Description

This invention relates to an electro-optical servo transducer head suitable for sensing the position of the head relative to servo information on a data storage disk e.g. a magnetic rigid, or floppy disk.

Background Art

The use of optical sensors to detect servo tracks on a magnetic disk is well known in the art, and many designs have been presented. In general, a light signal is directed to the magnetic recording disk medium and a reflected light signal is detected to provide an indication of the position of a magnetic head with respect to the tracks on the magnetic recording disk medium. The accuracy with which the magnetic head is positioned relative to the tracks dictates the distance to be maintained between adjacent tracks on the information recording medium, and also determines the density of the information storage. That is, it determines the amount of information which can be stored in a given amount of area on the information recording medium. The following references generally deal with various types of optical servo systems useful in magnetic recording:

1. D. M. Hart, IBM Technical Disclosure Bulletin, Vol. 16, No. 9, page 3020, Feb. 1974.
2. A. S. Hoagland, IBM Technical Disclosure Bulletin, Vol. 20, No. 10, page 4108, March 1978.
3. U.S. Patents 3,925,817; 4,123,788; and 4,176,381.
4. N. Koshino et al, IEEE Trans. on Magnetics, Vol. Mag. 16, No. 5, page 631, Sept. 1980.
5. R. A. Scranton, IBM Technical Disclosure Bulletin, Vol. 25, No. 12, page 6432, May 1983.
6. U.S. Patent 4275404.

In particular the following references are relevant to the present invention:

7. T. Hayashi, JP-A-52 136 611. This reference discloses a device according to the preamble of claim 1 of the present application. However, it suffers from a high degree of complexity and a bulky design, with too many separate components to be practical. It is also too heavy to be suitable for high speed motions of a magnetic head.
8. O. Hasegawa, JP-A-57 105 716. This reference discloses an improved centrosymmetric arrangement of a light source, detector and lens. However also in this case the device suffers of a high degree of complexity in that it is made up of a number of distinct components, and thus renders it difficult and expensive to build.

An integrated three-terminal LED/photodetector of a type that may be used in the invention is disclosed in IBM Technical Bulletin, vol. 25, no. 12, May 1983, pages 6654-5.

Generally, it is desirable that the optical sensor be of very light weight and small size, and be of low cost so as not to add appreciable expense to the magnetic heads and circuits used for detecting magnetically recorded information. It is also desirable that the optical sensor be mounted on the slider, or arm, which also contains the magnetic recording/reading head. The cited references show many designs, some of which include an optical sensor which is mounted on the slider holding the read/write head.

It is also desirable to provide an optical sensor in which the light emitting portion thereof and the light receiving portion thereof are located on the same structure, and in particular a monolithic structure such as a semiconductor wafer. This sort of approach is described in aforementioned references 5 and 6 where light emitting diodes (LED) and light detectors are formed in the same semiconductor structure. In reference 5, the light source and light detector can be a GaAs structure where the active layers of the light emitter and light detector are in the same plane. Light reflected from the surface of a magnetic disk is transmitted back through the light emitter to the detector, in an arrangement where it is necessary to make the light emitter sufficiently transparent to the reflected light. However, there is a critical alignment required in this type of structure since the light detector has to be properly and accurately aligned with respect to the light emitter in order to satisfactorily collect the reflected light from the disk.

In aforementioned reference 6, a monolithic optoisolator is described in which a light emitting diode and a photo diode are fabricated from the same epitaxial semiconductor layer. The light emitting diode is located at the center of the structure, and is surrounded by a generally annular photodiode. A graded bandgap structure is used and the light emitting diode and light receiving photodiode are electrically isolated from one another by channels which extend through the semiconductor into the substrate of the structure.

The device of reference 6 is used to perform the function of an optical transformer, in that it optically couples an input signal to an output circuit in order to provide an output signal in a circuit in which there is complete electric isolation between the input circuit and the output circuit. It is not used as a sensor for servo-positioning a magnetic head, or in applications where light has to be directed to an external surface and reflected therefrom for collection by a photodetector.

In optical servosystems, it is generally difficult to provide proper alignment between the light emitter and the light detector, as well as between the

emitter-detector combination and the optical system (lens, etc.) which is used for imaging the light onto another surface and for receiving the light reflected therefrom. The requirements of critical alignment and/or dimension in such prior systems involves additional cost and complexity, making these systems unattractive especially in high density recording. Accordingly, it is a primary object of this invention to provide an improved optical servo sensor for use in applications where precise positioning of a magnetic write/read head is required, and wherein no critical alignments or dimensions, to a first order, are required.

In many types of optical sensors used, for example, in servo applications, complex optical elements are required to couple light from the source to the magnetic recording surface and back to the photodetector. Accordingly, it is another object of the present invention to provide an improved optical servo sensor which requires only a single optical element that can be of very low cost.

In optical servo systems of the type using optical sensors, it is very important to provide a high resolution sensor, especially when ultra high recording densities are required. It is also important that the optical sensor be of low cost, small size, and light weight so that it can be incorporated in, for instance, magnetic head assemblies used to read and write information into a magnetic recording medium. Accordingly, it is another object of the present invention to provide an improved optical servo sensor where the optical sensor is of small size and light weight, and can be fabricated very cheaply.

In optical sensors using light emitting diodes and photo detectors on the same semiconductor chip, it has often been the situation that the close proximity of these elements on the same substrate caused electrical and optical cross-talk between the light source and the light detector. A large amount of direct light from the light source to the detector can saturate the detector and thereby render ineffective the detection of the reflected light signal. Accordingly, it is another object to provide an improved optical servo sensor in which the light source and the light detector are located in the same semiconductor substrate and very close to one another, without problems of ac electrical and/or optical cross-talk therebetween.

As noted previously, any required critical alignment or critical dimension will create additional costs and will add complexity to the optical servo sensor. As an example, in such sensors any deviation from alignment will adversely affect the performance of the device, and this will become increasingly more severe as the demands upon resolution are increased. Accordingly, it is another object of the present device to provide an improved optical servo sensor in which any deviation from alignment will have negligible effect to first order, and will not adversely affect the servoing performance of the sensor.

It is another object of the present invention to provide an improved optical servo sensor having the characteristics described in the preceeding objective, where the light source and the light detector are made by a technique providing self-alignment therebetween, and wherein the alignment of the light source/detector combination and the single optical element required for imaging is also not dependent on critical alignments or dimensions, to a first order.

The invention is set out in claim 1

The servo sensor may be comprised of a semiconducting light source, such as a light emitting diode (LED) fabricated of a p-n junction, a light detector also comprising a p-n semiconductor junction, where the light source and light detector are located in the same semiconductor chip, and an optical element which is comprised of a single, very simple lens. The entire system is axially symmetric in that the overall structure has cylindrical symmetry, the light source, reflected light detector, and lens being located on a common axis. Due to the cylindrical symmetry, there are no critical alignments or dimensions (to a first order) in this system.

The optical servo sensor is a portion of a magnetic read/write head structure, where the optical sensor can be located on the slider, or arm, used to house the magnetic read/write head. Light is emitted by the light source and is imaged to a small spot on a magnetic recording medium, such as a disk. Light is reflected from a servo track on the disk and is imaged onto the photodetector by the single lens element. This reflected light is a measure of the positioning of the read/write head with respect to a particular track on the disk.

In this invention it is to be understood that the optical servo sensor is located on the magnetic head, or on the slider, arm, or actuator used to position the head. Thus, when it is stated that the optical servo sensor is a part of the magnetic head structure, or located on the magnetic head, any of the above-mentioned locations (arm, slider, etc.) are included and intended.

In a preferred embodiment the light detector is located in the same chip of material as the light source and the two are aligned axially. The p-n junction of the light detector is located below the p-n junction of the light emitting source, where both junctions are in the same semiconductor chip. Light which is reflected from an object has to pass through the light source in order to reach the light detector in this embodiment. For this reason, the bandgap of the source p-n junction is chosen to be

larger than the bandgap of the detector p-n junction, and the thicknesses of the p- and n-type layers comprising the light source are sufficiently thin that a large percentage of the reflected light will pass through the light source to impinge upon the detector p-n junction. This embodiment has an advantage in that it can be used to collect light from a diffuse or specular surface. Thus, it is particularly suitable for detecting light reflected from a hard magnetic disk, whose surface is very mirror-like.

These and other objects, features, and advantages will be apparent from the following more particular description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of a magnetic head structure including an optical servo sensor, which is used to detect optical servo tracks on a data storage disk.

FIG. 2 is a cross sectional view of a semiconducting chip including a light emitting diode and a light receiving photodetector, where the p-n junction forming the light emitter is located over the p-n junction forming the light detector.

FIG. 3 is a schematic top view of a portion of the structure of FIG. 2, and is used to illustrate the electrical contacts to the light source and light detector.

FIG. 4 is a schematic illustration of the electrical equivalent of the light source and light detector, and also includes the electrical circuitry used to produce an output electrical signal indicative of the light reflected from a servo mark on a magnetic recording medium.

FIG. 5 is an emission spectrum of light from the light source of FIG. 2, while FIG. 6 is an absorption spectrum of the material of the emitting junction of conductor chip (FIG. 2), indicating that most of the reflected light passes through the light source and the n-layer without being significantly absorbed.

FIG. 7 illustrates an embodiment of the present invention in which the light detector is an axially symmetric structure surrounding the light source, and the optical element is a more complex lens having portions thereof with different focal lengths.

FIG. 8 is a cross-sectional view of the semiconductor chip in which a light source and light detector are formed, illustrating that the light detector has an axially symmetric structure, and is concentric with the light source.

FIG. 9 illustrates the use of an aperture in the embodiment of FIG. 7.

FIG. 10 illustrates the alignment of the axis of the light source/detector combination and the optical element, while FIG. 11 illustrates a situation in which the axes of the light source/detector combination and the optical element are misaligned.

FIGS. 12-15 illustrate different types of lens which can be used in place of the optical element in the embodiment of FIG. 7.

BEST MODE FOR CARRYING OUT THE INVENTION

FIG. 1 illustrates a data recording system and the alignment of a read/write head 20 with respect to an optical servo pattern 22 comprising servo marks and a data recording track 24, the servo pattern 22 and data track 24 being located on a magnetic disk 26. These tracks and the structure of the disk are well known in the art, and include both hard and floppy disks. The read/write head 20 is located above the disk 26 at a height which is chosen in accordance with the recording system, in a manner also well known in the art.

The optical position sensor is a portion of head 20 and is comprised of a light source-light detector couple 28 and a single axially symmetric optical element 30. Although the lens 30 and semiconductor chip comprising the light source/detector couple 28 is shown large in this figure, these elements are very small in accordance with the recording density required on magnetic disk 26. In a representative example, the distance from the top surface of head 20 to the top surface of disk 26 is approximately 30 mils (0,76 mm), and the diameter of spherical lens 30 is about 7.5 mils (0,19 mm). The lens 30 sits in a cone-shaped aperture 32 in head 20, the diameter of the aperture at the top surface of head 20 being, for example, about 45 mils (1,14 mm). Of course, these figures can be varied in accordance with the recording system, but are representative of the dimensions of the optical servo sensor of the present invention, and illustrate that this sensor device can be made very small to accommodate all types of data recording systems.

In the use of the position sensor of FIG. 1, light from the source is imaged onto a small spot (point) of the disk 26 by the lens 30, and the light reflected from that point is collected by lens 30 and sent to the light detector, which is also a part of the semiconductor chip comprising the light source/light detector couple 28. An ac signal is detected indicating the change of light received by the detector, which in turn is a measure of the position of the head 20 with respect to a desired recording track.

FIG. 2 is a schematic diagram of a cross-section of the semiconductor chip which comprises the light source/light detector couple 28. In this embodiment, the light source is a forward biased p-n junction 34, while the light detector is a reverse

biased p-n junction 36. The semiconductor structure is comprised of the p-type layer 38, the n-type layer 40, and the p-type layer 42. An ohmic contact 44 is made to the light emitting diode, while an ohmic contact 46 is made to the light detector. The area of the light source through which light travels to the disk is designated LED, standing for light emitting diode. A layer 48 of electrically conductive material is located on the bottom of the semiconductor chip, and serves as an ohmic contact to complete the electrical biasing for the light emitting junction 34 and the light detecting junction 36. An oxide layer 50 is used to provide electrical isolation between the ohmic contacts 44 and 46.

FIG. 3 is a top view of the structure of FIG. 2, indicating the ohmic contacts 44 and 46. From this view, it is apparent that the ohmic contact to the p-type layer 42 of the light source is generally annular in structure, and is connected to a contact band 52. The ohmic contact 46 to the detector can also be of large area, as indicated in FIG. 3.

The semiconductor chip is a tri-layer structure in which the light detector junction 36 is located beneath the light emitter junction 34, so that reflected light which is to be detected must pass through the light source. By proper choice of the materials comprising layers 38, 40, and 42, the bandgaps of the materials can be chosen to make the light source substantially transparent to the reflected light.

Another feature of the structure of FIG. 2 is that there is cylindrical symmetry between the light source and the light detector. This cylindrical symmetry extends also to the optical element 30 (FIG. 1) so that the entire optical sensor has cylindrical symmetry. Due to this symmetry, there are no critical angular alignments in this optical servo sensor, which is a feature that provides ease of manufacture and low cost, while at the same time providing good fabrication yields.

Other important features of this servo system are the minimum number of components which are required and the simplicity of these components. The light source and light detector are comprised of well known semiconducting materials such as GaAs and GaAlAs. By varying the amount of Al, the bandgap of the semiconductor can be changed, as is well known in the art. For example, the p-type layer 38 can be comprised of GaAs, while the n-type layer 40 can be comprised of GaAlAs. P-type layer 42 is produced by implanting impurities, such as zinc, into the GaAlAs layer 40. Of course, other semiconducting materials, including III-V and II-VI compounds, can be used to form the light emitting and light detecting junctions.

FIG. 4 schematically illustrates the electronic circuitry representing the light emitting and light detecting diodes and the arrangement of components used to provide an output signal. In this figure, the forward biased p-n junction 34 comprising the light source is indicated by diode 54, while the p-n junction 36 used for the light detector is indicated by the diode 56. The R-C circuit is a high-pass filter used to filter out dc components in order to allow only the ac component to pass to the current detecting operational amplifier 58, to which is connected a feedback resistor R_f. Biasing for the light source 54 is provided by the source V, which produces a current through resistor R_L. The light provided by source 54 is indicated by the arrow 60, while the light reflected from the data storage disk 62 is indicated by the arrow 64. Light 64 is collected by the detector 56, producing a diode current i_d which flows toward the detecting amplifier 58. The voltage V_0 across resistor R_f indicates the output signal.

In operation, light will be provided directly from the light source to the detector in the buried detector embodiment of FIG. 2. However, this will produce a dc component of current in the detector which is filtered out by the RC circuit in order to eliminate this dc offset. The direct light from the light source will not affect the performance of the device as long as it does not saturate the light detector, and as long as the noise due to the direct light from the source is much smaller than the signal due to the reflected light.

FIGS. 5 and 6 show the emission spectrum of the light source, and the absorption of the light emitting material in the semiconductor chip, respectively, and illustrate that the reflected light will pass through the light source to the light detector.

In more detail, FIG. 5 plots the relative intensity of the light emitted as a function of the energy of the light, where the quantity $E = E_{gp}$ is the bandgap of the p-type side of the emitter junction 34 (FIG. 2). Most of the light emitted by the forward biased junction 34 is at a frequency close to this bandgap.

FIG. 6 plots the absorption of the semiconductor material, and shows the absorption coefficient α as a function of the energy (and therefore, the frequency) of the absorbed light. The intensity I (x) as a function of distance into the emitting semiconductor material, where x is measured from the top surface of p-layer 42, is an exponential function of distance x. The absorption coefficient of the semiconductor material does not increase appreciably for the wavelengths of the reflected light, and therefore most of the reflected light goes through the p-layer 42 without being absorbed.

The embodiments shown in FIGS. 7-15 are particularly suitable as servo elements with diffuse reflectors such as floppy disks. However, these embodiments are not as suitable for mirror-like reflecting surfaces, due to the placement of the detector as an annular element surrounding the

light source.

In more detail, FIG. 7 shows an optical sensor comprising a single semiconductor chip 86 and a complete lens 88. Semiconductor includes a light source 90 and a coaxial annular light detector 92. Details of the semiconductor chip will be apparent from FIG. 8. Lens 88 includes a central portion 94 having a first radius of curvature and an outer portion 96 having a different radius of curvature. Consequently, the focal lengths of the two portions 94 and 96 are different.

Semiconductor chip 86 and lens 88 have cylindrical symmetry with respect to one another, and are located on a common axis in the support cylinder 98, which is comprised of a light-opaque material, such as a metal. A washer 100 supports the lens 88 and is fabricated of a light absorbing material, such as a plastic. A glass window 102 is located on the top surface of the structure. The device is located at a distance from the magnetic disk 104 such that light from the source 90 will be imaged to a point on the surface of disk 104.

In the operation of the sensor of FIG. 7, composite lens portion 94 has a shorter focal length than the outer lens portion 96. Therefore, lens portion 94 can focus the light source 90 to a point I on disk 104, while the diffused reflected light from point I is collected by the outer lens portion 96. Since the focal length of the lens portion 96 is larger, the collected diffused light is imaged over an area which includes the annular detector 92. This is indicated by the light rays 106 from the source which are focussed at point I, and by the diffuse reflected rays 108, which are imaged over an area including the detector 92.

FIG. 8 shows in more detail the semiconductor chip 86, which includes a light emitting p-n junction 110 and a light detecting p-n junction 112. The light emitting junction 110 is forward-biased, while the light detecting junction 112 is reverse-biased. Ohmic contacts 114 are provided to the light source, while ohmic contacts 116 are provided to the light detector. These contacts have the same physical geometry as the ohmic contacts shown in FIG. 3. The semiconductor chip 68 includes a substrate 118 of GaAs, and an n-type layer of GaAlAs. P-type regions 122 are diffused or ion implanted into layer 120 to create the light source junction 110 and the light detector junction 112. A metal layer 124 on the back of the GaAs substrate 118 serves as an ohmic contact.

The electrical circuit for the semiconductor chip 86 is the same as that shown in FIG. 4. The high pass filter comprised of the RC network is not required here, since the dc electrical and optical cross-talk between the light source and the light detector is negligibly small in this embodiment, even though they are built on the same semiconductor chip. Thus, only a very small amount of very direct light travels from the light source to the light detector, and there is no danger of saturation of the detector. The light source and the light detector are arranged concentrically on the chip 68. The light source is in the center and is much smaller than the detector in order to obtain a small spot size at location I on disk 104. The light detector is an area detector comprising an annular shaped junction area.

As noted previously, the outer portion 96 of the composite lens has a longer focal length than the inner portion, and therefore images the illuminated spot I to a point A behind the semiconductor chip 86, as shown in FIG. 9. However, the light coming from the outer lens section 96 is intercepted and detected by the circular, large area detector 92.

The outer composite lens section 96 not only collects light from the illuminated spot I, but also collects light from the source 90 and illuminates a ring around the spot I. In order to minimize this undesirable illumination, an aperture 126 is placed at the window of the sensor. The supporting washer 100 in FIG. 7 serves as an aperture, also.

The alignment of optical elements 88 with a source-detector couple is generally a crucial aspect in the fabrication of optical sensors. However, the cylindrical symmetry of the present device makes the alignment relatively less important. This is illustrated by FIGS. 10 and 11, where FIG. 14 illustrates the case where the lens 88 and source-detector couple are aligned, while FIG. 11 illustrates the situation when the axis of the lens and the semiconductor source-detector couple are misaligned. As is apparent from FIGS. 10 and 11, any deviation from alignment will be self-correcting and will not affect the performance of the device, to first order in the misalignment.

FIGS. 12-15 show different optical elements which can be used in place of the optical element 88 of FIG 7. In FIG. 12, two plano-convex lenses 128 and 130 are combined to form the composite lens. These lenses have different diameters, but the overall structure is similar to that of lens 88 in FIG. 7. The axes of the two lenses 128 and 130 do not require precise alignment in order to form a suitable optical element.

In FIG. 13, a lens 132 is used, having a transparent coating 134 (such as epoxy) on its outer region. This composite lens has an advantage in that it is very easy to fabricate.

In FIG. 14, a molded composite lens 135 is shown in the container tube 98, where the semiconductor chip 86 is located at the bottom of this container. A molded lens, such as lens 136, is very inexpensive to fabricate in large quantities.

FIG. 15 illustrates the use of a spherical lens 138 which is supported by the holding structure

140 located in the optical tube 98. A window 142 is located on one end of the structure 98, while the semiconductor chip 86 is located at the other end. In this structure, the aberrations of a spherical lens 138 are used to collect light and to image it onto the annealing detector. Although this is a very inexpensive alternative, its efficiency will not be as good as the efficiency obtainable using the previously mentioned lens elements.

The centro-symmetric symmetry of the arrangement shown in FIG. 7, and the alternatives thereto, minimize the problems of misalignment and critical dimensions. Composite lens 88 is located midway between the light source and the object, in order to allow tolerance on the positioning of the lens. For a lens located midway between chip 86 and the disk 104, and for the total distance between the light source and the object being $2f_1$, where f_1 is the focal length of the central section 94 of the lens 88, the range for the focal length f_2 of the outer lens portion 96 is given by the following expression:

$$2f_1 > f_2 > f_1.$$

The inner and outer radii r_1 and r_2 (see FIG. 8), respectively, of the annular light detector are given by the following expressions:

$$r_1 = \frac{2(f_2 - f_1)}{f_2} R_1,$$

$$r_2 = \frac{2(f_2 - f_1)}{f_2} R_2,$$

where R_1 and R_2 are the radii of the inner and the outer portions of the lens respectively as indicated in FIG. 7.

As mentioned previously, the embodiment of FIG. 7 is used for disks with diffusely reflecting surfaces. If the object 104 were a perfectly reflecting mirror, light would not be scattered from the object to the detector but instead would be reflected back to the source. Thus, the embodiment of FIG. 7 is more suitable for use with diffuse reflectors, such as floppy disks.

What has been described is a very simple optical sensor for use in servo positioning of read/write heads in data recording systems, such as magnetic recording systems. A single semiconductor chip is used to house a light source and a light detector, and the optical imaging element is a single lens. Cylindrical symmetry is maintained in order to minimize problems such as misalignment and the need for maintaining rigid dimensions of the components of the system.

Claims

1. Electro-optical transducer head (20) suitable for sensing the position of the head relative to information (22) on a data storage disk (26), including a light source (34) and a light detector (36) respectively for illuminating the information and for sensing the information by the reflected light, the light source and the light detector being coaxial with a lens included in the head through which the illuminating and reflected light pass, the light source, the light detector and the lens being centrosymmetric about their axis, characterized in that

   said light detector (36) is an area detector located at least within an annulus around said light source (34), and in that said lens (88) comprises two concentric portions having two different focal lengths, the focal length of the inner portion for imaging light from said source onto said storage medium being less than the focal length of the outer portion for deflecting scattered light from said medium to said light detector.

2. The transducer head as claimed in claim 1, wherein the light source and light detector are both formed in a monolithic semiconductor chip (38, 40, 42).

3. The transducer head as claimed in claim 1 or 2, where said light detector is located below said light source in said semiconductor chip, wherein light reflected from said data storage medium passes through said light source to said detector, the semiconductor material comprising said light source being substantially transparent to said reflected light.

4. The transducer head as claimed in claim 3, wherein said light source and said light detector are p-n junctions in said semiconductor chip, and where the bandgap of the light source junction is greater than the bandgap of said light detector junction.

5. The transducer head as claimed in claim 4, wherein said light source junction is forward biased and said light detector junction is reversed biased.

6. The transducer head as claimed in any preceding claim, wherein said lens is a composite lens comprising a spherical and/or a plano-

140 located in the optical tube 98. A window 142 is located on one end of the structure 98, while the semiconductor chip 86 is located at the other end. In this structure, the aberrations of a spherical lens 138 are used to collect light and to image it onto the annealing detector. Although this is a very inexpensive alternative, its efficiency will not be as good as the efficiency obtainable using the previously mentioned lens elements.

The centro-symmetric symmetry of the arrangement shown in FIG. 7, and the alternatives thereto, minimize the problems of misalignment and critical dimensions. Composite lens 88 is located midway between the light source and the object, in order to allow tolerance on the positioning of the lens. For a lens located midway between chip 86 and the disk 104, and for the total distance between the light source and the object being $2f_1$, where f_1 is the focal length of the central section 94 of the lens 88, the range for the focal length f_2 of the outer lens portion 96 is given by the following expression:

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The inner and outer radii r_1 and r_2 (see FIG. 8), respectively, of the annular light detector are given by the following expressions:

$$r_1 = \frac{2(f_2 - f_1)}{f_2} R_1,$$

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where R_1 and R_2 are the radii of the inner and the outer portions of the lens respectively as indicated in FIG. 7.

As mentioned previously, the embodiment of FIG. 7 is used for disks with diffusely reflecting surfaces. If the object 104 were a perfectly reflecting mirror, light would not be scattered from the object to the detector but instead would be reflected back to the source. Thus, the embodiment of FIG. 7 is more suitable for use with diffuse reflectors, such as floppy disks.

What has been described is a very simple optical sensor for use in servo positioning of read/write heads in data recording systems, such as magnetic recording systems. A single semiconductor chip is used to house a light source and a light detector, and the optical imaging element is a single lens. Cylindrical symmetry is maintained in order to minimize problems such as misalignment and the need for maintaining rigid dimensions of the components of the system.

Claims

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   said light detector (36) is an area detector located at least within an annulus around said light source (34), and in that said lens (88) comprises two concentric portions having two different focal lengths, the focal length of the inner portion for imaging light from said source onto said storage medium being less than the focal length of the outer portion for deflecting scattered light from said medium to said light detector.

2. The transducer head as claimed in claim 1, wherein the light source and light detector are both formed in a monolithic semiconductor chip (38, 40, 42).

3. The transducer head as claimed in claim 1 or 2, where said light detector is located below said light source in said semiconductor chip, wherein light reflected from said data storage medium passes through said light source to said detector, the semiconductor material comprising said light source being substantially transparent to said reflected light.

4. The transducer head as claimed in claim 3, wherein said light source and said light detector are p-n junctions in said semiconductor chip, and where the bandgap of the light source junction is greater than the bandgap of said light detector junction.

5. The transducer head as claimed in claim 4, wherein said light source junction is forward biased and said light detector junction is reversed biased.

6. The transducer head as claimed in any preceding claim, wherein said lens is a composite lens comprising a spherical and/or a plano-

* C L M S *

convex lens.

7. The transducer head as claimed in claim 6, wherein said lens is located substantially midway between said semiconductor chip and said data storage disk.

Revendications

1. Tête de transducteur électro-optique (20) pouvant détecter la position de la tête par rapport aux informations (22) d'un disque d'emmagasinage de données (26) comprenant respectivement une source de lumière (34) et un détecteur de lumière (36) pour éclairer les informations et pour détecter les informations par la lumière réfléchie, la source de lumière et le détecteur de lumière étant co-axiaux avec une lentille comprise dans la tête par laquelle passent la lumière d'éclairage et la lumière réfléchie, la source de lumière, le détecteur de lumière et la lentille étant centro-symétriques autour de leur axe, caractérisée en ce que:

ledit détecteur de lumière (36) est un détecteur de zone placé au moins dans un anneau autour de ladite source de lumière (34) et en ce que ladite lentille (88) comprend deux portions concentriques ayant deux distances focales différentes, la distance locale de la portion interne pour projeter la lumière à partir de ladite source sur ledit support d'emmagasinage étant inférieure à la distance focale de la portion externe pour dévier la lumière diffuse depuis ledit support sur ledit détecteur de lumière.

2. Tête de transducteur selon la revendication 1, dans laquelle la source de lumière et le détecteur de lumière sont tous deux formés dans une microplaquette semiconductrice monolithique (38, 40, 42).

3. Tête de transducteur selon les revendications 1 ou 2, où ledit détecteur de lumière est placé en-dessous de ladite source de lumière dans ladite microplaquette semiconductrice, dans laquelle la lumière réfléchie à partir dudit support d'emmagasinage de données passe par ladite source de lumière jusqu'au dit détecteur, le matériau semiconducteur constituant ladite source de lumière étant transparent à la dite lumière réfléchie.

4. Tête de transducteur selon la revendication 3, dans laquelle ladite source de lumière et ledit détecteur de lumière sont des jonctions p-n dans ladite microplaquette semiconductrice, et où l'intervalle de bande de la jonction de source de lumière est plus grand que l'intervalle de bande de ladite jonction de détecteur de lumière.

5. Tête de transducteur selon la revendication 4, dans laquelle ladite jonction de source de lumière est polarisée dans le sens direct et ladite jonction de détecteur de lumière est polarisée dans le sens inverse.

6. Tête de transducteur selon l'une quelconque des revendications précédentes, dans laquelle ladite lentille est une lentille composée comprenant une lentille sphérique et/ou une lentille plan-convexe.

7. Tête de transducteur selon la revendication 6, dans laquelle ladite lentille est placée à michemin entre ladite microplaquette semiconductrice et ledit disque d'emmagasinage de données.

Patentansprüche

1. Elektro-optischer Wandlerkopf (20), der zum Erfassen der Position des Kopfes bezüglich Informationen (22) auf einer Datenspeicherplatte (26) geeignet ist, mit einer Lichtquelle (34) beziehungsweise einem Lichtdetektor (36) zum Beleuchten der Informationen und zum Erfassen der Informationen durch das reflektierte Licht, wobei die Lichtquelle und der Lichtdetektor koaxial mit einer in dem Kopf aufgenommenen Linse sind, durch welche das ausstrahlende und reflektierte Licht hindurchgeht und die Lichtquelle, der Lichtdetektor und die Linse zentralsymmetrisch um ihre Achsen liegen, dadurch gekennzeichnet, daß

der Lichtdetektor (36) ein Flächendetektor ist, der zumindest innerhalb eines Kreisringes um die Lichtquelle (34) gelegen ist und daß die Linse (88) zwei konzentrische Teile mit zwei verschiedenen Brennweiten aufweist, wobei die Brennweite des inneren Teils zum Abbilden von Licht aus der Quelle auf das Speichermedium kleiner ist als die Brennweite des äußeren Teils zum Ablenken gestreuten Lichts von dem Medium zum dem Lichtdetektor.

2. Wandlerkopf nach Anspruch 1, bei welchem die Lichtquelle und der Lichtdetektor beide in einem monolithischen Halbleiterchip (38, 40, 42) ausgebildet sind.

3. Wandlerkopf nach Anspruch 1 oder 2, bei welchem der Lichtdetektor unter der Lichtquelle in dem Halbleiterchip gelegen ist, in dem von

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dem Speichermedium reflektiertes Licht durch die Lichtquelle zu dem Detektor hindurchgeht, wobei das die Lichtquelle aufnehmende Halbleitermaterial im wesentlichen transparent für das reflektierte Licht ist.

4. Wandlerkopf nach Anspruch 3, bei welchem die Lichtquelle und der Lichtdetektor p-n-Übergänge in dem Halbleiterchip sind und wobei der Bandabstand des Lichtquellenübergangs größer ist als der Bandabstand des Lichtdetektorübergangs.

5. Wandlerkopf nach Anspruch 4, bei welchem der Lichtquellenübergang in Vorwärtsrichtung und der Lichtdetektorübergang in Rückwärtsrichtung betrieben werden.

6. Wandlerkopf nach irgend einem vorgehenden Anspruch, bei welchem die Linse eine zusammengesetzte Linse mit einer sphärischen und/oder plankonvexen Linse ist.

7. Wandlerkopf nach Anspruch 6, bei welchem die Linse im wesentlichen auf halbem Wege zwischen dem Halbleiterchip und der Datenspeicherplatte gelegen ist.

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