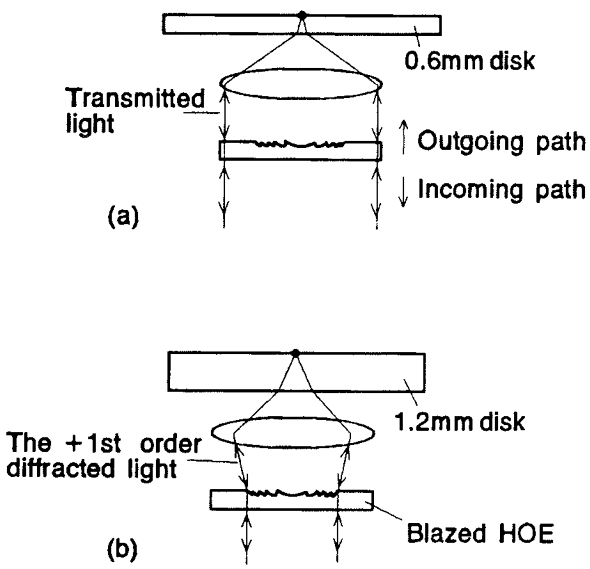

Fig.2. The functions of the HOE in the dual focus optical head.
(a) For 0.6mm disks, the zero order diffraction (=transmittance) is utilized on both the outgoing and the incoming path.
(b) For 1.2mm disks, the +1st order diffraction is utilized on both the outgoing and the incoming path.

2.2. Optical configuration of the dual focus optical head

Figure 3 shows the optical configuration of the dual focus optical head.

As mentioned above, the returning beam utilized to read signals is a plane wave in focused condition for both disks. Servo signals are obtained using only one photodetector (PD). As explained later, for the +1st order diffraction light the HOE also functions as an aperture. The center of the HOE must be near the optical axis, and so the HOE is combined with the objective lens.

This configuration requires only the addition of a HOE, which is a small, light and inexpensive element.

2.3. The mask pattern of the HOE

Figure 4 shows the mask pattern of the HOE. The gratings are drawn every two pitches in this figure. The HOE is blazed to increase the diffraction efficiencies of the +1st order and the zero order. The HOE pattern is designed as a concave lens. The focal point of the +1st order diffracted light is farther from the objective lens than that of the zero order diffracted light. Accordingly, when signals are read with one of the diffracted beams, the other does not interfere with it.

2.4. Blazing of the HOE

Figure 5 shows cross sectional views of the HOE, which has a staircase structure with 4 steps of equal height.[2]

(a) In the central region, the optical path length difference between the zero order and the +1st order diffracted light is equal to $N\lambda/4$ at the boundaries of each step, where λ is wavelength of the

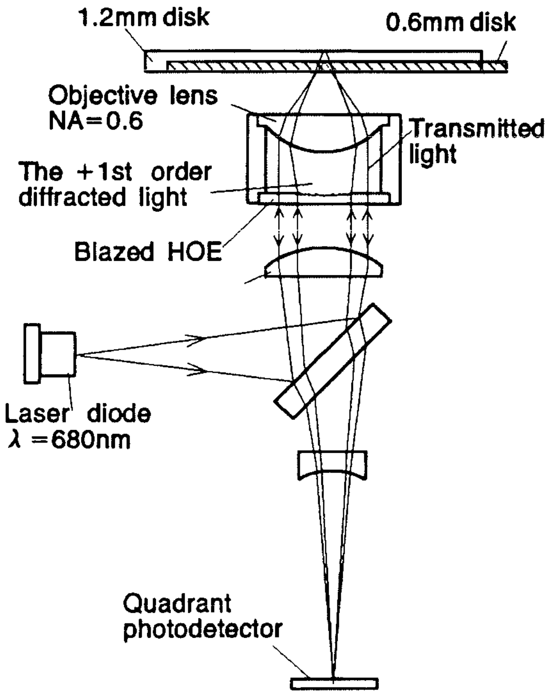

Fig.3. Optical configuration of the dual focus optical head.

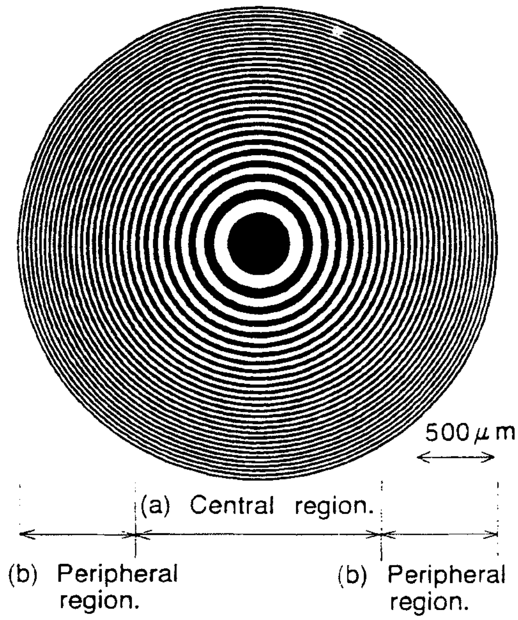

Fig.4. Mask pattern of the HOE.
The gratings are drawn every two pitches in this figure.

LD, and N is an integer. The NA of the central region was set to 0.4. Both the zero and the +1st order diffraction efficiencies are designed to be 38%. These conditions have not been optimized. The minimum pitch of this region is 22.7μm.

(b) In the peripheral region, the ratio of the step width w1/w2 decreases towards the edge part. This shape is an approximation of a blazed grating with smaller gradient. The minimum pitch of this region is 13.5μm.

Figure 6 shows the distribution of the zero and the +1st diffraction efficiencies. The horizontal axis represents the distance from optical axis, regarding NA as the scale reference. The +1st order diffraction efficiency decreases gradually towards the outer part of the HOE. This reduces the effective NA for the thick disk. The zero order transmittance of the HOE gradually increases towards the outer part of the HOE.

As a result, the light power of the zero order diffracted light is larger than that of the +1st order diffracted light.

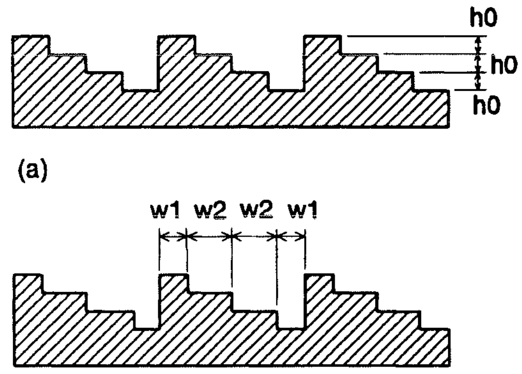

Fig.5. Cross sectional view of the blazed HOE.
(a) The central region. Optical path length difference is equal to $N\lambda/4$ at the boundaries of the steps.
(λ: wavelength, N: integer)
(b) The peripheral region: w1<w2.

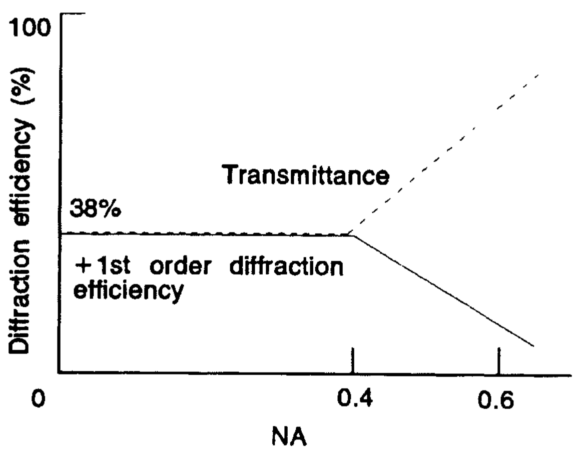

Fig.6. Designed diffraction efficiencies of the HOE. Diffraction efficiencies are schematically shown.

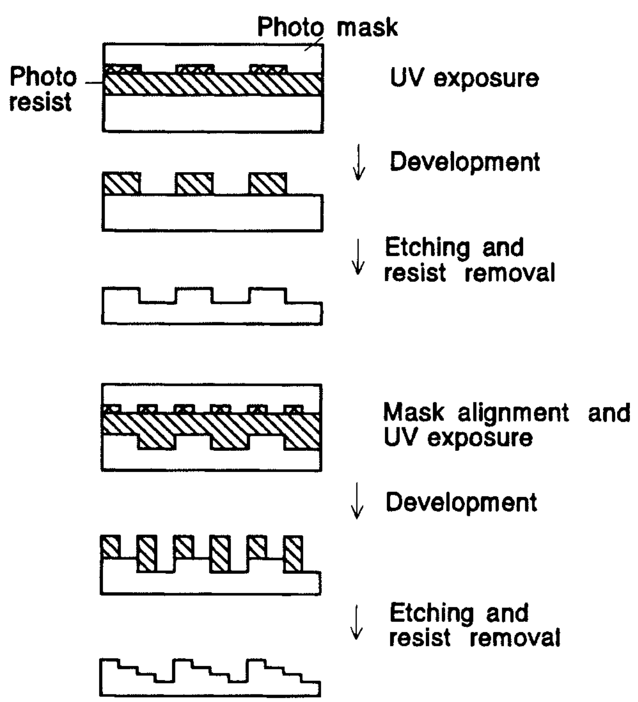

Fig.7. Fabrication process of the blazed HOE.

Figure 7 shows the process of fabrication of the blazed HOE with a 4-step staircase structure. The process consists of double photolithography and etch procedures.

3. EXPERIMENTAL RESULTS

3.1. Optical characteristics

In this optical system, it may appear at first glance that extraneous diffracted light would interfere with the focused spot and/or servo signal characteristics. The optical characteristics of the dual focus optical head were examined using mirror disks of 0.6mm and 1.2mm thicknesses. The wavelength of the laser diode was 680nm. The beam divergences parallel and perpendicular to the active layer were 9.7 degrees and 35.8 degrees respectively. The NA of the objective lens was 0.6 and the lateral magnification of the focusing optics from the LD to the disk was 1/9.375.

3.1.1 Quality of the focused spot

Figure 8 shows the intensity distribution of the focused spot on the disks. The directions X and Y respectively describe the directions parallel and perpendicular to the active layer of the LD.

(a) For the 0.6mm disk, the focused spot diameters were 0.59 mm at full width half maximum (FWHM) in both X and Y directions, identical to the focused spot diameters without the HOE.

Because the transmittance of the HOE changes gradually, the intensities of the first secondary maxima were less than 3% of that of the principal maximum, in spite of the transmittance of the central region being less than that in the peripheral region.

(b) For the 1.2mm disk, the focused spot diameters were 0.70 μ m and 0.69 μ m in the X and Y direction respectively, which should be small enough to read signals from conventional disks. Because the ratio of the step width w1/w2 decreases in the peripheral region of the HOE, the effective NA for the 1.2mm disk was reduced, though the effective

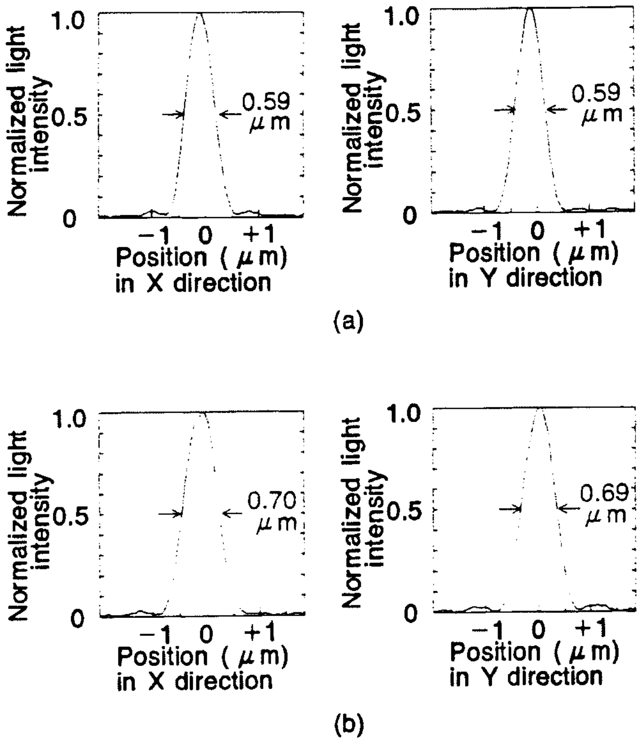

Fig.8. Intensity distribution of focused spot on the disks.
(a) For the 0.6mm disk. Spot diameters (FWHM) are 0.59 μ m on both X and Y direction.
(b) For the 1.2mm disk. Spot diameters (FWHM) are 0.70 μ m and 0.69 μ m in the X and Y direction, respectively.

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.

WHAT WILL YOU BUILD? | **sales@docketalarm.com** | **1-866-77-FASTCASE**

fastcase®
Smarter legal research.